UPES Centre for Continuing Education

The effect of inventory on Supply Chain

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Declaration by the Guide

This is to certify that the Mr Amarjeet Kumar Shrivastva , a student of MBA (Logistic and Supply Chain), SAP ID 500071746 of UPES has successfully completed this dissertation report on "The effect of inventory on Supply Chain" under my supervision.

Further, I certify that the work is based on the investigation made, data collected and analyzed by him and it has not been submitted in any other University or Institution for award of any degree. In my opinion it is fully adequate, in scope and utility, as a dissertation towards partial fulfillment for the award of degree of MBA.

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Thanking You

Yours Sincerely
for **L.G. Electronics India Pvt. Ltd.**

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ABSTACT

Supply chain management addresses the management of materials and information across the entire chain from suppliers to producers, distributors, retailers, and customers. In the past few decades, scholars gave ample attention about the impact of inventory on Supply Chain Management (SCM). Roughly speaking, research on supply chain management has been mainly focused on three major issues. One is the behavior of information flow; the second issue deals with inventory management; the third issue is orientated to planning and operations management. In this paper the second issue, namely inventory management will be discussed. It will follow the phases of classifying inventory; identify cost factors; assess cost components; calculate EOQ; giving suggestion and effect of inventory on supply chain will be discussed. The result is going to become clear under the analysis of two alternatives by using MCDM (Multiple Criteria Decision Making) method. The conclusion is when optimizing the inventory management, both up stream and down stream activities will run effectively.

1. Introduction

1.1 Background

Supply chain management addresses the management of materials and information across the entire chain from suppliers to producers, distributors, retailers, and customers. Traditionally, each company performs purchasing, production and marketing activities independently, so that it is difficult to make an optimal plan for the whole chain. In recent years, it has been realized that actions taken by one member of the chain can influence all others in the chain (see, for example, T.J. Peters 1982; Riddalls 2002). More and more companies have gradually recognized that each of them serves as part of a supply chain against other supply chains in terms of competition, rather than as a single firm against other individual firms. Since 1990, as the information technology has continuously developed, it is possible to coordinate all organizations and all functions involved in the whole chain. Consequently, supply chain management has been increasingly receiving attention from both academic researchers and practitioners.

Roughly speaking, research on supply chain management has been mainly focused on three major issues. One is the behavior of information flow through a supply chain (see, for example, Lee et al., 1997). The second issue deals with inventory management, which regards a supply chain as a multiechelon inventory system (see, for example, Axsater, 2000a; Zipkin, 2000, and the cited references in them). The third issue is orientated to planning and operations management of a supply chain based on queuing systems. (See the most related works, for example, Raghavan and Viswanadham, 2001; Song and Yao, 2002).

In this paper the second issue, namely inventory management will be discussed. There is a Chinese proverb saying, "*if you want to defeat an army, frustrate the chief first.*" It is also suitable for business fight. In the past few decades, scholars gave ample attention about the impact of inventory on Supply Chain Management (SCM). As a recently research shown, inventory cost account for 30% of the total capital cost. As matter of fact, successful inventory management is often the momentous symbol of competition victory and a well run organization .

1.2 Problem discussion

Inventory can range from raw materials, cash, finished goods, etc. Effective inventory management will optimize the supply chain, eliminate cash flow and reduce the possibility of occurrence on inventory shortage caused by variable orders. Consequently, it is of utmost importance to optimize inventory management to satisfy the company's strategy goal.

Lee et al. (1997) describe a problem frequently encountered in supply chains, called the bullwhip effect: demand variability increases as one move up the supply chain. This distorted information throughout the supply chain can lead to inefficiencies excessive inventory investment, poor customer service, lost revenues, misguided capacity plans, ineffective transportation and missed production schedules (Lee et al., 1997a).

1.3 Problem presentation

A company may save logistics costs and simultaneously improve service levels by redesigning its supply chain network. Unfortunately, because of the many complex logistical issues involved, it is generally difficult to analyze large systems in their entirety.

Considering the uncertainty of leadtime and demand, firms in practice have to encounter decisionmaking challenges to minimize the effect caused by uncertainty in the most cost saving way. In manufacturing and planning safety stocks and safety leadtime is included in the systems. Safety stock is a buffer of stock above and beyond that needed to satisfy production and gross requirements. Safety leadtime is a procedure whereby purchase orders are released and scheduled to be delivered one or more periods before necessary to satisfy production or customer demand (Vollmann, Berry, Whybark, 1997).

If uncertainty of demand and leadtime cannot be evaporating, can it be minimized? Reducing leadtime will eliminate uncertainty factor as well as more accurate demand forecasting.

1.4 Problem formulation

When the firms improve their inventory management, what is the reaction of other factors on supply chain?
How to improve the inventory from cost effective perspective?

1.5 Purpose

- To understand the impact of inventory on supply chain.
- To get the knowledge about how manufacturing firms deal with the inventory from costeffective view.
- In a broader point of view, it is a cost reduction procedure that can have an impact on the economies of the company directly and on other departments indirectly.

1.6 Relevance

The relevance of this research is shown together with a motivation of why it is important to do research within the area of inventory management. This study is both theoretically and practically relevant because it involves a working procedure of how to be more cost effective within inventory management. According to the optimization of inventory management, production manager can easily coordinate other department so as to improve supply chain to enhance the competition of the firms.

1.7 Delimitations and limitations

The study will be carried from the supply chain perspective; however the study area will be limited to the upstream of supply chain. The case company has no concrete method to calculate the inventory before. That means lack of information gathering.
But the author can bring something different inspiration to other research according to the conduction of hermeneutic scientific perspective.

2. Methodology

One crucial factor in any scholarly research is the theoretical perspective that will inform that research. The perspective will affect the kind of information gathered, the way it is interpreted, and the ultimate answers that the research will uncover.

2.1 Scientific perspectives

2.1.1 Positivism

Positivism is based on an objectivist epistemology. For a positivist, reality is objective – things are true or actual in fact, and that truth is not influenced by factors such as society, culture, or interaction with human cognition. There is "a conviction that scientific knowledge is both accurate and certain. " (Crotty 1998, p. 27) There is also the conviction that objective science is the only way of "interacting with the world cognitively, i.e. in terms of knowing and explaining and hence understandin g it and how it works – and this is science. " (Rapoport 2000, p. 110)

Positivist studies are primarily quantitative in nature (although qualitative positivist case studies are possible). Empirical science exemplifies the positivist methods, and knowledge is built through a process of inductive logic – hypotheses are developed and tested with experiments; as more and more facts accumulate, they can be used to construct general explanatory theory. Findings are validated when experiments are replicated and yield consistent results. Ideally, this testing involves testing under original conditions and also testing with variations – under different conditions, within different cultures, etc. (Rapoport 1997, p. 409)

Positivist investigations deal with observables – things that can be perceived with the human senses (aided by scientific instruments). Culture, society, and inborn cognitive structures would therefore not be legitimate topics for positivist investigation . It is possible for a phenomenon to be reduced to its component parts for study in a positivist framework; the findings for the parts will be valid when applied back to the whole.

Researchers conducting this type of study are expected to remain aloof from the experiment – they are observers only, and should not influence the course of the experiment or the results by their interaction with their subjects. These researchers proclaim their objectivity, the fact that their findings are not colored by their individual perspectives or prejudices. This point of view is becoming somewhat modified; some scientists remain within the positivist camp but temper very significantly the status they ascribe to their findings, the claims they make about them. It is not possible, they have come to recognize, to find some Archimedean point from which realities in the world can be viewed free from any influence of the observer's standpoint. They may claim a higher level of objectivity and certitude for scientific findings than for other opinions and beliefs, but the absoluteness has gone and claims to validity are tentative and qualified. (Crotty 1998, p. 40)

The positivist very much dwells within a world backed by centuries of scientific tradition. Although this position was born in the natural sciences, it has become an important theoretical perspective for social research as well. Although some would question whether the same research approach can be used in two such different disciplin es (Snodgrass and Coyne, 1997, p. 8), many, such as Amos Rapoport, still feel it the only route to knowledge.

2.1.2 Hermeneutics

Hermeneutic interpretation proceeds by what is known as the "hermeneutic circle." Central to this idea is the impossibility of understanding a whole without understanding the parts, and viceversa. The process of inquiry thus moves in a circle – first examining the parts to inform interpretations about the whole, then examining the newly illuminated whole to better understand the parts: As soon as we initially discover some elements that can be understood, we sketch out the meaning of the whole text. We cast forward or (forecast) a preliminary project, which is progressively corrected as the process of understanding advances.

Interpretation brings with it an anticipation, albeit vague and informal, of the meaning of the whole; and the light of this anticipation plays back to illuminate the parts.
(Snodgrass and Coyne 1997, p. 13)

Within this system, there is never a final "answer." Understanding moves around the circle, deepening with each revolution. It is also possible that the understanding reached will exceed that of the original author of the text: "This aim derives from the view that in large measure authors' meanings and intentions remains implicit and goes unrecognized by the authors themselves. Interpreters may end up with an explicit awareness of meanings, and especially assumptions, that the authors themselves would have been unable to articulate. " (Crotty 1998, p. 91)

Hermeneutic interpretation is influenced by the situation of the individual researcher. That person's history, culture, and prejudices cannot be transcended; they will color the nature of his or her interpretation. Because different investigators will bring different perspectives to their inquiry, there is the possibility (or probability) of different "truths" emerging from the same phenomena. These "truths " will also change over time, as researchers of the next age bring their particular situations to bear on the problems. As with phenomenology and other primarily qualitative disciplines, validity is a difficult question. Only the accumulation of consistent, supporting understanding can confer eventually validity to a hermeneutic study. Hermeneutics can provide a valuable perspective for the historical researcher, who must routinely deal with texts of various sorts, direct access to the historical players being of course impossible.

2.1.3 Comparison of the Two Theoretical Perspectives

The two methods are fundamentally different theoretical perspectives. While positivism aims to be objective and scientific, hermeneutics has at its core the idea that objectivity is impossible (since we are all participants in the world we're attempting to study). Their attitude towards "truth " is also diametrically opposed. The positivist believes in a single truth, one that can be uncovered through patient application. The hermeneutic researcher believes that every researcher will bring something different to other researchers.

2.2 Types of research

In logic, we often refer to the two broad methods of reasoning as the ***deductive*** and ***inductive*** approaches.

Deductive reasoning works from the more general to the more specific. Sometimes this is informally called a "topdown" approach. We might begin with thinking up a *theory* about our topic of interest. We then narrow that down into more specific *hypotheses* that we can test. We narrow down even further when we collect *observations* to address the hypotheses. This ultimately leads us to be able to test the hypotheses with specific data a *confirmation* (or not) of our original theories.

Inductive reasoning works the other way, moving from specific observations to broader generalizations and theories. Informally, we sometimes call this a "bottom up" approach (please note that it's "bottom up" and *not* "bottoms up" which is the kind of thing the bartender says to customers when he's trying to close for the night!).

