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# Min–max distribution free continuous-review model with a service level constraint and variable lead time

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ABSTRACT

In this paper, we provide a continuous-review $(Q, r, L)$ inventory model with a fill rate service constraint and a negative exponential crashing cost function with a variable lead time. Tajbakhsh [1] developed a closed-form solution that considered an order quantity and a reorder point. We extend the distribution free continuous-review inventory model to minimize the total cost by using a negative exponential lead time crashing cost function, and derive closed-form expressions for the optimal order quantity, reorder point, and lead time. Some numerical examples are presented to illustrate the model. We perform a sensitivity analysis to see the effects of parameter changes on the objective function. We have made the comparisons with the existing model.



## 1. Introduction

It has been reported that the mean and standard deviation of lead time demand is available while the specific distribution of lead time demand is quite difficult to obtain. Therefore, the industry needs a strategy such that the managers can calculate the minimum cost without having the information regarding the distribution of the lead time demand. This is the basic reason that the distribution free approach has been widely studied in the literature. Scarf [2] first suggested a min–max solution for a newsboy problem. Scarf's [2] ordering rule is practical and easy to use, but it is difficult to understand. Therefore, Gallego and Moon [3] simplified the proof of Scarf's [2] ordering rule for the newsboy problem and discussed several extensions including the recourse opportunity. Since then there are enormous number of models in this field which consider the distribution free approach. Moon and Choi [4] used the min–max distribution free approach to develop a continuous-review inventory model with a service level constraint. This was the 1st time to consider the service level constraint in the field of distribution free approach. Moon and Choi [5] provided the make-to-order (MTO) and make-in-advance (MIA) models using the distribution free procedures. They developed a two-echelon stochastic model of composite policies in a single period. They found the optimal on-hand inventory of finished products and raw materials at the beginning of the period when the demand follows a known distribution function. Moon and Yun [6] provided a job control problem by using distribution free approach to determine an optimal release time. The flow time is a random variable with a known probability distribution. They considered a trade-off between the penalty cost for late delivery and the holding cost for early finish. Moon and Choi [7] improved the continuous review inventory model by simultaneously optimizing both the order quantity and reorder point. Ouyang and Wu [8] provided a mixed inventory model with discrete lead time and order quantity as decision variables by the distribution free approach. They considered a service level constraint and developed an improved algorithm to obtain

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decision variables for both the cases i.e., for normal distribution and distribution free. Ben-Daya and Raouf [9] provided inventory models in which both lead time and order quantity are considered as decision variables. Then they proposed a model for different representations of the relationship between lead time crashing cost and lead time. Hariga and Ben-Daya [10] found the optimal reduction in the procurement lead time duration, jointly with the optimal ordering decisions, for some stochastic inventory models. The stochastic models reflected the classical continuous and periodic review models with a mixture of backorders and lost sales along with the base stock model. Bookbinder and Cakanyildirim [11] provided a $(Q, r)$ inventory model with stochastic lead time. They considered that the expected cost per unit time was jointly convex in the decision variable and obtained the global minimizer.

Wu [12] developed a production model by assuming that the ordering quantity is different with the receiving quantity and considered the distribution free approach. Pan et al. [13] derived a variable lead time model with two different types of crashing costs which are functions of lead time and order quantity. Wu et al. [14] extended Pan et al.'s [13] model by assuming defective items but ignoring the rework cost for the defective items. Chu et al. [15] discussed the mixed inventory backorder and lost sales problem in which both the lead time and order quantity were treated as decision variables. They developed lemmas to reveal the parameter effects and then presented two complete procedures for finding the optimal solution for the models. Lin and Chu [16] examined the inventory model with a service level constraint in which the lead time, reorder point, and order quantity were treated as decision variables. They developed lemmas to reveal the parameter's effects and then presented the complete procedures for finding the optimal solution for the inventory model in which the lead time demand is a decision variable. Wu et al. [17] provided a computational algorithmic procedure for an optimal inventory policy involving a negative exponential crashing cost and variable lead time demand. They extended the models of Ouyang et al. [18] and Ouyang and Wu [19] by considering the mixture of normal distributions and the mixture of free distributions, respectively. Deng et al. [20] discussed an inventory model with a negative exponential crashing cost along with time value money.

