INDIAN JOURNAL OF SCIENCE AND TECHNOLOGY

RESEARCH ARTICLE

Check for updates

OPEN ACCESS

Received: 10-09-2024

Accepted: 08-10-2024

Published: 30-10-2024

Citation: Baggiyalakshmi SA, Maragatham M (2024) An EPQ Model with Varying Demand for Uncertain Quality Products. Indian Journal of Science and Technology 17(40): 4221-4224. https://doi.org/10.17485/IJST/v17i40.2923

* **Corresponding author**.

anusuya1997bhc@gmail.com

Funding: None

Competing Interests: None

Published By Indian Society for Education and Environment (iSee)

ISSN
Print: 0974-6846
Electronic: 0974-5645

An EPQ Model with Varying Demand for Uncertain Quality Products

S Anusuya Baggiyalakshmi[1]*, M Maragatham[2]

1 Research Scholar, PG and Research Dept. of Mathematics, Thanthai Periyar Government Arts and Science College (Autonomous), Affiliated to Bharathidasan University, Tiruchirappalli, Tamil Nadu, India
2 Associate Professor of Mathematics, PG and Research Dept. of Mathematics, Thanthai Periyar Government Arts and Science College (Autonomous), Affiliated to Bharathidasan University, Tiruchirappalli, Tamil Nadu, India

Abstract

Objectives: This article delves into a production inventory model centered on non-deteriorating items amidst fluctuating demand. **Methods**: To minimize the total cost using the sine function as a demand function. **Findings**: In the manufacturing process, there's a chance of product damage, resulting in the final products being either flawless or flawed. Quality assessments occur during production to distinguish the flawless ones for immediate sale, while the flawed ones are marked down for later sale. "In this article, we use a sine function for demand which will increase first, and after a certain point it starts decreasing". **Novelty**: The existing method has discussed only increasing or decreasing demand, but the current study deals with both increasing as well as decreasing at the same time. **Applications**: Seasonal methods like umbrellas, Christmas decorative items, crackers, etc., have increasing demand for the particular season.

Keywords: Production Model; Fluctuating Demand; Sine function; minimizing Total Cost; Flawless items

1 Introduction

In the course of our daily routines, we face a multitude of needs, many of which aren't officially documented. Take seasonal goods, for instance; these products often see a surge in popularity during certain times, only to taper off later. Think of items like raincoats, sweaters, umbrellas, and trendy clothing during holidays and special occasions.

In [1] Maragatham M and Gnanavel G give the purchasing model for a deteriorating item, featuring a delayed payment structure and providing a price discount. Within this framework, the integration of a price discount for retailers is incorporated into the model[2] model introduces scheduling flexible manufacturing systems with stochastic optimization.

In the upcoming model, we discuss the demand with sine function which is not discussed in any other existing model. In this model we consider a particular period of T=180 days in that a seasonal product is considered, at first the demand starts increasing and after a certain time, it starts decreasing which is more relative in real- life situations.

In [3] we can see the best inventory approach for variable production rate with integrated smart production maintenance policy and technology-dependent demand rate is used but in [4], the economic production quantity model with three levels of production is used to obtain this model. [5] explains the non-instantaneous linear deteriorating items by linear time-dependent variable demand function is used and the model is given.

2 Methodology

Inventory management plays a crucial role in the success of any business. Effective management of inventory can lead to cost savings, improved customer satisfaction, and streamlined operations. One popular model used for inventory management is the Economic Production Quantity (EPQ) model. In this article, we will explore the principles of the EPQ model and how it can be effectively utilized for efficient inventory management.

One of the key advantages of the EPQ model is its ability to account for the time required to produce or replenish inventory. This is particularly beneficial for businesses that have in-house production facilities or rely on specific production lead times from their suppliers. To effectively utilize the EPQ model for inventory management, businesses need to consider several key factors. First and foremost, accurate demand forecasting is essential. By having a clear understanding of demand patterns, businesses can optimize their production schedules and minimize excess inventory levels.

In conclusion, the EPQ model offers a robust framework for businesses to optimize their inventory management processes. By considering production lead times, setup costs, and holding costs, businesses can leverage the EPQ model to minimize inventory-related expenses while maintaining adequate stock levels to meet customer demand. With the integration of technology and a focus on continuous improvement, businesses can harness the power of the EPQ model to achieve efficient and effective inventory management.

3 Results and Discussions

We address the need with a sine function in the next model, which is not covered in any other model that is currently in use. In this model, we take into account a specific time period, T=180 days, for a seasonal commodity. The demand for the product initially increases and then begins to decline after a set amount of time, more in line with real-world circumstances.

Also, we deal with Minimizing Total Cost for finding Total Cost we found Screening Cost, Holding Cost, and Production Cost.