In inductive reasoning, we begin with specific observations and measures, begin to detect patterns and regularities, formulate some tentative hypotheses that we can explore, and finally end up developing some general conclusions or theories. These two methods of reasoning have a very different "feel" to them when you're conducting research. Inductive reasoning, by its very nature, is more openended and exploratory, especially at the beginning. Deductive reasoning is more narrow in nature and is concerned with testing or confirming hypotheses. Even though a particular study may look like it's purely deductive (e.g., an experiment designed to test the hypothesized effects of some treatment on some outcome), most social research involves both inductive and deductive reasoning processes at some time in the project. In fact, it doesn't take a rocket scientist to see that we could assemble the two graphs above into a single circular one that continually cycles from theories down to observations and back up again to theories. Even in the most constrained experiment, the researchers may observe patterns in the data that lead them to develop new theories.

Research choices: qualitative and quantitative

The qualitative method is a conception of working procedures associated with that the scientist himself/herself is part of the social reality being analyzed. The data collection and analysis is performed at the same time and in interaction. Therefore, Warburton, R.D.H., (2004b) state that such studies have high flexibility, which is necessary since the structure is changed based on new experiences gained from the interaction.

It is worth bearing in mind that qualitative analysis is a cognitive process and that each individual has a different cognitive style. A person's way of thinking, and explanation of analysis, may seem crystal clear to someone with a similar cognitive style and very confusing to another person whose approach is different.

Consequently, the qualitative method aims to accomplish a complete description of the investigated area, but it tends to include smaller populations than quantitative investigations. Advocates of quantitative studies therefore criticize the qualitative method because of its subjectivity, since the gathering of facts and the results from the analysis to a very high extent is dependent on individuals (Douglas 1994). Further, some authors declare that when using this method it is not possible to make any generalization, why the results cannot be seen as generally valid. (Alsyouf 2004)

2.3 Data collection

By and large, there are some data collections strategies as following:
Collecting already existing data such as official statistic, available documents from government, organization etc.

Survey: this method is commonly used in social science studies. Questionnaires are designed by the researcher and answered a defined population. The responses can be compared across groups and statistical analysis can be then conducted to describe and compare the responses.

Interview: verbal communication that aims for answers to predecided question structured or unstructured and nonverbal behaviors can be captured and analyzed.

In this study, major theoretical data collection was collected at the library of Greater Noida University. And the main sources of empirical data were documentation and interviews as well as the observation of the author. Documents give the author access to important information, such as the stated rules, administrative papers and memorandums. The author is aware of the difficulty of getting access to some documents and sometimes to prove their credibility.

2.4 Reliability and Validity

It is important to visualize what method that has been used to give the reader a chance to repeat the study as well as give him/her the possibility to validate the evaluate its reliability. Reliability is about if the result from a research can be the same if the research is conducted again, and quantitative research reliability is concerned (Ballou, 2002).

The objective of this study is to ensure that if a latter investigator followed exactly the same procedures as described by a previous investigator and conducted a same case study all over again; the latter investigator should arrive to the similar findings and conclusions. (Yin, 2003)

Validity refers to the extent to which the findings are accurate or reflect the underlying purpose of the study. Internal validity refers to the ability of the research design to accurately answer the research questions. External validity refers to the capacity to generalize findings and develop inferences from the sample to the study population. In this study the author used interviews with closed questions, Internet sites, books and articles to have multiple sources of evidence for research.

2.5 Research method selection

The author is going to adopt hermeneutics perspective to deploy the analysis. As to research choice, a combination of quantitative and qualitative will be used. Thanks for the employees of the company since they offer amply relevant documents and figures to help me carry out the project.

3. Theory

3.1 The importance of inventory

Table 3-1 summarizes the INDIA. Gross National Product (GNP) and the levels of manufacturing and trade inventories over the 1974 to 1994 time period, and calculates the ratio of inventories to GNP.

It is apparent from Figure 3-1 that inventory as a percentage of GNP has been declining in recent years, from approximately 17 to 20 percent in the 1970s to a current level in the range of 13 to 14 percent. This decline is largely due to four factors. First, firms have become more expert at managing inventory in general, and thus have succeeded in improving inventory velocity, or the inventory turnover rate. Second, innovations and improvements in communications and information technology have help companies to become more effective in terms of how they manage inventories. The availability of technologies have resulted in companies being able to do business on a daily basis with less inventory. Third, increased competitiveness in our transportation industries has resulted in greater opportunities for shippers to purchase highquality as well as customized services, thus reducing to some extent the need to carry large inventories. Forth, overall sensitivity to the incurring of excess and non value added cost has motivated many firms to identify ways to reduce and even eliminate unnecessary levels of inventory.

In Current Dollars			
Year Ending	GNP ($ trillion)	Inventory ($ billion)	Ratio of Inventory To GNP
1974	1.43	286	20.00
1975	1.55	288	18.58
1976	1.72	319	18.55
1977	1.92	351	18.28
1978	2.16	397	18.38
1979	2.42	444	18.35
1980	2.63	483	18.37
1981	2.94	520	17.69
1982	3.07	520	16.94
1983	3.31	510	15.41
1984	3.78	546	14.44
1985	4.00	645	16.13
1986	4.24	657	15.50
1987	4.53	683	15.08
1988	4.87	735	15.09
1989	5.23	780	14.91
1990	5.46	820	15.02
1991	5.68	815	14.35
1992	5.96	832	13.96
1993	6.38	862	13.51
1994	6.73	893	13.27

Table 3-1 Percentage Ratio of Manufacturing and Trade Inventory to GNP

3.2 Definition and Purpose of inventory

Inventory is the stock of any item or resource used in an organization. An inventory system is the set of policies and controls that monitor levels of inventory and determine what levels should be maintained, when stock should be replenished, and how large orders should be. All firms (including JIT operations) keep a supply of inventory for the following reasons:

1. **To maintain independence of operations.** A supply of materials at a work center allows that center flexibility in operation. For example, because there are costs for making each new production setup, this inventory allows management to reduce the number of setups. Independence of workstations is desirable on assembly lines as well. The time that it takes to do identical operations will naturally vary from one unit to the next. Therefore, it is desirable to have a cushion of several parts within the workstation so that shorter performance times can compensate for longer performance times. This way the average output can be fairly stable.

2. **To meet variation in product demand.** If the demand for the product is known precisely, it may be possible to produce the product to exactly meet the demand. Usually, however, demand is not completely known, and a safety or buffer stock must be maintained to absorb variation.

3. **To allow flexibility in production scheduling.** A stock of inventory relieves the pressure on the production system to get the goods out. This causes longer lead times, which permit production planning for smoother flow and lowercost operation through larger lotsize production. High setup costs, for example, favor producing a larger number of units once the setup has been made.

4. **To provide a safeguard for variation in raw material delivery time.** When material in ordered from a vendor, delays can occur for a variety of reasons: a normal variation in shipping time, a shortage of material at the vendor's plant causing backlogs, an unexpected strike at the vendor's plant or at one of the shipping companies, a lost order, or a shipment of incorrect or defective material.

5. **To take advantage of economic purchase order size.** There are costs to place an order: labor, phone calls, typing, postage, and so on. Therefore, the larger each order is, the fewer the orders that need be written. Also, shipping costs favor larger orders – the larger the shipment, the lower the perunit cost.

For each of the preceding reasons (especially for items 3, 4, and 5), be aware that inventory is costly and large amounts are generally undesirable. Long cycle times are caused by large amounts of inventory and are undesirable as well.

3.3 Inventory costs

Inventory costs are important for three major reasons. First, inventory costs represent a significant component of total logistics costs in many companies. Second, the inventory levels that a firm maintains at points in its logistics system will affect the level of service the firm can provide to its customers. Third, cost tradeoff decisions in logistics frequently depend upon and ultimately affect inventory carrying costs.

3.3.1 Inventory carrying cost

In a landmark research project, Douglas M. Lambert cited four major components of inventory carrying cost: capital cost, storage space cost, inventory service cost, and inventory risk cost. The elements to be considered in each of these categories are identified in Appendix (1).

1. Capital Cost. Sometimes called the interest or opportunity cost, this cost type focuses upon what having capital tied up in inventory. The capital cost is frequently the largest component of inventory carrying cost. A company usually expresses it as a percentage of the value of the inventory the company holds. Virtually all companies seek to reduce inventory because management recognizes that holding excessive inventory provides no value added to the firm. The company must consider what rate of return it is sacrificin g on the cash invested in inventory.

2. Storage Space Cost. This category includes handling costs associated with moving products into and out of inventory, and storage costs such as rent, heating, and lighting. Such costs may vary considerably from one circumstance to the next. For example, firms can often unload raw materials directly from railcars and store them outside, whereas finished goods typically require safer handling and more sophisticated storage facilities.

3. Inventory Service Cost. Another component of inventory carrying cost includes insurance and taxes. Depending upon the product value and type, the risk of loss or damage may require high insurance premiums. In most cases, there will be few, if any, significant changes from year to year in the tax and insurance components of the inventory carrying cost.

4. Inventory Risk Cost. This final major component of inventory carrying cost reflects the very real possibility that inventory value may decline for reasons largely beyond corporate control. Any calculation of inventory risk costs should include the costs associated with obsolescence, pilferage, damage, theft, and other risks to inventoried product.

3.3.2 Order/Setup Cost

A second cost affecting total inventory cost is ordering cost or setup cost. Ordering cost refers to the expense of placing an order for additional inventory, and does not include the cost or expense of the product itself. Setup cost refers more specifica lly to the expense of changing or modifying a production or assembly process to facilitate product line changeovers, for example.

Order cost. The costs associated with ordering or acquiring inventory have both fixed and variable components (Parlar 2000). The fixed element may refer to the cost of the information system, facilities, and technology available to facilitate order placement activities. This fixed remains constant in relation to the number of orders placed.

There are also a number of costs that vary in relation to the number of orders that are placed for more inventories. Some of the types of activities that may be responsible for these costs include (1) reviewing inventory stock levels; (2) preparing and processing order requisitions or purchase orders; (3) preparing and processing receiving reports; (4) checking and inspecting stock prior to placement in inventory; (5) preparing and processing payment.

Setup Cost. Production setup costs may be more obvious than ordering or acquisition costs. Setup costs are expenses incurred each time a firm modifies a production line to produce a different item for inventory. The fixed portion of setup cost might include use of the capital equipment needed to change over production facilities, while the variable expense might include the personnel costs incurred in the process of modifying or changing the production line.

3.4 Fixed order quantity approach

Inventory models for calculating optimal order quantities and reorder points have been in existence long before the arrival of the computer. While EOQ may not apply to every inventory situation, most organizations will find it beneficial in at least some aspect of their operation. Anytime you have repetitive purchasing or planning of an item, EOQ should be considered. Obvious applications for EOQ are purchase to stock distributors and make to stock manufacturers, however, make to order manufacturers should also consider EOQ when they have multiple orders or release dates for the same items and when planning components and subassemblies. Repetitive buy maintenance, repair, and operating (MRO) inventory is also a good application for EOQ. Though EOQ is generally recommended in operations where demand is relatively steady, items with demand variability such as seasonality can still use the model by going to shorter time periods for the EOQ calculation. Just make sure your usage and carrying costs are based on the same time period.

