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Covid-19 Integrated Inventory Model with Lead Time and Ordering Cost Reduction Using Linear Case Function

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ABSTRACT

COVID 19's social distancing limits health and economic driven demand shift are predicted to close a number of small companies and Entrepreneurial endeavours, although there is little or no early evidence of their effects. This paper shows the large impact on small business during COVID 19, the inventory policy is developed for an item with stock level a demand rate that is dependent on storage time and a holding cost that is based on storage time. The main contribution of this study is that the integrated total cost of the suppliers and consumers integrated system is analysed by adopting linear type ordering cost reduction act dependent on lead time. An algorithm procedure for finding the optimal solution is developed. The mathematical model is solved analytically by minimizing the integrated total cost and the numerical examples are given to illustrate the results.

KEYWORDS: Covid-19; Small Business; Inventory models; Ordering cost reduction; Variable holding cost; Optimization.

I. INTRODUCTION

COVID-19's unexpected attack has shown a significant impact on human lives and businesses. Corona virus illness (COVID 19) is associate degree communicable disease caused by the SARS – COV – 2 virus. The impact on small businesses is severe. As a result, the supply chain was disrupted, which had an impact on entire globe trade. We observed that throughout the early stages of the pandemic and the forced lockdown implementation in the middle, according to surveys based on data from Current Population Surveys (CPS), small enterprises that had been running smoothly for a year as of March 2020. Their activity had been steadily declining for a long time. In this situation Industries have devoted respectable attention to reducing inventory cost. For instance, despite the big scope and various benefits of Just-In-Time production systems, that aim to eliminate waste by cutting surplus inventory and removing delays in operations, it's the resultant inventory price reduction that has captured the best public attention. In today's offer chain management surroundings, firms area unit mistreatment the JIT production to realize and maintain a competitive advantage.

JIT systems have the common attributes: consistently good quality, minimal fair amount sizes, continuous distribution, small intervals and shut provider ties. Hence, the management of interval length is one in every of the key factors to the success of JIT production. An additional crashing cost can be added to the lead time to improve customer service and reduce inventory in safety stocks. The crashing of lead time consists mainly of the subsequent components: order preparation, order transit, provider lead time, and delivery time. Liao and Shyu[10] in 1991 given a nonstop review model during which order quantity is preset and interval may be a distinctive decision variable. In 1994, Ben-Daya and Raouf[2] enhanced Liao and Shyu's[10] model by include each lead time as well as the order amount as decision factors. They derived the optimum interval and optimum order amount to reduce then add the ordering value, holding value, and interval crashing value. Banerjee[1] presented a collaborative economic-lot-size model, in which a merchandiser produces to order for a consumer on a lot-by-lot basis under certain deterministic conditions in 1986. Goyal[6] in 1988 more generalized the Banerjee[1] model (1986) by restful the idea of the lot-for-lot policy of the seller. As a result of exploitation the approach instructed within the Goyal[6] in 1988 model, significant reduction in inventory value may be achieved. Many researchers have shown that in integrated models, one partner's gain exceeds the opposite partner's loss. As a result, the net benefit may be shared among the entities in an amicable way (Goyal and Gupta[7] in 1989).

In this research, Covid-19 integrated inventory model with lead time and ordering cost reduction using linear case function. It is demonstrated that the proposed model has a lower total cost and a shorter lead time. Compared to Banerjee's[1] in 1986 and Goyal's[6] in 1988. Breaking down old boundaries may be easier with the integrated inventory model. The time spent in storage is separated into a series of distinct phases, each with rising holding costs. The new holding cost might be imposed retroactively as the storage time extends to the next time period. Hesham K. Alfares[8] in 2007. It represent many real-life situations during which the storage times are often classified into completely different ranges, every with its distinctive unit holding cost. As an example, three completely different holding cost rates could

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apply to short term, medium-term, and long-run storage. We specifically adapt Pan and Yang's[13] in 2002 model to account for the linear relation between lead time and ordering cost reductions.

