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Original Article

A Deterministic Inventory Model for Deteriorating Items with Biquadratic Demand, Constant Deterioration Rate and Salvage Value

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Abstract *- A deterministic inventory model is designed for the study to focus on deteriorating items with biquadratic demand, constant deterioration rate, and salvage value. The model works towards optimizing inventory levels to maximize Profit by efficiently managing perishable products. The study provides analytical solutions and numerical examples to showcase the practical application of the model in inventory management. In addition, the sensitivity analysis further explores the impact of the essential parameters in inventory management, highlighting the real-world applicability of the model.*

Keywords *- Inventory, Deterioration, Demand, Profit, Salvage Value.*

1. Introduction

Inventory management becomes a complex task for companies dealing with perishable items. The need for operative inventory control in such concerns would result in considerable financial loss. In some cases, it would also affect the availability of requisite items in the market. The existing traditional models have some impediments in managing perishable items, leading to product waste and financial loss. Ensuring cost-effectiveness and service quality are vital, and this can be achieved through improvised inventory management systems that, in turn, will lead to minimize costs and maximize profits.

The unpredictable demand nature of perishable goods or products is a major challenge in inventory control. The nature of floating demand is determined by factors like seasonal changes, market trends, and customer needs. The deteriorating nature of the products is another key factor that affects inventory decisions. The entangled demand structures ha ve a direct impact on Profit. The inconsistency in demand and deterioration is the biggest challenge that the existing models have not been able to completely resolve. Therefore, for the current investigation, a comprehensive model is developed that accounts for a constant deterioration rate and salvage value of unsold items, besides considering the variable nature of demand through a biquadratic demand function.

Inventory Models for perishable goods are gaining momentum in research primarily due to the deteriorating nature of products. Various studies have developed deterministic models considering varying demand patterns, deterioration rates and product costs. Constructive inventory control for such items is essential to minimize waste and optimization of resources.

A study carried out by Ghare and Schrader (1963) is a pioneering work that proposed the concept of exponential deterioration in inventory models, laying the foundation for further research. Later, this model was further extended by Covert and Philip (1973), using a Weibull distribution model considering variable deterioration for effective reflection of the real-world conditions. Shah and Jaiswal (1977) designed an order-level inventory model that takes into account the constant deterioration rate of inventory costs and control strategies.

Dave and Patel (1981) developed a time-dependent demand model for the study of deteriorating items, incorporating proportional cost considerations, highlighting the dynamic nature of demand patterns. Similarly, Hollier and Mark (1983) analyzed the replenishment policies framed for perishable items, emphasizing cost-effectiveness and adaptive strategies.

Ghosh and Chaudhuri (1991) added to this line of research by developing an EOQ model for examining the deteriorating items with shortages and linear demand, stressing the significance of dynamic demand in inventory control.

The study by Goyal and Giri (2001) provided a comprehensive review of the recent trends in deteriorating inventory modeling confronting demand variations, time-dependent holding costs, and shortages, opening gates for future research in the field.

An inventory model for time-dependent deteriorating items was developed by Mishra and Shah (2008), incorporating salvage value to enhance the inventory control of perishable goods. Venkateswarlu and Mohan (2014) introduced a quadratic demand model taking into account the constant deterioration and salvage value for realistic demand representation. Vinod Kumar Mishra (2014) explored models with regard to controllable deterioration rates, underscoring time-dependent demand and varying holding costs.

Further developments were made by Parmar Kitan and Gothi (2015), investigating EOQ models in view of constant deterioration rates and time-dependent demand, accommodating variable patterns. Karthikeyan and Shanthi (2015) made further advancements in the field by including cubic demand and salvage value, addressing complex demand scenarios. Similarly, Tripathi and Tomar (2018) proposed a quadratic time-sensitive demand model considering parabolic holding costs and salvage value for time-dependent factors.

Kumar (2019) concentrated on linear demand with regard to parabolic holding costs and salvage value, unravelling dynamic cost structures. Rahman and Uddin (2020) used a quadratic demand model to study the variable deterioration rates in time-dependent settings, underlining scenarios without shortages to manage economic uncertainties.

Recent advancement includes the study carried out by Aliyu and Sani (2020) with a generalized application of exponential demand considering constant holding and deterioration rates for further optimization of non linear systems. Suman and Kumar (2022) introduced deterministic inventory models with biquadratic demand and weibull deterioration rates, providing insights into fluctuating demand. Pooja Soni and Rajender Kumar (2022) examined it with a biquadratic demand taking variable deterioration rates and carrying costs for effective management of perishable items. Pathak et al. (2024) investigated two-warehouse inventory models with regard to biquadratic demand, shortages and inflation under economic constraints.

This paper fills the research gap by considering the salvage value and biquadratic demand associated with the inventory model. The inclusion of salvage value in deterministic inventory models of deteriorating items paves the way for precise cost and Profit analysis by considering the residual value of unsold or partially deteriorated items. The model helps in efficient inventory management by optimizing order quantity and cutting down losses.

2. Notations and Assumptions

2.1. Notations

The Mathematical model is based on the following notations:

$I(t)$: Inventory level at time $t,\ 0 \leq t \leq T$

$D(t)$: The demand rate is deterministic and is a biquadratic function of time

$D(t) = a + bt + ct^2 + dt^3 + et^4,\ 0 \leq t \leq T$, where a, b, c, d, e ≠ , and 0 are constants.

θ : Constant deterioration rate $(0 \leq \theta \leq 1)$

o_c : Ordering cost per unit time

h_c : Constant holding cost per unit per time unit

p_c : Purchase cost per unit

p: Selling price per unit

d_c : Deterioration cost per cycle

Q : Order quantity or replenishment quantity

I_0 : Initial inventory level to meet starting demand

T : Cycle length

γ : Salvage coefficient

$TP(T)$: Total Profit per unit time

TP^* : Maximum Profit per unit time

T^* : Optimum cycle length

Q^* : Economic order quantity or optimal order quantity

2.2. Assumptions

The Mathematical model is based on the following assumptions:

1. Time Horizon: The model assumes an infinite time period for inventory management.
2. Demand Rate: The Demand rate is deterministic and varies biquadratically with time.
3. Deterioration Rate: Items deteriorate at a constant rate over time.
4. Salvage Value: Items have a salvage value if unsold by their end-of-life cycle.

5. Replenishment: Inventory is replenished instantaneously when required with no lead time.
6. Shortages are not allowed, ensuring demand is always met.
7. Holding cost: Holding costs remain constant over time.
8. Single-item inventory: The model is designed to manage a single item.

3. Mathematical Formulation and Solution of the Model

Let $I(t)$ Denote the inventory level at any time t. The decrease in inventory level results from both demand and deterioration. Over the period $[0, T]$, the inventory level steadily decreases and eventually reaches zero $t = T$.

