INVENTORY ANALYSIS FOR STATIONERIES

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Abstract: - This research paper aims in providing optimum stock levels for a businessman which plays a pivotal role in business survival and existing expansion. The paper aims at providing optimum solutions to local retailers to help them minimize their costs and maximize their profits with the help of inventory management using LPP. We have used three methods of LPP for solving this problem of inventory management in the paper. This paper also guides a businessman in solving various inventory problems using LPP. This Research paper takes a case of a local retailer who had to maintain a minimum stock level in order to avoid customer turnover. However he was unable to have an optimum mix of products. We have provided an optimum mix of different stationery products for maintaining optimum profit for the retailer. In our analysis we found out that the inventory levels which were maintained by shopkeeper were erratic. We helped him in reaching an optimum level where there were changes made in the inventory.

INVENTORY ANALYSIS FOR STATIONERIES

Earlier, before the industrial revolution, merchants had to write down the purchases and keep an eye of how many goods were sold during the day and how many were left. Inability to forecast sales, would leave them to slow down business and hence cause problems.

Post industrial revolution in the early 1930s, the first modern checkout system was introduced. This system used punch cards which were inserted into a computer. However, this system was too expensive. As there are advances in technology and we moved towards modernization, in the last 1940s and early 1950s, ultraviolet light sensitive ink and reader formed a part of the modern barcoding system. This invention was leveraged by later inventors to develop the very first ordering system where the system would then read the punch card, process the information in the store room, and then bring the product to then customer.

Later inspired by UV sensitive markings, a new way of managing inventory was developed, The Barcode. There were many barcode technologies used at that time. However, they were inaccurate. To overcome this, the industry adopted Universal Product Code (UPC) in the mid 1970s. with the implementation of inventory tracking software, paper and clipboard systems were abolished.

In today's world, many businessmen are unaware and fail to maintain optimum inventory levels. This research paper aims at providing solutions to local retailers to minimize inventory costs leading to profit maximization.

Linear Programming is a technique used to determine how limited resources in a business can be used to achieve a specified objective. Linear programming, hence, is an optimisation technique.

It consists of as linear function to be maximized or minimized subject to certain constraints in the form of linear equations or inequalities.

Maintaining and keeping track of optimum inventory has been a perennial concern for businesses.

Inventory management primarily refers to allocating the right number of goods at the right place in any supply chain. It refers to how effectively one can manage the right amount of stock anytime in a given supply scenario.

Main objectives of inventory management are:

- Avoiding lost sales
  The last thing a businessman wants is to lose a customer. So, having goods at the right time will lead to smooth business dealings.
- Discount benefits
  Buying stock in bulk is beneficial for a business as suppliers are generous in giving discounts.
- Minimizing ordering costs
  Ordering small quantities multiple times will increase the ordering cost per order of the business.

LITERATURE REVIEW

A Research Paper on Linear Programming Problem gives views on the various characteristic, uses, advantages and disadvantages of Linear Programming. It also gives detailed explanation of the methodology of a linear programming problem. The problem that tis research paper takes on is that a manufacturing firm discontinued the production of a particular product so there is excess production capacity. So, in order to utilize the excess production capacity, they have to figure out which existing product to produce and in what quantity (Vinod).

This research paper (Lawrence D. Burns, 1984) “Distribution Strategies that Minimize Transportation and Inventory Cost “is typically oriented towards how Operation Research techniques can be used to minimize transportation cost and also inventory costs of businesses be it Manufacturer, Supplier or Retailer. In this paper there are two selling strategies which is taken into consideration which are Direct Shipping and Peddling. The main objective of this paper is to find the trade-off between the cost of the above-mentioned distribution strategies. Easily measurable parameters are used to find out explicit formulas and these formulas require spatial density instead of actual location of the customer. This simplifies distribution and also provides accuracy on the practical implications of the same. This paper also facilitated sensitivity analysis to show how sensitive costs and operating strategies are to change in parameter values.