The pandemic's economic cost appears to be immense, and everyone is concerned how the economy can recover Kalogiannidis,et.al[9] in 2020. Within a week, the pandemic had made a huge impact on small enterprises, even before funding became available Robert[14] in 2020. The combination of vendor and buyer for improving inventory control performance has attracted a lot of attention. Banerjee[1] in 1986 proposed a joint economic-lot-size model in which a vendor produces to order for a buyer on a lot-by-lot basis, assuming that the vendor makes at a finite rate. Goyal[5] in 1976 was one of the first to investigate an integrated inventory model for a single-buyer system. Many scholars have presented various sorts of integrated inventory systems using the framework he proposed. Banerjee[1] in 1986 adapted Goyal's[5] in 1976 model and proposed a combined economic lot size model in which a vendor and a buyer share the same lot size. Produces for a buyer who wants to place a lot-by-lot order. Goyal[6] in 1988 expanded on Banerjee's[1] in 1986 approach by allowing the vendor's lot for lot policy to be relaxed. He proposed that the vendor's economic output amount be a positive integer multiple of the purchase. Pan and Yang[13] in 2002 extended Goyal's[6] in 1988 model by include lead time as a decision variable, resulting in a new model.

A lower total estimated cost and a shorter lead time are both advantages. In the model as described by Pan and Yang[13] in 2002, Yang and Pan[13] in 2002 addressed variable lead time and quantity improvement investment with normal distributional demand. Ouyang et al.[12] in 2004 extend Pan and Yang[13] in 2002 and attempted the development of a single-vendor, single-buyer integrated production inventory model, assuming that the lead time is a random variable, and the lead time is a decision variable. Ouyang et al.[11] in 1996 went a step farther. The model of Ben-Daya and Raouf[2] in 1994, in which shortages were permitted and the total number of stockouts was limited Back orders and lost sales are mixed together. Vijayashree and Uthayakumar[15] in 2016 proposed an integrated inventory optimization model with cost of setup and investment in quality improvement diminution. In some cases, the reduction of lead time and the reduction of ordering/set-up costs may be linked. A reduction in the lead time could go hand in hand with a decrease in the Costs of ordering and setup and vice versa. Electric Data Interchange (EDI) technology, for example, could minimise both lead time and ordering/set-up time at the same time. There has been minimal research into the relationship between lead times and ordering cost reduction. To provide clarity and analytical tractability, as well as to provide insight a linear function was used to formulate the above relationship in Chiu[3] in 1998 and Chen et al.[4] in 2001. The goal of this study is to determine an effective inventory strategy for small businesses that will reduce the value of the integrated total cost for both the suppliers and the consumers during a pandemic. To discover the best strategy, an algorithm is created, and numerical examples are used to demonstrate the solution technique in the linear case.

II. NOTATIONS AND ASSUMPTIONS

$D_a -$ *Annually demand average,*

$P_r -$ *The rate of production,*

$O -$ *Order quantity of the consumer,*

$CO -$ *Consumer's ordering cost per order,*

$S_c -$ *Supplier set − up cost per set − up,*

$L -$ *Length of lead time,*

$R -$ *Ordering cost per order,*

$H_i -$ *Holding cost of the item in time i,*

$\gamma -$ *Demand parameter indicating elasticity in relation to the inventory model,*

$S -$ *Fixed transportation cost per shipment,*

$n -$ *Integer that represents the number of lots in which the supplier delivers the products to the consumer.*

The following are the assumptions expressed within the paper:

1. The merchandise is formed at a finite rate of production P, and P is larger than D_a.

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2. Throughout the lead time L, the demand Y follows a traditional distribution with a mean of L and a standard deviation of $\sigma\sqrt{L}$
3. The reorder point (ROP) is calculated by adding the calculable demand throughout the lead time and therefore the safety stock.
4. Inventory is evaluated on a daily basis.
5. The lead time has m parts, that are crashed one at a time, beginning with the one with the bottom crashing price per unit time and dealing up to the foremost expensive.
6. If a shorter lead time is requested, the vendor's further expenses are entirely transferred to the consumer.
7. Only when the storage period exceeds certain discrete values is it expected that the holding cost per unit rises.
8. The cost of holding varies as a function of storage time in an increasing step.