The following differential equation represents the inventory level over the interval [0, T]

$\frac{dI(t)}{dt} + \theta(t)I(t) = -D(t), \ 0 \le t \le T$

$$\frac{dI(t)}{dt} + \theta I(t) = -(a + bt + ct^2 + dt^3 + et^4) ----- (1)$$

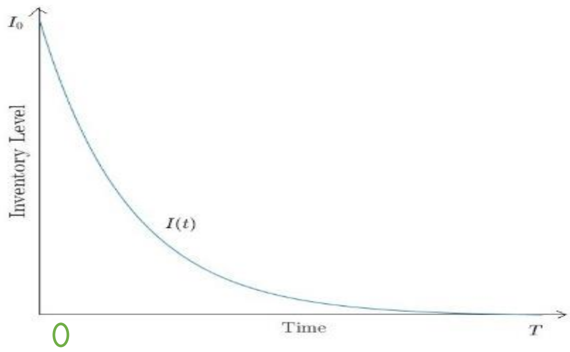

Fig. 1 Graphical Representation of Inventory System

The Solution is

$$I(t)e^{\theta t} = -\left[\left(at + \frac{bt^2}{2} + \frac{ct^3}{3} + \frac{dt^4}{4} + \frac{et^5}{5}\right) + \theta\left(\frac{at^2}{2} + \frac{bt^3}{3} + \frac{ct^4}{4} + \frac{dt^5}{5} + \frac{et^6}{6}\right)\right] + K ----- (2)$$

$$I(t) = 0 \ When \ t = T$$

Equation ② gives

$$K = aT + \frac{bT^2}{2} + \frac{cT^3}{3} + \frac{dT^4}{4} + \frac{eT^5}{5} + \theta\left(\frac{aT^2}{2} + \frac{bT^3}{3} + \frac{cT^4}{4} + \frac{dT^5}{5} + \frac{eT^6}{6}\right)$$

The Solution is

$$\begin{aligned} I(t) = {} & a(T - t) + \frac{b}{2}(T^2 - t^2) + \frac{c}{3}(T^3 - t^3) + \frac{d}{4}(T^4 - t^4) + \frac{e}{5}(T^5 - t^5) + \frac{a\theta}{2}(T^2 - t^2) + \frac{b\theta}{3}(T^3 - t^3) \\ & + \frac{c\theta}{4}(T^4 - t^4) + \frac{d\theta}{5}(T^5 - t^5) + \frac{e\theta}{6}(T^6 - t^6) - a\theta(Tt - t^2) - \frac{b\theta}{2}(T^2t - t^3) - \frac{c\theta}{3}(T^3t - t^4) \\ & - \frac{d\theta}{4}(T^4t - t^5) - \frac{e\theta}{5}(T^5t - t^6) - \frac{a\theta^2}{2}(T^2t - t^3) - \frac{b\theta^2}{3}(T^3t - t^4) - \frac{c\theta^2}{4}(T^4t - t^5) \\ & - \frac{d\theta^2}{5}(T^5t - t^6) - \frac{e\theta^2}{6}(T^6t - t^7) \qquad ----- (3) \end{aligned}$$

The maximum inventory level is obtained by putting $t = 0$ in Equation (3)

$$I_0 = I(0) = aT + \frac{bT^2}{2} + \frac{cT^3}{3} + \frac{dT^4}{4} + \frac{eT^5}{5} + \frac{a\theta T^2}{2} + \frac{b\theta T^3}{3} + \frac{c\theta T^4}{4} + \frac{d\theta T^5}{5} + \frac{e\theta T^6}{6}$$

Ordering cost, $OC = o_c$

Total demand over the cycle period $[O, T] = \int_O^T D(t)\,dt$

$$= aT + \frac{bT^2}{2} + \frac{cT^3}{3} + \frac{dT^4}{4} + \frac{eT^5}{5}$$

Number of deteriorated units = Initial order quantity − Total demand in the cycle period $[O, T]$

$$= I_0 - \int_O^T D(t)dt$$

$$= \frac{a\theta T^2}{2} + \frac{b\theta T^3}{3} + \frac{c\theta T^4}{4} + \frac{d\theta T^5}{5} + \frac{e\theta T^6}{6}$$

Deterioration cost per cycle is

$$DC = d_c \times No\ of\ deteriorated\ units$$

$$= d_c\left(\frac{a\theta T^2}{2} + \frac{b\theta T^3}{3} + \frac{c\theta T^4}{4} + \frac{d\theta T^5}{5} + \frac{e\theta T^6}{6}\right)$$

Total inventory holding cost for the cycle period $[O, T]$ is

$$HC = h_c \int_O^T I(t)\,dt$$

$$HC = h_c\left[\frac{aT^2}{2} + \frac{bT^3}{3} + \frac{cT^4}{4} + \frac{dT^5}{5} + \frac{eT^6}{6} + \frac{a\theta T^3}{6} + \frac{b\theta T^4}{8} + \frac{c\theta T^5}{10} + \frac{d\theta T^6}{12} + \frac{e\theta T^7}{14} - \frac{a\theta^2 T^4}{8} - \frac{b\theta^2 T^5}{10} - \frac{c\theta^2 T^6}{12} - \frac{d\theta^2 T^7}{14} - \frac{e\theta^2 T^8}{16}\right]$$

Purchase cost over the period [0, T] = Purchase cost × Total demand over [0, T]

$$= p_c\left(aT + \frac{bT^2}{2} + \frac{cT^3}{3} + \frac{dT^4}{4} + \frac{eT^5}{5}\right)$$

Sales Revenue = Price × Total demand

$$= p\left(aT + \frac{bT^2}{2} + \frac{cT^3}{3} + \frac{dT^4}{4} + \frac{eT^5}{5}\right)$$

Salvage Value $= \gamma p_c\left(\frac{a\theta T^2}{2} + \frac{b\theta T^3}{3} + \frac{c\theta T^4}{4} + \frac{d\theta T^5}{5} + \frac{e\theta T^6}{6}\right)$

Total Profit per unit time is

$$TP(T) = \frac{1}{T}[Sales\ Revenue - Purchase\ cost - Ordering\ cost - Deterioration\ cost - holding\ cost + Salvage\ value]$$

$$TP(T) = (p - p_c)\left(a + \frac{bT}{2} + \frac{cT^2}{3} + \frac{dT^3}{4} + \frac{eT^4}{5}\right) - \frac{o_c}{T} + (\gamma p_c - d_c)\left(\frac{a\theta T}{2} + \frac{b\theta T^2}{3} + \frac{c\theta T^3}{4} + \frac{d\theta T^4}{5} + \frac{e\theta T^5}{6}\right) - h_c\left(\frac{aT}{2} + \frac{bT^2}{3} + \frac{cT^3}{4} + \frac{dT^4}{5} + \frac{eT^5}{6} + \frac{a\theta T^2}{6} + \frac{b\theta T^3}{8} + \frac{c\theta T^4}{10} + \frac{d\theta T^5}{12} + \frac{e\theta T^6}{14} - \frac{a\theta^2 T^3}{8} - \frac{b\theta^2 T^4}{10} - \frac{c\theta^2 T^5}{12} - \frac{d\theta^2 T^6}{14} - \frac{e\theta^2 T^7}{16}\right)$$