Agarwal and Seshadri [21] proposed some known bounds for fill rate constraint in a $(Q, r)$ inventory model. They found some upper bounds for an order quantity and a reorder point which indicate that a classical EOQ is the lower bound of the order quantity. They discussed an efficient algorithm that exploits these bounds. These bounds can be used to enhance the efficiency of the existing algorithm. Tajbakhsh [1] derived closed-form expressions for the model of Moon and Choi [4]. Lo [22] discussed an economic order quantity model with lead time reduction and price discount. Hung [23] proposed a continuous review inventory model with time value of money and lead time crashing cost. Chen and Hsiao [24] modified the lead time crashing cost by assuming an allocation for each lot. Jaggi and Arneja [25] discussed a periodic review inventory model with unstable lead time and setup cost with backorder discount. Moon et al. [26] developed a distribution free model for uncertain capacity. Dey and Chakraborty [27] discussed a periodic review inventory model with variable lead time and negative exponential crashing cost. Recently, Sarkar and Majumder [28] derived an integrated inventory model with discrete lead time reduction without any service level constraint. Takemoto and Arizono [29] derived the impact of non-conforming items on $(s,S)$ inventory model with customer order reservation and cancelation. Ning et al. [30] discussed an inventory model with fresh product's deterioration and perishability.

This study extends the model of Moon and Choi [4] with a negative exponential crashing cost related to lead time. According to Ben-Daya and Raouf [9], the crashing cost related to lead time can be used to reduce the total cost, and they derived the closed form expressions by considering order quantity, lead time, and reorder point. This model assumes a negative exponential crashing cost with lead time to reduce total cost. We summarize our contribution compared with other models in Table 1.

This paper is organized as follows: In Section 2, we develop a mathematical model in which closed-form solutions have been obtained. In Section 3, Numerical examples are presented to illustrate our model. A sensitivity analysis has also been performed to see the effects of parameter changes on the objective function. Section 4 summarizes this paper and gives some conclusions.

## 2. Mathematical model

To establish the mathematical model, the following notation and assumptions are used.

Notation

| | |
|---|---|
| $Q$ | order quantity (decision variable) |
| $r$ | reorder point (decision variable) |
| $L$ | lead time (weeks) (decision variable) |
| $h$ | holding cost per unit per unit time |
| $A$ | fixed ordering (setup) cost per order |
| $D$ | average demand per year |
| $X$ | lead time demand (random variable) |
| $\mu$ | average lead time demand |
| $\sigma$ | standard deviation of lead time demand |
| $E(x)$ | mathematical expectation of x |
| $x^+$ | $\max\{x, 0\}$ |
| $E(X-r)^+$ | expected shortage quantity at the end of the cycle |

**Table 1**
Literature review.

| Study | Service level constraint | Distribution free approach | Variable lead time | Crashing cost | Closed form expression |
|---|---|---|---|---|---|
| Tajbakhsh [1] | √ | √ | | | √ |
| Scarf [2] | | √ | | | |
| Gallego and Moon [3] | | √ | | | |
| Moon and Choi [4] | √ | √ | | | |
| Moon and Choi [5] | | √ | √ | | |
| Moon and Yun [6] | | √ | | | |
| Moon and Choi [7] | | √ | | | |
| Ouyang and Wu [8] | √ | √ | √ | √ | |
| Ben-Daya and Raouf [9] | | | √ | √ | |
| Hariga and Ben-Daya [10] | | √ | √ | | |
| Bookbinder and Cakanyildirim [11] | | | √ | | |
| Wu [12] | | √ | √ | | |
| Pan et al. [13] | | √ | √ | √ | |
| Wu et al. [14] | | √ | √ | √ | |
| Lin and Chu [13] | √ | √ | √ | √ | |
| Chu et al. [15] | √ | √ | √ | √ | |
| Wu et al. [17] | | √ | √ | √ | |
| Ouyang and Wu [19] | | √ | √ | √ | |
| Deng et al. [20] | | | √ | √ | |
| Agarwal and Seshadri [21] | √ | √ | | | |
| Lo [22] | | √ | √ | √ | |
| Hung [23] | | √ | √ | √ | |
| Chen and Hsiao [24] | | √ | √ | √ | |
| Jaggi and Arneja [25] | | √ | √ | √ | |
| Moon et al. [26] | | √ | | | |
| Dey and Chakraborty [27] | | | √ | √ | |
| Sarkar and Majumder [28] | | √ | √ | | |
| This study | √ | √ | √ | √ | √ |

