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Progress in Nonlinear Dynamics and Chaos

Inventory Control Logistics and Technicalities

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Abstract. Inventory can be regarded as a stock of goods. Here, we consider inventory as an idle but usable resource. It includes; labor, raw materials, finished goods and equipment stock is reserved to provide a flow of supply. In addition to design, planning, and inventory control, the applications of queueing theory can also be found in performance evaluation and improvement, logistics and transportation, and other areas of supply chain**.** The scope of logistics has been considerably extended, as it has been recognized as one of the important tools for developing competitiveness. In this work, efforts are being intensified on harmonizing the logistic technicalities with inventory control.

Keywords: Inventory control, logistics, technicalities, Labour, raw materials, finished goods, equipment, variable cost, demand, production, transportation, stock, ordering.

AMS Mathematics Subject Classification (2010): 90B05, 90B06, 90B22, 90B30

1. Introduction

The scope of logistics has been considerably extended, as it has been recognized as one of the important tools for developing competitiveness. (see [2]) Competitive advantage means the company has the ability to differentiate itself, in the customer's eyes, and also is operating at a lower cost and greater profit. Logistics facilitates in getting products and services as and when they are needed and desired to the customer. It also helps in economic transactions, serving as a major enabler of growth of trade and commerce in an economy. With reference to an organization, an organization gets a concrete shape due to its structure. In the earlier times, the suppliers in distribution activities were spread across the entire structure, thus resulting in an overlapping of activities and finally in unaccountable authority and responsibility. In today's process driven organization, where the focus has shifted from functions to process, logistics has become an essential part of the process.

2. Logistics and technicalities

Nowadays corporations look only for sustainable competitive advantage, not only for growth, but also to survive. The target on competition is now being directed from the product to the supply chain. Today, logistics management is based on the system concept and cost approach. Transportation, warehousing, handling of material, inventory management and order processing are the major logistics activities, which impact the customer cost and operation. Integrated logistics helps in taking the cost out of the supply chain and also enhance the customer service level.

Business organizations across the world are struggling for competitiveness, not only for growth but also for survival alone. The factors responsible for this are liberalized economies of the countries across the world. Moreover, the customers have become more demanding and look for value added services from prospective suppliers, as he wants value for the money he is spending. In such a situation, business organizations across the world have started reviewing their business processes and have realized that cost cutting and differentiation in value delivery are solutions to the current problem Outsourcing is the transfer of a function previously per-formed in-house to an outside provider. Outsourced providers are often referred to as con-tractors or “third parties. “When "outsourced" work is contracted out, the outsourcing business or agency still provides over-sight. Once it is decided to outsource, identifying a short list of partners can be a daunting task.

3. Cost consideration

Just like all employees, there is utmost need to pay people who are rendering services to customers in the queue system for the services they render to the customers (see [7]). The following are some areas of interest in this particular aspect. (i) the total cost of such services (ii) ways and means of reducing such costs without lowering the standard of the services and (iii) making profits in the ventures where queuing systems are in practice. All these are very imperative whenever any well-developed queue systems are in practice

Take the following case as an example; Book suppliers draw books from bookstore in a large bookstore. The manager feels worried about the time spent by the cashier in issuing out receipts to the customers and wants to find out if by employing one assistant cashier, his worries could be eliminated. In his investigations, he discovers that; there exists simple queue, each book supplier is being paid \$5 per hr., the cashier receives \$7 per hr., also able to answer 24 customers every hr. and that if an assistant cashier is employed, would earn \$6 per hr. and the no of customers attended to would be increased to 30 pre hr. Also, an average number of 20 customers visit the bookstore per hr. from this phenomenon, we determine whether it’s worthwhile to employ the service of an assistant cashier or not.

First, if we consider the existing system before deciding whether the service of an assistant cashier is needed at all. Here, the average arrival rate is given by:
$\lambda = 20h^{-1}$ and the average service rate is given by: $\mu = 24h^{-1}$.

$\therefore$ The Traffic intensity = $\rho = \lambda/_{\mu} \quad \frac{20}{24} = \frac{5}{6}$.

We have that the number in the system = $\frac{\rho}{1-\rho} = 5$.

$\therefore$ the cost of supplying book per hour = \$5 x 5 = \$25

Note also that for the new system, after the service of an assistant cashier has been employed , we have as follows: Traffic intensity = ρ = 20/30 = 2/3 .