As its name implies, the fixed order quantity model involves ordering a fixed amount of product each time reordering takes place. The exact amount of product to be ordered depends upon the product's cost and demand characteristics and upon relevant inventory carrying and reordering costs.

Firms using this approach generally need to develop a minimum stock level to determine when to reorder the fixed quantity. This is usually called the reorder point. When the number of items in inventory reaches the predetermined level, the fixed order quantity (also called the economic order quantity or EOQ) is automatically ordered. In a sense, the predetermined ordering level triggers the next order.

3.4.1 Under condition of certainty

The following are the principal assumptions of the simple EOQ model:

- A continuous, constant, and known demand rate and lead time
- The satisfaction of all demand
- No inventory in transit and one item of inventory
- No limit on capital availability and infinite planning horizon
- Price and cost are independent of order quantity or time

The EOQ in units can be calculated using the following formula:

$$EOQ = \sqrt{2AC/DV}$$

Where

A = the ordering cost per order

D = annual demand or usage of product (number of units)

C = annual inventory carrying cost (as a percentage of product cost)
V = average cost of one unit of inventory

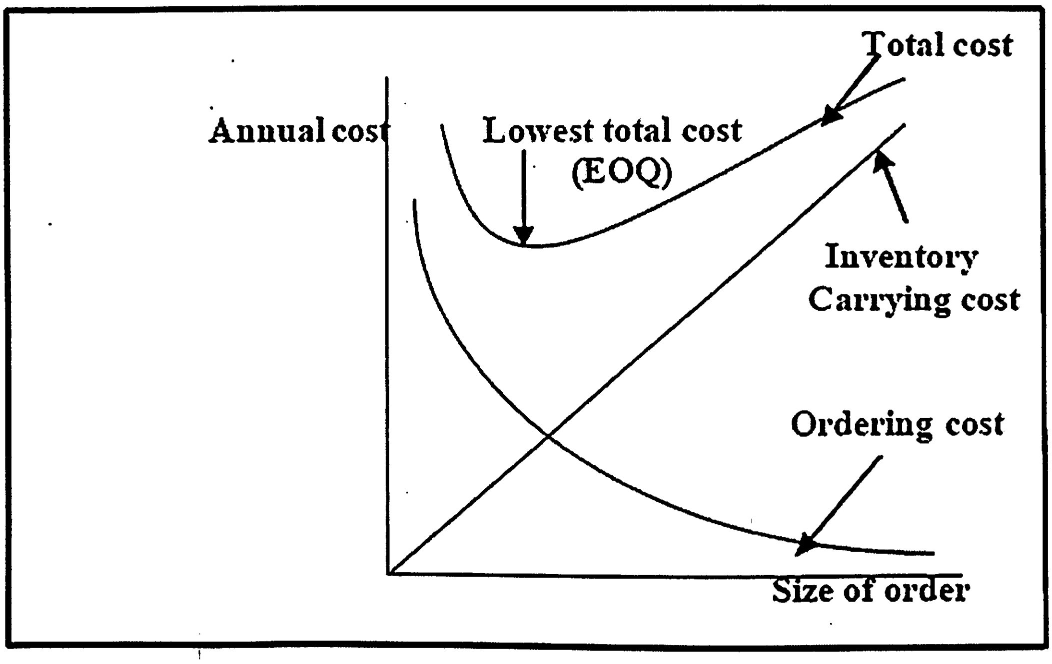


Figure 3.1 Cost required to determine the Most Economical Order Quantity

Safety stock and reorder point

The previous model assumed that demand was constant and known. In the majority of cases, though, demand is not constant but varies from day to day. Safety stock must therefore be maintained to provide some level of protection against stockouts. Safety stock can be defined as the amount of inventory carried in addition to the expected demand. In a normal distribution, this would be the mean. For example, if our average monthly demand is 100 units and we expect next month to be the same, if we carry 120 units, then we have 20 units of safety stock.

Knowing when to order was as necessary as knowing how much to order. The *when*, generally called a reorder point, depends on inventory level – that is, some number of units. Under the assumptions of certainty, a firm needs only enough inventories to last during the replenishment time or lead time. Therefore, given a known lead time, multiplying lead time length by daily demand determines the reorder point.

3.4.2 Uncertainty of demand and lead time length

This section considers the possibility that both demand and lead time may vary. It builds upon the preceding section in attempting to make this inventory approach more realistic. As expected, however, determining how much safety stock to carry will be noticeably more complex now than when only demand varied.

As in the previous, the critical issue is just how much product customers will demand during the lead time. If demand and lead time are constant and known in advance, calculating the reorder point would be easy. Now that both demand and lead time may vary, the first step is to study the likely distribution of demand during the lead time. Specifically, we must accurately estimate the mean and standard deviation of demand during lead time.

Appendix (2) illustrates three key properties of a normal distribution. The normal distribution is symmetrical, and its mean (average) equals its mode (highest point). Approximately 68.26 percent of the area under the normal curve lies within one standard deviation (1σ) from the mean, 95.44 percent within two standard deviations ($2\ \sigma$), and 99.73 percent within three standard deviations ($3\ \sigma$).

After calculating values for the mean and standard deviation of demand during lead time, we can describe the stockout probability for each particular reorder point. For example, imagine that Appendix (2) represents demand distribution during lead time. Setting the reorder point equal to $X + 1\ \sigma$ will result in an 84.13 percent probability that lead time demand will not exceed the inventory amount available. Increasing the reorder point to $X + 2\ \sigma$ raises the probability of not incurring a stockout to 97.72 percent; reordering at $X + 3\ \sigma$ raises this probability to 99.87 percent. Note that in the case of uncertainty, increasing the reorder point has the same effect as increasing the safety stock commitment. A firm must ultimately find some means to justify carrying this additional inventory.

We may calculate the mean and standard deviations for lead time demand using the following formulas:

$$\sigma^2 = L(\sigma_D)^2 + D^2(\sigma_{LT})^2$$

Where
X = mean (average) demand during lead time
σ = standard deviation of demand during lead time
L = mean (average) of lead time length
σ LT = standard deviation of lead time length
D = mean (average) daily demand
σ D = standard deviation of daily demand

3.5 Relationships with other activities

The objective of supply chain management is to provide a high velocity flow of high quality, relevant information that will enable suppliers to provide an uninterrupted and precisely timed flow of materials to customers (Zinn 2002). However, unplanned demand oscillations, including those caused by stockouts, in the supply chain execution process create distortions which can wreck havoc up and down the supply chain. There are numerous causes, often in combination, which will cause these supply chain distortions to start what has become known as the "Bullwhip Effect". Subsequently, the effect of inventory with other activities will be demonstrated.

3.5.1 Materials management

Materials management is typically comprised of four basic activities:
1. Anticipating materials requirements
2. Sourcing and obtaining materials

3. Introducing materials into the organization
4. Monitoring the status of materials as a current asset

Function performed by materials management includes purchasing or procurement, inventory control of raw materials, receiving, warehousing, production scheduling and transportation (Federgruen 1984b). The scope of materials management used in this thesis views the activity as an organizational system with the various functions as interrelated, interactive subsystems.

Figure 3-2 highlights the major objectives of materials management. Low costs, high levels of service, quality assurance, low levels of tiedup capital, and support of other functions. Each objective is clearly linked to overall corporate goals and objectives.

Thus tradeoff among the objectives must be made using a broad perspective of materials flow throughout the total system, from source of supply to the ultimate customer.

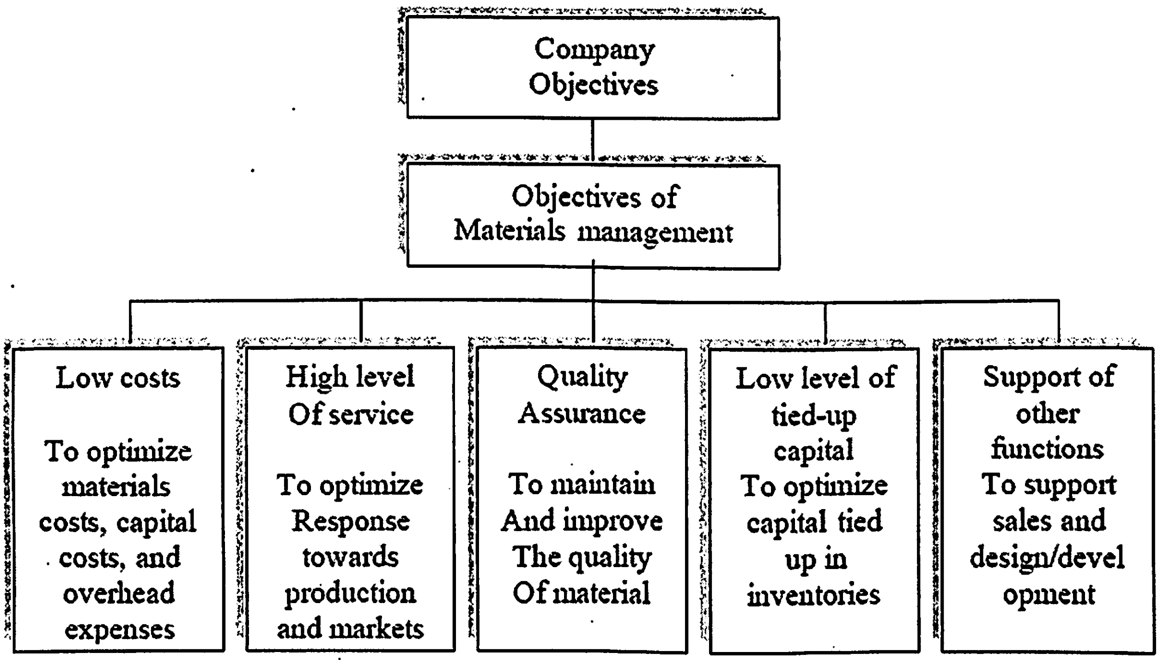


Figure 3.2.The major objectives of materials management

3.5.2 Procurement

Procurement is the process that a manufacturer, a wholesaler, or retailer, buys materials services and supplies from outside suppliers to support its operation. Comparing with purchasing from supply chain management perspective, procurement emphasizes on relationships between buyers and sellers and is in a higher, strategic level activity (Bowersox et al., 2002). For many companies, the purchase of materials from suppliers ' accounts for fifty percent of manufacturing costs and in some cases (e.g. the automotive industry) this figure can be over seventy percent (Lambert, 1998).

The focus on procurement as a key capability in organizations has stimulated a new perspective regarding its role in supply chain management. Bowersox et al. (2002), discussed procurement perspectives mainly as:

Continuous supply
Production should be ensured with continuous material supply. Production stoppage increased operation costs and results in an inability to provide finished goods or service to customers.

Minimize inventory investment
Modern procurement is to maintain supply continuity with the minimum inventory investment possible. This requires balancing the costs for carrying excessive material against the possibility of a production stoppage. The goal is to have needed materials arrives just before scheduled production.

Quality improvement
Procurement can play a critical role in the quality of a firm's products or services. When used materials and parts are of poor quality, the finished goods quality will not satisfy customer requirements. Quality improvement through procurement also impacts on costs in the firm by scrap and rework in the production.