III. MODEL FORMULATION

Based on previous notations and assumptions, the consumer's total annual cost is calculated as follows:

ETC_c = Ordering cost + Retroactive holding cost + Line haul cost + Lead time crashing cost

While CO is the ordering cost per order, $\left({D_a}/{O}\right) CO$ is the estimated ordering cost per year.

The reordering point, based on the assumption (3) $+R\rho\sqrt{L}$, The safety factor is denoted by R. The estimated linehaul cost per year is given by $\left({D_a}/{O}\right) S$ and the estimated annually retroactive holding cost is given by $\left[\frac{RD_a(1-\gamma)(2-\gamma)}{h_i}\right]^{\frac{1}{2-\gamma}}$.

Lead time can be broken down into n mutually independent components, as per Liao and Shyu (1991) each of which has a different crashing cost for reduced lead time and is characterised by a piecewise linear function. The ith component has a crashing cost per unit time e_i, as well as a maximum duration f_i and a minimum duration g_i. The components of lead time are crashed one by one, starting with the one with the least e_i and working up to the most e_i, and so on, let $\sum_{i=1}^{n} f_i \leq L \leq \sum_{i=1}^{n} g_i$.

L_i be the length of the lead time component that has been reduced to its shortest duration then L_i can be represented as

$$L_i = \sum_{j=1}^{i} f_j + \sum_{j=i+1}^{n} g_j$$

$$L_i = \sum_{j=1}^{i} f_j + \sum_{j=1}^{n} g_j - \sum_{j=1}^{i} g_j$$

$$L_i = \sum_{j=1}^{n} g_j - \sum_{j=1}^{i} (g_j - f_j)$$

$$L_i = L_o - \sum_{j=1}^{i} (g_j - f_j)$$

Where $L_o \equiv \sum_{j=1}^{i} g_j$

The crashing cost of the lead time C(L) is denoted by:

$$\text{C(L)} = e_i(L_{i-1} - L) + \sum_{j=1}^{i-1} e_j(g_j - f_j) \qquad L \in (L_i, L_{i-1}] \qquad \dots (1)$$

As a result, the estimated annual lead time crashing cost is $\left({D_a}/{O}\right)$ C(L).

The estimated cost to the consumer is calculated as follows:

$$ETC_c(O,L) = \left({D_a}/{O}\right) CO + \left[\frac{RD_a(1-\gamma)(2-\gamma)}{h_i}\right]^{\frac{1}{2-\gamma}} + \left({D_a}/{O}\right) S + \left({D_a}/{O}\right) \text{C(L)} \quad \dots (2)$$

The total estimated annual cost of the supplier's inventory model is represented by:

$$ETC_s = carrying\ cost + set - up\ cost$$

Considering U is the supplier's set-up cost per set-up and nO is the vendor's production quantity in a lot, $\left[\frac{D_a}{nO}\right]U$ is the estimated set-up cost per year: The integrated inventory model is intended for possible outcomes where a supplier's production begins after an order is made and once the production process is completed, a steady number of units are added to inventory each day. The vendor manufactures the item in a quantity of nO, and the consumer receives it in n lots, each with a quantity of O.

The supplier's average inventory can be computed as follows:

$$I_s = \left\{\left[\ nO\left(\frac{O}{P_r} + (n-1)\frac{O}{D_a}\right) - \frac{n^2O^2}{2P}\right] - \left[\frac{O}{D_a}\left(1 + 2 + \cdots + (n-1)\right)O\right]\right\} \Big/ \left(\frac{nO}{D_a}\right)$$

$$= \frac{O}{2}\left(n\left(1 - \frac{D_a}{P_r}\right) - 1 + \frac{2D_a}{P_r}\right) \quad \ldots (3)$$

Therefore, the supplier's estimated carrying cost per year is

$$h_i\left(\frac{O}{2}\left(n\left(1 - \frac{D_a}{P_r}\right) - 1 + \frac{2D_a}{P_r}\right)\right)$$

This shows that the estimated total annual cost for the supplier is:

$$ETC_s(O, n) = \frac{D_a}{On}U + h_i\frac{O}{2}\left(n\left(1 - \frac{D_a}{P_r}\right) - 1 + \frac{2D_a}{P_r}\right) \quad \ldots (4)$$

