ANALYTIC HIERARCHY PROCESS FOR SELECTION OF OPTIMAL INVENTORY CONTROL POLICY

A PROJECT REPORT

Submitted By

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BONAFIDE CERTIFICATE

Certified that this project report entitled "**Analytic Hierarchy Process for selection of optimal inventory control policy**" is the bonafide work of

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who carried out the project work under my supervision.

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TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Mr.C.Yuvaraj Kumar** of final year M.E (Industrial Engineering) Kumaraguru college of Technology has undergone a project entitled "**Analytic hierarchy(AHP) for selecting optimal inventory control policy**" in our concern. He has successfully completed and implemented the same for our concern.

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CERTIFICATE

This is to certify that Mr.C.YUVARAJ KUMAR.

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Abstract

ABSTRACT

Inventory control is observed to be an important function of an organization and the function in inventory control is to determine the appropriate level of holding stocks, ordering sequence and also the quantity of materials to be ordered so that the total cost incurred will be as minimum as possible. This paper describes the key features of inventory control system and application of Analytic Hierarchy Process (AHP) technique to evaluate the best policy of inventory control. The study reviews the most important criteria and sub criteria affecting the selection of the optimal inventory control policy and determines their respective priority values imposing the AHP methodology. Five most popularly used inventory control policies are considered and then subsequently ranked using the AHP under multi-criteria environment. These considerations together with pair-wise comparison matrices and evaluating methodology lead to prioritize the conflicting criteria for selecting the optimal policy.

ஆய்வு சுருக்கம்

இருப்புநிலை கட்டுப்பாடு என்பது ஒவ்வொரு உற்பத்தி நிறுவனத்திலும் மிக முக்கிய பங்கு வகிக்கிறது. இருப்புநிலை கட்டுப்பாட்டை இந்த ஆய்வின் மூலம் மிக நேர்த்தியான முறையில் நேர்முகப்படுத்தவும் மற்றும் உற்பத்தியின் நிதி நிலையை குறைக்கவும் உதவுகிறது. இந்த ஆய்வின் மூலம் இருப்பு நிலை கட்டுப்பாட்டின் முக்கிய அம்சங்களை பற்றியும் பகுப்பு படிநிலை செயல் (AHP) திறன் வகையறுக்கப்படுகிறது. இந்த அய்வில் உற்பத்தி நிறுவனங்களில் உபயோகபடுத்தப்படும் மிகச்சிறந்த ஐந்து இருப்புநிலை கட்டுப்பாடு நெறிகளை எடுத்துக் கொண்டு, அதன் மூலம் சிறந்த இருப்புநிலை கட்டுப்பாட்டை கண்டறியபடுகிறது. இந்த ஆய்வின் சிறப்பு அம்சமாக, ஐந்து இருப்புநிலை கட்டுப்பாடும் அணிச்சேர்க்கையாக (Pair-wise comparison matrix) கணக்கிடப்பட்டு பின்பு அதில் இருந்த அணைத்து வழிமுறைகளிலும் மிகச் சிறப்பாக செயல்படும் இருப்புநிலை கட்டுப்பாட்டை (Inventory control) செயல்படுத்த உதவுகிறது.

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LIST OF ABBREVATIONS

AHP	Analytic Hierarchy Process
MCDM	Multi-criteria decision-making
OQ	Order quantity
FXD	Fixed
FLU	Fluctuating
ANC	Anticipatory
RC	Relevant Cost
OC	Ordering Cost
ICC	Inventory Carrying Cost
SOC	Under and over stocking Stock
SS	Safety Stock
LT	Lead Time
DF	Demand forecasting
QT	Qualitative Technique
TSA	Time series Analysis
CA	Casual Approach
ROP	Reorder Point
LEOQ	Lead time consumption less than EOQ
EEOQ	Lead time consumption equal to EOQ
MEOQ	Lead time consumption more than EOQ
PRP	Perpetual Review Policy
PEP	Periodic Review Policy
TBP	Two Bin Policy
MRP	Material Requirement Planning
ORP	Optional Replenishment Policy
CR	Consistency Ratio

Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Inventory control is a critical aspect of successful management. With high carrying costs, companies cannot afford to have any money tied up in excess inventories. The objectives of good customer service and efficient production must be met at minimum inventory levels. This is true even though inflation causes finished goods inventories to increase in value. Putting inventory on the shelf ties up money, and to minimize the amount tied up, a company must match the timing of demand and supply so that the inventory goes on the shelf just in time for the customer to require it .The turbulence and rapid change in the global market necessitates finding out the functions of an organization to be replanned at a faster rate such that the response time is short enough to be comparable with the rate of change. Inventory control is observed to be an important function of an organization and the basic emphasis in inventory control is to determine the appropriate level of holding stocks, ordering sequence and also the quantity of materials to be ordered so that the total cost incurred will be as minimum as possible.

Inventory control is concerned with minimizing the total cost of inventory. In the U.K. the term often used is stock control. The three main factors in inventory control decision making process are

- The cost of holding the stock (e.g., based on the interest rate).
- The cost of placing an order (e.g., for row material stocks) or the set-up cost of production.
- The cost of shortage, i.e., what is lost if the stock is insufficient to meet all demand.

Broadly speaking, the essence of inventory control consists of finding answers to three basic questions related to necessity, time and quantity. The usual question often asked in inventory management is that how much of material is to be kept and when it is to be carried. Getting the right material at the right time can generate very significant results. Timely purchasing of materials is a very important factor, specially when the materials are independent. The demand and supply conditions impose certain limitations within which the relevant costs are to be minimized.

1.2 FUNCTION AND TYPES OF INVENTORIES

Inventory is a stock of physical goods held at a specific location at a specific location at a specific time. Each distinct item in the inventory at a location is termed a stock keeping unit (SKU), and each SKU has a number of units in stock. Each location is a stock point. The local supermarket, for example, is a stock point with a huge inventory of food. Dairy Farms 2% milk in half-gallon containers is an SKU with a specific number of units in stock.

Why do companies keep inventories? Inventories exist because demand and supply cannot be matched for physical and economic reasons. We go to the supermarket to buy a half-gallon container of milk. How could the store supply it without inventorying milk? Our demand obviously cannot be matched to the cow's supply in time, place, or form.

1.2.1 Transaction Stocks

Transaction stocks are those necessary to support the transformation, movement, and sales operations of the firm. Active work-in-progress stocks materials currently being worked on or moving between work centers constitutes a large part of transaction stocks, as do pipeline inventories. Pipeline or transportation inventories are inventories in transit. The size of the pipeline inventory is as much a function of the length of the pipeline as of the rate of sales at the retail stock point.

1.2.2 Organization Stocks

Organization stocks represent investment opportunities to achieve operating efficiencies. Fluctuation or safety stock is an organization stock designed to buffer against uncertainty. Average daily sales of twenty containers of milk, for example, can be met by a transaction stock of twenty units. Sales above twenty would have to supported by a buffer stock held to avoid stock outs when sales are higher than expected.

Anticipation inventory or leveling inventory may be an attractive investment if it is cheaper to hold stock than to alter short-term production capacity. Seasonal peaks in demand may be met by building inventories earlier during periods of slack demand and excess capacity.