Assumptions

1. We consider a negative exponential crashing cost function as in Wu et al. [17]. Because many studies on lead time reduction and setup cost/time reduction used a negative exponential crashing or reduction cost function, we also use a negative exponential crashing cost function [17,20,27]. The total crashing cost is represented:

$$R(L) = \alpha e^{-\theta L}.$$

The values of lead time crashing cost for the values of $L$ are used to estimate the parameters $\alpha$ and $\theta$. The service level is more than 50% and this constraint used to reduce the cost on the distribution free continuous-review inventory model.

We extend Tajbakhsh's [1] closed-form solutions for Moon and Choi's [4] continuous-review $(Q, r)$ inventory model. Our purpose is to reduce the total cost with a negative exponential crashing cost related to lead time. The service level constraint is considered in a different way. We consider the cost equation of Moon and Choi [4] as

$$C(Q,r) = \frac{AD}{Q} + h\left(\frac{Q}{2} + r - \mu\right).$$

Then, we introduce the total cost reduction, which is done through negative exponential crashing cost and variable lead time as described in Wu et al. [17]. The total cost expression is as follows:

$$C(Q,r,L) = \frac{AD}{Q} + h\left(\frac{Q}{2} + r - \mu L\right) + \frac{D}{Q}R(L).$$

Because the lead time crashing cost follows a negative exponential distribution, the cost function can be rewritten as

$$C(Q,r,L) = \frac{AD}{Q} + h\left(\frac{Q}{2} + r - \mu L\right) + \frac{D}{Q}\alpha e^{-\theta L}.$$

Our objective is to minimize the $C(Q, r, L)$ subject to a specified fill rate. The fill rate is defined as the partial demand satisfied directly from inventory.

This service measure is denoted by $\beta$, which equals

$\beta$ = expected demand satisfied per replenishment cycle/expected demand per replenishment cycle.

This $\beta$ is considered as the fraction of customer demand that is met routinely, and can be written as

$$\beta = 1 - \frac{E(X-r)^+}{Q},$$

which reduces to

$$E(X-r)^+ = (1-\beta)Q.$$

Let $\Delta = r - \mu L$ where $\Delta$ is the safety stock.
We can write the cost function as follows:

$$C(Q,\Delta,L) = \frac{AD}{Q} + h\left(\frac{Q}{2} + \Delta\right) + \frac{D}{Q}\alpha e^{-\theta L}.$$

To minimize $C(Q, \Delta, L)$ subjected to a specified service constraint is under the least favorable distribution. This model is solved by the min–max distribution-free approach, which was suggested by Scarf [2] and further explained easily by Gallego and Moon [3]. Using this concept, we obtain the minimum cost at the optimal $(Q, \Delta, L)$ for the least favorable distribution function in $F$.

To obtain the least favorable distribution in $F$, we can use the following lemma as per Gallego and Moon [3]:

$$E(X-r)^+ \leqslant \frac{\sqrt{\sigma^2 L + (r-\mu L)^2} - (r-\mu L)}{2} \quad \text{for any } F \in F.$$

Moreover, this upper bound is tight. By considering $\Delta_\beta$ as the safety stock with respect to $\beta$, we can obtain $\Delta_\beta$ as follows:

$$(\sqrt{(\sigma^2 L + \Delta_\beta^2)} - \Delta_\beta)/2 = (1-\beta)Q,$$

which implies $\Delta_\beta = \frac{\sigma^2 L}{4(1-\beta)Q} - (1-\beta)Q$.
Using $\Delta_\beta$, we obtain

$$C(Q,\Delta_\beta,L) = \frac{AD}{Q} + h\left(\frac{Q}{2} + \Delta_\beta\right) + \frac{D}{Q}\alpha e^{-\theta L} = \frac{AD}{Q} + \left(\beta - \frac{1}{2}\right)hQ + \frac{h\sigma^2 L}{4(1-\beta)Q} + \frac{D}{Q}\alpha e^{-\theta L}.$$

