ISSN PRINT 2319 1775 Online 2320 7876
Research paper Volume 11, Iss 10, 2022

Profit Analysis of Particle Swarm Optimization based Inventory System

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Abstract

Particle swarm optimization is a set of intelligent search tools used to solve suboptimal problems to reduce total inventory cost or maximize total profit. In this study, the particle swarm optimization (PSO) method was used to improve the overall results of the inventory model. Additionally, solutions for optimizing order quantity and cost effectiveness are discussed in detail. Here we consider a numerical example demonstrating the use of the design and, finally, we perform sensitivity analysis of the variable using the best product.
Keywords: Inventory, particle swarm optimization, deteriorating items, profit.

Introduction

The problems of damaged products and the demand for shredded products will be crucial to the simple answer of inventory control and the results of the OR research study. Due to the competitive market and uncertainty, it is very difficult for any production and sales enterprise to ensure the stability of its design. The handling and distribution of goods is an essential part of the reasonable price and operation of any business owner, whether it is a seven-star hotel, a printing house, a manufacturing company's store or a hospital. Inventory accounts for a large portion of a company's total assets and requires inventory management. Material costs make up the majority of these models, and inventory makes up a significant portion of the operating budget. Therefore, product management and product management play an important role in product management. Special attention is maintained during cleaning of the product/item as the product does not deteriorate.

Particle swarm optimization is widely used to solve many real-time nonlinear optimization problems. Ouyang et al. (2006) called this phenomenon “non-immediate spoilage” and created non-immediate inventory for damaged goods while allowing for delayed payment. Mana and Chaudhari (2006) and Zhou and Gu (2007) present an ideal product for a weak product. Liao (2008) presents an uncontained emergency economic order quantity (EOQ) inventory of nonperforming products on secondary credit standby. Lee et al. (2010) report on negative evaluation of inventory research. Singh and Malik (2010, 2011) investigated the demand pattern of inventory of goods with poor location storage capacity. Malik and Singh. (2011) provides information about the analysis of product management systems and software application processes to determine different needs.

Gupta et al. (2013) stated that the most important decision for the inventory of the product is the model suitable for the damaged equipment. Sarkar and Sarkar (2013) refer to high stock levels to prevent multiple disasters in inventory needs in case of partial backlog. Sarkar and Sarkar (2013) reported the financial version in which costs are cheaper in production. Singh et al. (2014) analyzed product models using computational software. Some

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of the most significant additional data regarding direct adverse effects of the product was found by Singh et al. (2011), Sharma et al. (2013), Malik et al. (2016, 2018, 2021), Vikram et al. (2016), Mathur et al. 2019). Sarkar et al. (2015) provides quality improvement and cost savings in stock products by managing delivery times. Malik et al. (2008, 2016) investigated the impact of time differences on the demand for products. Malik et al. (2014) and Yadav and Malik (2014) investigate optimization for different models, auctions, inventory, and simulation strategies. Recently, Tyagi et al. (2022) and Malik et al. (2022) emphasized the impact of uncertainty in the stock market.

The use of particle swarm optimization methods in solving production and sales problems has become a new trend in recent years. Many optimization methods can be used to solve business problems. Pauley et al. (2007) provide a comprehensive overview of particle swarm optimization (PSO) techniques. Kennedy and Eberhart in 1995; Shi and Eberhart (1998) discovered particle swarm optimization technology. Particle Swarm Optimization (PSO) guidelines have different features available in the search space. Mousavi et al. (2017) and Kumar et al. (2022) studied optimization guidelines to deal with inconsistencies and inventory management in the supply chain. Since the planning process is non-linear, optimization techniques and particle swarm optimization techniques are used as methods. To find the meaning of numbers, we look for their meaning.