Lot size or cycle inventories are held to achieve some payoff from setting up equipment. Having set up equipment, manufacturing people invariably want a long production run to avoid repeating the setup for the same item in the near future. Going to the bank to cash a check, for example, involves travel time and downtime from other activities. For that reason, most of us carry a lot size or cycle stock in our wallets to avoid going to the bank every time we want to make a purchase.

The last two types of organization stocks are more specialized investment opportunities. Scheduling stocks are work-in-progress stocks held between operations to allow schedulers a choice of jobs to place on the productive resource. In this way, high resource utilization can be achieved. Speculative stocks are those held in anticipation of price increases.

1.2.3 Excess Stock

Excess stock has no purpose. Unlike transaction and organization stock, it owes its existence to oversight rather than to necessity or to operating efficiency.

1.2.4 Levels of Inventory

Within the framework of transaction, organization, and excess stock. inventory may occur at various levels or echelons within the company. An echelon. level. or stage is a stock point that is under control of the company. Raw materials, work-in-progress, high-level components and finished products belong to different echelons. Raw materials are raw in the sense that the company has not done any work on them. Work-in-progress inventories are manufacturing inventories that are undergoing processing or are in line at work centers, with similar personnel/machine capabilities. High-level components are parts and assemblies that are ready to be assembled into the finished product. These are often stored ready to be assembled when needed. Finished goods are products that are ready to be shipped to the customer.

1.3 INVENTORY CONTROL PROBLEM

The inventory control problem is a type of problem encountered within the field of optimal control. One issue is infrequent large orders vs. frequent small orders. Calculating shipping costs, volume discounts, storage costs, and capital costs, this can be figured with mathematical precision. Basically, how much money do you wish to have tied up in inventory?

A second issue is having the needed merchandise on hand in order to make sales during the appropriate buying season(s). A classic example is a toy store pre-Christmas. If one does not have the items on the shelves, one will not make the sales. And the wholesale market is not perfect. There can considerable delays, particularly with the most popular toys. So, the entrepreneur or business manager will buy on spec. Another example is a furniture store. If there is a six week, or more, delay for customers to get merchandise, some sales will be lost. And yet another example is a restaurant, where a considerable percentage of the sales are the value-added aspects of food preparation and presentation, and so it is rational to buy and store somewhat more to reduce the chances of running out of key ingredients. With all these examples, the situation often comes down to these two key questions: How confident are you that the merchandise will sell, and how much upside is there if it does?

And a third issue comes from the whole philosophy of Just In Time, which argues that the costs of carrying inventory have typically been under-estimated, both the direct, obvious costs of storage space and insurance, but also the harder-to-measure costs of increased variables and complexity, and thus decreased flexibility, for the business enterprise.

1.3.1 Reasons for Keeping Stock: There are three basic reasons for keeping an inventory:

1. Time - The time lags present in the supply chain, from supplier to user at every stage, requires that you maintain certain amount of inventory to use in this "lead time"

2. Uncertainty - Inventories are maintained as buffers to meet uncertainties in demand, supply and movements of goods.

3. Economies of scale - Ideal condition of "one unit at a time at a place where user needs it, when he needs it" principle tends to incur lots of costs in terms of logistics. So Bulk buying, movement and storing brings in economies of scale, thus inventory. All these stock reasons can apply to any owner or product stage.

1.3.2 Special Terms in Inventory

1. Stock Keeping Unit (SKU) is a unique combination of all the components that are assembled into the purchasable item. Therefore any change in the packaging or product is a new SKU. This level of detailed specification assists in managing inventory.

2. Stock out means running out of the inventory of an SKU.

3. "New old stock" (sometimes abbreviated NOS) is a term used in business to refer to merchandise being offered for sale which was manufactured long ago but that has never been used. Such merchandise may not be produced any more, and the new old stock may represent the only market source of a particular item at the present time.

1.3.3 Just-In-Time

Just-in-time (JIT) is an inventory strategy implemented to improve the return on investment of a business by reducing in-process inventory and its associated carrying costs. The process is driven by a series of signals, which can be Kanban, that tell production processes when to make the next part. Kanban are usually 'tickets' but can be simple visual signals, such as the presence or absence of a part on a shelf. When implemented correctly, JIT can lead to dramatic improvements in a manufacturing organization's return on investment, quality, and efficiency. Some have suggested that "Just on Time" would be a more appropriate name since it emphasizes that production should create items that arrive when needed and neither earlier nor later.

Quick communication of the consumption of old stock which triggers new stock to be ordered is key to JIT and inventory reduction. This saves warehouse space and costs. In recent years manufacturers have touted a trailing 13 week average as a better predictor for JIT planning than most forecasters could provide.

Chapter 2

Literature Review

CHAPTER 2

LITERATURE SURVEY

Following are the overview of the relevant work done earlier related to the problem identified and the methodology to be adopted to solve the chosen problem for this work. It gives the description of literature reviewed from various research papers published in international and national journals, proceedings of various conferences and books.

Refael Hasin and Nimrod Megiddo.(1991). The authors has analyzed inventory scheduling model with forbidden time intervals. The objective is to minimize the long –term average cost per time unit. Unlike most of the literature on inventory theory, no restrictive assumptions are made about the nature of optimal solutions. Rather it proved that optimal policies exist, and that some of them are cyclic with cycles of a particular structure. It is then shown that such optimal policies can be computed and an algorithm is given.

Kevin H. Shang and Jing- Sheng Song.(2003). In this journal, an N-Stage serial supply system has been developed with deterministic transportation lead times between stages and optimal inventory policy for this system is known to be echelon base-stock policy, which can be computed through minimizing N nested convex functions recursively. To identify the key determinants of the optimal policy, they developed a simple and surprisingly good heuristic. The bounds and the heuristic, which can be easily obtained by simple spread sheet calculations, enhance the accessibility and implement ability of the multiechleon inventory theory.

Edward J. Fox, et al.(2006). In this journal, the author has analyzed a periodic-review inventory model where the decision maker can buy from either of two suppliers. With the first supplier, the buyer incurs a high variable cost but negligible cost: With the second supplier, the buyer incurs a lower variable cost but a substantial fixed cost. Consequently, ordering costs are piecewise linear and concave. They showed that a reduced form of generalized (s,S) policy is optimal for both finite and infinite-horizon problems.

Mahadevan, et al.(2003). In this journal, the authors has employed a "push" policy and developed several heuristics based on traditional inventory models. This research is focused on product recovery, and in particular on production control and inventory management in the remanufacturing context. Demand is uncertain and also follows a Poisson process. The decision problems for the remanufacturing facility are when to release returned products to the remanufacturing line and how many new products to manufacture.

Ge Wang, et al.(2004). In this journal, the authors has developed integrated analytic hierarchy process (AHP) to match product characteristics with supplier characteristics to qualititatively determine supply chain strategy. In this paper, they related product characteristics to supply chain strategy and adopt supply chain operations reference (SCOR) model level 1 performance metrics as the decision criteria. An integrated analytic hierarchy process (AHP) and preemptive goal programming (PGP) based multi-criteria decision making methodology is then developed to take into account both qualitative and quantitative factors in supplier selection.

Kai-YingChen.(2006). In this journal, the author has developed Manufacturing execution system(MES) for gathering real time production line information, supporting manufacturing decision making and increasing manufacturing efficiency.AHP is used to decide the priority of performance measurement indices.