To find: Maximum Profit per unit time

$$\frac{dTP(T)}{dT} = (p - p_c)\left(\frac{b}{2} + \frac{2cT}{3} + \frac{3dT^2}{4} + \frac{4eT^3}{5}\right) + \frac{o_c}{T^2} + (\gamma p_c - d_c)\left(\frac{a\theta}{2} + \frac{2b\theta T}{3} + \frac{3c\theta T^2}{4} + \frac{4d\theta T^3}{5} + \frac{5e\theta T^4}{6}\right) - h_c\left(\frac{a}{2} + \frac{2bT}{3} + \frac{3cT^2}{4} + \frac{4dT^3}{5} + \frac{5eT^4}{6} + \frac{a\theta T}{3} + \frac{3b\theta T^2}{8} + \frac{2c\theta T^3}{5} + \frac{5d\theta T^4}{12} + \frac{3e\theta T^5}{7} - \frac{3a\theta^2 T^2}{8} - \frac{2b\theta^2 T^3}{5} - \frac{5c\theta^2 T^4}{12} - \frac{3d\theta^2 T^5}{7} - \frac{7e\theta^2 T^6}{16}\right)$$

Equating the above equation to zero and simplifying by multiplying both sides by $1680T^2$ In order to determine T that maximizes the total Profit per unit time, as follows:

$$(p - p_c)(840bT^2 + 1120cT^3 + 1260dT^4 1344eT^5) + 1680 \times o_c + (\gamma p_c - d_c)(840a\theta T^2 + 1120b\theta T^3 + 1260c\theta T^4 + 1344d\theta T^5 + 1400e\theta T^6) - h_c(840aT^2 + 1120bT^3 + 1260cT^4 + 1344dT^5 + 1400eT^6 + 560a\theta T^3 + 630b\theta T^4 + 672c\theta T^5 + 700d\theta T^6 + 720e\theta T^7 - 630a\theta^2 T^4 - 672b\theta^2 T^5 - 700c\theta^2 T^6 - 720d\theta^2 T^7 - 735e\theta^2 T^8) = 0$$

The value of T obtained gives the maximum Profit, provided it satisfies $\frac{d^2TP(T)}{dT^2} < 0$.

$$\frac{d^2TP(T)}{dT^2} = (p - p_c)\left(\frac{2c}{3} + \frac{3dT}{2} + \frac{12eT^2}{5}\right) - \frac{2o_c}{T^3} + (\gamma p_c - d_c)\left(\frac{2b\theta}{3} + \frac{3c\theta T}{2} + \frac{12d\theta T^2}{5} + \frac{10e\theta T^3}{3}\right) - h_c\left(\frac{2b}{3} + \frac{3cT}{2} + \frac{12dT^2}{5} + \frac{10eT^3}{3} + \frac{a\theta}{3} + \frac{3b\theta T}{4} + \frac{6c\theta T^2}{5} + \frac{5d\theta T^3}{3} + \frac{15e\theta T^4}{7} - \frac{3a\theta^2 T}{4} - \frac{6b\theta^2 T^2}{5} - \frac{5c\theta^2 T^3}{3} - \frac{15d\theta^2 T^4}{7} - \frac{21e\theta^2 T^5}{8}\right)$$

Substituting the value of T in $\frac{d^2TP}{dT^2}$

we get $\frac{d^2TP}{dT^2} < 0,$ which shows that the total Profit we obtained is maximum.

4. Solution Methodology

To maximize the Profit per unit of time, the following equation must be solved to obtain T.

$$\frac{d(TP)}{dT} = 0 \qquad ------ (4)$$

with the optimality condition

$$\frac{d^2(TP)}{dT^2} < 0 \qquad ------ (5)$$

5. Algorithm

An iterative algorithm is suggested to obtain the optimal results for the total Profit (TP), initial stock (Q), and cycle length (T).

Step 1: Enter the value of every parameter needed for the model.
Step 2: Evaluate the cycle length T using equation (4) and assume this value as T^*.
Step 3: Check the optimality condition using (5).
Step 4: If the condition in step 3 is met, proceed to step 5; if not, go back to steps 1 through 3 for various parameter values.
Step 5: Find the optimal initial inventory stock I_0 Q and TP values for T^*.
Step 6: Stop once the optimal values are found.

6. Numerical Example

This section provides a numerical example to demonstrate the model's practical implementation.

The solution is obtained by applying the algorithm given above. Here MATLAB is used to perform the computations.

Example:

For the given model, the values of various parameters are taken as follows:
a =500, b =35, c=26, d=37, e =17, $\theta = 0.1$, o_c =100, h_c =10, p =15, p_c= 10, d_c=8, $\gamma = 0.1$
The optimal values are obtained as follows
Optimal cycle length (T*) =0.194036 (116.77 days)
Maximum Profit per unit time (TP*) = Rs 1476.10
Economic order quantity (Q) =98.71units.

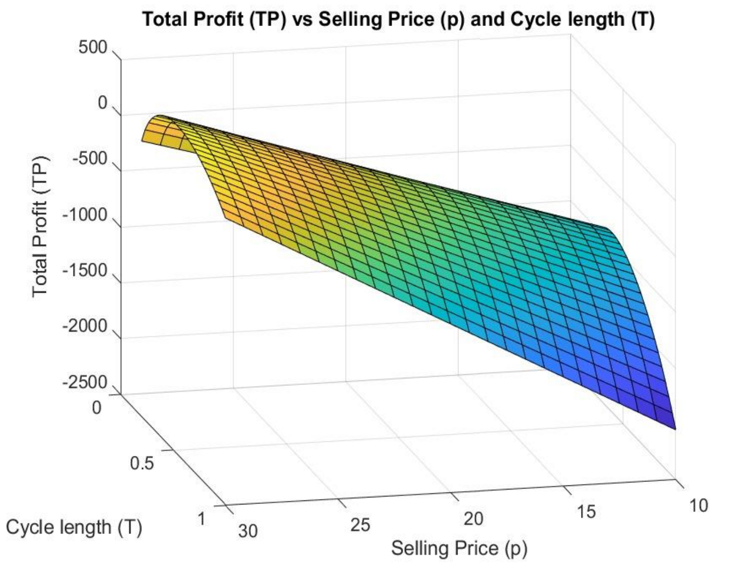

Fig. 2 3 Dimensional graphical representation of TP on the inventory model

7. Sensitivity Analysis

This section presents a sensitivity analysis to illustrate the proposed model. Sensitivity analysis is conducted to study how variations in model parameters affect the total Profit (TP), cycle time (T), and order quantity (Q). The following parameters were individually varied by ±20% and ±10%, and the corresponding changes in TP, T, and Q were observed.