Supplier development
Successful procurement depends on locating or developing suppliers, analyzing their capabilities, and selecting and working with those suppliers to achieve continuous improvement.

Pricing and purchasing discount
Price is an obvious concern in procurement. No one wants to pay a higher price than necessary. When using discount some other factors should be considered. For example, a discount for prompt payment of an invoice offered by one supplier must be compared with other suppliers' offers, which may have different percents or time periods involved.

Purchase Economies – Discount versus storage cost
One reason for accumulating physical supply inventory is that the company may be able to realize purchase economies (Towill 1982). For example, firms may buy raw materials in large quantities because of available price discounts. Although the company will need to store what it does not immediately use, the increased inventory costs may be less than what the company saves by buying in large quantities. This is becoming important to firms involved in offshore sourcing activity, which may result in significant quantity discount. In such cases, companies are trading off between a purchase price discount and storage costs. As long as the amount saved on the purchase price exceeds storage costs, these companies are willing to accumulate raw materials inventory.

Although this logic makes sense, it is not unusual for companies to stockpile inventories of materials and component parts without regard to whether or not the true cost tradeoffs justify doing so. Adherence to the strategy of carrying material inventories to take advantage of purchase price discounts is a practice that needs to be supported by a conscientious and objective analysis of the full range of relevant costs.

3.5.3 Demand management

Demand generates forecasts based on sales history, currently scheduled orders, scheduled marketing activities and customer information (Veinott 1966). Ideally, demand management works collaboratively and interactively both internally across the firm's functional components and externally with supply chain partners to develop a common and consistent forecast for each item period, location and item.

The forecast must also incorporate feedback from customers to integrate the influence of combined demand generation activities such as advertising and promotion. Practically, demand management and forecasting are closely related, and forecasting is an extensive topic in itself (Bowersox at al., 2002).

Demand forecasting is a critical tool in the management toolbox. Because the mostly widely cited reasons for forecasting include:

- Increase customer satisfaction
- Reduce stock out
- Scheduling production more efficiently
- Lowering safety stock requirements
- Reducing product obsolescence costs
- Managing shipping better
- Improving pricing and promotion management
- Making more informed pricing decisions

And above reasons are essential to management decision making.
The forecasting time frames are: (1) long term forecasts, usually cover more than three years and are used for long range planning and strategic issues. (2) Midrange forecasts usually range from one to three years and address budgeting issues and sales plans. (3) Short term forecasts are most important for the operational logistics planning process. They project demand into the next several months and, in some cases, more than a year ahead (Chien 1989).

3.5.4 Transportation

A major focus in logistics is upon the physical movement or flow of goods, or upon the network that moves the product. The logistics manager is responsible for selecting the mode or modes of transportation used in moving the raw materials or for developing private transportation as an alternative.

A direct relationship exists between transportation and the level of inventory and number of warehouses required (Aghezzaf 2001). For example, if firms use a relatively slow means of transport, they usually have to keep higher inventory levels and usually have more warehousing space for this inventory. They may examine the possibility of using faster transport to eliminate some of these warehouses and the inventory stored therein.

One reason companies may accumulate inventories of finished or semi finished product is similar to a reason for accumulating raw materials: transportation economies (Jaillet 1997). By shipping in carloads or truckload quantities rather than less than car loads or less than truck load quantities, a company may experience lower per unit transportation rates. As long as the transportation cost savings exceed any expenses associated with warehousing the additional volumes of product, it will be advantageous to ship in the larger quantities. Also, shipments in large volumes may experience better service, such as faster transit times and more reliable and consistent service. These results will help to reduce other costs such as in transit Inventory carrying cost and potential costs of lost sales due to product unavailability at point of sale or use.

3.5.5 Customer service

Another area of importance is customer service. Customer service has received widespread attention over the last ten or more years. Peters and Waterman, in their popular nonfiction best seller, In search of excellence, lauded the importance of getting close to your customers" as a means of achieving success in business. Customer service is a complex topic, and one that concerns other functional company areas. Customer service levels in many ways glue together other logistics areas. Decisions about inventory, transportation, and warehousing relate to customer service requirements. While customarily the logistics area does not completely control customer service decisions, logistics plays an extremely important role in ensuring that the customer gets the right product at the right place and time. Logistics decisions about product availability and inventory lead time are critical to customer service.

3.5.6 Warehousing and storage

Warehousing is an integral part of every logistics system. We can define warehousing as that part of a firm's logistics system that stores products (raw materials, parts, goods in process, finished goods) at and between point of origin and point of consumption of items being stored (Richard 1995). The term distribution centre (DC) is sometimes used, but the terms are not identical. Warehouse is the more generic term. With an increasing interest in improving inventory turns and reducing time to market, the role of distribution increasingly focuses on filling orders rapidly and efficiently.

3.6 Supporting tools

Adopting a few tools can make the analysis intelligible and legible. The following tools will be applied in analysis chapter.

3.6.1 Cause effect diagram

A cause effect diagram is a structured process used to organize ideas into logical groupings used in brainstorming and problem solving exercises (VitaRs, 2005) Cause effect diagram looks like a fishbone and therefore also known as fishbone diagram. The diagram is an effective tool to help finding the causes of a problem. It consists of a line to a box that is the effect. From there it has main branches, which are usually categorized into seven different cause categories: manpower, management, milieu, measure, machinery, method and material (Slack et al., 2001; Hill, 2005).

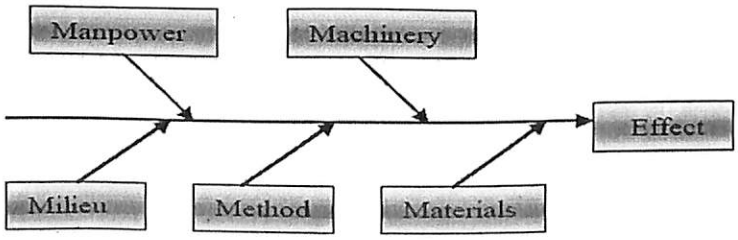


Figure 3.3 Causeeffect Diagram (Based on slack et al., 2001)

3.6.2 Multiple Criteria Decision Making

MCDM consists of a finite set of alternatives where the decision maker can select criteria and weight them according to their importance. The evaluation ratings are aggregated taking into account the weights of the criteria, which can be both qualitative and quantitative. The goal is to determine whether one alternative is better than another, given the same set of goals (AlNajjar & Alsyouf, 2003)

A decision making matrix is shown in figure 3-4 , where c is the importance of the j criterion and r is the rating of the i alternative on the j criterion. The criterion weight is multiplied with the rating and then summed in horizontal column. (Nijkamp & Delft, 1977; Zanakis et al., 1998)

	Criterion					
Alternative	c_1	c_2	...	c_j	...	c_n
1	r_{11}	r_{12}	...	r_{1j}	...	r_{1n}
2	r_{21}	r_{22}	...	r_{2j}	...	r_{2n}
.	.	.		.		.
.	.	.		.		.
.	.	.		.		.
I	r_{i1}	r_{i2}	...	r_{ij}	...	r_{in}
.	.	.		.		.
.	.	.		.		.
L	r_{l1}	r_{l2}	...	r_{lj}	...	r_{ln}

Figure 3.4 MCDM Matrix (Zanakis et al. 1998)

4. Empirical findings

4.1 Products

The company that was giving to us by our teacher is NPCL. Their main task is to offer their customer electricity, district heating, and IT communications. Their customers are both individual persons and companies. The plant that is producing electricity and district heating in Greater Noida is called plant. In the plant all district heating and 2530% of Greater Noida's annual electricity consumption are produced. II is the second plant and it is exclusively run on biomass fuel. The new boiler has an effect of 104 MW, 66 MW goes to heating. The generator has an effect of 38 MW for electricity. The more district heat that is being used, the more electricity can be produced. From 1997 until now the share of biomass fuels that is being used is over 95%. The two most important products are district heating and electricity. These are the two products that we choose because the district heating is a growing product and they now are trying to install district heating in the hole town (Greater Noida) and the total connected district heat customers is 5 000 (4 000 family houses). The electricity was chosen because its goes hand and hand with the district heating. When the company is producing district heating the debris of it becomes electricity. Greater Noida Energy Electricity net AB, which is a subsidiary company that is owned by NPCL, is responsible for service and maintenance of the electricity net in Greater Noida. NPCLs electricity sales are made since 1999 by Östkraft AB that is a company that is partly owned by NPCL.

The principle for district heating is that water circular in a closed piping system (Figure 1). Water is heated up at splant that have an outgoing temperature between 80-110° C. Then its lead out to the properties; there the heat is lead to the water system. The cooling water is lead back to the plant that has a temperature between 42-50° C, and then it's circulated.

The electricity is made by the debris from steam (Figure 41). The principle is that a steam turbine transforms the steams energy to mechanical energy. It has an effect of 38 MW. Detail description can be seen in Appendix 3.

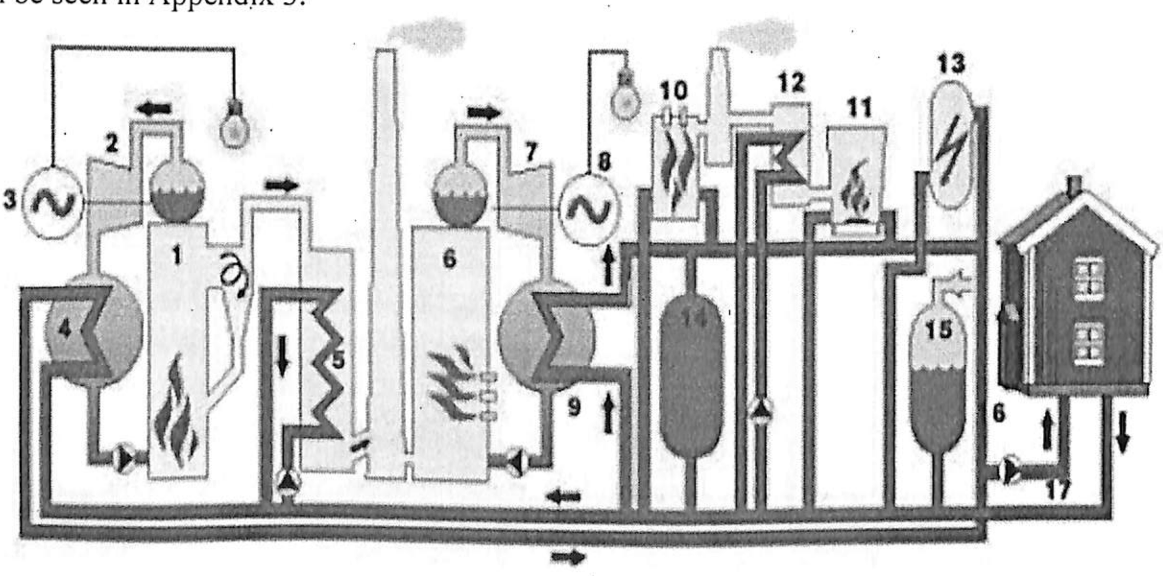
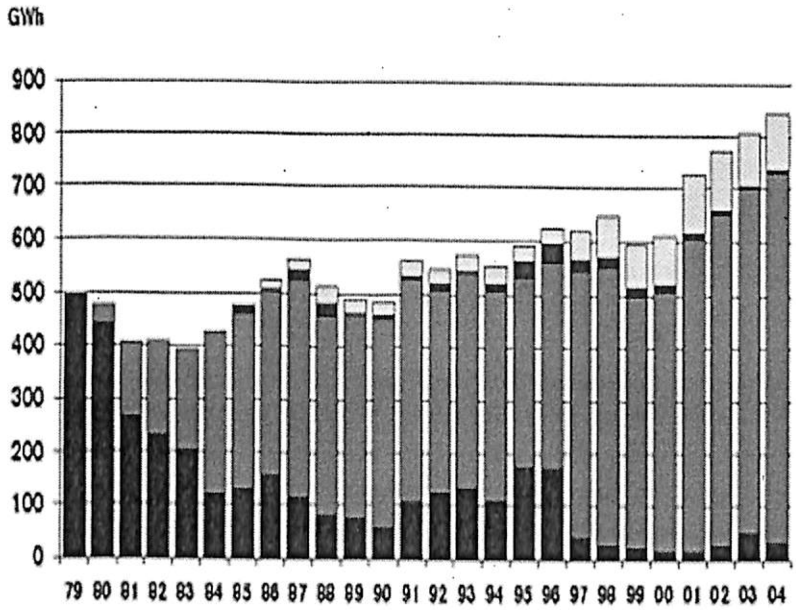


Figure 4.1: This is the process in s plant. Here one can see how the electricity and district heating are made.