James E. Smith, et al.(2004). In this journal, the authors has developed Decision settings comprised of any combination of certainty or uncertainty. competitive or noncompetitive situations which include managerial decisions in manufacturing sector. Decision analysis is primarily a prescriptive discipline, built on normative and descriptive foundations. It also discusses normative and descriptive developments that have advanced prescriptive methodologies and applications.

Yuyue Song, et al.(2003). In this journal, the author has considered a stochastic-demand periodic review inventory model with sudden obsolescence. They characterized the structure of the optimal policy and proposed a dynamic programming algorithm for computing its parameters and utilized this algorithm to approximate the solution to the continuous-review sudden obsolescence problem with general obsolescence problem with general obsolescence distribution.

Jing-An Li, et al.(2006). In this journal, the authors has discussed and derived the optimal stationary supply, that is, the optimal ordering policy of the distributor. Generally, the order that the distributor places at the manufacturer is larger than that the retailer places at the distributor. In order to afford this large order, there should exist a long-tern supply to the distributor. Also computational results are presented.

Min Wu (2007). In this journal, the author has illustrated a simplified supplier selection problem in SCM (Supply Chain Management). SCM emphasizes on the strategic cooperative relationship between core enterprise and enterprise alliance. The selection of strategic partners is an important decision-making problem in SCM and is the key to successful SCM. In this paper, aiming for the supplier selection problem. The author discusses a class of (Analytic Hierarchy Process) AHP technique-simulation approach which is valuable in that it examines the uncertainty in AHP and helps to reduce the uncertainty in AHP to some extent.

Soren glud Johansen (2005). In this journal, the author has proposed Base stock policies for studying inventory system, which can be evaluated through erlang's loss formula when the lead times are mutually independent. This is often the case only if the base-stock S is one. If S is larger than one, The Erlangrian lead times become stochastically dependent under the realistic assumption that the replenishment orders do not cross in time. They made this assumption and showed for any positive S that the number of replenishment orders outstanding has an equilibrium distribution. It turns out to be easy to compute the stock-out frequency recursively for $S=1,2\ldots\ldots$

Chapter 3

Analytic Hierarchy Process

CHAPTER 3

ANALYTIC HIERARCHY PROCESS

3.1 INTRODUCTION

The analytic hierarchy process (AHP) is a multi-criteria decision-making tool in which important elements are arranged in a hierarchical structure descending from an overall goal to criteria, sub-criteria and alternatives in successful levels. This technique attempts to analyze the impact of the alternatives or decision options at the lowest level of the hierarchy on the overall goal of the problem. The standard procedure for AHP implementation can be divided into the following four steps:

1. Define the problem and determine the overall goal.
2. Structure the hierarchy from the top down to bottom comprising of the overall goal, criteria, sub-criteria and alternatives present in the problem.
3. Construct a set of pair wise comparisons for each level expressing the preference between two different criteria at the same level. The numerical judgments are then summarized in a comparison matrix for each hierarchy level. The AHP technique makes it possible to take into account slight considerations in judgments. If the inconsistency level exceeds a value of 0.10, some modifications in the judgments may be required.
4. By calculating the normalized eigenvectors of the pair wise comparison matrices, it is possible to determine the final priorities of the alternatives or decision options.

3.2 DESCRIPTION

The Analytic Hierarchy Process (AHP) is a structured technique for helping people deal with complex decisions. Rather than prescribing a "correct" decision, the AHP helps people to determine one. Based on mathematics and human psychology, it was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then. The AHP provides a comprehensive and rational framework for structuring a problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions. It is used throughout the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, and education.

Several firms supply computer software to assist in applying the process. Users of the AHP first decompose their decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be analyzed independently. The elements of the hierarchy can relate to any aspect of the decision problem—tangible or intangible, carefully measured or roughly estimated, well- or poorly-understood—anything at all that applies to the decision at hand.

Once the hierarchy is built, the decision makers systematically evaluate its various elements, comparing them to one another in pairs. In making the comparisons, the decision makers can use concrete data about the elements, or they can use their judgments about the elements' relative meaning and importance. It is the essence of the AHP that human judgments, and not just the underlying information, can be used in performing the evaluations.

The AHP converts these evaluations to numerical values that can be processed and compared over the entire range of the problem. A numerical weight or priority is derived for each element of the hierarchy, allowing diverse and often incommensurable elements to be compared to one another in a rational and consistent way. This capability distinguishes the AHP from other decision making techniques.

In the final step of the process, numerical priorities are derived for each of the decision alternatives. Since these numbers represent the alternatives' relative ability to achieve the decision goal, they allow a straightforward consideration of the various courses of action.

3.3 MODEL THE PROBLEM AS A HIERARCHY

The first step in the Analytic Hierarchy Process is to model the problem as a hierarchy. In doing this, participants explore the aspects of the problem at levels from general to detailed, then express it in the multileveled way that the AHP requires. As they work to build the hierarchy, they increase their understanding of the problem, of its context, and of each other's thoughts and feelings about both.

A hierarchy is a system of ranking and organizing people, things, ideas, etc., where each element of the system, except for the top one, is subordinate to one or more other elements. Diagrams of hierarchies are often shaped roughly like pyramids, but other than having a single element at the top, there is nothing necessarily pyramid-shaped about a hierarchy.

Human organizations are often structured as hierarchies, where the hierarchical system is used for assigning responsibilities, exercising leadership, and facilitating communication. Familiar hierarchies of "things" include a desktop computer's tower unit at the "top," with its subordinate monitor, keyboard, and mouse "below."

In the world of ideas, we use hierarchies to help us acquire detailed knowledge of complex reality: we structure the reality into its constituent parts, and these in turn into their own constituent parts, proceeding down the hierarchy as many levels as we care to. At each step, we focus on understanding a single component of the whole, temporarily disregarding the other components at this and all other levels. As we go through this process, we increase our global understanding of whatever complex reality we are studying.

Think of the hierarchy that medical students use while learning anatomy—they separately consider the musculoskeletal system (including parts and subparts like the hand and its constituent muscles and bones), the circulatory system (and its many levels and branches), the nervous system (and its numerous components and subsystems), etc., until they've covered all the systems and the important subdivisions of each. Advanced students continue the subdivision all the way to the level of the cell or molecule. In the end, the students understand the "big picture" and a considerable number of its details. Not only that, but they understand the relation of the individual parts to the whole. By working hierarchically, they've gained a comprehensive understanding of anatomy.

Similarly, when we approach a complex decision problem, we can use a hierarchy to integrate large amounts of information into our understanding of the situation. As we build this information structure, we form a better and better picture of the problem as a whole.

An AHP hierarchy is a structured means of describing the problem at hand. It consists of an overall goal, a group of options or alternatives for reaching the goal, and a group of factors or criteria that relate the alternatives to the goal. In most cases the criteria are further broken down into sub criteria, sub-sub criteria, and so on, in as many levels as the problem requires.