Here in this paper (Abara, 1989) “Applying Integer Linear Programming to the Fleet assignment Problem “Integer Linear Programming method which is one of the Operation Research tools is used to find optimal or near optimal assignments for fleets in Airline industry. The objective of fleet assignment is to assign maximum amount of flight segments as possible to the ten fleets of the American Airline. Objective function being saving on operating costs while maximizing profits. The integer program formulation solves the fleet assignment problem by assigning the flights to a particular aircraft type provided the schedule and the time of arrival and departure is given. The formulation for the said assignment is simple and the paper also provides theoretical explanation for the constraints which have been taken up in the paper. IBM 3081Machine is used to find the optimal or near optimal assignment for the following problem. This paper helps in analyzing the different probabilities in the assignment of the airline fleet without one’s prior knowledge in airline industry. This paper has also taken into consideration real time constraints which also help in reliability of the assignment.

This paper (Christian H. Timpe, 2000)” Optimal Planning in large Multi-site production network” looks forward to how Operation Research tools can be used to solve supply chain and manufacturing process problems in real time. Here the Integer Program technique is used to solve production-planning problems where demand and other commercial considerations are accounted. The main ideology of this paper is to prepare a production plan for multi-purpose for machines which can be operated at different modes and also producing different products. This model takes into consideration scattered network of multi-purpose plants which are located in different countries. This model helps in facilitating the acceptation or rejection of short-term delivery demands and also helps in maintaining storage tank levels which is present at the production sites. It also shows how these levels may benefit the production houses. This paper is not considering a single plant but a multi plant network scattered around different locations and this model mostly provides optimal solution but if fails in finding the optimality a safe bandwidth is obtained

The research paper (Woubante, 2017)"The optimization of product mix and Linear programming Applications written by Gera Workie Woubante published in 19th June, 2017 helps us in making efficient use of resources at every stage of supply chain. Linear programming is used for optimization of product mix. This research paper deals with optimization of production input. This research paper concluded that ability to use resource efficiently was one of the major constraints in the industry.

METHODOLOGY

FORMATION OF MATHEMATICAL MODEL OF L.P.P

There are three forms:

- General form of L.P.P
- Canonical form of L.P.P
- Standard form of L.P.P

These are written in 'statement form' or in 'matrix' form as explained in subsequent paragraphs.

General form of L.P.P

a) Statement form: This is given as follows - "Find the values of x_1, x_2... x_n which optimize $z = c_1x_1 + c_2x_2 + \ldots + c_nx_n$ subject to :

$$a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n \le (\text{or} = \text{or} \ge)\ b_1$$
$$a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n \le (\text{or} = \text{or} \ge)\ b_2$$
$$a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n \le (\text{or} = \text{or} \ge)\ b_m$$
$$x_1, x_2, \ldots x_n \ge 0$$

where all the coefficients (c_j, a_{ij}, b_i) are constants and x_j's are variables.
(i = 1,2,... m)
(j = 1,2,... n) "

b) Matrix form of general L.P.P. This is stated as follows - "Find the values of x_1, x_2, ... x_n to maximize: $z = c_1x_1 + c_2x_2 + \ldots + c_nx_n$
Let z be a linear function on a R^n defined by

i. $z = c_1x_1 + c_2x_2 + \ldots c_nx_n$
where c_j are constants. Let a_{ij} be m*n matrix and let { b_1, b_2, ... b_m } be set of constraints such that

ii. $a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n \le (\text{or} = \text{or} \ge)\ b_1$
$a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n \le (\text{or} = \text{or} \ge)\ b_2$
$a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n \le (\text{or} = \text{or} \ge)\ b_m$
And let

iii. $x_j \ge 0$ $j = 1,2,\ldots n$

The problem of determining an n-tuple (x_1, x_2,... x_n) which make z a minimum or a maximum is called 'General linear programming problem'.

Canonical Form of L.P.P

a) Statement form: This form is given as follows:

"Maximize $z = c_1x_1 + c_2x_2 + \ldots\ldots + c_nx_n$
subject to constraints $a_{i1}x_1 + a_{i2}x_2 + \ldots\ldots + a_{in}x_n \leq b_i$; (i= 1,2,....,m)
$x_1x_2\ldots\ldots x_n \geq 0$ "