3.1 Assumptions and Notations

Assumptions:

- Demand is a sine function over (0-T) where (T=180) days.
- One product is considered over a period of time.
- All products are taken as good.
- Both production and consumption will be in the period of $0 \ to \ t_1$.
- Production will be stopped at t_1.
- After t_1 only consumption occurs.

Notations:

- P – Production rate per unit time.
- Q - Inventory level
- D(t) – demand rate, $D(t) = kt - bsint$ where k and b are positive constants.
- d – Screening Cost per unit.
- c_1 – Holding Cost per unit.
- T- The length of total time we consider (T=180 days).
- t_1 – At the time the production will get stopped
- h – holding cost per unit.
- TC – Total Cost.

3.2 Mathematical Modelling

Our forthcoming model addresses demand with sine function, a topic not covered by any other model that is currently in use. In this model, a specific time period T is taken into account. A seasonal product is taken into account, where demand initially increases and then gradually declines over time, more in line with real-world circumstances.

$$\frac{dI(t)}{dt} + \theta I(t) = kt - bsint \quad 0 \le t \le t_1 \tag{1}$$

$$\frac{dI(t)}{dt} = -bsint \quad t_1 \le t \le T \tag{2}$$

Integrate Equation (1) we get

$$I(t) \,.\, e^{\int \theta dt} = \int e^{\int \theta dt} (kt - bsint) dt + c$$

$$I(t) = \left[\frac{kt}{\theta} - \frac{k}{\theta^2} - \frac{t}{\theta} + \frac{1}{\theta^2} + \frac{t^3}{6\theta} - \frac{t^2}{2\theta^2} + \frac{t}{\theta^3} - \frac{1}{\theta^4}\right] + \left[\frac{k-1}{\theta^2} + \frac{1}{\theta^4}\right] e^{-\theta t};\, 0 \le t \le t_1 \tag{3}$$

From Equation (2), integrate we get

$$I(t) = bcost + c \tag{4}$$

$$I(t_1) = bcost_1 + c \tag{4.1}$$

In Equation (3) put $t = t_1$, we get

$$I(t_1) = \left[\frac{t_1 6(k-1) + t_1^3}{6\theta} + \frac{2(1-k) - t_1^2}{2\theta^2} + \frac{t_1}{\theta^3} - \frac{1}{\theta^4}\right] + \left[\frac{k-1}{\theta^2} + \frac{1}{\theta^4}\right] e^{-\theta t_1} \tag{3.1}$$

From Equation (3.1) and Equation (4.1) the LHS is equal so equating RHS

$$bcost_1 + c = \left[\frac{t_1 6(k-1) + t_1^3}{6\theta} + \frac{2(1-k) - t_1^2}{2\theta^2} + \frac{t_1}{\theta^3} - \frac{1}{\theta^4}\right] + \left[\frac{k-1}{\theta^2} + \frac{1}{\theta^4}\right] e^{-\theta t_1}$$

Substitute $'c'$ in Equation (4)

$$I(t) = bcost + \frac{kt_1^2}{2} - \frac{t_1^2}{2} - \frac{kt_1^3\theta}{6} + \frac{\theta t_1^3}{6} + \frac{bt_1^2}{2} - b;\, t_1 \le t \le T \tag{5}$$

Screening Cost

$$SC = d\int_0^{t_1} I(t)\, dt$$

$$= d\int_0^{t_1} \left[\frac{kt}{\theta} - \frac{k}{\theta^2} - \frac{t}{\theta} + \frac{1}{\theta^2} + \frac{t^3}{6\theta} - \frac{t^2}{2\theta^2} + \frac{t}{\theta^3} - \frac{1}{\theta^4}\right] + \left[\frac{k-1}{\theta^2} + \frac{1}{\theta^4}\right] e^{-\theta t}\, dt$$

$$SC = d\left[\frac{(k-1)\,t_1^3}{6} - \frac{(k-1)\,\theta t_1^4}{24}\right] \tag{6}$$

Holding Cost

$$HC = c_1\left[\int_0^{t_1} I(t) + \int_{t_1}^{T} I(t)\right]$$

$$= c_1\left[\int_0^{t_1}\left[\tfrac{kt}{\theta}-\tfrac{k}{\theta^2}-\tfrac{t}{\theta}+\tfrac{1}{\theta^2}+\tfrac{t^3}{6\theta}-\tfrac{t^2}{2\theta^2}+\tfrac{t}{\theta^3}-\tfrac{1}{\theta^4}\right]+\left[\tfrac{k-1}{\theta^2}+\tfrac{1}{\theta^4}\right]e^{-\theta t}dt+\int_{t_1}^{T}\left(bcost+\tfrac{kt_1^2}{2}-\tfrac{t_1^2}{2}-\tfrac{kt_1^3\theta}{6}+\tfrac{\theta t_1^3}{6}+\tfrac{bt_1^2}{2}-b\right)dt\right]$$

$$HC = c_1\left[\frac{t_1^3}{3}-\frac{kt_1^3}{3}+\frac{k\theta t_1^4}{8}-\frac{\theta t_1^4}{8}+\frac{bt_1^2T}{2}+\frac{bt_1^2T}{2}+\frac{kt_1^2T}{2}-\frac{t_1^2T}{2}-\frac{kt_1^3\theta T}{6}+\frac{\theta t_1^3T}{6}-\frac{bT^3}{6}\right]$$