The joint estimated total yearly cost is given by: If the consumer's order quantity is O and the vendor's lot size is nO, then

$$JETC(O, L, n) = \frac{D_a}{On}\left[CO + S + \frac{U}{n} + C(L)\right] + \left[\frac{RD_a(1-\gamma)(2-\gamma)}{h_i}\right]^{\frac{1}{2-\gamma}}$$
$$+h_i\frac{O}{2}\left(n\left(1 - \frac{D_a}{P_r}\right) - 1 + \frac{2D_a}{P_r}\right) \quad \ldots (5)$$

IV. LINEAR FUNCTION

We suppose that the following relationship exists between lead time and ordering cost reductions:

$$\frac{L_o - L}{L_o} = \sigma\left(\frac{CO_o - CO}{CO_o}\right) \quad \ldots (6)$$

where $\sigma(> 0)$ is a constant scaling parameter that describes the linear associations between lead time reduction percentages and ordering cost reduction percentages. By using O and L as choice variables,

The ordering cost CO can be written as a linear function of L by considering relationship (6).

$$CO(L) = w + zL \quad \ldots (7)$$

Where $w = \left(1 - \frac{1}{\sigma}\right)CO$ and $z = \frac{CO_o}{\sigma L_o}$

Using (7) in (5)

$$JETC(O, L, n) = \frac{D_a}{On}\left[(w + zL) + S + \frac{U}{n} + C(L)\right] + \left[\frac{RD_a(1-\gamma)(2-\gamma)}{h_i}\right]^{\frac{1}{2-\gamma}}$$
$$+h_i\frac{O}{2}\left(n\left(1 - \frac{D_a}{P_r}\right) - 1 + \frac{2D_a}{P_r}\right) \quad \ldots (8)$$

We get the following results by equating the partial derivatives of JETC(O, L, n) with regard to O and L in each time interval (L_i, L_{i-1}),

$$\frac{\partial JETC(O,L,n)}{\partial O} = -\frac{D_a}{O^2}\left[CO + \frac{U}{n} + S + C(L)\right] + \frac{h_i}{2}\left[n\left(1 - \frac{D_a}{P_r}\right) - 1 + \frac{2D_a}{P_r}\right] = 0 \quad \ldots (9)$$

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$$\frac{\partial JETC(O,L)}{\partial L} = \frac{D_a}{O}[y + e_i] = 0 \qquad \dots (10)$$

As a result, for fixed L∈ (L_i, L_{i-1}), $JETC(O, L, n)$ is convex in O, because

$$\frac{\partial^2 JETC(O,L)}{\partial O^2} = \frac{2D_a}{O^3}\left[CO + \frac{U}{n} + S + C(L)\right]$$

As a result, for fixed O, $JETC(O, L, n)$ is concave in L∈ (L_i, L_{i-1}), since

$$\frac{\partial^2 JETC(O,L)}{\partial L^2} = 0$$

As a result, the minimal joint estimated total annual cost will occur at the interval's end points for fixed Q. We have (9) as a result of (9).

$$O = \left[\frac{2D_a\left[CO+\frac{U}{n}+S+C(L)\right]}{h_i\left[n\left(1-\frac{D_a}{P_r}\right)-1+\frac{2D_a}{P_r}\right]}\right]^{\frac{1}{2}} \qquad \text{L} \in (L_i, L_{i-1}) \qquad \dots (11)$$

The joint estimated total annual cost for a given value of n is given by:

$$JETC(n) = \sqrt{2D_a h_i\left[n\left(1-\frac{D_a}{P_r}\right) - 1 + \frac{2D_a}{P_r}\right]\left[CO + S + \frac{S_c}{n} + C(L)\right]} \qquad \dots (12)$$

We can remove the terms that aren't changed by n and just take the square of n

$$(JETC(n))^2 = 2D_a h_i \begin{bmatrix} \left(CO + S + C(L)\right)\left(\frac{2D_a}{P_r} + 1\right) + S_c\left(1 - \frac{D_a}{P_r}\right) \\ +n(CO + S + C(L))\left(1 - \frac{D_a}{P_r}\right) + \frac{S_c}{n}\left(\frac{2D_a}{P_r} + 1\right) \end{bmatrix}$$