4.2 Demand management

Greater Noida city's energy demand is supplied by power plant (Figure 42). Bio fuel contains of forestry remains, chip, bark and peat. Bio energy is not increasing the level of climate changing greenhouse gases in the atmosphere. Instead, it can contribute to reducing levels of nitrogen in forest soil, thus reducing the risk of leaching. The oil use has reduced from 100% to 5% during the last 25 years.



Degree days/ normal year	Percentage until normal	Year
3448	94,4	1988
2992	81,9	1989
3009	82,4	1990
3463	94,8	1991
3362	92	1992
3448	94,4	1993
3381	92,6	1994
3602	98,6	1995
4004	109,6	1996
3629	99,3	1997
3451	94,5	1998
3312	90,7	1999
2931	80,2	2000
3529	96,6	2001
3360	92	2002
3471	97	2003
3417	95,5	2004

Figure 4.2: Annual energy production at NPCL. Black= Oil, green= bio fuel, blue= electricity and turquoise= stack gas condenser. The table shows how degree days/normal year and percentage up to the normal is changing each year. The normal degree days/year is 3653.

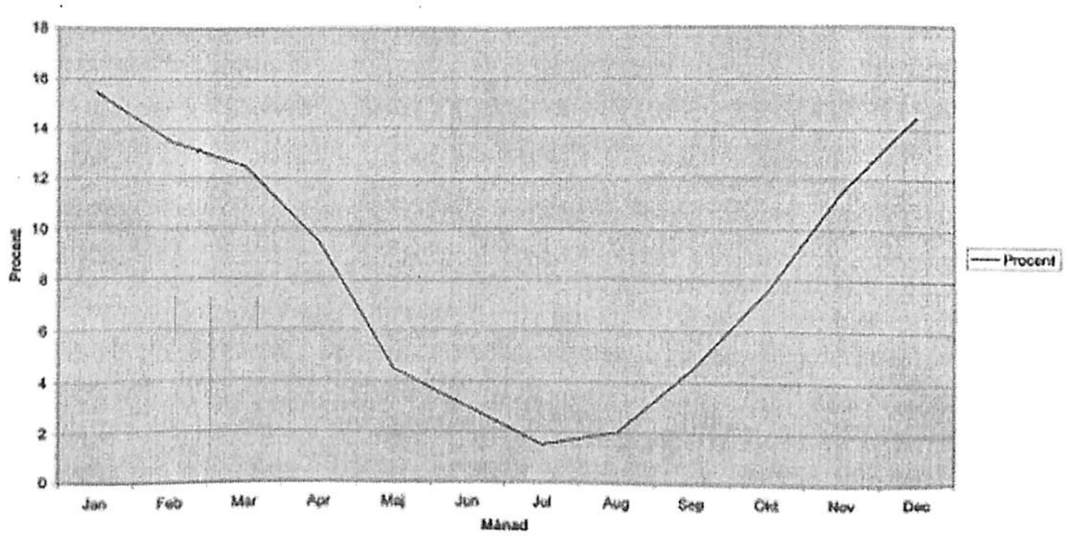


Figure 4.3: Monthly sales are distributed over one year in percent.

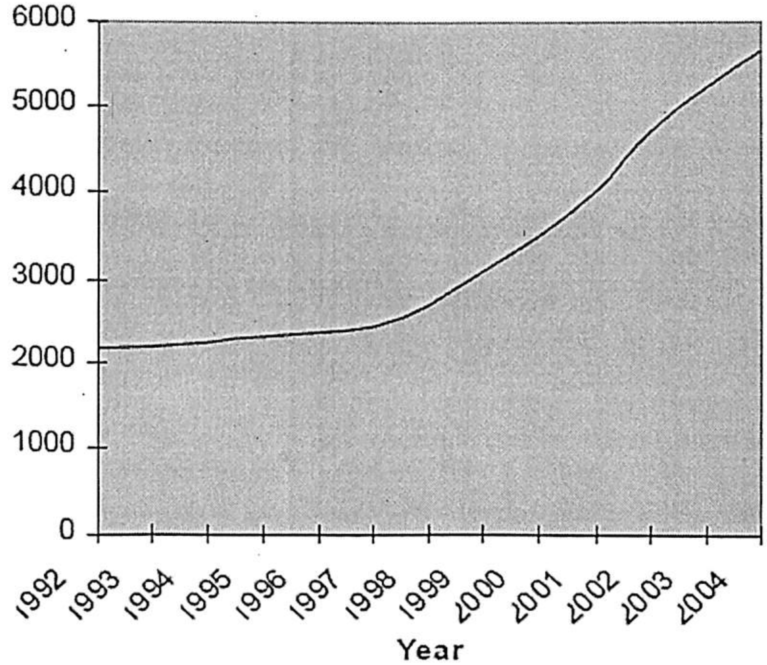


Figure 4-4: Graph presenting how the subscriber is growing every year.

The company uses historical data and weather reports when making their forecasting. Although having personal that have worked there for a long time and have great experience in this area will make it easer to do the forecasting. The company is looking at the historical data and getting prognoses from Swedish meteorological and hydrological institute (SMHI) to forecast the future demand. SMHI is making it easier to plan and decide for weather activities. The figures that are presented under demand management all have part in the forecasting of the future demand. The figure with energy supplying at s plant (Figure 4-2), one can see how the company is growing by that they is using more bio fuel. Figure of the sales in percentage (Figure4-3) makes it easier to forecast the future demand because the figure does not change drastically. One can see that under the winter months the sales is very high because it's cold and when the summer comes the production is dropped because of the warm weather. The graph of the subscribers that grows every year (Figure 4-4) combine with the map of the growth of the district heating net (Figure 45) gives an idea how the subscribers will grow and that is a big help when the time for forecasting the demand is in.

4.3 Logistics systems

NPCL does not have any critical margins because if the company went out of stock would the whole city not get any heat. When there is time for budget proposition, the company looks if the stock of oil is enough for the planned activity. If the stock is not enough then they have to order oil and the ordering of oil is a long procedure because the time of delivery is very long for the thick oil. For the thin oil that is used in the help steam boiler the ingestion is going on continuous. The chip is ordered on Thursdays and the first arrival will come on Sundays. That is the chip that is used for the coming week. So in one week the ordered chip should be heated up.

In the company the most important combustion material is chip. Forestry chips come from the final logging and thinning of an area of forest, with the treetops and branches collected into large piles which are covered in order to dry out.

It takes about two to three hours for the chip to be fired up from that they put it on the conveyor belt until it is in the boiler and out on the district heat net. The time that the district heat water takes for it to reach the customers it is depending on different things for example on the season (if it is high load (winter) it gives high flow and short delivery time), what the temperature is that day or how far the customer have to s plant. It can range between parts of an hour to almost a whole day.

4.4 Procurement

NPCL use 68 supplier when it comes to chip deliveries, and the most important selection criteria they use are the cheapest suppliers gets the delivery. NPCL use this criterion mainly because the difference in chip only depends on the moisture content, which NPCL have an independent controller to check every delivery that arrives to the company. NPCL has some quality requirements, but according to Ankit, buyer at procurement department, no one has failed the requirements in 20 years. Suppliers get paid according to the energy level of the chip. Therefore they have to use the system with order once a week, as we all know it is even difficult to foresee the weather so it always have to be a smaller safety stock.

When it comes to oil suppliers it is more economic to buy bigger amount so NPCL united with Sydkraft to get a lower price.

To secure the delivery to NPCL they use suppliers from in east to west they also have a system where the spread the contract period for all the suppliers so the don't need to negotiate with all the suppliers at the same time. With this system the always have contracted suppliers that are committed to deliver chips. The contract time is usual between 13 years and they use retailer price index when contract is written.

4.5 Inventory Management

According to Ankit NPCL doesn't have total control over its inventory. He explained that he has to leave his office once and a while to have visual overlooks on the inventory to see if the numbers in the computer are in line with reality.

Trucks are coming in to the power plant every day. All loads are weighted and moisture content samples are taken from each truck as well. So far NPCL has full control over its inventory. The problem is when the biomass fuel is shipped into the ovens. It's hard if not impossible to know exactly how much fuel that is used. The problem occurs when the bio fuel is stored at NPCL. Normally is the moisture content between 30-55%. The moisture in the fuel can vary a little during storage depending what the weather it is. If it is sunny the moisture content will shrink and if rainy weather it will increase. Even if it is small variances each day it can have big effect in longer terms. Hence a regular visual inspection is necessary.

In production different biofuels are used: bark, chip, shavings, and peat. NPCL also have capacity to use oil as a fuel, due to high cost and environmental issues the usage of oil is less than 5% of the company's annual energy production. Oil is used more or less as a safety fuel in wintertime in case of the biofuel can't generate enough of energy. Mainly is chip used, but to maintain high efficiency in the power plant the biofuels has to be blended some. Peat is considered as a biofuel, but it is more correct to consider peat somewhere in between biofuel and oil. Therefore is NPCL trying to reduce the use of this kind of fuel. It is not without difficulty since peat has a higher energy value compared to the other biofuels.

At present, almost all types of fuels are necessary. Oil expensive and bad for the environment, but on the other hand it has a high energy value and is easy to store. Therefore is oil good as safety fuel. The other products are biofuels and they are cheap to buy, but only using one type of biofuel would decrease the efficiency on the power plant. Hence a combination is necessary. Chip is the main product of these biofuels since it has a high energy value compared to its price. It is clearly that chip is the most important product for NPCL.