Notations and Assumptions

In order to get the best results from this system, we use the following symbols and ideas here:

$D=d_1-d_2t$	Demand of the item
L	Maximum inventory level
R	Maximum life-time for the product
Cd	Deteriorating cost per item
Cs	Sales revenue cost per item
Co	Ordering cost per order
C_h	Holding cost per unit time per item
Cp	Purchasing cost per item
$\theta(t)$	Time-dependent deteriorating rate, $\theta(t)=\frac{1}{1+R-t}$, where $0\leq\theta(t)\leq 1$,
TPF	Profit inventory function

1. The demand rate is the linear decreasing function of time.
2. Lead-time is zero and the shortages are not used here.

Mathematical Model

In this case, the product level (N_1) decreases and does not become negative due to the need for the [0, t_1] interval (Figure 1). Demand and destruction begin immediately after time t_1 and stop when the stock drops to zero. From the differential equation [0, T] the product level of development over time can be determined:

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$$\frac{dN_1(t)}{dt} = -D(t) \qquad 0 \le t \le t_1 \qquad \ldots (1)$$

$$\frac{dN_2(t)}{dt} + \frac{1}{1+R-t} I_2(t) = -D(t) \qquad t_1 \le t \le T \qquad \ldots (2)$$

Using the boundary conditions $N_1(0) = L$, $N_1(T) = 0$ respectively. From (1) and (2), we get

$$N_1(t) = L - d_1 t + d_2 \frac{t^2}{2}, \qquad 0 \le t \le t_1 \qquad \ldots (3)$$

$$N_2(t) = (1+R-t)\left[d_3 \log\left(\frac{1+R-t}{1+R-T}\right) + d_2(T-t)\right], \quad t_1 \le t \le T \qquad \ldots (4)$$

Where $d_3 = d_1 - d_2(1+R)$

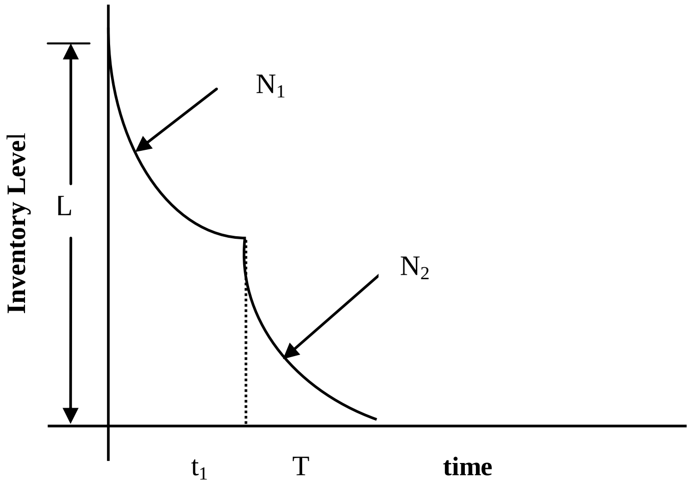

Fig.1 Inventorymodel

Due to continuity of N(t) at t=t_1, from equations (3) and (4), we have

$$\Rightarrow \qquad L = d_1 t_1 - d_2 \frac{t_1^2}{2} + \left(d_3 \log\left(\frac{1+R-t_1}{1+R-T}\right) + d_2(T-t_1)\right) \qquad \ldots (5)$$

The optimum inventory profit function per cycle contains the following values:

Sales revenue cost per cycle

$$SRC = C_s \int_0^T D(t)\,dt = C_s\left[d_1 T - d_2 \frac{T^2}{2}\right] \qquad \ldots (6)$$

Ordering cost

OC= C_o …(7)

Holding cost

$$HC = C_h \left(\int_0^{t_1} N_1(t)dt + \int_{t_1}^{T} N_2(t)dt \right)$$

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$$= C_h \left[\begin{array}{l} Lt_1 - \frac{d_1}{2} t_1^2 + \frac{d_2}{6} t_1^3 + (1+R)\left\{ d_3 (T - t_1) + \frac{d_2}{2} (T - t_1)^2 \right\} \\ + \frac{d_3}{4}\left(T^2 - t_1^{\ 2}\right) + \frac{d_3 (1+R)}{2} (T - t_1) - \frac{d_2}{6}\left(T^3 + 2t_1^3 - 3Tt_1^2\right) \\ + d_3 \log\left(\frac{1+R-t_1}{1+R-T}\right)\left\{ \frac{(1+R)^2}{2} - t_1 (1+R) + \frac{t_1^2}{2} \right\} \end{array} \right] \ldots.(8)$$