The hierarchy can be visualized as a diagram like the one below, with the goal at the top, the alternatives at the bottom, and the criteria filling up the middle. In such diagrams, each box is called a node. The boxes descending from any node are called its children. The node from which a child node descends is called its parent. Applying these definitions to the diagram below, the five Criteria are children of the Goal, and the Goal is the parent of each of the five Criteria. Each Alternative is the child of each of the Criteria, and each Criterion is the parent of three Alternatives. In practice, many Criteria have one or more layers of sub criteria. These are not shown in this simplified diagram. Also, to avoid clutter in AHP diagrams, the lines between the Alternatives and Criteria are often omitted or reduced in number. Regardless of any such simplifications in the diagram, in the actual hierarchy each Alternative is connected to every one of its covering criteria—the lowest-level criteria, sub criteria, etc. of which it is a child.

The design of any AHP hierarchy will depend not only on the nature of the problem at hand, but also on the knowledge, judgments, values, opinions, needs, wants, etc. of the participants in the process.

As the AHP proceeds through its other steps, the hierarchy can be changed to accommodate newly-thought-of criteria or criteria not originally considered to be important; alternatives can also be added, deleted, or changed.

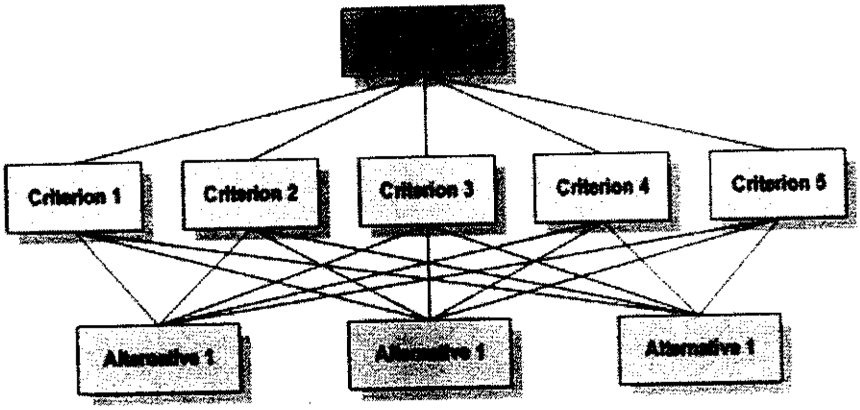

FIG 3.1 A SIMPLE AHP HIERARCHY

3.4 THE USE OF ARBITRARY SCALES

AHP is based on pair wise comparisons where the relative importance of different attributes is given a value on a scale of 1 to 9 or the inverse (1/9th to 1). These values are in practice assigned by verbal elicitation of decision makers. For example, if a person says attribute A is "moderately more important" than attribute B, A is said to have a relative weight of 3 times that of B while being "extremely more important" will give A a weight of 9 times that of B. While this scale is commonly used in AHP, it is arbitrary and alternative scales have been proposed. Empirical research has found "...that the perceived meaning of the verbal expressions varies from one subject to the next and also depends on the set of elements involved in the comparison." . This is a well known result (since the 1930s) from Thurstone's work on attitude scales. However, these researchers felt the problem was correctable in that the scales could be based on empirical evidence of AHP user perceptions.

3.5 RANK CHANGE DUE TO ADDITION OF INDIFFERENT CRITERIA

A recently published criticism finds a flaw in "...another feature of AHP which may be, and in many application contexts will indeed be, an even stronger shortcoming of the method." It consists in the fact that the addition of indifferent criteria (for which all alternatives perform equally) causes a significant alteration of the aggregated priorities of alternatives, with important consequences. The authors conclude that, as a result of this error "Almost all applications of AHP are potentially flawed."

3 .6 RESPONSES BY AHP PROPONENTS

Proponents argue that in spite of these concerns, the process works well in practice and is extremely popular among decision-makers in the private and public sectors.

Chapter 4

Methodology

CHAPTER 4

METHODOLOGY

4.1 INTRODUCTION

The analytic hierarchy process (AHP) is a powerful tool that can be applied to any kind of MCDM problem for evaluating performance measures of the alternatives .Most of the solution approaches for MCDM problem consist of the following two steps, i.e.

1. Aggregation of the judgments with respect to the goals and alternatives related to the problem, and
2. Ranking of the alternatives or decision options according to the aggregated judgments

The basic rules for solving MCDM problems essentially involve in the following four stages. eg.

1. Specification of the problem.
2. Information analysis
3. Choosing the appropriate method
4. Evaluation of alternatives

This project is basically dedicated to implement the AHP methodology and develop systematic steps for decision making to solve the complex problem of optimal inventory control policy selection under stated conditions so as to meet specific organizational requirements.

4.2 CRITERIA, SUB-CRITERIA AND ALTERNATIVES FOR INVENTORY CONTROL POLICY SELECTION

The multitude of material types and their complex characteristics suggests the following criteria and sub-criteria to be taken into consideration while selecting the optimal inventory control policy under given conditions

4.2.1 Order quantity (OQ):

The quantity of material for which the order is to be placed determines the appropriate level of inventory and ordering sequence in such a way that the total cost will be minimum. Order quantity may be of three types,

i. Fixed (FXD)
ii. Fluctuating (FLU)
iii. Anticipatory (ANC).

4.2.1.1 Fixed (FXD)

Order is placed for a specific quantity of material at a critical point of time when the stock reaches a prescribed threshold level. It is assumed that the future demand for a product is known or it can be easily predicted that how much of material will be required during each cycle of production. Such a case is called inventory ordering under certainty. For example, in batch production, one can exactly predict the requirement for the raw material. In this situation, a fresh quantity of material is to be topped up to make the inventory level maximum. The lot size is determined based on the formulations of the economic order quantity (EOQ).

4.2.1.2 Fluctuating (FLU)

Here, order quantity varies depending upon the fluctuations in the demand or supply pattern. One may be totally ignorant about the variations in the demand or supply pattern. This is a case of inventory ordering under uncertainty, for example, placement of orders for raw materials in case of a new product having no existing historical data.

4.2.1.3 Anticipatory (ANC)

In this case, order quantity remains fixed as per the anticipation of the future demand or supply pattern. The order quantity may take the form of an inventory build-up during the slack or pick period. Inventory build-up ahead of holiday or in anticipation of strike or provision of initial inventory to a new product or sales promotion item are the examples of anticipation inventory.

4.2.2 Relevant cost (RC): There are several cost factors that strongly affect the total cost of inventory. In general, these cost factors have the following classifications,i.e

i. Ordering Cost (OC)
ii. Inventory Carrying Cost (ICC)
iii. Under and Over Stocking Cost (SOC)

4.2.2.1 Ordering Cost (OC)

It is the sum of resultant costs associated with various activities while finalizing an order. The level of activities may vary for different products, but it mainly includes the costs related to follow-up, receiving and inspection, source development, advertisement, tender etc.

4.2.2.2 Inventory carrying cost (ICC)

It is associated with the storage of inventory items and mainly encompasses the interest, depreciation, overhead, obsolescence costs while storing the inventories.

4.2.2.3 Under and Over Stocking cost (SOC)

Under-stocking cost is caused by the non-fulfillment of demand for a particular product due to stock-out of materials. It causes loss of production, sale and goodwill of the organization. On the other hand, overstocking cost is the cost basically arising due to opportunity loss caused by the excessive investment in the inventory items for a longer period of time than necessary which in turn, causes blockage of funds that carry substantial amount of interest.

4.2.3 Safety Stock (SS)

To meet the emergency, a general level of stock is usually maintained which is one kind of insurance stock to care of situations when the consumption rate increases or the delivery date slips. It may take low, medium or high values.