$\therefore$ Number in system = = $\frac{\rho}{1-\rho} = 2$.

We have that (i) Book supplying costs \$5 x 2 = \$10h^{-1}. Assistant cashier’s cost = \$6h^{-1}. Therefore, Total cost = \$(10 + 6) = \$16h^{-1}, and the net savings per hour =

$(25-16) = $9h^{-1}. From this analogy, it's clear that the employment of an assistant cashier would be worthwhile.

4. The multi-channel systems

A queue system in which there are more than one service point is referred to as the multi-channel system. The channels may be in series or parallel or it may be of the mixture of both. ([6])

Definition: Suppose that c is the number of channels. Then, we have as follows:

(a) The Traffic intensity is given by: $\rho = \frac{\lambda}{c\mu}$

(b) Given that n is the number of customers in the system. Then,

pr(n = 0) = $\rho_o = \frac{c!(1-\rho)}{(\rho c)^c + c!(1-\rho)\left(\sum_{n=0}^{c-1}\frac{1}{n!}(\rho c)^n\right)}$

(c) The probability of not queuing on arrival is given by: $\rho_n = \frac{(\rho c)^c}{c!(1-\rho)}\rho_o$

(d) The average number of customers in the system is given by: $\bar{s} = \frac{\rho(\rho c)^c}{c!(1-\rho)^2}\rho_o + \rho c$

(e) The average number of customers in the system is : $\bar{n} = \frac{\rho(\rho c)^c}{c!(1-\rho)^2}\rho_o$

(f) The average time spent in the system is : $\bar{t} = \frac{(\rho c)^c\,\rho_o}{c!(1-\rho)^2\,c\mu} + \frac{1}{\mu}$

(g) Average time spent in the queue is : $\bar{w} = \frac{(\rho c)^c\rho_o}{c!(1-\rho)^2 c\mu}$

Consider fueling station which employs four petrol attendant who on the average each serves five customers an hour. The average number of customers requiring service is fifteen per hour [6].

The following can be determined accordingly using the formulae. (i) The tragic intensity ρ, (ii) The probability that there is no customer in the system (iii) the probability of not requiring queue on arrival(iv) the average no of customer in the system (v) the average no of customer in the queue (vi) the average time spent in system (vii) the average time spent in the queue.

(i) $\rho = \frac{\lambda}{c\mu} = \frac{15}{4x5} = \frac{3}{4} = 0.75$

(ii) $\rho_o = \frac{c!(1-\rho)}{(\rho c)^c + c!(1-\rho)\left(\sum_{n=0}^{c-1}\frac{1}{n!}(\rho c)^n\right)}$

$= \frac{4!\left(\frac{1}{4}\right)}{\left(4X\frac{3}{4}\right)^4 + 24\left(\frac{1}{4}\right)\left(\frac{1}{0!}(3)^0 + \frac{1}{1!}(3)^1 + \frac{1}{2!}(3)^2 + \frac{1}{3!}(3)^3\right)} = \frac{6}{(3)^4 + 6\left(1 + 3 + \frac{9}{2} + \frac{9}{2}\right)}$

$= \frac{6}{81 + 6(13)} = \frac{2}{17 + 26} = \frac{2}{53} \cong 0.04$

(iii) $\rho_n = \frac{(\rho c)^c}{c!(1-\rho)}\rho_o = \frac{(3)^4 X\frac{2}{53}}{24\left(\frac{1}{4}\right)} = \frac{27}{53} \cong 0.51$

(iv) $\bar{s} = \frac{\rho(\rho c)^c}{c!(1-\rho)^2}\rho_o + \rho c = \frac{\frac{3}{4}(3)^4 \cdot \frac{2}{53}}{24\left(\frac{1}{16}\right)^2} + 3 = \frac{81}{53} + 3 = 4.53 \cong 5$

(v) $\bar{n} = \bar{s} - \rho c = 4.53 - 3 = 1.53\ (\cong 2)$

(vi) $\bar{t} = \frac{(\rho c)^c\,\rho_o}{c!(1-\rho)^2\,c\mu} + \frac{1}{\mu} = \frac{(3)^4 \cdot \frac{2}{53}\rho_o}{24\left(\frac{1}{4}\right)^2 4X5} + \frac{1}{5} \cong$ 18.1 min

(vii) $\overline{w} = \frac{(\rho c)^c \rho_o}{c!(1-\rho)^2 c\mu} = \frac{(3)^4 . \frac{2}{53}\rho_o}{24.\frac{1}{16}. 5x4} = \frac{27}{53x5} = 6.11\text{min}$

