JIT: the best approach after lockdown in country

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Abstract: After the lockdown it is not easy to get into the previous position. All producers need to change their working method as there is no production during the whole period and to deal with such a huge mass is not an easy task. As the production is stopped during the lockdown. When lockdown is open, inventory will be almost finished. The demand of economy falls so rapidly that there is a requirement to adopt such technique that can be used to cope up with such situation and raise an economy. Just in Time (JIT) is such a technique used in inventory that is not only cost saving but also time saving. In this paper, a mathematical model of JIT is introduced and an example with numerical is applied. Certain methods ought to adopt to implement JIT to raise an economy of the country.

Keywords: JIT; Just in Time; pandemic; economy; lockdown; production; inventory; implement; simulation technique.

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1 Introduction

Spread of a pandemic became a common challenge to all the countries. It was first coming in the news at the end of December 2019. China was the first place where it was released and gradually it spread in other countries by different means and sources. All countries deal in their own way. In India, main source was people coming visiting from other countries. It was destroying all countries whether its economically, physically, politically or emotionally. People are losing their lives day by day. The metre of deaths is high day by day. Sooner or later all countries had to face the situation of lockdown.

In India first case was caught in the last of January. All countries were in the position of fear. Honourable Prime Minister Narendra Modi has to pass several guidelines and rules to deal with the situation. Lockdown is the thing where all the country is stopped where they are. A position where there is no production of anything and the demand of essential things will be as it was.

Without production how it could be possible for country to manage the population that is already in crores. After -position of a lockdown need to be considered very gently. It is like that everything should start afresh. New techniques should be adopted to come out with the situation and the most important thing to raise economy. This situation is not less than the situation of after World War II. Every technique should be in such a way that the result should be in favour of economy. No doubt economy is the backbone of a country.

Inventory is an important part of supply chain. One keeps a good track of inventory to deal with a situation like this. There are certain cost involves in an inventory like set-up

cost, carrying cost and shortage cost etc. There is a big amount involves in carrying cost. Inventory method is also known as Just in Case inventory where the producer spends a huge amount in holding the items. He keeps the items stored according to the expected future demand.

Just in Time (JIT) where 'No Inventory' is considered. At the moment with demand, items are delivered. All the money which is spent in holding the items is saved now. JIT was first introduced after the situation of World War II. After lockdown situation is alike. In JIT there is no waste of natural resources. JIT eliminated the total waste and natural resources and producers start manufactured the products when they have got the order and are paid for it. JIT works on total quality management and workers need to trained for it that how the quality can be driven in their work.

2 Literature review

Inventory is the main concern of supply chain management. Various studies have been done in such fields in since many decades. Several studies on EOQ models have been done yet. Several studies have been done in same directions with different constraints. Some studies have been done on EOQ model where the items are decaying in nature and the demand is constant. Technology is integrated day by day and situations are challenging day by day. Now various studies have been done where there is a situation of zero inventory so as to make profits. The concept of JIT which was first introduced by Toyota company in 1970.

Lehtonen and Holmström (1998) shows through case studies various scope of improvement in paper studies by implementing JIT. Sandanayak (2008) shows the impact of selected key JIT parameters on an automotive component-manufacturing environment. Singh et al. (2010) deals an inventory model for defective items with flexible production, multi-variate demand and partially backlogged. Kootanaee et al. (2013) presented the concept, objectives of JIT and the factor necessary for implementation. Singhal and Singh (2013) considered multi items inventory system with fuzzified and price dependent demand under volume flexible environment. Singh and Vishnoi (2013) deals an integrated two-warehouse inventory model with price dependent consumption rate with ameliorating and deteriorating items. Singhal et al. (2014) presented a probabilistic inventory model for Weibull deteriorating items with flexibility and reliability consideration. Singhal et al. (2016) developed a stochastic partial backlogging inventory models for deteriorating items with time dependent demand and volume elasticity. Kanchan et al. (2016) in their studies propose a framework to implement JIT in Valve company. Ezema et al. (2017) presented a JIT algorithm and models in production system. Riza et al. (2018) proposed an EOQ model and introduced various inventory cost. They have taken a case study of a Japanese company. Vishnoi et al. (2018) developed a supply chain inventory system for decaying items under inflation with expiration date and variable holding cost. Singhal and Singh (2018) considered a volume flexible supply chain model for both time and quality dependent decaying items with multiple market demand.

In this paper, we developed an inventory model with the concept of JIT which is very realistic condition during and after lockdown. We also discussed two cases here:

- without shortages
- with shortages.

The whole study is explained by numerically and also represented with graphically.