4.2.4 Lead Time (LT)

It can be defined as the period of time that elapses between the recognition of a need and its fulfillment, internal, external and others are three major categories of lead times

i. Internal
ii. External
iii. Others.

4.2.4.1 Internal

It starts from identifying the need for an item till an order is placed for that item. Requirement for an inventory item is first identified and suitable sources are then located before the placement of orders.

4.2.4.2 External

Once an order is placed, the purchaser has to wait till the supplier delivers the material. External lead time is the period of time between the placement of an order and actual delivery of the material by the supplier.

4.2.4.3 Others

It is the time required for inspection, transportation of the material for which the order is placed. It basically includes the time period between the dispatch of the material by the supplier and its actual receipt.

4.2.5 Demand Forecasting (DF)

It is one of the most critical issues of inventory management as forecasting of the actual demand is the root of planning for production and required inventory control. Generally, three different techniques are used for demand forecasting, i.e.

i. Qualitative Technique (QT)
ii. Time Series Analysis (TSA)
iii. Casual Approach (CA)

4.2.5.1 Qualitative technique (QT)

It is a method of projecting the future requirement for materials during the order cycle based on qualitative data, such as expert opinions, special information etc. The past historical data may or may not be considered in the qualitative analysis. The Delphi method where estimates and opinions about the future requirements for materials are sought from the experts in an iterative way is the best example of this technique.

4.2.5.2 Time Series Analysis (TSA)

It is used to identify the systematic seasonal variation, cyclical pattern, trend pattern etc. as present in the historical demand data. The basic assumption is that the future will be similar to the past periods. Moving average, autoregressive moving average (ARMA), exponential smoothing techniques etc are the examples of this method.

4.2.5.3 Causal approach (CA)

Here, the demand for multiple items is projected which involves anticipatory requirements of the entire product line. This method deals with refined and specific information concerning variables to develop a relationship between a lead event and the event being forecasted. The demand forecast is based on a correlation of one event to the other.

4.2.6 Reorder Point

It is a method of controlling the stock to establish a reorder level which, when reached, will indicate that the stock needs replenishment. There may be three possibilities to determine a reorder point as mentioned below

1. Lead Time Consumption Less than EOQ (LEOQ)
2. Lead Time Consumption equal to EOQ (EEOQ)
3. Lead Time Consumption more than EOQ (MEOQ)

4.2.6.1 Lead Time consumption less than EOQ (LEOQ)

Order is placed when the stock reaches a point of minimum level. Reorder level is equal to the minimum stock level plus the lead time consumption stock. After the placement of an order, fresh stock is received and the consumption continues.

4.2.6.2 Lead Time consumption equal to EOQ (EEOQ)

When the earlier supply reaches at store, an order is placed immediately for the next lot of fresh material. The first order is placed instantly when the material is received at time t_1, similarly the second order is placed at time t_2 so that material will be received at time t_3 and so on, where $t_3>t_2>t_1$.

4.2.6.3 Lead time consumption more than EOQ (MEOQ)

Order is placed when the virtual stock (stock in hand plus stock in order) reaches the lead time consumption level. Here, maximum stock is kept. In other words, when the lead time consumption is more than EOQ, an order is to be processed.

However, it must be assured that at the reorder point, there should be sufficient stock to maintain the production until the replenishment arrives.

4.3 INVENTORY CONTROL POLICIES

Basically from the application point of view, the inventory control policies can be divided into the following five classes

4.3.1 Perpetual review policy (PRP)

This inventory control policy works when the stock level for a specific material reaches a pre-determined re-order level, then it reviews the requirement and places order for a fixed quantity of material. Quite obviously, the day on which the stock level reaches the predetermined value. Will vary from time to time depending upon the fluctuations in the demand pattern. In this case, the time interval between two consecutive orders may vary, but generally the order quantity will remain fixed.

4.3.2 Periodic review policy (PEP)

In this policy, the review is made on a particular date, say on the first day of every month. At that point, one calculates the consumption rate, stock level and order quantity of the material that are required to make the stock maximum on the date of replenishment. Here, the time interval between two consecutive orders will remain fixed but the order quantity may vary.

4.3.3 Two bin policy (TBP)

The term 'two bin policy' is applied to the visual method of stock control using two actual bins or one bin is divided into two sections. Only one section of the bin is used for a particular time period and after the consumption of materials from the first section, the second section is broken and suitable steps are taken to replenish the first one. This policy reviews the inventory status of materials after each transaction.

4.3.4 Material requirement planning (MRP)

Today the MRP system is well accepted as an efficient method of material planning since it relates product design and inventory control to product demand. It is a computer based system that makes master production schedule to explore it into the required amount of raw materials, parts, sub assemblies and assemblies needed in each of the planning horizon and then reducing these materials requirements to account for materials that are in inventory or on order and finally developing a schedule of order for purchased materials and produced parts over the planning horizon. It is suitable when demand for items is dependent on other items. Usually, MRP system exploits the forecast data about dependence on demand in managing inventories and controlling the production lot sizes of the parts that go into the making of the final product. The objective of MRP is to avoid inventory stock-outs so that the production runs smoothly, according to plans and also to reduce the investment in raw materials and work-in-progress inventories.

Material Requirements Planning (MRP) is software based production planning and inventory control system used to manage manufacturing processes. Although it is not common nowadays, it is possible to conduct MRP by hand as well.

An MRP system is intended to simultaneously meet three objectives:

1. Ensure materials and products are available for production and delivery to customers.

2. Maintain the lowest possible level of inventory.

3. Plan manufacturing activities, delivery schedules and purchasing activities.

Manufacturing organizations, whatever their products, face the same daily practical problem - that customers want products to be available in a shorter time than it takes to make them. This means that some level of planning is required.

Companies need to control the types and quantities of materials they purchase, plan which products are to be produced and in what quantities and ensure that they are able to meet current and future customer demand, all at the lowest possible cost. Making a bad decision in any of these areas will make the company lose money. A few examples are given below:

If a company purchases insufficient quantities of an item used in manufacturing, or the wrong item, they may be unable to meet contracts to supply products by the agreed date.

If a company purchases excessive quantities of an item, money is being wasted - the excess quantity ties up cash while it remains as stock and may never even be used at all. This is a particularly severe problem for food manufacturers and companies with very short product life cycles. However, some purchased items will have a minimum quantity that must be met, therefore, purchasing excess is necessary. Beginning production of an order at the wrong time can cause customer deadlines to be missed.

MRP is a tool to deal with these problems. It provides answers for several questions:

What items are required?

How many are required?

When are they required?

MRP can be applied both to items that are purchased from outside suppliers and to sub-assemblies, produced internally, that are components of more complex items.

The data that must be considered include:

1. The end item (or items) being created. This is sometimes called Independent Demand, or Level "0" on BOM (Bill of materials).

2. How much is required at a time.

3. When the quantities are required to meet demand.

4. Shelf life of stored materials.

5. Inventory status records: Records of net materials available for use already in stock (on hand) and materials on order from suppliers.