We want to minimize $C(Q, \Delta_\beta, L)$ over $Q > 0$. Because it can be verified that $\frac{\partial^2 C(Q\Delta,_\beta,L)}{\partial Q^2} > 0$ for $Q > 0$, $C(Q, \Delta_\beta, L)$ is a convex function in Q. To obtain a unique global minimizer of $C(Q, \Delta_\beta, L)$ , we solve

$$\frac{\partial C(Q,\Delta_\beta,L)}{\partial Q} = -\frac{AD}{Q^2} + \left(\beta - \frac{1}{2}\right)h - \frac{h\sigma^2 L}{4(1-\beta)Q^2} - \frac{D}{Q^2}\alpha e^{-\theta L} = 0.$$

By assumption, the service level $\beta$ is in $0.5 < \beta < 1$. Hence, we can obtain a unique global minimizer as follows:

$$Q_\beta = \sqrt{\frac{4D(1-\beta)(A+\alpha e^{-\theta L}) + h\sigma^2 L}{2(1-\beta)(2\beta-1)h}}.$$

Again, by using the condition $0 < 2\beta - 1 < 1$, we find

$$Q_\beta > \sqrt{\frac{2AD}{(2\beta-1)h}} > \sqrt{\frac{2AD}{h}} = EOQ.$$

Considering necessary conditions to find the optimal cost value, we determine

$$\frac{\partial C(Q,\Delta_\beta,L)}{\partial Q} = -\frac{AD}{Q^2} + \left(\beta - \frac{1}{2}\right)h - \frac{h\sigma^2 L}{4(1-\beta)Q^2} - \frac{D}{Q^2}\alpha e^{-\theta L},$$

$$\frac{\partial C(Q,\Delta_\beta,L)}{\partial L} = \frac{h\sigma^2}{4(1-\beta)Q} - \frac{D}{Q}\alpha\theta e^{-\theta L}.$$

Equating both of the above equations to zero, we obtain the optimal values of our decision variable as

$$Q_\beta = \sqrt{\frac{4D(1-\beta)(A+\alpha e^{-\theta L}) + h\sigma^2 L}{2(1-\beta)(2\beta-1)h}},$$

$$L_\beta = \frac{1}{\theta} ln\left(\frac{4(1-\beta)\alpha\theta D}{h\sigma^2}\right),$$

$$\Delta_\beta = \frac{\sigma^2 L_\beta}{4(1-\beta)Q_\beta} - (1-\beta)Q_\beta.$$

These closed-form solutions are easier to implement than the iterative procedure described in Moon and Choi [4]. We extended Tajbakhsh's [1] closed-form solutions by considering variable lead time, which can be used to reduce the total cost further.

## 3. Numerical examples

We use the following data for the examples:

$D = 600$ units per year, $A = \$200$ per order, $h = \$20$ per unit per year, $\sigma = 6$ units per week, and $R(L) = 156e^{-\theta L}$, with $L$ in weeks, $\alpha = 156$. $\theta$ is a given parameter.

**Example 1.** We compare the results between two models: one with consideration oflead time crashing cost and service level constraint and another with onlyusinglead timecrashingcost. The comparison is given in Table 2.

We obtain the minimum cost of \$2400.61 while Ben-Daya and Raouf [9] found $C^{*}(Q, L) = \$2692.98$. We saved \$292.37, a 12.18% savings.

**Example 2.** We compare the results between two models: one with crashing cost related to lead time and another with fixed lead time. See Table 3 for the comparison.

We derive that the minimum value occurs at $C^{*}(Q, \Delta_{\beta}, L) = \$2214.43$ and Tajbakhsh [1] found $C^{*}(Q, \Delta_{\beta}) = \$2225.67$. We saved \$11.24, a 0.51% savings.