3 History of JIT

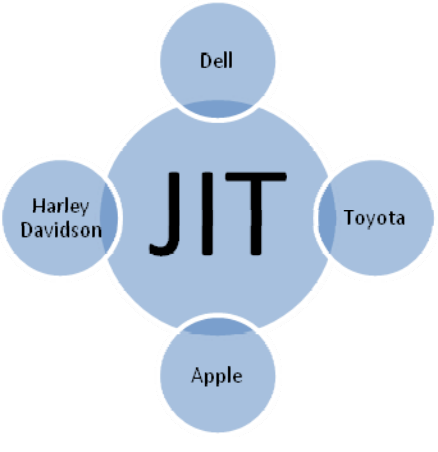
JIT was first introduced in early 1970s by Taiichi Ohno, Vice president of Toyota production plants. They implemented first time as there was a need to raise the economy. After World War II, Japan wanted to improve the productivity and want to overcome with the challenges over worldwide. JIT helped Japan to cope up with the situation and they genuinely raise their economy. Japanese is able to achieve the level of the quality of products and as well as the level of productivity. Since then there is an evolution of this technique which continuously showing productive results. This technique was not only used in automobiles but in other sector also. Now, it's a part of trend and now it's become a part of management.

4 Companies using JIT

There are many companies those are using JIT in their framework

- Harley Davidson
- DELL
- Toyota
- Apple

These are few examples those are using JIT and got a very good result.



5 Notations and assumptions

- D = Demand
- Q = Quantity
- R = reorder value
- D/Q = No. of cycle in a year
- $E(EI)$ =Expected value of ending inventory
- C_0 = Ordering cost
- C_c = Carrying cost
- C_s = Expected shortage cost per unit
- S_c = Shortage cost
- $\overline{S}(x)$ = Expected value shortage in a cycle
- LTD = Lead time demand
- $O.C$ = Ordering cost
- $S.S$ = Safety stock which is kept in every cycle
- $\overline{s}(x)$ = Expected value of the shortage
- C_s =Expected shortage cost per unit
- $E[EI]$ = Expected value of ending inventory.

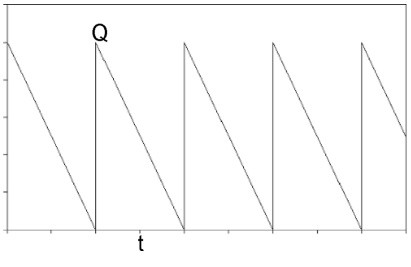
6 Mathematical model for JIT

JIT works on an assumption that the stock is allowed to fall zero and the demand is fulfilled as the demand rise. For JIT models some of the stock will be kept as safety stock with every cycle. We have discussed two cases:

- shortages are not allowed
- shortages are allowed.

The graph of JIT will be as follows if there is no holding cost involved (Figure 1).

Figure 1 Representation of inventory model with JIT



6.1 Case I: Shortages are not allowed

In general, for an economic model, the equation is given by where shortages are not allowed:

Total cost ($T.C$) = Ordering cost + holding cost

$$T.C = O.C + C_c \tag{1}$$

Equation for JIT is given by,

$$\text{Min of } T.C = T.C' = \frac{D}{Q}c_0 + \left(\frac{Q}{2} + S.S\right)C_c \tag{2}$$

In JIT model, ending inventory of every cycle is the beginning inventory of next cycle.

For every reoder cycle, we have

$$T.C' = \frac{D}{Q}c_0 + \left(\frac{Q}{2} + E\left[EI\right]\right)C_c \tag{3}$$

(In ideal situation $E(EI) = 0$)

We can write $E(EI)$ as

$$E(EI) = r - LTD$$

where, LTD = Lead time Demand and for every reorder cycle, expected ending inventory can be replaced as $r - LTD$.

Equation (3) can be written as

$$T.C' = \frac{D}{Q}c_0 + \left(\frac{Q}{2} + r - LTD\right)C_c \tag{4}$$

Now, we have to find value of r and Q.

To minimise the total cost, diffrentiating equation (4) w.r.t 'r' and 'Q' and equating to 0.

$$\frac{\partial T.C'}{\partial r} = 0 \text{ and } \frac{\partial T.C'}{\partial Q} = 0,$$

We get, $Q = \sqrt{\frac{2DC_0}{C_c}}$.

6.2 Case II: Shortages are allowed

For an economic model the equation is given by where shortages are allowed.

Total cost (T.C) = ordering cost + holding cost + shortage cost

$$T.C = \text{O.C} + C_c + S_c \tag{5}$$

Equation for JIT is given by,

$$\text{Min of } T.C = T.C' = \frac{D}{Q}c_0 + \left(\frac{Q}{2} + S.S\right)C_c + \frac{\overline{s}(x)c_s D}{Q} \tag{6}$$

In JIT model, ending inventory of every cycle is the beginning inventory of next cycle.