Characteristics of canonical form

1. Objective function is of the "maximization" type.
   Note: minimization of function f(x) is equivalent to maximization of function {-f(x)}
   $\therefore$ Minimize f(x) = Maximize {-f(x)}
2. All constraints are of the type "less than or equal to" viz "≤" except the non-negative restrictions.
   Note: An inequality of more than (≥) can be replaced by less than (≤) type by multiplying both sides by -1 and vice versa.
   eg: $2x_1 + 3x_2 \geq 100$ can be written as $-2x_1 - 3x_2 \leq -100$
3. All variables are non-negative viz $x_j \geq 0$

b) Canonical form of L.P.P with matrix notations:
" Maximize Z = CX , subject to the constraints $AX \leq b$
$X \geq 0$
Where $X = (x_1, x_2, \ldots\ldots, x_n)$; $C = (c_1, c_2, \ldots\ldots, c_n)$
$b^T = (b_1, b_2, \ldots\ldots, b_m)$; $A = (a_{ij})$ where i= 1, 2,..., m j= 1, 2,...., n "

The Standard Form of L.P.P

a) Statement form
" Maximize $Z = c_1x_1 + c_2x_2 + \ldots + c_nx_n$
Subject to the constraints $a_{i1}x_1 + a_{i2}x_2 + \ldots + a_{in}x_n = b_i$ (i= 1, 2,...., m)
$x_1x_2\ldots x_n \geq 0$ "

Characteristics of Standard form

1. Objective function is of maximization type.
2. All constraints are expressed in the function of equality form except the restrictions.
3. All variables are non- negative.

Note: *constraints given in the form of "less than or equal" (≤) can be converted to the equality form by adding "slack" variables. Similarly, those given in "more than or equal" (≥) form can be converted to the equality form by subtracting "surplus" variables.*

b) Standard form of L.P.P in matrix notations:
" Maximize Z = CX
subject to the constraints
AX =b $b \geq 0$ and $X \geq 0$
where $X = (x_1, x_2, \ldots\ldots x_n)$; $C = (c_1, c_2, \ldots., c_n)$
$b^T = (b_1, b_2, \ldots\ldots, b_m)$; $A = (a_{ij})$
i = 1, 2, ..., m ; j = 1, 2, ..., n "
Note: *coefficients of slack and surplus variables in objective function are always assumed to be zero.*

Sensitivity analysis is the study of how the uncertainty in the output of a mathematical model or system (numerical or otherwise) can be apportioned to different sources of uncertainty in its inputs. A related practice is uncertainty analysis, which has a greater focus on uncertainty quantification and propagation of uncertainty; ideally, uncertainty and sensitivity analysis should be run in tandem.

The technique used to determine how independent variable values will impact a particular dependent variable under a given set of assumptions is defined as **sensitive analysis**. It's usage will depend on one or more input variables within the specific boundaries, such as the effect that changes in interest rates will have on a bond's price.

It is also known as the what – if analysis. Sensitivity analysis can be used for any activity or system. All from planning a family vacation with the variables in mind to the decisions at corporate levels can be done through sensitivity analysis.

ANALYSIS

Today the problem that we are trying to solve is of a retail stationery owner who wants a minimum Inventory of rupees 25000 but does not know the quantity of products to be kept with him. He needs to keep min inventory cost in order to avoid customer turnover.

His inventory involves the following items:

1. Copy paper or printer paper
2. Staplers
3. Notebooks
4. Two types of Files: Soft
5. Hard cover
6. Brown Tape

His inventory constraints involve:

Minimum quantity of Copy Paper, which is ₹250 per unit should have a minimum of 20 and a maximum of 30 units.

Minimum quantity of Staplers, which are ₹48 per unit, should be 25 and maximum should be 30 units.

Minimum quantity of Books which are, on an average, ₹60 per unit, should be 72 and maximum should be 150 units.

Minimum quantity of File1, which is ₹15 per unit, should be 72 and maximum should be 100 units.

Minimum quantity of File2, which is ₹75 per unit, should be 36 and maximum should be 95 units.

Minimum quantity of Brown tape, which is ₹50 per unit, should be 50 and maximum should be 60 units.