Furthermore, neglecting the terms that are independent of n,

$$Y(n) = h_i\, n(CO + S + C(L))\left(1 - \frac{D_a}{P_r}\right) + \frac{S_c}{n}\left(\frac{2D_a}{P_r} + 1\right) \qquad \dots (13)$$

The adequate value of n = n* is provided when

$$Y(n^*) \le Y(n^* - 1)$$
$$Y(n^*) \le Y(n^* + 1) \qquad \dots (14)$$

When relevant values are substituted in (11) we get:

$$n^*(n^* - 1) \le \frac{S\left(\frac{2D_a}{P_r}+1\right)}{h_i\, n(CO+S+C(L))\left(1-\frac{D_a}{P_r}\right)} \le n^*(n^* + 1) \qquad \dots (15)$$

ALGORITHM

Step 1 Set m=2

Step 2 For every $L_i, i = 1,2, \dots, n$, determine O_i using equation (11)

Step 3 Find the corresponding value of JETC (O_i, L_i, n) by using O_i in equation (8)

Step 4 To find the minimum value of JETC$(O_i{}^*, L_i, n)$ where i =1,2,3…n.

Let $JETC(O_n{}^*, L_n, n) = min_{i=1,2,3,\dots,n}$ JETC$(O_i{}^*, L_i, n)$ then $(O_n{}^*, L_n)$ is the optimal solution for fixed n.

Step 5 To get JETC$(O_n{}^*, L_n{}^*, n)$, set n=n+1 and repeat steps (2)–(4).

Step 6 If JETC$(O_n{}^*, L_n{}^*, n) \le$ JETC$(O_{n-1}{}^*, L_{n-1}{}^*, n-1)$; If not, proceed to step 4; otherwise, proceed to step 7.

Step 7 JETC$(O_n{}^*, L_n{}^*, n) =$ JETC$(O_{n-1}{}^*, L_{n-1}{}^*, n-1)$, then (O^*, L^*, n^*) is the optimal solution. For linear case the optimal ordering cost $A(L) = w + zL$

V. NUMERICAL EXAMPLE

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Consider the following criteria of an inventory system: $D_a = 1000unit/year, S_c = \$400/\text{set} -$ up, P_r =3200unit/year, R = 2.33, CO = \$25/order, and the lead time is composed of three components as stated in table 1(Ben-daya[2] in1994). From(13), we have n=2,3,4,5. Using the preceding technique, optimal integer solutions with $n^* = 2$, lead time $L^* = 6days$, and $O^* = 316units$. The joint estimated total annual cost is \$1608.23.

Table 1 Data for Lead time

Component of Lead time i	standard time frame $f_i(days)$	limited time frame $g_i(days)$	Unit crashing cost $e_i(\$/day)$
1	16	2	0.40
2	16	2	1.20
3	10	3	5.00

Table 2 Result for JETC

σ	i	L_i	n	$CO(L)$	$h_i = 5$		$h_i = 6$		$h_i = 7$	
					O_i	$JETC$	O_i	$JETC$	O_i	$JETC$
5.00	0	6	2	25	316	1608.23^*	289	1757.82	267	1894.61
	1	4	3	23	210	1803.96	192	1971.30	178	2125.34
	2	3	4	22	169	2034.03	154	2223.02	143	2397.17
	3	1	5	21	155	2398.25	141	2405.97	131	2426.83
2.50	0	6	2	25	316	1608.23	289	1757.82	267	1894.61
	1	4	3	22	210	1803.96	192	1971.30	177	2119.77
	2	3	4	20	168	2021.76	153	2210.02	142	2383.07
	3	1	5	17	153	2372.19	140	2592.94	129	2797.39
1.25	0	6	2	25	316	1608.23	289	1757.82	267	1894.61
	1	4	3	18	208	1780.45	190	1944.60	176	2096.72
	2	3	4	15	165	1992.16	151	2177.14	140	2347.61
	3	1	5	8	149	2312.40	136	2528.21	126	2726.8
1.00	0	6	2	25	316	1608.23	289	1757.82	267	1894.61
	1	4	3	17	207	1775.40	189	1939.88	175	2091.34
	2	3	4	13	164	1980.03	150	2163.65	139	2333.25
	3	1	5	4	147	2285.67	135	2498.67	125	2694.90
0.75	0	6	2	25	316	1608.33	289	1757.82	267	1894.61
	1	4	3	14	205	1761.02	187	1923.95	174	2074.13