*Sensitivity analysis*

We performed a sensitivity analysis for key parameters in Examples 1 and 2 and the results are shown in Table 4. If holding cost and ordering cost increase, the total cost of the system is also increased. The opposite nature of cost changes are

**Table 2**
Comparison of two models ($\theta = 1$).

| Distribution free model with a service level constraint and lead time crashing cost | | Distribution free model with lead time crashing cost | |
|---|---|---|---|
| $(Q, \Delta_{\beta}, L)$ | $C^{*}(Q, \Delta_{\beta}, L)$ | $(Q, L)$ | $C^{*}(Q, L)$ |
| (125.03, 5.927, 2.34) | \$2400.61 | (115, 2.17) | \$2692.98 |

**Table 3**
Comparison of two models ($\theta = 6$).

| Distribution free model with lead time crashing cost | | Distribution free model with fixed lead time | |
|---|---|---|---|
| $(Q, \Delta_{\beta}, L)$ | $C^{*}(Q, \Delta_{\beta}, L)$ | $Q, \Delta_{\beta})$ | $C^{*}(Q, \Delta_{\beta})$ |
| (115.34, 0.381, 0.69) | \$2214.43 | (115.92, 1.563) | \$2225.67 |

**Table 4**
Sensitivity analysis for the key parameters.

| Parameters | Changes (in %) | $C^{*}(Q, \Delta_{\beta}, L)$ for $\theta = 1$ | $C^{*}(Q, \Delta_{\beta}, L)$ for $\theta = 6$ |
|---|---|---|---|
| $\alpha$ | −50 | −2.10 | −0.41 |
| | −25 | −0.87 | −0.17 |
| | +25 | +0.67 | +0.13 |
| | +50 | +1.21 | +0.24 |
| $\theta$ | −50 | +5.70 | +2.18 |
| | −25 | +2.17 | +0.78 |
| | +25 | −1.48 | −0.50 |
| | +50 | −2.56 | −0.85 |
| $h$ | −50 | −32.16 | −30.22 |
| | −25 | −15.02 | −13.94 |
| | +25 | +13.65 | +12.46 |
| | +50 | +26.32 | +23.88 |
| $A$ | −50 | −22.53 | −27.19 |
| | −25 | −10.55 | −12.53 |
| | +25 | +9.54 | +11.13 |
| | +50 | +18.31 | +21.24 |

shown for two given parameters $\theta$ and $\alpha$. If $\theta$ is increased, the total cost is decreased while if $\alpha$ is increased, the total cost is increased.

## 4. Conclusions

We presented the distribution free continuous-review $(Q, r, L)$ inventory system with a fill rate as service level. We considered order quantity, reorder point, and lead time as decision variables. Our main goal in developing this model is to reduce total cost by using a negative exponential crashing cost function with related lead time. We developed closed-form expressions for the optimal order quantity, reorder point, and lead time. Using our closed-form expressions, practitioners can easily get results with a smaller total cost. This model can be extended to studies of discrete lead time and fuzzy demand. In addition, developing models with different types of crashing cost functions might be interesting research problems.