Item	Percentage of annual sales	Customer service	Classification Category
Chips	68%	97.7%	A
Shavings	13%	97.7%	A
Bark	8%	97.7%	B
Peat	6%	94.7%	B
Oil	5%	99.9%	C

Table 5-1 ABC analysis for inventory of raw materials

NPCL is a typical order to stock company and the variation is clearly seasonal. The seasonal variation is strong over the year, but relatively low compared to same period from previous years. The production has increased a little bit the last years, due to expansion of distribution to customers. This variance is easy to predict. Since NPCL produce heat and electricity to its customers, the company carefully overlooking the weather castings. Unexpected temperature change has normally little effect on the production. The ordered weathercast reaches about one week. Using the information from the weathercasts are the orders processed. Hence can the demand be determined as seasonal, due to high changes in production throughout the year.

It is impossible to determine exactly how long the biofuel are kept in inventory, since some is used directly and some biofuel stays in the bottom of the pile for a unknown time. Ankit explains that the biofuel is stored by average for one week. It takes approximate three days (also an average) for the suppliers to deliver their biofuel. The lead time during distribution to customer can be neglected since it is so short compared to the other lead times. The total lead time from giving the call to the suppliers until the customer gets heat and electricity in their home is then about 10 days. Hence can the total lead time be determined as certain. That something unexpected can happen which of course always be kept in mind.

The goal of NPCL is to have less than one hour of interruption per year. That means a very high service level (99,99%), but it is necessary since the customer demand a very high service level and no interruptions.

4.6 Distribution

NPCL distribute electricity and district heating, the electricity is distributed on global electricity network were the subsidiary company Greater Noida Energy takes over and the district heating is distributed in the local municipal heating network. The municipal heating network is extended almost all over Greater Noida, and where their network isn't extended they shall extend it in a short future so that all citizens can be offered district heating. NPCL also use an accumulator to store the district heating close to the central heater. This is necessary to make the production of district heating more even. They are not using a warehouse because it is too much heat used in the morning, when people wake up, and in the evening when people comes home from work. When it comes to transportation strategy NPCL have build the network to optimize maintenance and distribution.

District heating pipelines normally is dug down in the ground next to the streets. In some cases pipes are placed in to a tunnel under ground. To operate the flow of district heating they use pumps that normal is in the production plant. In the public heating network where there is more than one production plant, as well as in big network with big difference in level, also use pump station out in the network.

To build a public heating network so that it can manage the demand on reliability of service and long life. Dependent on the dimension on the pipelines and local conditions can the cost varies from 2000-12000 Rs/meter. The branch works a great deal with quality assuring the network to get as long life cycle as possible. A well built public heating network can have a life cycle up to 100 years.

Greater Noida city where built before the district heating technology was invented. Therefore they have to adapt to city structure when they build the local public heating network.

5. Analysis

5.1 Classifying inventory

Multiple product lines and inventory control require companies to focus upon more important inventory items and to utilize more sophisticated and effective approaches to inventory management. Inventory classification is usually a first step toward efficient inventory management.

Figure 5-1 demonstrates ABC analysis as it applies to inventory management. The diagram indicates that only 20 percent of the items in the product line account for 80 percent of total sales. The items that make up this 20 percent are referred to as A items, due to the significant portion of sales for which they are responsible. The items in the B category account for approximately 50 percent of the items in the product line, yet make up only an additional 15 percent of total sales. Finally, the C items are represented by the remaining 30 percent of the items, which account only for approximately 5 percent of sales.

In many ABC analyses, a common mistake is to think of the B and C items as being far less important than the A items, and subsequently to focus most or all of management's attention on the A items. For example, decision might be made to assure very high in stock levels for the A items and little or no availability for the B and C items.

There are a number of additional reasons not to overlook the importance of the B and C items. Sometimes, the use of B and C items may be complementary to the use of A items, meaning that the availability of B and C items may be necessary for the sale of A items.

Performing a Pareto analysis on these products is somewhat hard since almost all types of fuels are necessary. Oil expensive and bad for the environment, but on the other hand it has a high energy value and is easy to store. Therefore is oil good as safety fuel. The other products are bio fuels and they are cheap to buy, but only using one type of bio fuel would decrease the efficiency on the power plant. Hence a combination is necessary. Chip is the main product of these bio fuels since it has a high energy value compared to its price. It is clearly that chip is the most important product for NPCL.

We notice that only item of oil achieve the level of firm's goal about customer service. That's why the company is inclined to combine the items when delivery them to the manufacturing plant. According to the survey of Biomass Energy Centre at Greater Noida University, they can easily increase the percentage of customer service by combining the materials. Thus, it is crucial to optimize the percentage of the inventory.

5.2 Identify cost factors

Just as mentioned in the Chapter 3, inventory cost can be divided into carrying cost and order cost. In order to give a holistic view of the factors and elements of carry in cost, a Cause Effect diagram is used as following:

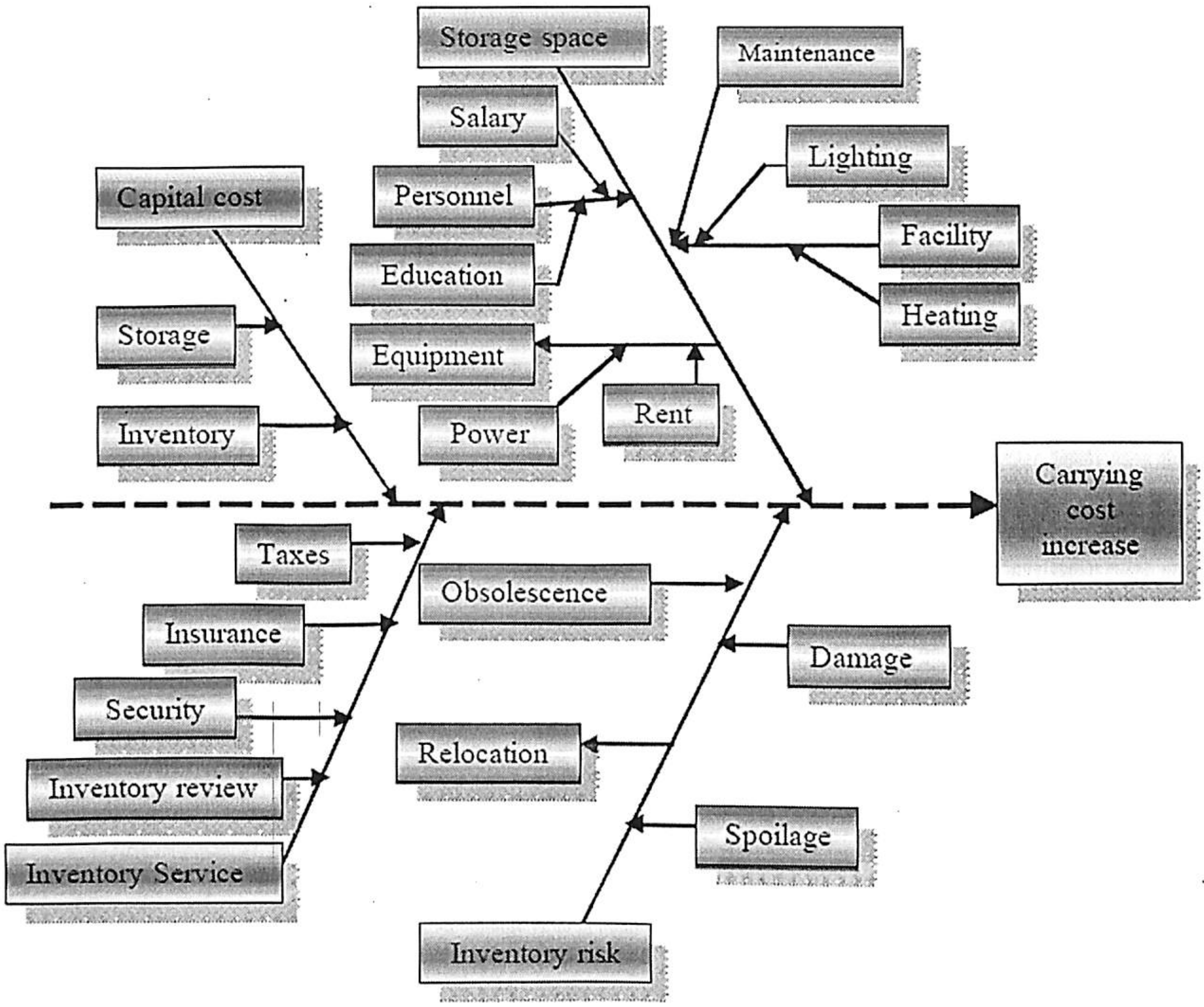


Figure 5-1: Cause Effect diagram of carrying cost factor

5.3 Assess cost components

For the identified cost elements, the next step involved calculation and assessment of each item.

5.3.1 Ordering cost factor:

Transportation cost: Obviously, this factor refers to costs for external transportation from supplier to NPCL's plant. As we known, main raw materials the company used is chips. The firm has no special large truck for transport this kind of material. It is therefore that all transportation for raw material is included in the raw material price. No deliver terms are stated in the purchasing order. Thus, there is no cost for transportation to consider.

Procurement: As mentioned in theory part, production should be ensured with continuous material supply. The company uses 6-8 suppliers when it comes to chip deliveries; hence, the supplier resources never short. They sign contract with supplier for a period of 1-3 years.

The personnel at NPCL spend 3 hours each week on this aspect, and each hour costs approximately RS 200. Production is performed 50 weeks yearly. This gives a total procurement cost of RS 30,000 (= 200*50*3)

Material handing: It takes approximately 20 minutes to move 3 trucks of raw material from the loading dock to the storage space. Each hour cost Rs 200. And we can conclude the material handing cost is Rs 83,333.

Payment: The personnel at NPCL devote about 2 hours each week for raw material payment, and each hour costs approximately Rs 200. Production is running 50 weeks yearly as well. This gives a total payment cost of Rs 20,000. (= 2*200*50)

Total ordering: hence, we can easily come to the total ordering cost, namely Rs 133,333. The company order times are 617. Consequently, each ordering costs Rs 216.

5.3.2 Carrying cost factor:

Capital cost: the company had a mean inventory value of Rs 8,000,000 in raw material, 100,000 RS tied up in storage stands and 160,000 RS tied up in warehouse truck. The raw material is charged for 70% of the use of storage stands and warehouse trucks. This means a total capital cost of 8,182,000 RS. (=100,000*70% + 160,000*70% + 8,000,000)

Storage space cost: The cost of salary for the storage personnel is totally 1,800,000 RS, of which 40% is charged the raw material storage. Personnel costs for facility maintenance, inventory review, and internal transportation are though already considered. Thus, storage space cost is 720,000 RS.

Inventory service cost: As shown in Figure 5-2, there are four elements in inventory Service. Regarding the tax factor, some governments tax inventory. But in India this is not the case. Thus, no taxes for keeping inventory are considered. The insurance for raw material in store is in this case negligible. NPCL does not have an extra insurance for their raw material, and other parts of the insurance are much more significant.

As to the element of security, NPCL pays a yearly fee of 25,000 RS, and the raw material storage corresponds to 40% of the facility space. Hence, the security cost is 10,000 RS (25,000*40%). This is not the best way to estimate rather it is necessary to take the protected value into consideration.