6. Bills of materials: Details of the materials, components and subassemblies required to make each product.

7. Planning Data: This includes all the restraints and directions to produce the end items. This includes such items as: Routings, Labor and Machine Standards, Quality and Testing Standards, Pull/Work Cell and Push commands, Lot sizing techniques (i.e. Fixed Lot Size, Lot-For-Lot, and Economic Order Quantity), Scrap Percentages, and other inputs. There are two outputs and a variety of messages/reports:

Output 1 is the "Recommended Production Schedule" which lays out a detailed schedule of the required minimum start and completion dates, with quantities, for each step of the Routing and Bill of Material required to satisfy the demand from the MPS.

Output 2 is the "Recommended Purchasing Schedule". This lays out both the dates that the purchased items should be received into the facility AND the dates that the Purchase orders, or Blanket Order Release should occur to match the production schedules.

Purchase orders: An order to a supplier to provide materials.

Reschedule notices: These recommend cancelling, increasing, delaying or speeding up existing orders.

Note that the outputs are recommended. Due to a variety of changing conditions in companies, since the last MRP / ERP system Re-Generation, the recommended outputs need to be reviewed by trained people to group orders for benefits in set-up or freight savings. These actions are beyond the linear calculations of the MRP computer software.

MRP/ERP Systems were first introduced by George Plossl and Joseph Orlicky in the late 1960s. Oliver Wight contributed the evolution to MRP II, to include more than the factory production and material needs. ERP evolved with the change in hardware / software capability and "Interface" interpretations between software.

The major problem with MRP systems is the integrity of the data. If there are any errors in the inventory data, the bill of materials (commonly referred to as 'BOM') data, or the master production schedule, then the outputted data will also be incorrect. Most vendors of this type of system recommend at least 99% data integrity for the system to give useful results. Another major problem with MRP systems is the requirement that the user specify how long it will take a factory to make a product from its component parts (assuming they are all available). Additionally, the system design also assumes that this "lead time" in manufacturing will be the same each time the item is made, without regard to quantity being made, or other items being made simultaneously in the factory.

A manufacturer may have factories in different cities or even countries. It is no good for an MRP system to say that we do not need to order some material because we have plenty thousands of miles away. The overall ERP system needs to be able to organize inventory and needs by individual factory, and intercommunicate needs in order to enable each factory to redistribute components in order to serve the overall enterprise.

This means that other systems in the enterprise need to work properly both before implementing an MRP system, and into the future. For example systems like variety reduction and engineering which makes sure that product comes out right first time (without defects) must be in place.

Production may be in progress for some part, whose design gets changed, with customer orders in the system for both the old design, and the new one, concurrently. The overall ERP system needs to have a system of coding parts such that the MRP will correctly calculate needs and tracking for both versions. Parts must be booked into and out of stores more regularly than the MRP calculations take place. Note, these other systems can well be manual systems, but must interface to the MRP. For example, a 'walk around' stock take done just prior to the MRP calculations can be a practical solution for a small inventory (especially if it is an "open store").

The other major drawback of MRP is that takes no account of capacity in its calculations. This means it will give results that are impossible to implement due to manpower or machine or suppler capacity constraints. However this is largely dealt with by MRP II.Generally, MRP II refers to a system with integrated financials. An MRP II system can include finite / infinite capacity planning. But, to be considered a true MRP II system must also include financials.

In the MRP II (or MRP2) concept, fluctuations in forecast data are taken into account by including simulation of the master production schedule, thus creating a long-term control. A more general feature of MRP2 is its extension to purchasing, to marketing and to finance (integration of all the function of the company), ERP has been the next step.

4.3.5 Optional replenishment policy (ORP): This policy reviews the inventory status of the materials at a particular interval of time that is not strictly followed and can be changed as per the requirement.The interactions between various inventory control policies and different criteria that affect the selection of the optimal policy are shown in Table 4.1

TABLE 4.1 INTERACTIONS BETWEEN VARIOUS INVENTORY CONTROL POLICIES

	Perpetual Review Policy	Periodic Review Policy	TwoBin Policy	MRP	Optional Replenishment Policy
Orderquantity	Fixed	Fixed	Variable	Variable	Variable
RelevantCost	Fixed	Fixed	Fixed	Variable	Variable
Safety stock	Medium	Medium	Large	Small	Very Large
Lead time	Variable	Fixed	Fixed	Variable	Variable
Demand rate	Fixed	Fixed	Fixed	Fixed	Fixed
Reorder point	Fixed	Fixed	Variable	Variable	Fixed

The analytic hierarchy process (AHP) is a multi-criteria decision-making tool in which important elements are arranged in a hierarchical structure descending from an overall goal to criteria, sub-criteria and alternatives in successful levels. This technique attempts to analyze the impact of the alternatives or decision options at the lowest level of the hierarchy on the overall goal of the problem. The standard procedure for AHP implementation can be divided into the following four steps:

a) Define the problem and determine the overall goal.

b) Structure the hierarchy from the top down to bottom comprising of the overall goal, criteria, sub-criteria and alternatives present in the problem.

c) Construct a set of pair wise comparisons for each level expressing the preference between two different criteria at the same level. The numerical judgments are then summarized in a comparison matrix for each hierarchy level. The AHP technique makes it possible to take into account slight considerations in judgments. If the inconsistency level exceeds a value of 0.10, some modifications in the judgments may be required.

d) By calculating the normalized eigenvectors of the pair wise comparison matrices, it is possible to determine the final priorities of the alternatives or decision options.

A central problem with the pair wise comparisons is how to quantify the linguistic choices selected by the decision maker during the evaluation process. Usually, the qualitative answers of a decision maker are expressed in the form of some numbers, most of the time, ratios of integers. Paired comparisons are eventually expressed by using such a scale. Such a scale is a one-to-one mapping between the set of discrete linguistic choices available to the decision maker and a discrete set of numbers that represents the importance or weight of the previous linguistic choices. The original scale proposed by Satty is exhibited in Table 4.2

TABLE 4.2: SCALE OF RELATIVE IMPORTANCE ACCORDING TO SAATY

Scale value	Interpretation
1	Equal importance of i and j
2	Between equal and weak importance of i over j
3	Weak importance of i over j
4	Between weak and strong importance of i over j
5	Strong importance of i over j
6	Between strong and demonstrated importance of i over j
7	Demonstrated importance of i over j
8	Between demonstrated and absolute importance of i over j
9	Absolute importance of i over j

The next step is to extract the relative importance of different criteria implied in the pair-wise comparisons. Saaty asserted that in order to determine the priority vector of the criteria, the estimation of the right principal eigenvector of the pair wise comparison matrix is essential. One of the most practical issues in the AHP technique is that it allows slight inconsistencies in the paired judgments. If all the judgments are perfectly consistent, then the relation $a_{ij} = a_{ik}.a_{kj}$ should always be true for any combination taken from the pair-wise comparison matrix.

However, perfect consistency rarely occurs in practice. In the AHP exercise, the pair-wise comparisons are considered to be adequately consistent if the corresponding consistency ratio (CR) is observed to be less than 0.10. If the CR value is greater than 0.10, a revision in the comparison matrix is necessary. This process is repeated until a CR value of 0.10 or less is achieved. After the alternatives are compared with respect to each other in terms of each decision criteria and the individual priority values are derived, the synthesis step is performed. The priority vectors of different criteria become the columns of decision matrix. Therefore, if a MCDM problem has n criteria and m alternatives, the decision maker is required to construct n judgment matrices of order m x m and one judgment matrix of order n x n. Finally, the composite priorities or preference values for the alternatives are determined.