For every reoder cycle, we have

$$T.C' = \frac{D}{Q}c_0 + \left(\frac{Q}{2} + E[EI]\right)C_c + \frac{\overline{s}(x)c_s D}{Q} \tag{7}$$

(In ideal situation $E(EI) = 0$)

$$\overline{S}(x) = \int_r^{\infty} (x - r) f(x) dx \tag{8}$$

Shortage occurs when demand excess the reorder value

$$\therefore r < x < \infty$$

$(x - r)f(x)$ is the expected shortage or we can say that expected quantatity by which demand exceeds.

We can also write

$$E(EI) = r - LTD$$

where, LTD = Lead time Demand and for every reorder cycle, expected ending inventory can be replaced as $r - LTD$.

Equation (7) can be written as:

$$T.C' = \frac{D}{Q}c_0 + \left(\frac{Q}{2} + r - LTD\right)C_c + \frac{\overline{s}(x)c_s D}{Q} \tag{9}$$

Now, we have to find value of r and Q.

To minimise the total cost, diffrentiating equation (9) w.r.t 'r'and 'Q' and equating to 0.

$$\frac{\partial T.C'}{\partial r} = 0 \text{ and } \frac{\partial T.C'}{\partial Q} = 0$$

We get

$$\frac{\partial \overline{S(x)}}{\partial r} = -\frac{QC_c}{DC_s}$$

Here $\frac{QC_C}{DC_S}$ is the estimate of the shortage and $Q = \sqrt{\frac{2D(C_0 + \overline{S}(x)C_s}{C_c}}$.

7 JIT's implementation after lockdown

As JIT suggests that there should not be so much inventory and a consumer should get exactly when he needs. JIT is directly associated with a real demand of consumer. As it is obvious that the production in India is stagnant due to the lockdown and economy is very

down due to pandemic so there should be an immediate action to be taken so as to lift up the economy.

As we have discussed that JIT is cost efficient as compare to economic model because one can save so much of a cost by minimising the ordering cost.

There are two important factors of ordering cost, i.e.,

- transportation
- inspection.

As the equation suggest that the ordering cost can be controlled.

So, to minimise transportation cost, one can use the local or nearby producers and in such a way the nearby and the economy around us will be improved which clearly stated that to use **Swadeshi** products. If the local market rises, economy will rise tremendously. Now the time is demanding of total Swadeshi and high jump in economy.

Secondly, the inspection would be done by the supplier and not by the company. So, the amount which is involved in the inspection of items by the organisation will be saved and at the same time, so much time of the producer will also be saved.

8 Numerical analysis

In the below numerical a situation can be clearly understood that by switching JIT to EOQ model is the demand of a situation after lockdown. And by controlling the ordering cost we can save a huge amount of money and lift up economy.

Suppose there is an annual demand of a single quantity 15,000 and the ordering cost, unit cost and holding cost be Rs. 5000, Rs. 100 and Rs. 20 (shortages are not allowed).

So, holding cost = Rs.20

In case of normal EOQ model

$D = 15{,}000$

$C_0 = \text{Rs. } 5000$

$C = \text{Rs. } 100$

$C_h = \text{Rs. } 20$

Here, Q is given by the formula

$$Q = \sqrt{\frac{2DC_0}{C_c}} = 2738.61$$

And the total cost spent on holding and ordering is given by

$$T = \sqrt{2DC_0C_c} = \text{Rs. } 54772.25$$

Total money spent on inventory is given by

$$\frac{QC}{2} = \text{Rs. } 136930.5$$

Here

$$N = D/Q = 5.47 \sim 5$$

Therefore, there will be 5 orders in a year.

In every 2.4 month (12/5, 1 year =12 months) we have to place the order and there will be a huge amount, i.e., Rs 136930.5, in keeping the inventory.

The total cost involved ordering and holding is also high.

Now,

As we know that in JIT model, there is no cost in keeping the inventory. So the total cost in keeping the inventory and the total cost spent on ordering and holding cost will be saved.

In the below iteration it is shown that on keeping by decreasing the ordering cost only, there is a tremendous change in the model (Table 1).