5. Inventory control

Inventory is a stock of goods. An inventory is an idle but usable resource. It includes; labor, raw materials, finished goods and equipment stock is reserved to provide a flow of supply. In addition to design, planning, and inventory control, the applications of queueing theory can also be found in performance evaluation and improvement, logistics and transportation, and other areas of supply chain [4]. For instance, a newly established business would like to decide on the number of telephone lines it has to install in a cost-effective manner. Identify the elements of the underlying process of the telephone answering system and indicate the specific data that need to be collected to establish the parameters of the system. Also identify the performance measures of interest.

There are three basic types of Inventory: Raw Material, Work in Progress, and Finished Goods (see [2]).

Raw Material

This includes all the purchased parts and direct materials that go into the end product. This type of material has value added to it as it flows together as subassemblies, assemblies and finally into the shippable product.

Work-in-Process

Refers to the inventory waiting in the process for being assembled into final products.

Finished goods

These refer to the inventory, which are ready for delivery to the distribution centers, retailers, and wholesalers or to the customers directly.

The pressures to reduce inventories, and therefore working capital requirements, are increasing even in times of relatively low interest rates. The opportunities to use a finite source of capital, of just more efficiently but in ways that yield high rates of return for employing the essentially idle capital elsewhere in the business. For example, reducing inventories could provide the necessary capital to finance such things as: new product development, expanded marketing and sales, modernization, business process redesign, improved supply chain management, expansion, acquisitions, debt reduction among others.

Need for inventory control: (see [2]).

1. Increase in the size of manufacturing units: With the increase in manufacturing units, there is a necessity to have sufficient inventory control so that increasing inventories do not become non-value added expenditure. Increasing inventory can erode the profits of the company and the possibility of inventory control arises.

2. Wide variety and complexity of the requirements: The requirements of the modern industry have necessitated the need for conscious inventory management.

3. High idle time cost of machine and men: If men and machines are kept idle, it is highly uneconomical for the firm. Inventory levels have to be managed keeping this factor in mind.

4. Liquidity: There is an increased stress on liquidity in today's organizations, where it becomes a necessity to maintain liquidity at the levels of nearly 10-20 per cent of the total capital invested in finished goods.

Inventory Control Problems

The structure of service and service discipline tell us the number of servers, the capacity of the system, that is the maximum number of customers staying in the system including the ones being under service. The service discipline determines the rule according to the next customer is selected. The most commonly used laws are

(i) FIFO - First In First Out:

Who comes earlier leaves earlier. This is very common in most of our service provisions. It occurs in eateries, supermarkets, stationeries and bookshops, restaurants, hotels and motels, banks, fueling stations, bus-parks and in general, places where customers demand several forms of services.

(ii)LIFO/LCFO/FILO - Last Come First Out:

who comes later leaves earlier. This occurs mostly to items demanding services. Examples abound in the following instances (i) individuals' or public garages where many vehicles are parked especially, in a strict strait spaces. Here, last vehicles to enter have to come out first for proper and safe orderliness. (ii) In places where safe keeping is required as necessary such as in provision and material stores and shops. Here, items are packed after the daily sales and (or) services. Each item has to be removed the following day from the store, beginning from the last to the first. (iii) Items such as chairs and tables which are dumped in a space having a single entrance. They have to be removed beginning from the last.

(iii) **RS -** Random Service:

The customer is selected randomly. This kind of services is daily given to many of our items as each service may demand. For example, washing of clothing materials, vehicles, plates, polishing of shoes, transferring of eggs, loaves of bread and other materials from one position to another by hand picking. All these may be done randomly without necessarily following any specific rule, formalities or laws.

(iv) **Priority**.

Here, personalities determine the order in most cases. Imagine a president of a country or governor or a director or CEO of a company who demand money from a given bank or who is in need of the National Identity registration, where majorities are on queue already. Do we expect that such important personalities or **VIP** go queue up like others do? Definitely and without any hesitation, their delegates or themselves as the case may be, have to be given due priority for the so called services due to their positions or offices. As a way of digression one can easily classify the following into any suitable foregoing most commonly used laws : (i) The order in which the consumption of bonus and the original (authentic) credit or data awarded to a customer by the service provider of a given communication service company (ii) The order of the delivery of a highly fertile pig whose matrix contains eight piglets (iii) The order of selection of the paper arranged for a printing machine (iv) The order of selecting pupils for competition in a sport race. (v) The order of picking peanuts for consumption from a flat container. In solving all these simple seemly puzzles, certain factors are definitely to be considered in order to arrive at desired results as required.