Deterioration cost

$$DC = C_d \int_{t_1}^{T} \theta(t)\ N_2(t) dt$$

$$= C_d \left[d_3 (T - t_1) + d_3 (1 + R - t_1) \log\left(\frac{1+R-t_1}{1+R-T}\right) + \frac{d_2}{2}(T - t_1)^2 \right] \qquad \ldots(9)$$

Purchasing cost

$$PC = C_p \times L = C_p \left[\begin{array}{l} d_1 t_1 - d_2 \frac{t_1^2}{2} \\ + (1 + R - t_1)\left(d_3 \log\left(\frac{1+R-t_1}{1+R-T}\right) + d_2 (T - t_1) \right) \end{array} \right] \ldots.(10)$$

Thus the optimum profit function (TPF) per cycle per unit time is

$$TPF = \frac{1}{T}[SRC - OC - HC - DC - PC] \qquad \ldots.\ (11)$$

To determine the optimal cycle time T*, we have to maximize the profit inventory function. To minimize the TPF, we have

$$\frac{dTPF}{dT} = 0 \text{ and } \qquad \frac{d^2 TPF}{dT^2} < 0 \qquad \ldots.\ (12)$$

The inventory profit function is highly non-linear in nature.

Particle Swarm Optimization

Generally speaking, managers rely on mathematical calculations and computer models developed by mathematicians, statistics, and business engineers to solve management and control problems. There are many best practices that are exempt because they have certain pricing models and limitations. Particle swarm algorithm (PSO) technology is a special research based on the behavior of bird flocks. Eberhart and Kennedy developed this algorithm. The proposed strategy assumes that inventory management is modeled using a particle swarm optimization (PSO) strategy with variable costs.

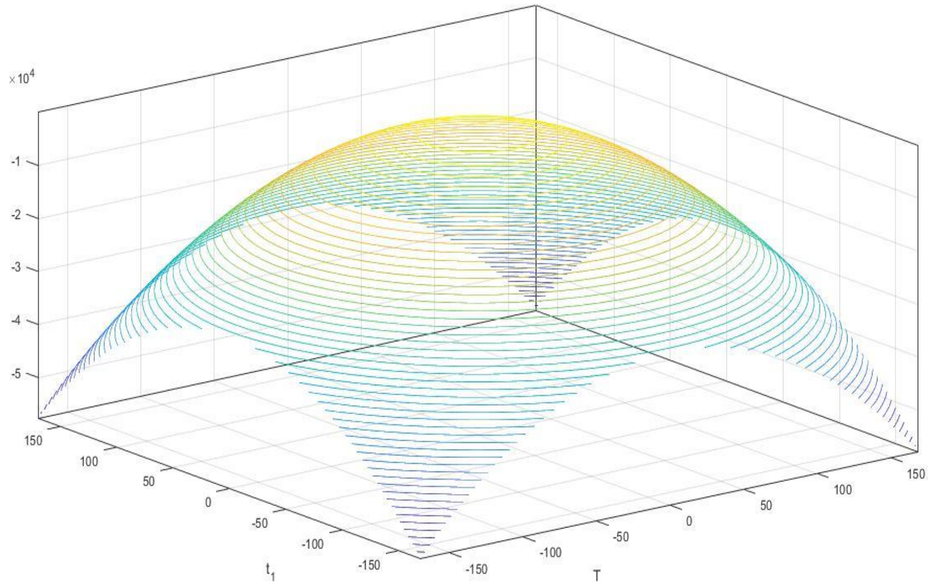

Fig.2 Total Profit function with PSO

This audited build and evaluation is within the well-known framework and can be extended to include optimization strategies and PSO algorithms helps professionals with seasonal goods including fruits, vegetables, packaged foods, medicines, luxury goods, and more.