Inventory review is performed both weekly (48 weeks) and monthly (12 months). The monthly review requires 5 hours to a cost of 300 RS each hour. The weekly review takes about half an hour, to a cost of 200 RS per hour. The cost for inventory review is thus 22,800 RS (5*300*12 + 0.5*200*48). The total cost of inventory service is 27,800 RS.

Inventory risk cost: This factor contains four elements. First, there is no obsolescence concept for the NPCL since the materials they used are chips or oil. It is of no necessary to consider about this part.

5.4 Application of EOQ

To be able to make the calculations the following figures were obtained from the case company:

Ordering cost	216 RS
Annual demand	1750 tons
Total inventory	20,000,000 RS
Inventory value	21,000 RS

To find the inventory carrying cost the relevant figures where gathered from NPCL:

Reason	
Mean inventory value	8,000,000 RS
Handling equipment	160,000 RS
Personnel stores	100,000 RS
Storage space	720,000 RS
Inventory service	27,800 RS
Total	9,007,800 RS

This gives the following values:
A = ordering cost (RS per order) = 216 RS
D = annual demand = 1750 tons
C = annual inventory carrying cost = 9,007,800/20,000,000 = 0.45 = 45%
V = average value of one unit of inventory = 21,000 RS

When put in the formula the result is as following:
EOQ ≈ 9 Units per order
Calculations for ROL
The formula used:
X = D*L

$$\sigma^2 = L(\sigma_D)^2 + D^2(\sigma_{LT})^2$$

Where
X = mean (average) demand during lead time
σ = standard deviation of demand during lead time
L = mean (average) of lead time length
σ LT = standard deviation of lead time length
D = mean (average) daily demand
σ D = standard deviation of daily demand
The necessary figures were obtained from the company:

Average demand/day	4 tons
Demand variation	24tons
Average supplier leadtime	2 days

Lead time variation	13 days
Safety stock	10 tons

This gives the following values:
$X = D*L = 4*2 = 8$ tons
$\sigma \approx 5$

The reorder point for the 3 σ (99.87%) service level was 23 tons. (8 + 3*5)

If we compared the reorder point with safety stock, it is easily to come to the conclusion that there is something wrong with safety stock. In other word, they must be using other materials to replenish. Otherwise they can't achieve the customer service level.

5.5 Suggestion

This phase deals with finding and evaluating three suggestions for the inventory management of the company. According to the identification of the different alternatives by using MCDM (Multiple Criteria Decision Making) method, how to optimize the inventory will become gradually clear.

5.5.1 Alternative 1

The first suggestion advocated by the author here is to reduce the ordering times meanwhile to increase the quantities. At present, ordering times are 617. We can reduce this figure to 309. This method gives suppliers more space to schedule their transportation and optimize their transportation cost. Then the company may discuss with the suppliers to negotiate the price of raw materials. If the suppliers give the company a 1% discount, the company will save 200,000 RS. This is typical win win model.

Obviously, under this circumstance inventory review time will be reduced. Inventory review is performed both weekly (48 weeks) and monthly (12 months). The monthly review requirements can be reduced from 5 to 2.5 hours to a cost of 300 RS each hour. The weekly review takes from about half an hour to 15 minutes, to a cost of 200 RS per hour. The cost of saving for inventory review is thus 11,400 RS.

The personnel at NPCL spend 15 hours each week on procurement aspect, this figure can be eliminated to 7.5 hours, and each hour costs approximately 200 RS. Production is performed 50 weeks yearly. This gives a total procurement saving cost of 75,000 RS (= 200*50*7)

If the company adopts this blue print, they can save 286,400 RS. (200,000+11,400+75,000) It seems to be good by using this alternative, but apparently stockout problem is coming. The following alternative can settle it.

5.5.2 Alternative 2

As we know, tons of each time ordering is 2.8. (Annual demand/ordering times) In this alternative the figure changes to 5. The average annual demand is 1750 tons divided by 5, ordering times comes to 350. Subsequently, the cost factor will be identified.

Same principle , the company can benefit 245,485 RS (286,400*300/350) from discount, inventory review and labor cost because of the reduction of ordering times. The company accordingly can hold more inventories during two reorder points. As to customer service level, it is thereby an advantage at least.

Hence, total cost can be reduced by this method. (The broken line is the original cost.) The optimized cost factors graph show as following:

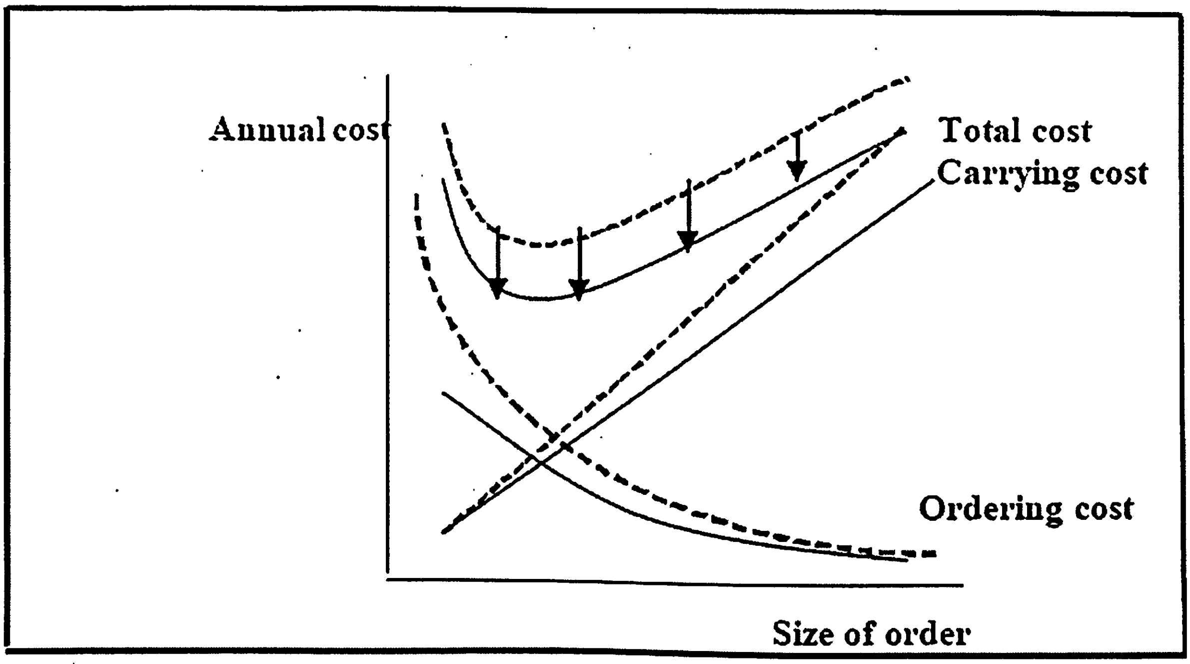


Figure 5-2 Total Cost Optimization

5.6 Discuss the effect of inventory on supply chain

Quite a few factors in the supply chain, namely procurement, transportation, warehousing and storage and customer service level will be identified under the circumstance of inventory optimization.

5.6.1 Procurement

By optimizing inventory management, the following advantages of procurement will achieve:

- Increase customer satisfaction
- Reduce stock out
- Scheduling production more efficiently
- Managing shipping better
- Improving pricing and promotion management
- Making more informed pricing decisions

NPCL does not have any critical margins because if the company went out of stock would the whole city not get any heat. Thus, increasing customer level is the essential item to the company. Decreasing the ordering times and enhancing the quantities of each time will dramatically reduce stock out. And it also can make scheduling production more efficiently and accurately. Meanwhile, the company helps the suppliers decrease the transportation cost. This will give the company more bargain space.

5.6.2 Transportation

By shipping in carloads or truckload quantities rather than less than car loads or less than truck load quantities, a company may experience lower per unit transportation rates. As long as the transportation cost savings exceed any expenses associated with warehousing the additional volumes of product, it will be advantageous to ship in the larger quantities. Also, shipments in large volumes may experience better service, such as faster transit times and more reliable and consistent service. It is of a main element as to the company. These results will help to reduce other costs such as in transit inventory carrying cost and potential costs of lost sales due to product unavailability at point of sale or use.

5.6.3 Warehousing and storage

If the company uses the method of reducing the ordering times, it will affect the warehousing and storage somewhat. But the trend of the number of customers increases obviously. Customer service polices, such as a 24 hour delivery standard, may require a number of field warehouses in order to minimize total costs while achieving the standard. By keeping some excess inventory in field warehouse locations, companies can respond quickly to meet unexpected demand. In addition, excess inventory allows manufacturers to fill customer orders when shipments to restock the field warehouses arrive late.

5.6.4 Customer service

By eliminating the ordering times meanwhile increasing the holding of inventory, the company can easily satisfy customers' service.

Service levels (%)	Average cycle Stock	Safety stock (units)	Total average Inventory (units)
68.26	4	5	9
84.13	4	7	11
95.44	4	10	14
99.73	4	12	16
99.87	4	15	19

Table 5-2: Average inventory levels given different service levels

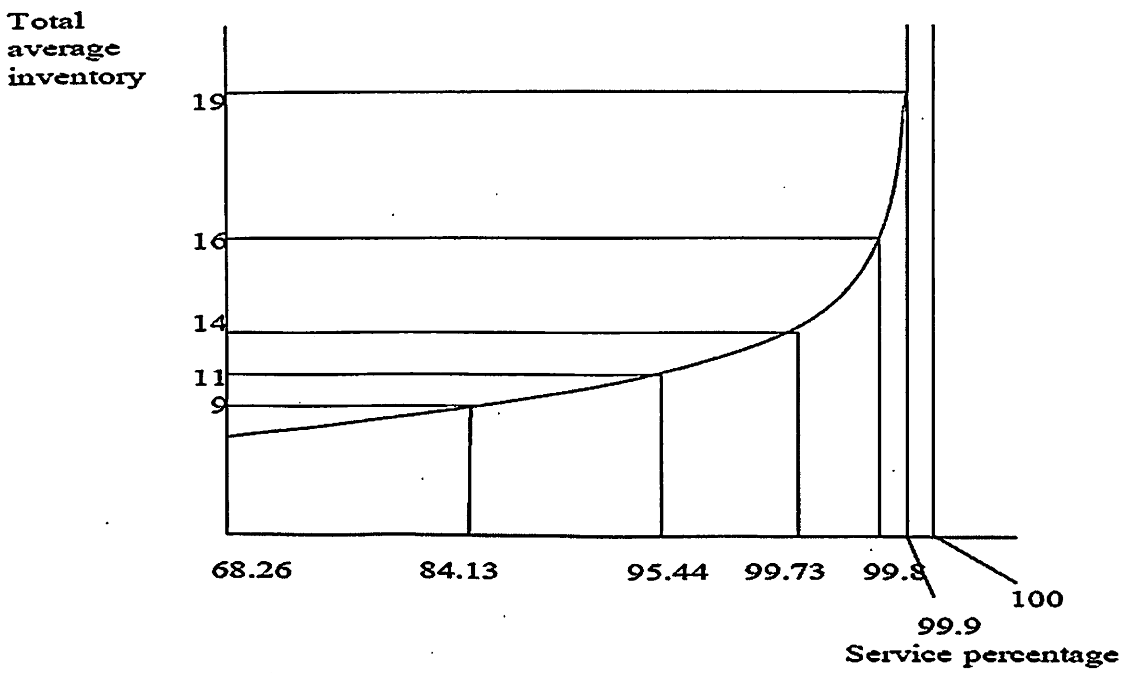


Figure 5-3: Relationship between total average inventory and customer service levels

6. Results

According to the analysis of 2 alternatives, the company can get a more holistic view of inventory control.