Putting it in Equation form:

a= Copy Paper

b= Staplers

c= Books

d= File1

e= File2

f= Brown tape

Max Z = 250a+48b+60c+15d+75e+50f

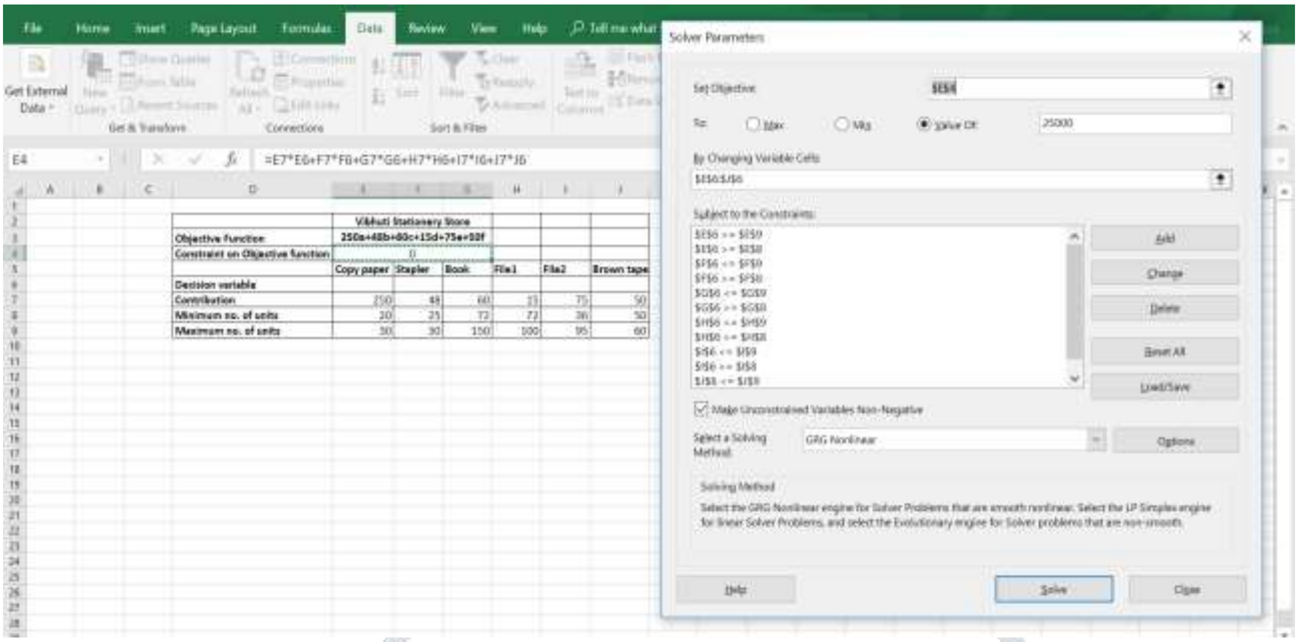
Subject to constraints:

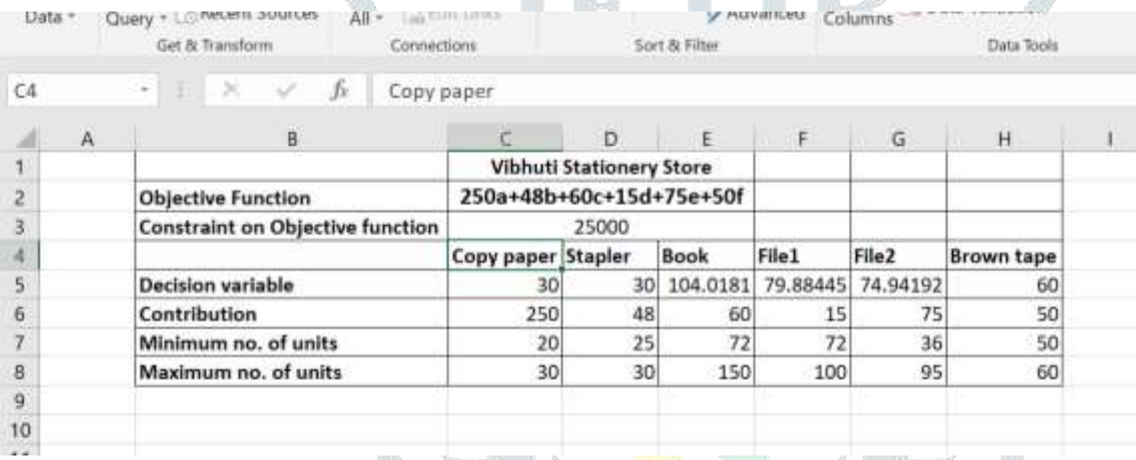
- a<=20
- a>=30
- b<=25
- b>=30
- c<=72
- c>=150
- d<=72
- d>=100
- e<=36
- e>=95
- f<=50
- f>=60

Also, we have the additional condition that there should be a minimum inventory of ₹25000.