Chapter 5

Data Collection

CHAPTER 5

DATA COLLECTION

The detailed steps involved in the application of the analytic hierarchy process for selecting the optimal inventory control policy are described here with the help of Steel manufacturing industry.

5.1 DESIGNING AN INVENTORY CONTROL POLICY SELECTION MODEL

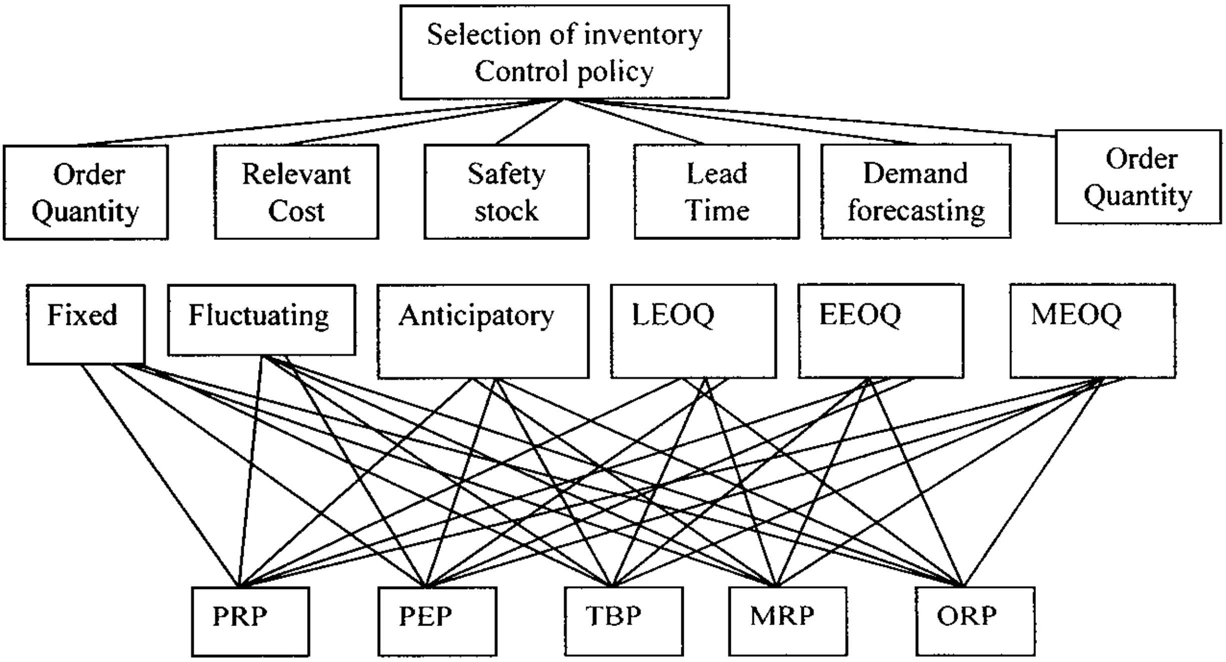

FIG 5.1 DEVELOPED HIERARCHY FOR THE INVENTORY CONTROL POLICY SELECTION

Figure 5.1 shows the developed hierarchy along with the overall goal, criteria, sub-criteria and alternatives involved in the selection of an inventory control policy in a typical organizational setup. The top hierarchy level has the goal of selecting the optimal policy and its priority value is assumed to be one. The next level consists of six different criteria considered to be most important in this decision-making problem. These criteria are pair-wise compared with respect to each other according to their importance in fulfilling the overall goal of the problem. The pair-wise comparison matrix for second level criteria of the hierarchy is shown in Table 5.2.

In the above matrix, as the criteria 'Order quantity (OQ) has between equal and weak importance over criteria 'Relevant cost (RC), an integer value of 2 is entered at the row OQ and column RC position and its reciprocal value is assigned at the row RC and column OQ position. If the criteria being compared are found to be of equal importance, a value of one is allotted at that particular position. Hence, all the diagonal entries in the matrix are one.

In order to check the consistency of judgments, it is necessary to estimate the right principal eigenvector and maximum Eigen value of the comparison matrix. For the above matrix, the λ_{max} value is calculated as 6.116 and other Eigen values are 0.0099+0.7483i, 0.0099-0.7483i, -0.0521+0.3846i, -0.0521-0.3846i and -0.0320 respectively. The normalized Eigen vector is $[0.3501, 0.2606, 0.1681, 0.1091, 0.0660, 0.0461]^T$ which can be treated as the priority values of different criteria. Based on the λ_{max} value, the consistency ratio (CR) is calculated as 0.0187, which is less than 0.10, indicating the fact that the judgments at the second level of the hierarchy are consistent. There is also an easy and straightforward method to determine the priority vector and λ_{max} value. At first, in the comparison matrix, normalize the column of numbers by dividing each entry by the sum of the corresponding column entries. Then the normalized elements for each row are added up and the average is taken. This provides the priority vector (C) as shown in Table 5.1.

TABLE 5.1: COMPUTATION OF PRIORITY VECTOR

Criteria	OQ	RC	SS	LT	DF	ROP	Priority vector
OQ	0.3704	0.4669	0.3243	0.3051	0.3226	0.3000	0.3482
RC	0.1852	0.2335	0.3243	0.3051	0.2581	0.2500	0.2594
SS	0.1852	0.1167	0.1622	0.2034	0.1935	0.1500	0.1685
LT	0.1234	0.0778	0.0811	0.1017	0.1290	0.1500	0.1105
DF	0.0741	0.0584	0.0541	0.0508	0.0645	0.1000	0.0670
ROP	0.0617	0.0467	0.0541	0.0339	0.0323	0.0500	0.0464

The priority vector for different criteria can also be expressed in the following form:
$C^T = [0.3482, 0.2594, 0.1685, 0.1105, 0.0670, 0.0464]$

Where, C^T is the transpose of the priority vector C.

Further to check the consistency of judgments, the values of λ_{max}, Consistency index (CI) and consistency ratio (CR) are calculated as follows:

$(A.C)^T = [2.1489, 1.6020, 1.0335, 0.6705, 0.4057, 0.2828]$

Where, A is the pair-wise comparison matrix and $(A.C)^T$ is the transpose of (A.C).
$\lambda_{max}=1/6[2.1489/0.3482+1.6020/0.2594-1.0335/0.1685+0.6705/0.1105-0.4057/0.0670-0.2828/0.0464]$
$= 6.1164$

CI= (6.1164-6)/6-1 = 0.0233
CR=CI/RI = 0.0187 [for n=6, RI =1.24]

It can be shown that both the methods for computing the priority vector and consistency ratio value will give almost similar results. The RMS error value between the above mentioned two methods while estimating the criteria priority vector also obtained.

Similarly, the sub-criteria at the third level of the hierarchy are again pair-wise compared to have their relative importance and the following is the judgment matrix (Table 5.2) when different sub-criteria under 'order quantity' criteria are compared against each other. The above matrix has a consistency ratio of 0.0457.