Average Total Cost is

$$TC=\tfrac{1}{T}\left\{A+p(kt_1)+c_1\left[\tfrac{t_1^3}{3}-\tfrac{kt_1^3}{3}+\tfrac{k\theta t_1^4}{8}-\tfrac{\theta t_1^4}{8}+\tfrac{bt_1^2T}{2}+\tfrac{bt_1^2T}{2}+\tfrac{kt_1^2T}{2}-\tfrac{t_1^2T}{2}-\tfrac{kt_1^3\theta T}{6}+\tfrac{\theta t_1^3T}{6}-\tfrac{bT^3}{6}\right]+d\left[\tfrac{(k-1)t_1^3}{6}-\tfrac{(k-1)\theta t_1^4}{24}\right]\right\}$$

Differentiate with respect to "t_1"

$$\frac{\partial TC}{\partial t_1}=\frac{1}{T}\left\{pk+c_1\left[t_1^2-kt_1^2+\frac{k\theta t_1^3}{2}-\frac{\theta t_1^3}{2}+bt_1T+kt_1T-t_1T-\frac{kt_1^2\theta T}{2}+\frac{\theta t_1^2T}{2}\right]+d\left[\frac{(k-1)t_1}{2}-\frac{(k-1)\theta t_1^3}{6}\right]\right\}$$

We found the optimum value of t_1 to minimize the Total cost

$$\frac{\partial TC}{\partial t_1}=0$$

Again, differentiating with respect to "t_1"

$$\frac{\partial^2 TC}{\partial t_1^2}=\frac{1}{T}\left\{c_1\left[2t_1-2kt_1+\frac{3k\theta t_1^2}{2}-\frac{3\theta t_1^2}{2}+bT+kT-T-kt_1\theta T+\theta t_1T\right]+d\left[(k-1)t_1-\frac{(k-1)\theta t_1^2}{2}\right]\right\}$$

$$\frac{\partial^2 TC}{\partial t_1^2}>0;$$

The Optimal Solution t_1 can be found by Solving the above equations with any numerical method.

Example:

The values T=180, c_1 =2, K=7, b=4, p=5, d=1, A=10000, and θ=0.04 are examined as an example. We determined the ideal value of t_1 where t_1 =164.29414 days by utilizing the model mentioned above.

4 Conclusion

This study presents a production model that found the optimum value of t_1 where the production should stop thereby minimizing the total cost. In this model, the demand is a sine function which will be more relative to the seasonal products in real-life situations. With this model, we can make a good profit in the seasonal products. The previous EPQ models dealt with either increasing or decreasing demands, variable demands, and linear time-dependent demand; but the proposed model gives an increasing and decreasing demand in a short period, which is more relative to the real-life situation of seasonal products.

References

1) Maragatham M, Gnanavel G. A purchasing inventory model for different deteriorations under permit delay in payments and price discount. *International journal of Engineering & Scientific Research*. 2018;6:2347–6532. Available from: https://www.researchgate.net/publication/357340336.
2) Elyasi M, Altan B, Ekici A, Özener OO, Yanıkoğlu İ, Dolgui A. Production planning with flexible manufacturing systems under demand uncertainty. *International Journal of Production Research*. 2024;62(1-2):157–170. Available from: https://dx.doi.org/10.1080/00207543.2023.2288722.
3) Asghar I, Kim JS. An Automated Smart EPQ-Based Inventory Model for Technology-Dependent Products under Stochastic Failure and Repair Rate. *Symmetry*. 2020;12(3):388–388. Available from: https://dx.doi.org/10.3390/sym12030388.
4) Narang P, Kumari M, De PK. Production Inventory Model with Three Levels of Production and Demand for Deteriorating Item under Price, Stock and Advertisement Dependent Demand. In: Gunasekaran, A, Sharma, K J, Kar, S, editors. Lecture Notes in Operations Research. Springer Nature Singapore. 2023;p. 49–68. Available from: https://doi.org/10.1007/978-981-19-8012-1_4.
5) Rabiu S, Ali MKM. Optimizing inventory dynamics: a smart approach for non-instantaneous deteriorating items with linear time function dependent variable demands and holding costs, shortages with backlogging. *Journal of Applied Mathematics and Computing*. 2024;70(4):3193–3217. Available from: https://dx.doi.org/10.1007/s12190-024-02089-1.