The aim of all investigations in queueing theory is to get the main performance measures of the system which are the probabilistic properties (distribution function, density function, mean, variance) of the following random variables: number of customers in the system, number of waiting customers, utilization of the server/s, response time of a customer, waiting time of a customer, idle time of the server, busy time of a server. Of course, the answers heavily depend on the assumptions concerning the distribution of inter-arrival times, service times, number of servers, capacity and service discipline. It is quite rare, except for elementary or Markovian systems, that the distributions can be computed. Inventory ensures constant supply of goods for sale or production of goods, customers are satisfied, operations are not delayed, supply of stock are regular, extra cost such as processing an order and handling of purchases are avoided, substantial savings derivable from large but less frequent production runs are guaranteed. All these are advantages even through, stocks are held at a cost which include insurance and storage cost, stocks are kept at a risk that include deterioration and money invested an inventing cannot generate income.

Definitions [see7]

a) Ordering frequency: This is the rate at which stock is ordered. It could be annually, biannual and monthly.
b) Ordering Quantity(Q): This is the size of stock ordered at a given time.
c) Average Stock: This is equal to a half of the offering quantity. It is denoted by $\left(\frac{Q}{2}\right)$.
d) Ordering Cost This is fixed per order irrespective of size of the order. It is the fixed charge each time a stock is ordered.
e) Stock holding cost: This is the cost of keeping the average stock for a given period. It is expressed as a given percentage of the stock value. Hence, if a stock cost $150 per unit and it cost 15% to hold a stock, then the stock holding cost of a unit of the stock is given by 15% of $150 = $22.50. Therefore, if an average of 1000 stock is held within the period then, the total stock holding cost would be given by 1000 x $22.5 =22,500
f) Economic Order Quantity (EOQ) The *EOQ* is the quantity that sets the holding cost and the ordering cost of stock in equilibrium. Stock may be ordered at varying quantity. The *EOQ* can also be referred to as (*EBQ)* the Economic Batch Quantity. This is when it is manufactured within the system.
g) Total Variable Cost (V) This is equal to the stock holding cost plus the ordering cost. Now, suppose that D is the annual demand for stock, C represents the fixed ordering cost per order, P is the cost per unit stock,

Q is the size of order and r is the stock holding cost in percentage. We have that the Total stock holding cost is given by the product of the cost of holding one stock and the average stock

$= rPx\frac{Q}{2} = rP\frac{Q}{2}$

Ordering cost = the product of the number of orders and ordering cost per order $= \frac{D}{Q}$XC $= \frac{CD}{Q}$

Therefore total variable cost is V= rP$\frac{Q}{2} + \frac{CD}{Q}$ …………(*)

By applying differentiate on (*), wrt Q, we have that $\frac{dV}{DQ} = \frac{rP}{2} - \frac{CD}{Q^2}$

Obtaining the second derivative again, we have $\frac{d^2V}{dQ^2} = \frac{2CD}{Q^3} > 0$

At minimum part of V, we have that $\frac{dV}{dQ} = 0 \Rightarrow \frac{CD}{Q^2} = \frac{rP}{2} \Rightarrow Q^2 = \frac{2CD}{rP} \Rightarrow Q = \sqrt{\frac{2CD}{rP}}$

This is the quantity of stock to be ordered that will minimize the total variable cost.

6. Instances

Suppose that a company demands 600 units of stock annually and the cost per order is $500 when a unit cost of stock is $60 and for the stock value to hold, it costs 25%.

We have that C= $500, D=600, r= 25% and P= $60, then

$Q = \sqrt{\frac{2CD}{rP}} = \sqrt{\frac{2X500X600}{0.25X60}} = \sqrt{40000} = 200.$

The number of orders $= \frac{D}{Q} = \frac{600}{200} = 3$. And V= $\frac{rPQ}{2} + \frac{CD}{Q} = \frac{0.25X60X200}{2} + \frac{\$500x600}{200}$=$3000.

Also, total cost = fixed cost + total variable cost = DP+V = 600X$60+$3000= $39,000

7. Conclusion

Putting all logistics and technicalities in place, it is very clear that inventory control plays very vital roles in productivities and enterprises in general.

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