Table 1 Effect of total cost and cost of keeping inventory

Demand	*Ordering cost*	*Holding cost*	*Quantity*	*T.C*	*Cost of keeping inventory*
15,000	5000	20	2738.613	54772.26	136930.6394
15,000	4000	20	2449.49	48989.79	122474.4871
15,000	3000	20	2121.32	42426.41	106066.0172
15,000	2500	20	1936.492	38729.83	96824.58366
15,000	2000	20	1732.051	34641.02	86602.54038
15,000	1000	20	1224.745	24494.9	61237.24357
15,000	700	20	1024.695	20493.9	51234.75383
15,000	600	20	948.6833	18973.67	47434.1649
15,000	500	20	866.0254	17320.51	43301.27019
15,000	400	20	774.5967	15491.93	38729.83346
15,000	300	20	670.8204	13416.41	33541.01966
15,000	200	20	547.7226	10954.45	27386.12788
15,000	100	20	387.2983	7745.967	19364.91673

9 Observations

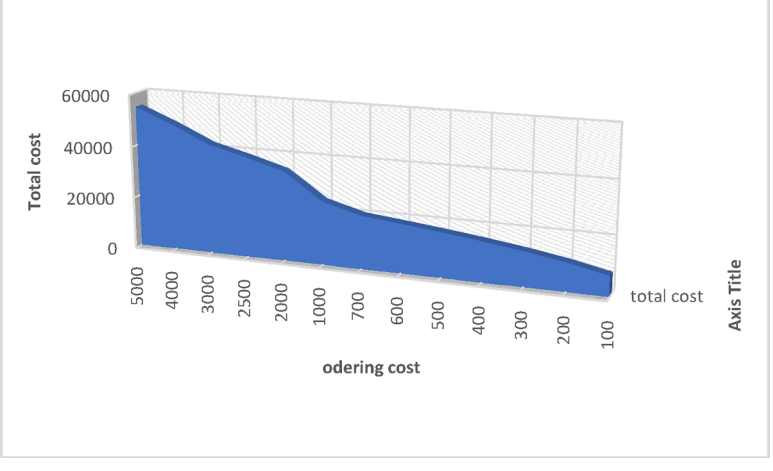
As the table describes that as the ordering cost decreases the total cost spent on ordering cost and holding cost is also coming down. The average cost on keeping the inventory is also decreasing. This is the amount which will be saved in JIT model. Because, this is the amount which is spent in keeping the inventory.

In JIT model a huge amount is saved like this. The amount of inventory will be transferred when there is an amount. The producer money will not be indulged in the market as he will be getting payments soon from the market. This table represent that the effect of ordering and holding cost is very much on the whole system. JIT system deals with the real demand of customer and producer has the payment at every reorder.

The order cycle can a week or two weeks in JIT model. In the present scenario of lockdown there is a need of such a technique because the producer should have something in his hand as economy is stagnant and there is a need to fulfil the demand at the moment it is ordered.

The below 3D graph (Figure 2) depicts that as the ordering cost decreases the total cost is also keep on decreasing.

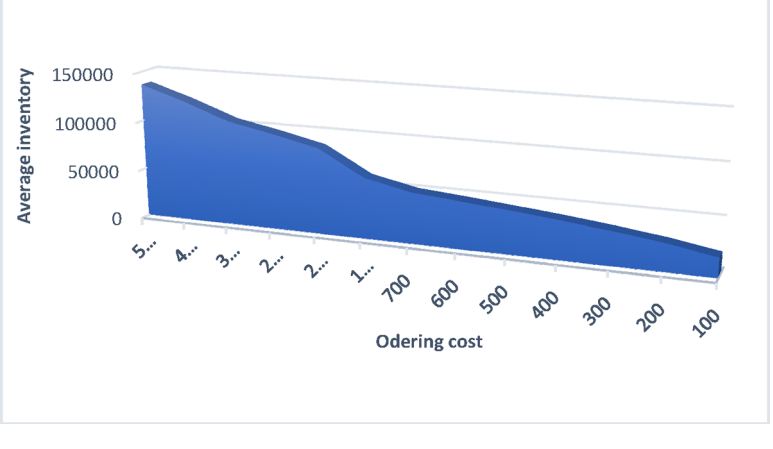
Figure 2 Ordering cost vs. total cost (see online version for colours)



In the period of lockdown, it is very necessary to save this money and help to uplift economy.

The following 3D graph (Figure 3) depicts that as the ordering cost decreases, the average inventory cost is decreased. JIT system says no to inventory. This technique again can help to save money and to uplift economy.

Figure 3 Ordering cost vs. average inventory cost (see online version for colours)



10 Conclusions

As we can see in through the diagrams and table that because of the holding cost there is a drastically impact on the total cost of the system.

By taking care of the holding cost, the money spent on keeping inventory can be saved and it will help to raise the economy of the country (shown in the above table).

There are two suggestions which can be given on the basis of above study:

Holding cost can be decreased by two factors:

- Saving the **transportation cost** – that can only be done by preferring local market and warehouses. As less as there will be near ware houses, it will not only increase local economy but also help in the time of today.
- Being **Swadeshi** is the best concept.

Quality inspection can be done by customer only. That will save the huge amount of cost spent by producer.

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