Alternative 1 can save 286,400 RS because of ordering times' reduction. As to company, it is perfect. However, the ratio of stock out accordingly rise meanwhile customer service level will be decreased. This is lack of tolerance from perspective of the whole company's running.

By using the alternative 2, it is obvious that the optimization of inventory control drives the supply chain cost effectively. According to raising the quantities of each ordering time, the company can hold more inventories during a period of two reorder points. Now maybe someone is doubtful of the problem of storage space. But the variability figure of inventory after optimization just swing at a low level. The company is easily going to deal with it. Meanwhile, more important a somewhat increasing of customer service level can be achieved.

Synchronously, the company helps the suppliers decrease the transportation cost. This will give the company more bargaining space. Excellent collaboration can achieve win win efficiently. That is why a large number of companies engage in build good relationship with their supplier and vendor.

Due to a purchase- to-order style of the case company, it is suitable to perform an EOQ model analysis. The calculation result shows that the company cannot achieve their customer service goal by the present safety stock level. During rushing hour the chips may run out if customer needs rise sharply. The company has to use other materials to replace chips. This will increase the cost unconsciously. Quite a few factors cannot be seen directly. It is also difficult to identify these cost factors because referring too much element. Sometimes, it is better to easy things.

By using the method of decreasing ordering times and rising quantities, the company may optimize their whole supply chain. Firstly, cost of procurement and inventory review go down. The situations of using safety stock correspondingly eliminate. Then the production line can run smoothly. Also, by keeping some excess inventory in field warehouse locations, companies can respond quickly to meet unexpected demand.

7. Conclusions

7.1 Answering the problem formulation

Due to the effective inventory management, procurement goal can be achieve quickly. As we know, inventory is the joint of the whole supply chain. When optimize the inventory management, upstream activities will run effectively meanwhile downstream activities will go ahead without any stoppage.

In this case study, the company will save RS 200,000 from procurement. More important is the relationships are consolidated through this win win style.

By the holding of safety stock, customer service level will rise a little. As we know, when the level reach a certain point, it is not easy to improve furthermore.

7.2 Shortage of this thesis

Apparently, there is no perfect work. Therefore, a discussion of some aspects that could have been done better in this research is necessary:

- During the interview the author just visits 3 departments of the case company. If it is possible, more departments, more better. The author comes to this conclusion when the project needs more information.
- Within a case study however, this is often a utopia. The author has both a pre understanding and to some extent preconceived ideas, and therefore the backgrounds most likely have affected this research. But this will give a different perspective for further study.

8. Recommendation

By and large, the company has a good leader of the inventory control. But it is better to help other assistant involving this activity. Following tips may give inspiration to the case company:

Inventory control: the company can adjust the inventory level properly. When calculating the cost, it is better to use unification units. For example, units of material handling and payment cost calculation are trucks. And the unit of material demand is tons. Sometimes it will cause inaccurate of the cost calculation.

Attitude: Maintaining inventory accuracy must be an integral part of the attitude of the organization. Like quality, customer service, and plant safety, accuracy must be promoted throughout the organization as everyone's responsibility. This attitude must start at the top levels.

Dedicate positions for managing inventory: Make sure you have control of which employees are affecting your inventory. This is especially true in manufacturing operations where the priorities of machine operators and production supervisors are meeting the production schedule, keeping the machines running, and ensuring the quality of the product being produced. Inventory accuracy will never be a primary responsibility of these types of positions. Once you come to this realization it is easy to see the benefits of putting your inventory and material handling responsibilities in the hands of people whose primary responsibility is inventory.

Storage Areas: How you store your product will also affect accuracy. Crowded unorganized areas become "black holes" for missing product. Crowded areas also cause increase damage to product that is often disposed of without inventory corrections being made. High density storage makes it very difficult to accurately count the product. Tidying up locations of materials are necessary.

Know your inventory system. The more you know about how your specific inventory system works, the more successful you'll be in optimizing its features. Computer systems are regularly blamed for things that are usually turn out to be human error, however, occasionally your computer system can be the source of the problem. Bugs, glitches, hiccups or whatever you want to call them do occur and changes to system parameters to optimize functionality in one area can create havoc in a seemingly unrelated area. The only way to determine the source and correct these problems is to have a thorough understanding of how your system is set up and how the specific programs process the information. The bigger advantage to acquiring a high level of system knowledge lies in the amount of information you'll be able to extract from your system.

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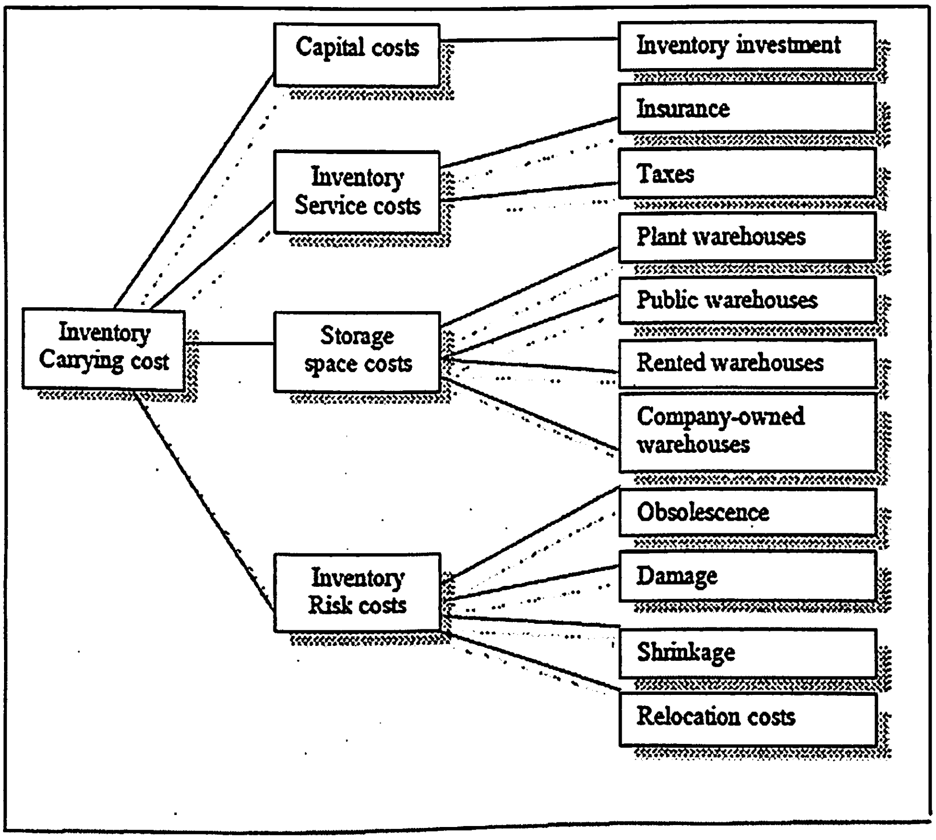
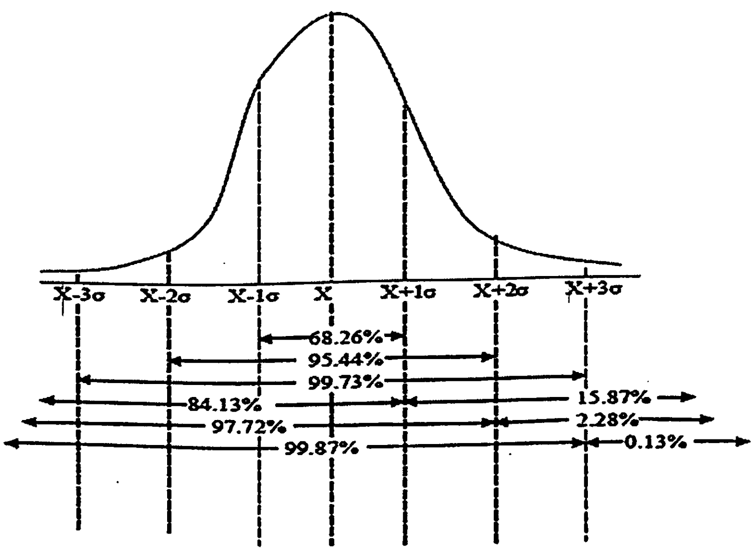
Appendix

Appendix (1)



Normative Model of Inventory Carrying Cost methodology

Appendix (2)



Properties of a normal distribution

Appendix 3

A great deal has to happen for us to be able to supply district heating and electricity ot our customers – a complicated system that can be summarized as follows:

1 **Boiler (2)** fired almost exclusively using bio fuel, but can also be fired using oil. The boiler is a Circulating Fluidized Bed (CFB) boiler, which means that the combustion takes place in a sand bed at a temperature of around 800-900 C. As the sand bed becomes permeated with the combustion gases, it starts behaving like a boiling liquid. Some of the sand is swept up in the flue gases and is separated in the following cyclone and recycled to the combustion chamber. This is the process that gives the boiler its name.

2 **Steam turbine** converts the energy of the steam into mechanical work. The turbine comprises two modules which together drive a single generator via their own axle. The steam initially has a pressure of 140 bar (a) and a temperature of 540 C.

3 **Generator** converts the turbine's mechanical energy into electricity. It rotates at 1500 revolutions a minute. Electricity approx 38 MW .

4 **Turbine condense** cools the steam into water. Provides 66 MW district heating.

5 **Flue gas condenser** cools the flue gases from the boiler (1). The steam in the flue gases is condensed to water, producing 1020 MW district heating.

6 **Boiler (1)** fired by biofuel and oil.

7 **Steam turbine** converts the energy of the steam into mechanical work.

8 **Generator** produces approximately 20 MW electricity.

9 **Turbine condenser** produces 55 MW heat.

10 **Oil fired hot water boiler** is used for peak demand and as a reserve in the event that something serious should happen to the other boilers. Power 50 MW.

11 **Biofuel fired hot water boiler** with prefurnace . District heating 27 MW.

12 **Glue gas condenser** cools the flue gases from the hot water boiler (11). The steam in the flue gases is condensed to water, producing 4-7 MW heat. Flue gases are purified at the same time.

13 **Electric boiler** produces 25 MW district heating.

14 **District heating accumulator** stores the hot water for peak demand.

15 **Expansion tank** keeps the district heating network pressurized. It also evens out al the volume changes in the network.

16 District heating pumps keep the district heating water constantly circulating between the plant and the customers.

17 District heating pipelines transfer the hot water to the district heating customers and the cooled water to the combined heat and power plant.