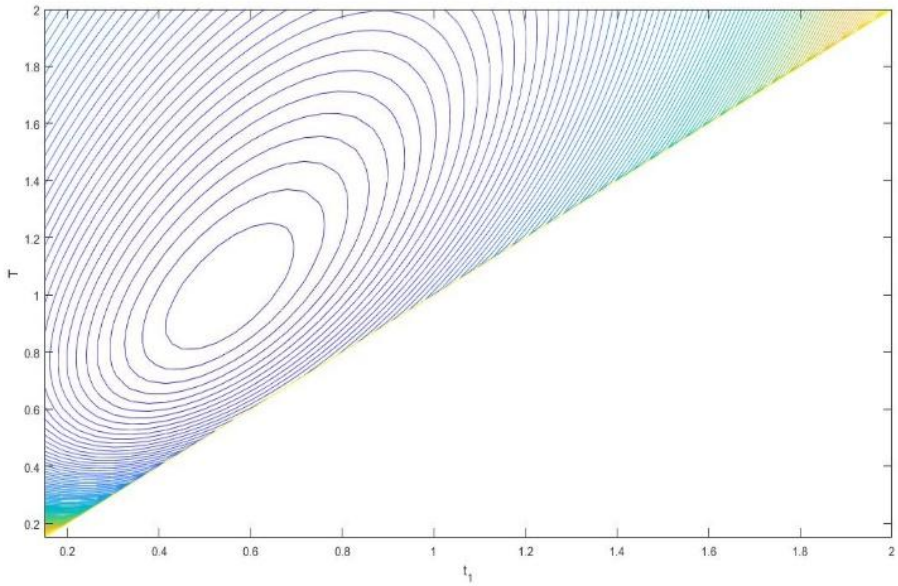

Fig.3 Graphical representation of PSO

Numerical example

Due to incorrectness and uncertainty of the parameters, it is very difficult and risky to a business manager of a production firm to make a perfect model with exact data for their future work. However, we take the following values of the parameters used: C_o=100, C_p=10, C_h=0.25, C_d=5, R=25 and d_1=1000, d_2=10, Cs=6.

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C_o	C_p	C_h	C_d	C_d	t_1*	T*	L*	TPF
110	9	0.26	4	6	0.6448	2.4241	105.76	1324.21
100	9	0.26	4	6	0.7048	2.4269	105.76	1472.41
90	9	0.26	4	6	0.8449	3.3139	105.76	1718.01
110	5.1	0.26	4	6	0.9421	3.0012	105.76	1162.41
100	5.2	0.26	4	6	0.5642	3.9142	105.76	1354.62
90	5.3	0.26	4	6	0.7162	4.0162	181.62	1556.98
110	9	0.26	4	6	0.8188	4.9004	106.49	1449.08
100	9	0.28	4	6	0.8189	4.1124	106.49	1359.07
90	9	0.30	4	6	0.9273	4.1124	106.49	1849.98
110	9	0.26	4	6	0.7074	1.8924	106.49	1946.08
100	9	0.26	5	6	0.7742	1.8829	106.49	1844.01
90	9	0.26	6	6	0.7949	0.4162	108.81	1654.02
110	9	0.26	4	6.1	0.6942	0.8157	116.72	1762.81
100	9	0.26	4	6.2	0.6824	0.88461	120.81	1764.82
90	9	0.26	4	6.3	0.6449	0.88461	120.81	1866.09

Using the PSO techniques, we get the optimum result as the optimal ordering cycle T*=2.4269, TPF*=1472.21 and L*=105.76.

Conclusion

In most of the higher inventory models, the researchers, authors indicate a fixed rate of deterioration. However, in general terms, the maximum number of goods / items is transferred to the pot since their maximum lifespan is about to expire. However, according to the authors, the view of construction time as a function of various weather deteriorations, that is, the neutral material, has not yet been agreed upon. The concept of this optimization model for research studies can be used for many commercial industries, sectors, manufacturing companies and retail businesses. Finally, the costs / benefits of the product model are measured numerically and characterized by various parameters to achieve the same results. For further research, we looked at changes in product demand, price differences between members, inflation, demand, partial orders and environmental uncertainty etc.

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