Table 1. Effect of "a" on T, TP and Q

Parameter	Change in parameter	T	TP	Q
a	-20% Change	0.2170	1086.4104	88.7020
	-10% Change	0.2046	1279.7045	93.8351
	10% Change	0.1850	1675.1435	103.3376
	20% Change	0.1770	1876.4787	107.7832

Table 2. Effect of "b" on T, TP and Q

Parameter	Change in parameter	T	TP	Q
b	-20% Change	0.1938	1473.6523	98.4284
	-10% Change	0.1939	1474.8762	98.5667
	10% Change	0.1942	1477.3255	98.8440
	20% Change	0.1943	1478.5510	98.9830

Table 3. Effect of "c" on T, TP and Q

Parameter	Change in parameter	T	TP	Q
c	-20% Change	0.1940	1475.8767	98.6593
	-10% Change	0.1940	1475.9886	98.6823
	10% Change	0.1941	1476.2126	98.7283
	20% Change	0.1941	1476.3246	98.7513

Table 4. Effect of "d" on T, TP and Q

Parameter	Change in parameter	T	TP	Q
d	-20% Change	0.1940	1476.0556	98.6918
	-10% Change	0.1940	1476.0781	98.6985
	10% Change	0.1940	1476.1231	98.7120
	20% Change	0.1941	1476.1455	98.7187

Table 5. Effect of "e" on T, TP and Q

Parameter	Change in parameter	T	TP	Q
e	-20% Change	0.1940	1476.0974	98.7040
	-10% Change	0.1940	1476.0990	98.7046
	10% Change	0.1940	1476.1021	98.7059
	20% Change	0.1940	1476.1037	98.7065

Table 6. Effect of "θ" on T, TP and Q

Parameter	Change in parameter	T	TP	Q
θ	-20% Change	0.1956	1483.6120	99.3081
	-10% Change	0.1948	1479.8477	99.0049
	10% Change	0.1933	1472.3703	98.4095
	20% Change	0.1925	1468.6566	98.1176

Table 7. Effect of "OC" on T, TP and Q

Parameter	Change in parameter	T	TP	Q
OC	-20% Change	0.1738	1584.8377	88.2487
	-10% Change	0.1842	1528.9753	93.6176
	10% Change	0.2034	1425.7746	103.5395
	20% Change	0.2123	1377.6563	108.1614

Table 8. Effect of "HC" on T, TP and Q

Parameter	Change in parameter	T	TP	Q
HC	-20% Change	0.2159	1580.1044	110.0616
	-10% Change	0.2041	1526.6893	103.9160
	10% Change	0.1853	1427.9300	94.2023
	20% Change	0.1777	1381.8595	90.2780

Table 9. Effect of "DC" on T, TP and Q

Parameter	Change in parameter	T	TP	Q
DC	-20% Change	0.1917	-35.2052	97.4982
	-10% Change	0.1929	720.4285	98.0954
	10% Change	0.1952	2231.8119	99.3282
	20% Change	0.1965	2987.5634	99.9645

Table 10. Effect of "pc" on T, TP and Q

Parameter	Change in parameter	T	TP	Q
p	-20% Change	0.1955	2482.7366	99.4410
	-10% Change	0.1947	1979.4117	99.0709
	10% Change	0.1933	972.8031	98.3443
	20% Change	0.1927	469.5190	97.9880

Table 11. Effect of"d_c" on T, TP and Q

Parameter	Change in parameter	T	TP	Q
c_p	-20% Change	0.1955	1483.9721	99.4772
	-10% Change	0.1948	1480.0287	99.0891
	10% Change	0.1933	1472.1875	98.3259
	20% Change	0.1926	1468.2893	97.9507

Table 12. Effect of "γ" on T, TP and Q

Parameter	Change in parameter	T	TP	Q
γ	-20% Change	0.1939	1475.1209	98.6100
	-10% Change	0.1939	1475.6106	98.6576
	10% Change	0.1941	1476.5908	98.7530
	20% Change	0.1942	1477.0812	98.8008