E4 =E7*E6+F7*F6+G7*G6+H7*H6+I7*I6+J7*J6

	Vibhuti Stationery Store					
Objective Function	250a+48b+60c+15d+75e+50f					
Constraint on Objective function	0					
	Copy paper	Stapler	Book	File1	File2	Brown tape
Decision variable						
Contribution	250	48	60	15	75	50
Minimum no. of units	20	25	72	72	36	50
Maximum no. of units	30	30	150	100	95	60





	Vibhuti Stationery Store					
Objective Function	250a+48b+60c+15d+75e+50f					
Constraint on Objective function	25000					
	Copy paper	Stapler	Book	File1	File2	Brown tape
Decision variable	30	30	104.0181	79.88445	74.94192	60
Contribution	250	48	60	15	75	50
Minimum no. of units	20	25	72	72	36	50
Maximum no. of units	30	30	150	100	95	60

According to our analysis we have reached the conclusion that the retail owner should keep approximately 30 units of the Copy paper, 30 units of Staplers, 104 units of books, 80 units of File1, 75 units of File2 and 60 units of Brown tape.

If he keeps the units mentioned above, his inventory cost will be close to ₹25000.

His constraint of the inventory cost will thus be met.

Sensitivity Analysis

Microsoft Excel 16.0 Sensitivity Report
Worksheet: [Book1]Sheet1
Report Created: 04-10-2018 14:34:30

Variable Cells

Cell	Name	Final Value	Reduced Gradient
C5	Decision variable Copy paper	30	0
D5	Decision variable Stapler	30	0
E5	Decision variable Book	104.0181474	0
F5	Decision variable File1	79.88445248	0
G5	Decision variable File2	74.94192495	0
H5	Decision variable Brown tape	60	0

Constraints

Cell	Name	Final Value	Lagrange Multiplier
C3	Constraint on Objective function 250a+48b+60c+15d+75e+50f	25000	0

According to the sensitivity report, these constraints seem to be very volatile. It tells us that even a slight change in the quantity of products kept in inventory will change the cost of the inventory kept a lot.

Excel solver helps us to find the optimal inventory cost that the stationery shop should have at times so to avoid customer turnover. Inventory management is very important for retail shops as they encounter customers at daily basis and there is a lot of competition in this market as these shops are usually seen in cluster so if the customer is not met with the demands then he will eventually procure his demands from some other shop. So as to avoid this inventory management helps us to find the minimum inventory to be kept at times to avoid such situations.

The above solutions have helped us to know how much inventory the store must keep with itself so as to meet the demands of the customer. LPP method was used to reach the solution. We were provided with what the actual demand was of the shop as the retailer knew how much quantity of products must be required but sometimes his assumptions may go wrong. So with the help of Excel Solver we have provided the exact amount of quantity which must be adhered to so the demand will be met. In this way he will have the exact quantity and also this will help him to reduce the cost of inventory, as at times he might end up spending more and then the daily demand will be met but he will have a surplus of the goods. LPP helps in minimising the cost by providing the exact quantity of goods and thereby reducing the inventory cost.

We were also provided with a sensitivity report which explains how closely variables are linked with each other. So the sensitivity report explains how the quantity of one variable will have the effect on cost of inventory. This is in way helpful as we can come to know that by reducing or increasing the quantity how we can have different cost of inventory.

The above analysis was done by Excel Solver and the method used was LPP which helped us in having a minimum inventory cost of Rs.25000/-

CONCLUSION

This paper has concluded that Linear programming has a vast scope where many methods, uses, requirements etc are to be seen.
Linear programming is a versatile technique that can be used to represent a number of real-world situations. One of the chief advantages of linear programming is that businesses can use the technique to solve

problems that involve multiple variables and constraints. The use of computers has made this technique easier to apply.
In our given situation, our retailer deals with a lot of constraints for his inventory management.
We have been able to quantify his requirements and reach the optimum level of stock that he should keep for his day to day business purposes.
Linear programming can be used in any sector where an individual wants to minimize costs and maximize their profits.
Inventory analysis has played a key role in this paper to help the retailer maintain an optimum stock levels.
With the help of various methods in LPP we were successful in helping the retailer amend his inventory levels and provide right number of quantities to be maintained for maximizing the profits

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