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## References

[1] M.M. Tajbakhsh, On the distribution free continuous-review inventory model with a service level constraint, Comput. Ind. Eng. 59 (2010) 1022–1024.
[2] H. Scarf, A min max solution of an inventory problem, in: Studies in the Mathematical Theory of Inventory and Production, Stanford University Press, Stanford, CA, 1958, pp. 201–209.
[3] G. Gallego, I. Moon, The distribution free newsboy problem: review and extensions, J. Oper. Res. Soc. 44 (1993) 825–834.
[4] I. Moon, S. Choi, The distribution free continuous review inventory system with a service level constraint, Comput. Ind. Eng. 27 (1994) 209–212.
[5] I. Moon, S. Choi, Distribution free procedures for make-to-order (MTO), make-in-advance (MIA), and composite policies, Int. J. Prod. Econ. 48 (1997) 21–28.
[6] I. Moon, W. Yun, The distribution free job control problem, Comput. Ind. Eng. 32 (1997) 109–113.
[7] I. Moon, S. Choi, A note on lead time and distributional assumptions in continuous review inventory models, Comput. Oper. Res. 25 (1998) 1007–1012.
[8] L.Y. Ouyang, K.S. Wu, Mixture inventory model involving variable lead time with a service level constraint, Comput. Oper. Res. 24 (1997) 875–882.
[9] M. Ben-Daya, A. Raouf, Inventory models involving lead time as a decision variable, J. Oper. Res. Soc. 45 (1994) 579–582.
[10] M. Hariga, M. Ben-Daya, Some stochastic inventory models with deterministic variable lead time, Eur. J. Oper. Res. 113 (1999) 42–51.
[11] J.H. Bookbinder, M. Cakanyildirim, Random lead times and expedited orders in $(Q,r)$ inventory systems, Eur. J. Oper. Res. 115 (1999) 300–313.
[12] K.S. Wu, $(Q, r)$ Inventory model with variable lead time when the amount received is uncertain, Inf. Manage. Sci. 11 (2000) 81–94.
[13] J.C. Pan, Y.C. Hsiao, C.J. Lee, Inventory models with fixed and variable lead time crashing costs considerations, J. Oper. Res. Soc. 53 (2002) 1048–1053.
[14] J.W. Wu, W.C. Lee, H.Y. Tsai, A note on defective units in an inventory model withsub-lot sampling inspection for variable lead-time demand with the mixture of free distributions, Int. Trans. Oper. Res. 11 (2004) 341–359.
[15] P. Chu, K.L. Yang, P.S. Chen, Improved inventory models with service level and lead time, Comput. Oper. Res. 32 (2005) 285–296.
[16] H.J. Lin, P. Chu, Note on stochastic inventory models with service level constraint, J. Oper. Res. Soc. Jpn. 49 (2005) 117–129.
[17] J.W. Wu, W.C. Lee, H.Y. Tsai, Computational algorithmic procedure of optimal inventory policy involving a negative exponential crashing cost and variable lead time demand, Appl. Math. Comput. 184 (2007) 798–808.
[18] L.Y. Ouyang, N.C. Yeh, K.S. Wu, Mixture inventory model with backorders and lost sales for variable lead time, J. Oper. Res. Soc. 47 (1996) 829–932.
[19] L.Y. Ouyang, K.S. Wu, A minimax distribution free procedure for mixed inventory model with variable lead time, Int. J. Prod. Econ. 56–57 (1998) 511–516.
[20] P.S. Deng, R.H.J. Lin, C.Y. Hung, J. Chang, H. Chao, S.T. Jung, J.S.J. Lin, P. Chu, Inventory models with a negative exponential crashing cost taking time value into account, J. Oper. Res. Soc. Jpn. 51 (2008) 213–224.
[21] V. Agarwal, S. Seshadri, Distribution free bounds for service constrained $(Q,r)$ inventory systems, Naval Res. Logist. 47 (2000) 635–656.
[22] M.C. Lo, Economic ordering quantity model with lead time reduction and backorder price discount for stochastic demand, Am. J. Appl. Sci. 6 (2009) 387–392.
[23] K.C. Hung, Continuous review inventory models under time value of money and crushable lead time consideration, Yugosl. J. Oper. Res. 21 (2011) 293–306.
[24] L.C. Chen, Y.C. Hsiao, Modified controllable lead time model with stochastic demandand batch shipment policy, J. Int. Manage. Stud. 6 (2011) 1–14.
[25] C.K. Jaggi, N. Arneja, Periodic inventory model with unstable lead-time and setup cost with backorder discount, Int. J. Appl. Decis. Sci. 3 (2010) 53–73.
[26] I. Moon, B.H. Ha, J. Kim, Inventory systems with variable capacity, Eur. J. Ind. Eng. 6 (2012) 68–86.
[27] O. Dey, D. Chakraborty, A fuzzy random periodic review system with variable lead time and negative exponential crashing cost, Appl. Math. Model. 36 (2012) 6312–6322.
[28] B. Sarkar, A. Majumder, Integrated vendor-buyer supply chain model with vendor's setup cost reduction, Appl. Math. Comput. 224 (2013) 362–371.
[29] Y. Takemoto, I. Arizono, The impact of non-conforming items on $(s,S)$ inventory model with customer order reservation and cancellation, Industrial Engineering and Management Systems 8 (2009) 72–79.
[30] Y. Ning, L. Rong, J. Liu, Inventory models for fresh agriculture products with time-varying deterioration rate, Ind. Eng. Manage. Syst. 12 (2013) 23–29.