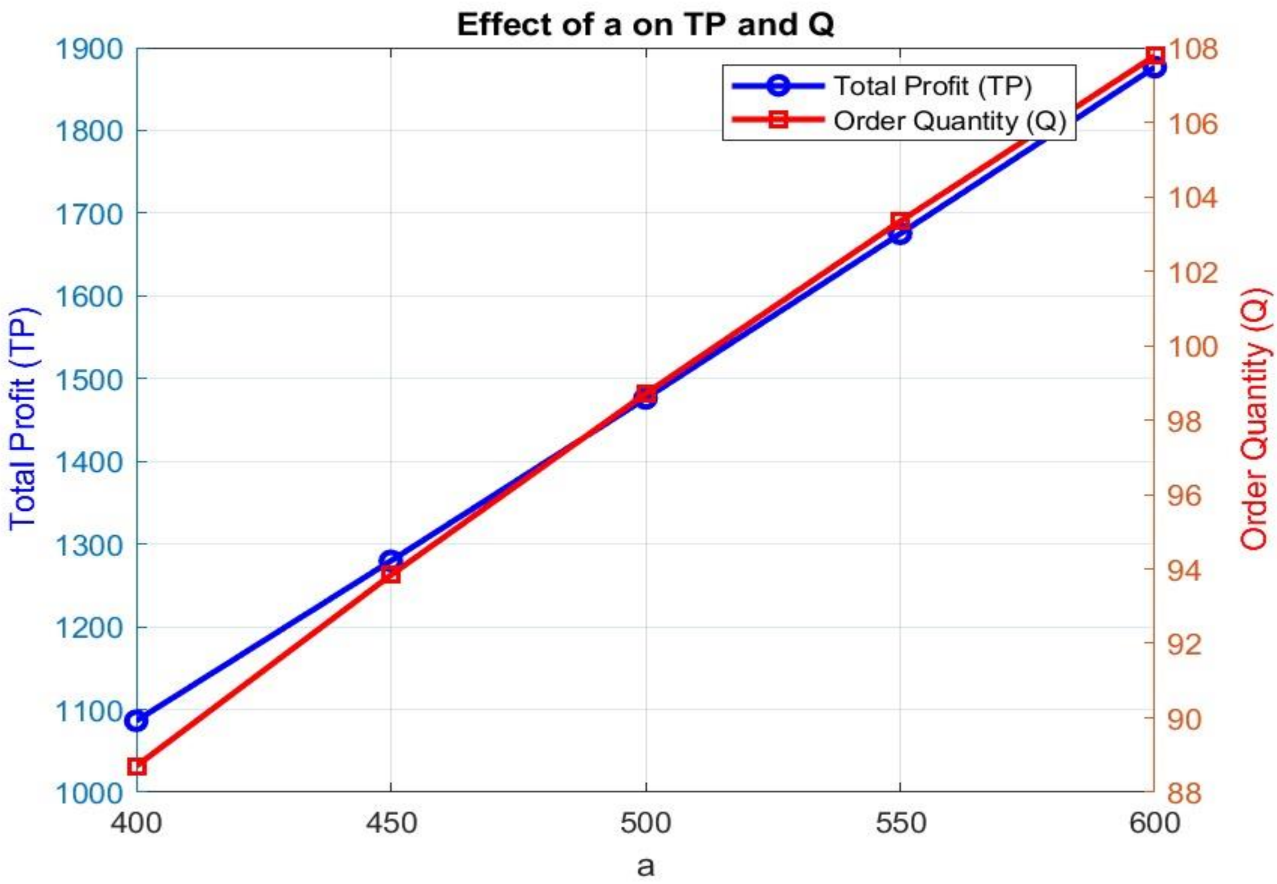

Fig. 3.1

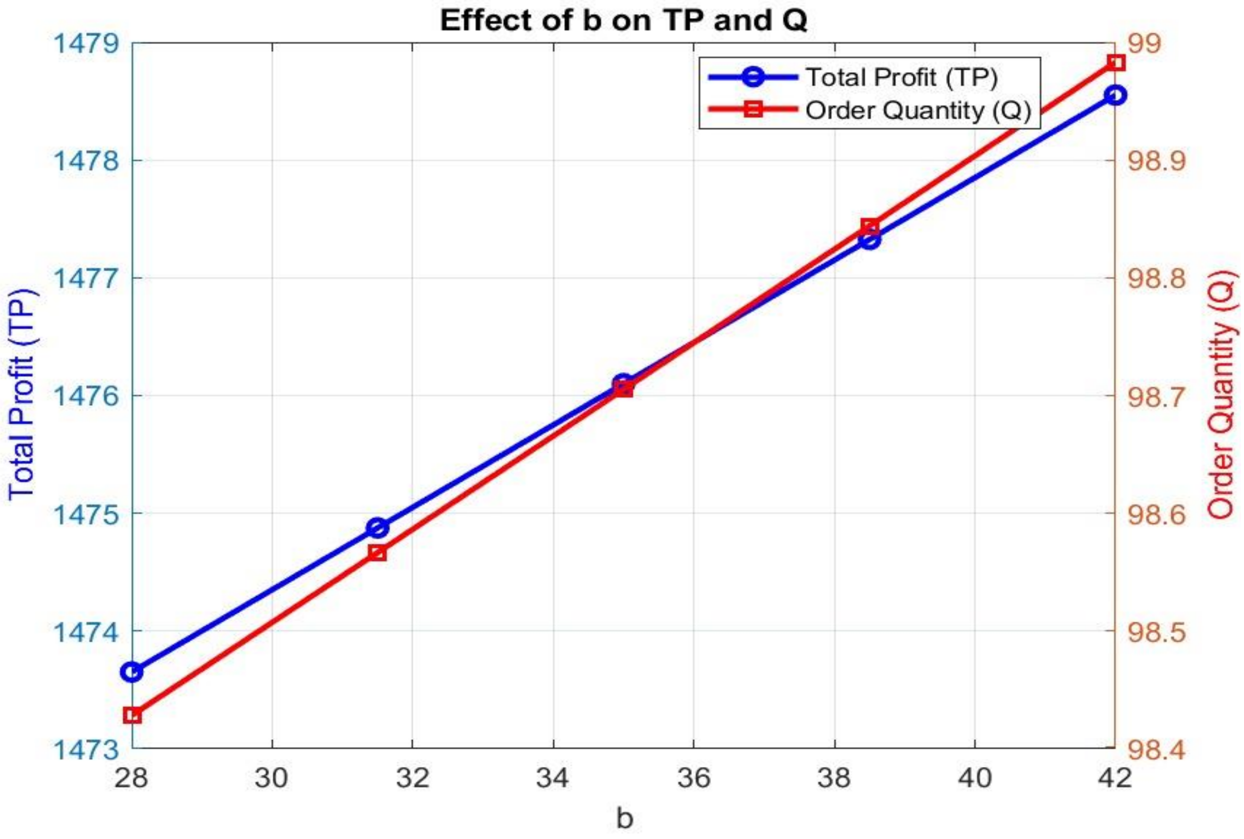
Effect of b on TP and Q
Total Profit (TP)
Order Quantity (Q)
1479
1478
1477
1476
1475
1474
1473
99
98.9
98.8
98.7
98.6
98.5
98.4
28
30
32
34
36
38
40
42
b

Fig. 3.2

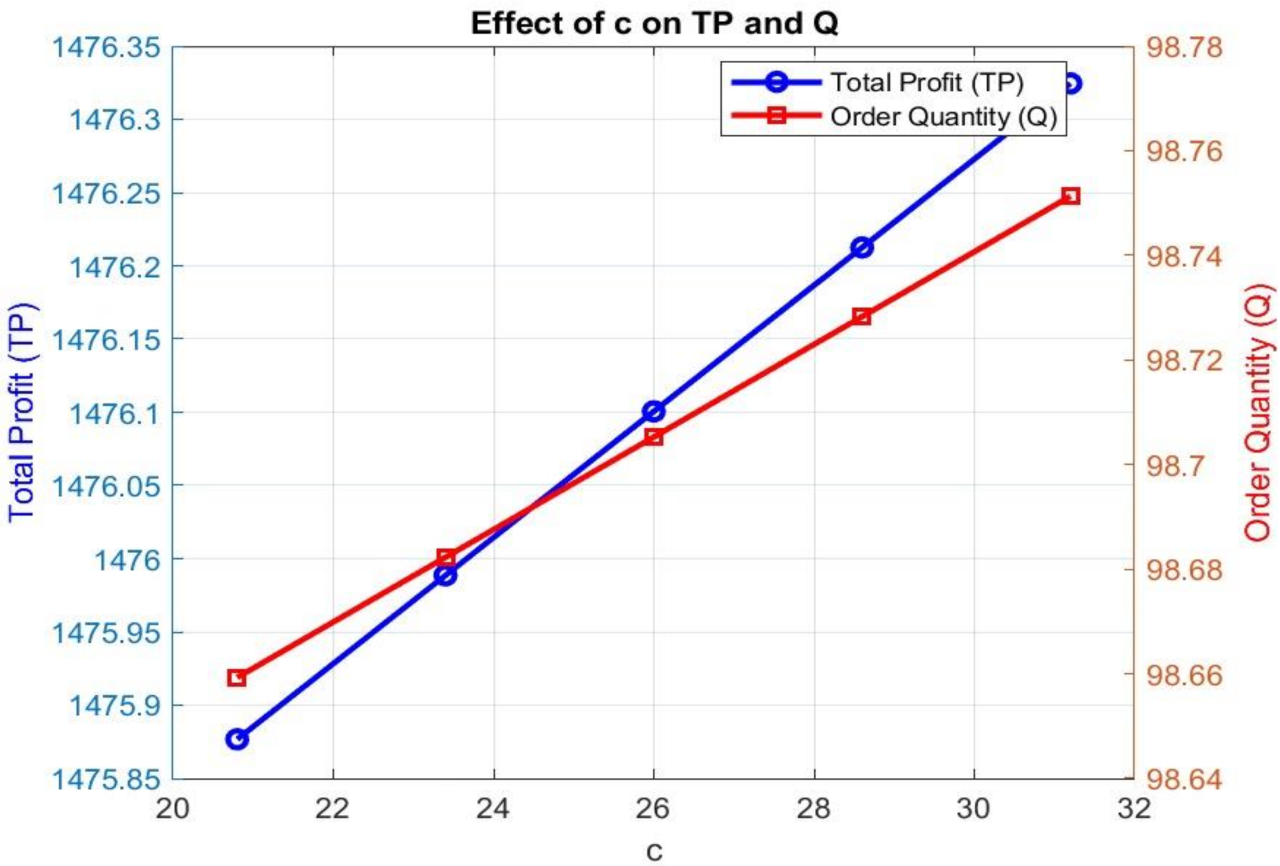
Effect of c on TP and Q
Total Profit (TP)
Order Quantity (Q)
1476.35
1476.3
1476.25
1476.2
1476.15
1476.1
1476.05
1476
1475.95
1475.9
1475.85
98.78
98.76
98.74
98.72
98.7
98.68
98.66
98.64
20
22
24
26
28
30
32
c