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	2	3	4	8	162	1949.36	148	2130.27	137	2296.98
	3	1	5	-3	144	2237.60	132	2446.09	122	2638.10

*The Joint estimated minimum annual cost.

Table 3

	n=1				n> 1	
	Decision of the consumer	Supplier decision	Banerjee's model	This $MODEL^{*}$	Goyal's model	This $MODEL^{*}$ (n = 2)
Order size of the consumer	100	716	369	759	198	316
Supplier's lot size	100	716	369	759	396	632
Consumer's annual cost	528.23	98.06	1221.0	94.10	852.0	186.46
Supplier's annual cost	4078.13	1118.02	1314.6	1119.97	1653.6	1422.91
Joint annual total cost	4606.36	1216.08	2535.6	1214.07	2505.6	1608.23

*It include lead time crashing.

Before estimating the safety stock, the models should take it into account. In comparison to Banerjee's model, the proposed model is shown to provide a significantly lower cost and shorter lead time for n=1. In the Goyal in 1988 model, the minimal yearly cost for n higher than one is $2505.6, while in this research, it is just $1608.23. Table 4 illustrates the outcomes of the model calculations.

Both the consumer and the supplier set their own inventory policies. Equation is used by the provisioner to calculate his economic order quantity (2). In each period interval $(L_i,\ L_{i-1})$, calculate the first derivative of a function ETC_s to get the smallest cost lot size with regards to O and L and set them both to zero; as a result:

$$\frac{\partial ETC_s}{\partial O} = -\frac{D_a}{O^2 n} S_c + \frac{h_i}{2}\left[n\left(1-\frac{D_a}{P_r}\right) - 1 + \frac{2D_a}{P_r}\right] = 0 \qquad \dots (16)$$

$$\frac{\partial ETC_s}{\partial n} = -\frac{D_a}{n^2 O} S_c + \frac{O h_i}{2}\left(1-\frac{D_a}{P_r}\right) = 0 \qquad \dots (17)$$

As a result, for fixed O, the supplier's minimal estimated total annual cost will occur at the interval's end points. From equation (16),

$$O = \left[\frac{2D_a S_c}{n h_i\left[n\left(1-\frac{D_a}{P_r}\right)-1+\frac{2D_a}{P_r}\right]}\right]^{\frac{1}{2}} \qquad L \in (L_i,\ L_{i-1}) \quad \dots (18)$$

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Table 4 Distribution of the total annual cost

Model type	Consumer		Supplier	
Independent	Quantity of Order	282.84	Quantity of Production	848.52
	Total cost per year	$205.0	Total cost per year	$1664.64
Integrated	Quantity of Order	316	Quantity of Production	632
	Total cost per year	$186.46	Total cost per year	$1422.91
	Total annual cost distributed	$204.91	Total annual cost distributed	$1664.73

It is evident that ordering O = 282.84 units with a lead time of L = 42 days at a total annual cost of $205.0 is the best policy. The consumer's purchase quantity will be an integer multiple of the economic production quantity. The sole unknown variable in (4) is n. Let n be 1, 2, 3,..., and choose the one that minimises equation (4). Since O = 282.84, the supplier has yielded n = 2 at a total annual cost of $1664.64. As a result, the total annual cost is $1869.64. The annual cost should be split between the supplier and the consumer as follows:

$$\gamma = \frac{ETC_c(O^*,L^*)}{ETC_c(O^*,L^*)+ETC_s(O^*,n^*)} \quad \text{... (19)}$$

Consumer's expense $= \gamma[JETC(O^*,\ L^*, n^*)]$

Supplier's expense$= (1-\gamma)[JETC(O^*,\ L^*, n^*)]$

Table 5 summarises the allocation that resulted. The supplier should pay the consumer $18.4 per year in compensation. The interaction between a supplier and a consumer has been the subject of a lot of research. The integrated model has the potential to improve the supplier –consumer relationship significantly.