TABLE 5.2: JUDGMENT MATRIX FOR DIFFERENT SUB-CRITERIA UNDER 'ORDER QUANTITY' CRITERIA

Sub-criteria	Fixed	Fluctuating	Anticipatory	Priority value
Fixed	1	2	2	0.493
Fluctuating	1/2	1	2	0.311
Anticipatory	1/2	1/2	1	0.196

Applying the similar approach, the priority values of other sub-criteria are also obtained as shown below.

TABLE 5.3: PRIORITY VALUES OF SUB-CRITERIA

OQ	RC	SS	LT	DF	ROP
λ_{max}= 3.053	λ_{max}= 3.009	λ_{max}= 3.009	λ_{max}= 3.003	λ_{max}= 3.108	λ_{max}= 3.018
CR=0.046	CR=0.007	CR=0.046	CR=0.002	CR=0.093	CR=0.015

5.1.2 MODEL ASSESSMENT AND DECISION-MAKING

In the previous sub-section, the priority values of different criteria and sub-criteria are estimated and these priorities are now used to determine the preference values and performance ratings of the alternative inventory control policies .For this, the alternatives are pair-wise compared against each other with respect to each of the sub-criteria at the third level of the hierarchy. The preference value for each alternative is now calculated by multiplying each value in the weightage of sub-criteria column by the respective value in the criteria weightage column, then again multiplying with the element in the column for each alternative and adding up the results. Table 5.2 shows the judgment matrix when the alternative policies are pair-wise compared from the point of view of sub-criteria 'Fixed' lot size under 'Order quantity' criteria.

Chapter 6

Results And Discussions

CHAPTER 6

RESULTS AND DISCUSSIONS

The priority values of different criteria and sub-criteria are estimated and shown in table 6.1.These priorities are now used to determine the preference Values and performance ratings of the alternative inventory control policies.

TABLE 6.1 PRIORITY VALUES FOR DIFFERENT CRITERIA, SUB-CRITERIA AND ALTERNATIVES

Criteria	SubCriteria	Wt1	Wt2	PRP	PEP	TBP	MRP	ORP
OQ	FXD	0.493	0.3501	0.4146	0.2598	0.1748	0.0898	0.0610
	FLU	0.311	0.3501	0.4391	0.2808	0.1438	0.0847	0.0516
	ANC	0.196	0.3501	0.4063	0.2629	0.1721	0.1059	0.0528
RC	OC	0.540	0.2606	0.3484	0.3484	0.1378	0.0943	0.0711
	ICC	0.297	0.2606	0.2883	0.2196	0.3486	0.0924	0.0511
	SOC	0.163	0.2606	0.4272	0.2599	0.1581	0.0962	0.0586
SS	LOW	0.528	0.1681	0.0452	0.0673	0.1298	0.2946	0.4631
	MEDIUM	0.332	0.1681	0.2775	0.2837	0.2603	0.1107	0.0678
	HIGH	0.140	0.1681	0.2072	0.336	0.2549	0.1154	0.0868
LT	INTERNAL	0.458	0.1091	0.3696	0.2439	0.209	0.1093	0.0682
	EXTERNAL	0.416	0.1091	0.4770	0.2440	0.1410	0.0840	0.0540
	OTHERS	0.126	0.1091	0.3644	0.2758	0.1792	0.1182	0.0624
DF	QT	0.517	0.0660	0.0917	0.0845	0.1203	0.4772	0.2263
	TSA	0.359	0.0660	0.2379	0.2974	0.2638	0.1151	0.0858
	CA	0.124	0.0660	0.4146	0.2598	0.1748	0.0899	0.0609
ROP	LEOQ	0.387	0.0461	0.3836	0.2522	0.2247	0.0843	0.0552
	EEOQ	0.443	0.0461	0.0893	0.0848	0.1223	0.4232	0.2804
	MEOQ	0.170	0.0461	0.3696	0.2439	0.209	0.1092	0.0681

For this, the alternatives are pair-wise compared against each other with respect to each of the sub-criteria at the third level of the hierarchy. Table 6.1 exhibits the priority values of the alternatives with respect to all the sub-criteria. This table also includes the priority values of different criteria and sub-criteria, considered in the present problem. Wt1 and Wt2 represent the sub-criteria and criteria priority values respectively .The preference value for each alternative is now calculated by multiplying each value in the weightage of sub-criteria column by the respective value in the criteria weightage column, then again multiplying with the element in the column for each alternative and adding up the results.

Table 6.2 shows the detailed results of the computation of the preference value for each alternative. From the table, it is clear that the perpetual review policy (PRP) has the highest preference value followed by the periodic review policy (PEP). The preference values of the alternatives are shown in 6.2.Fig 5.1 exhibits the effects of different criteria on the performance of the alternative inventory control policies and it is observed that the perpetual review policy (PRP) outperforms the other policies from the point of view of most of the criteria as considered in the present problem. It also reveals two interesting facts. Firstly, the material requirement planning (MRP) policy is severely affected by lead time (LT) and on the other hand, safety stock (SS) has a significant effect on the performance of the optional replenishment policy (ORP).

TABLE 6.2 RESULTS OF INVENTORY CONTROL POLICIES

Sub Criteria	PRP	PEP	TBP	MRP	ORP
FXD	0.0716	0.0448	0.0302	0.0155	0.0105
FLU	0.0478	0.0306	0.0157	0.0092	0.0056
ANC	0.0279	0.0180	0.0118	0.0073	0.0036
OC	0.0490	0.0490	0.0194	0.0133	0.0100
ICC	0.0223	0.0170	0.0270	0.0072	0.0040
SOC	0.0181	0.0110	0.0067	0.0041	0.0025
LOW	0.0040	0.0060	0.0115	0.0261	0.0411
MEDIUM	0.0155	0.0158	0.0145	0.0062	0.0038
HIGH	0.0049	0.0079	0.0060	0.0027	0.0020
INTERNAL	0.0185	0.0122	0.0104	0.0055	0.0034
EXTERNAL	0.0216	0.0111	0.0064	0.0038	0.0025
OTHERS	0.0050	0.0038	0.0025	0.0016	0.0009
QT	0.0031	0.0029	0.0041	0.0163	0.0077
TSA	0.0056	0.0070	0.0063	0.0027	0.0020
CA	0.0034	0.0021	0.0014	0.0007	0.0005
LEOQ	0.0068	0.0045	0.0040	0.0015	0.0010
EEOQ	0.0018	0.0017	0.0025	0.0086	0.0057
MEOQ	0.0029	0.0019	0.0016	0.0009	0.0005
Preference value	**0.3300**	**0.2475**	**0.1820**	**0.1332**	**0.1073**

Based on this approach, it is observed that the perpetual review policy is the best choice for controlling the inventory items and 'Order quantity' is the most important criteria.

Chapter 7

Conclusions

CHAPTER 7

CONCLUSION

The AHP-based inventory control policy selection approach is based on knowledge and pair-wise comparison matrices for solving the multi-criteria decision making problems. The results clearly favor AHP methodology and the approach is found to be better than the other scoring techniques because it will consider all the important criteria and sub-criteria relevant to the problem and the decision maker will not have to be concerned about the bias in the judgments while selecting the optimal policy. Based on this approach, it is observed that the perpetual review policy is the best choice for controlling the inventory items and 'Order quantity' is the most important criteria. Knowledge-base systems in conjunction with the AHP can also be developed for performing the pair-wise comparisons for various organizational and managerial decision-making tasks.

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