Fig. 3.3

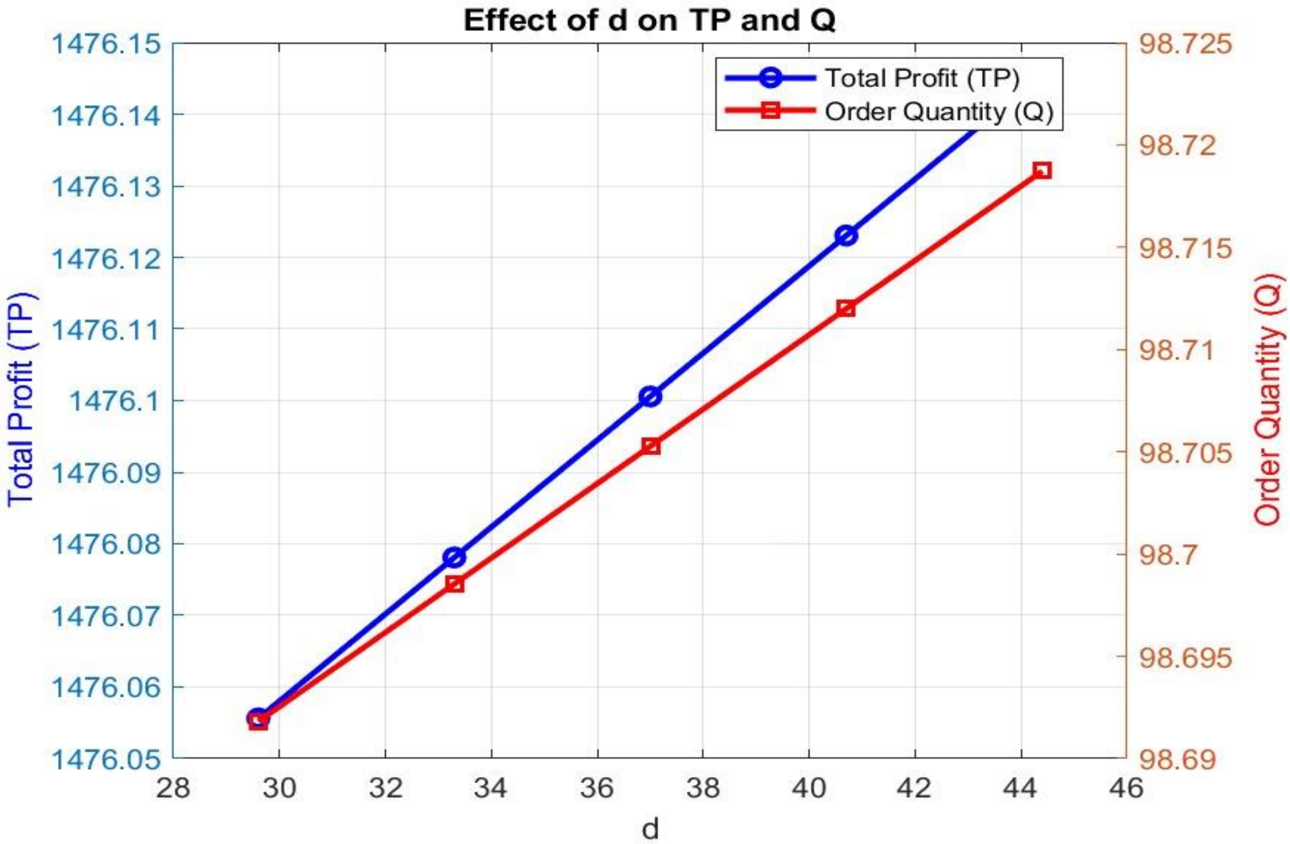
Effect of d on TP and Q
Total Profit (TP)
Order Quantity (Q)
1476.15
1476.14
1476.13
1476.12
1476.11
1476.1
1476.09
1476.08
1476.07
1476.06
1476.05
98.725
98.72
98.715
98.71
98.705
98.7
98.695
98.69
28
30
32
34
36
38
40
42
44
46
d