VI. CONCLUSION

In the last few decades, globalisation has transformed the business world, and despite numerous natural (e.g., bushfires, droughts, earthquakes, floods, and hurricanes) and human (e.g., global financial crisis, pandemics such as SARS and Ebola, terrorism, and wars) disasters, we have always managed to bounce back. Covid-19 stands out in this context because of the rapidity with which it has spread over the world and wreaked havoc on the global economy. One of the challenges would be for governments and private businesses to predict the risk associated with each stage of the reopening in order to manage the overall uncertainty associated with this process and avoid a second wave of Covid-19 cases with similar or potentially worse economic consequences. In this situation businesses adopted numerous inventory model to overcome the crisis. Inventory model helps them to optimize their estimated total cost it maximize their profit even though in pandemic situation and the loss can be gradually overcome by inducing the method. By optimising the order quantity, reorder point, and lead time, we may reduce the overall estimated annual cost. A process of finding is used with the assumption that the lead time and ordering cost reduction act dependent. It has been proven that the expected outcomes are identified. Numerical cases have been solved and simple optimization algorithms have been constructed. Using the formulas as a result of the work that has been done, it can be inferred that it minimize the total annual cost. The future scope of this research is to consider the holding cost as a diminishing step function of storage duration as another extension idea. Analysis of the effectiveness of various types of imperfect production systems and inspection procedures on integrated inventory models is another relevant study area.

VII. REFERENCES

[1] Banerjee A (1986) A joint economic-lot-size model for purchaser and vendor. Decision Sci 17:292–311.

[2] Ben-Daya M, Raouf A (1994) Inventory models involving lead time as decision variable. J Oper Res Soc 45:579–582

[3] Chiu PP (1998) Economic production quantity models involving lead time as a decision variable. Master Thesis: National Taiwan University of Science and Technology.

[4] Chen CK, Chang HC, Ouyang LY (2001a) A continuous review inventory model with ordering cost dependent on lead time. Inf Manag Sci 12:1–13

[5] Goyal SK (1976) An integrated inventory model for a single suppliersingle customer problem. Int J Prod Res 15:107–111

[6] Goyal SK (1988) A joint economic-lot-size model for purchaser and vendor: a comment. Decis Sci 19:236–241

[7] Goyal SK, Gupta YP (1989) Integrated inventory models: the vendor– buyer coordination. Eur J Oper Res 41:261–269

[8] Hesham, K. Alfares., 2007, Inventory model with stock-level dependent demand rate and variable holding cost, Int. J. Production Economics 108 (2007) 259–265

[9] Kalogiannidis, S. (2020). Impact of Effective Business Communication on Employee Performance. European Journal of Business and Management Research, 5(6).

[10] Liao, C. J. and Shyu, C. H., 1991, An analytical determination of lead time with normal demand. International Journal of Operations & Production Management, 11, 72±78.

[11] Ouyang,L.Y.,Yen, N.C. and Wu, K.S., 1996, Mixture inventory model with backorders and lost sales for variable lead time. Journal of the Operational Research Society, 47, 829±832.

[12] Ouyang LY, Wu KS, Ho CH (2004) Integrated vendor–buyer cooperative models with stochastic demand in controllable lead time. Int J Prod Econ 92:255–266

[13] Pan CHJ, Yang JS (2002) A study of an integrated inventory with controllable lead time. Int J Prod Res 40:1263–1273

[14] Robert, F. (2020). The impact of COVID-19 on small business owners: Evidence from the first three months after widespread social-distancing restrictions. Journal Of Economics & Management Strategy, 29(4), 727-740. Retrieved

[15] Vijayashree M, Uthayakumar R (2016c) Inventory models involving lead time crashing cost as an exponential function. Int J Manag Value Supply Chains 7:29–39