Fig. 3.4

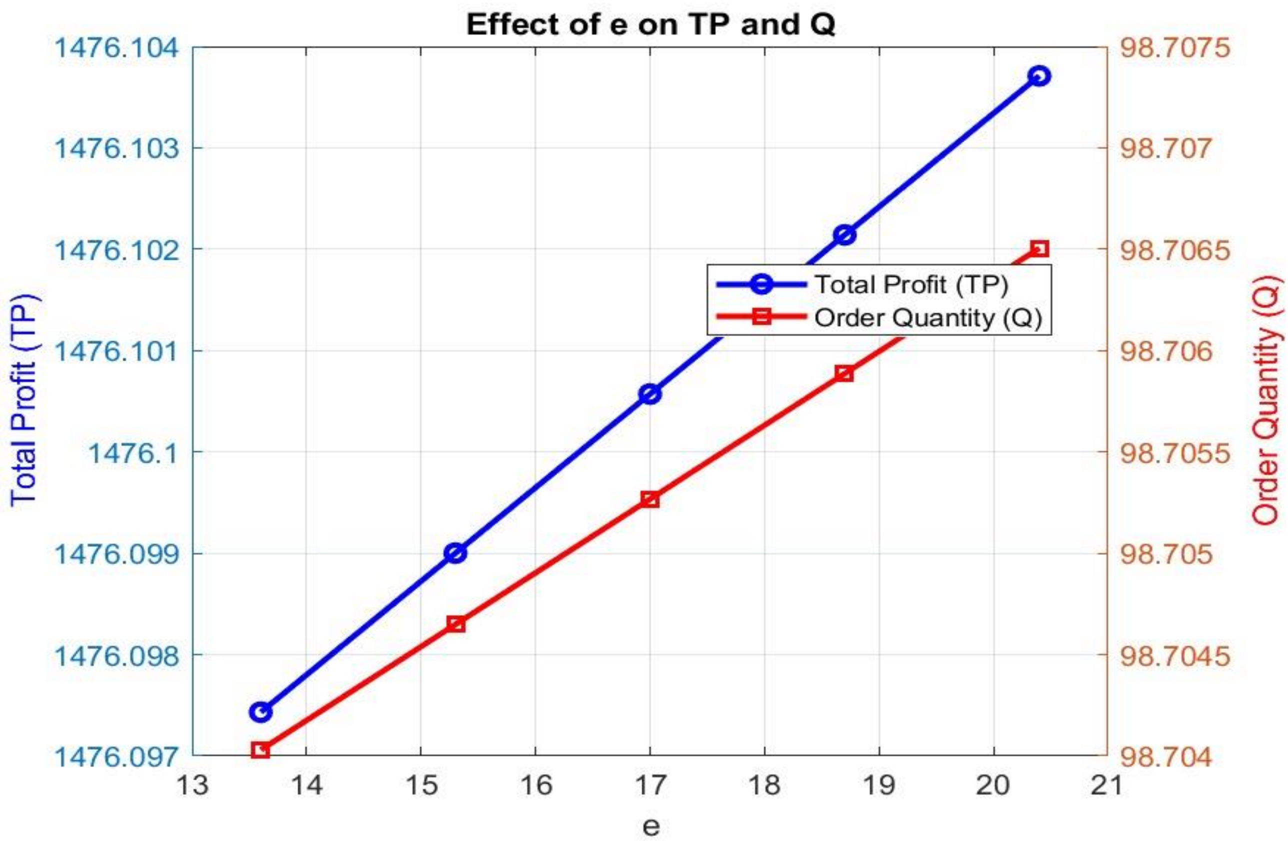
Effect of e on TP and Q
Total Profit (TP)
Order Quantity (Q)
1476.104
1476.103
1476.102
1476.101
1476.1
1476.099
1476.098
1476.097
98.7075
98.707
98.7065
98.706
98.7055
98.705
98.7045
98.704
13
14
15
16
17
18
19
20
21
e

Fig. 3.5

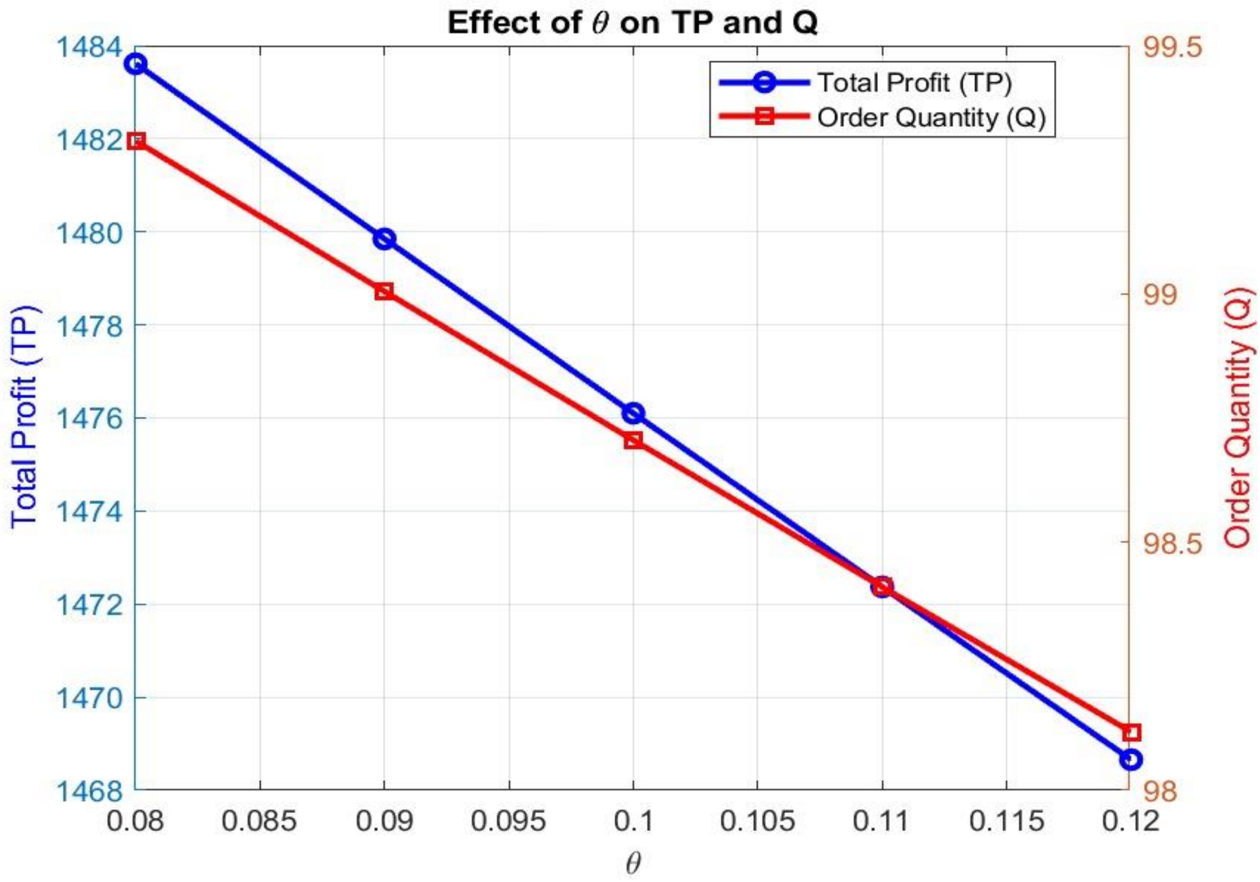
Effect of θ on TP and Q
Total Profit (TP)
Order Quantity (Q)
1484
1482
1480
1478
1476
1474
1472
1470
1468
99.5
99
98.5
98
0.08
0.085
0.09
0.095
0.1
0.105
0.11
0.115
0.12
θ

Fig. 3.6

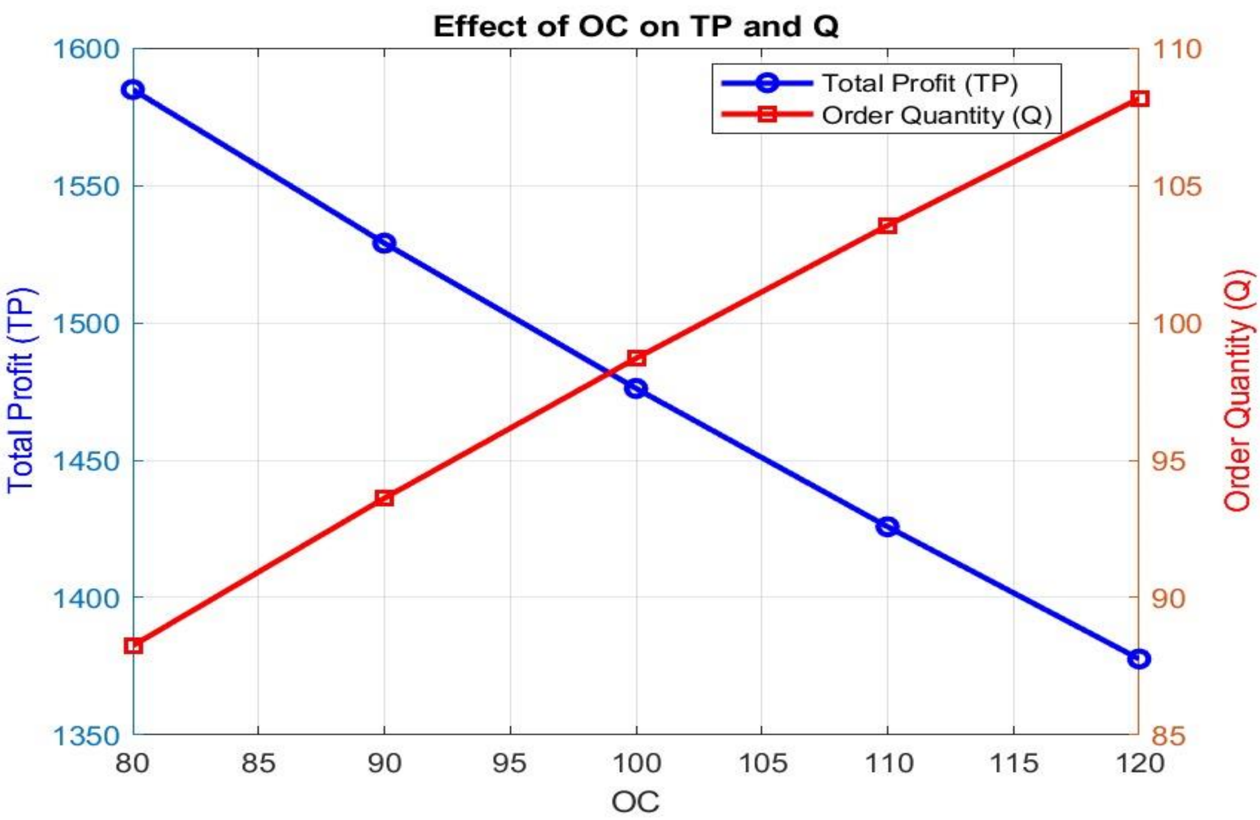
Effect of OC on TP and Q
Total Profit (TP)
Order Quantity (Q)
1600
1550
1500
1450
1400
1350
110
105
100
95
90
85
80
85
90
95
100
105
110
115
120
OC

Fig. 3.7

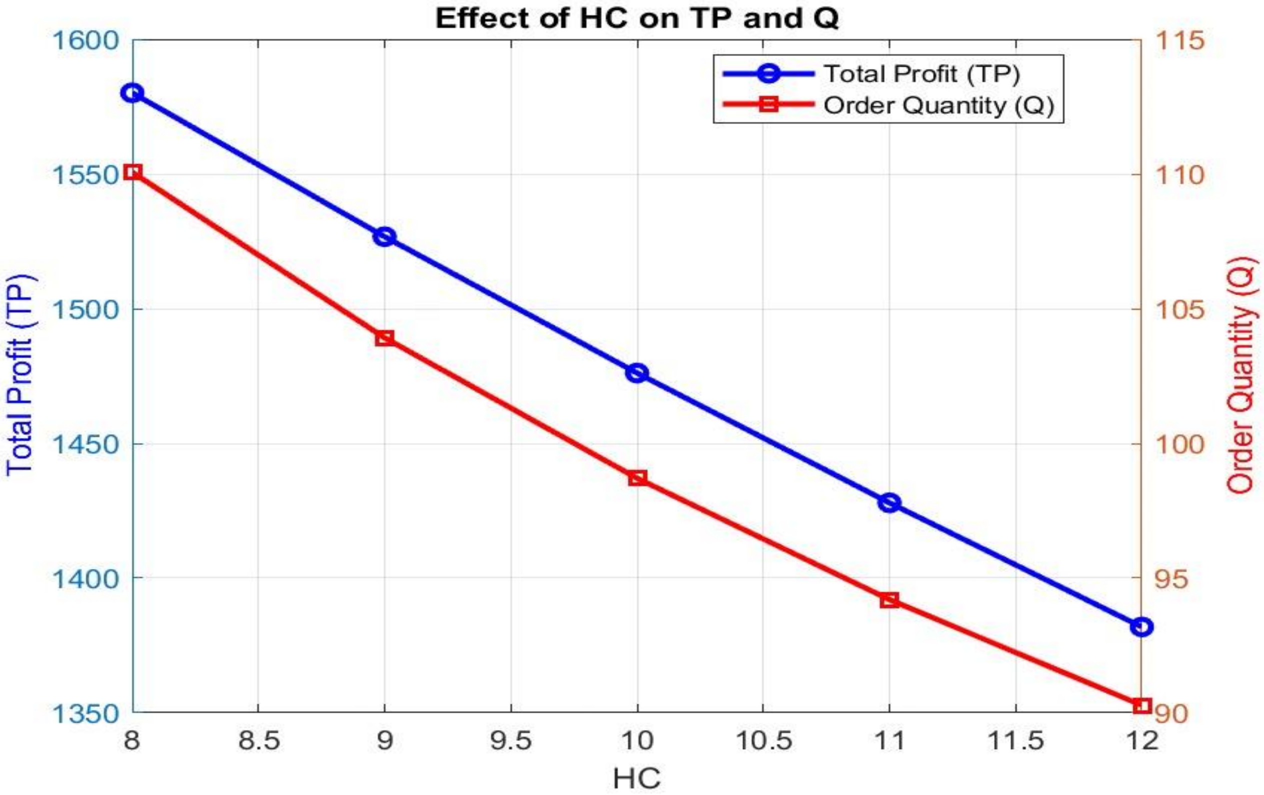
Effect of HC on TP and Q
Total Profit (TP)
Order Quantity (Q)
1600
1550
1500
1450
1400
1350
115
110
105
100
95
90
8
8.5
9
9.5
10
10.5
11
11.5
12
HC

Fig. 3.8

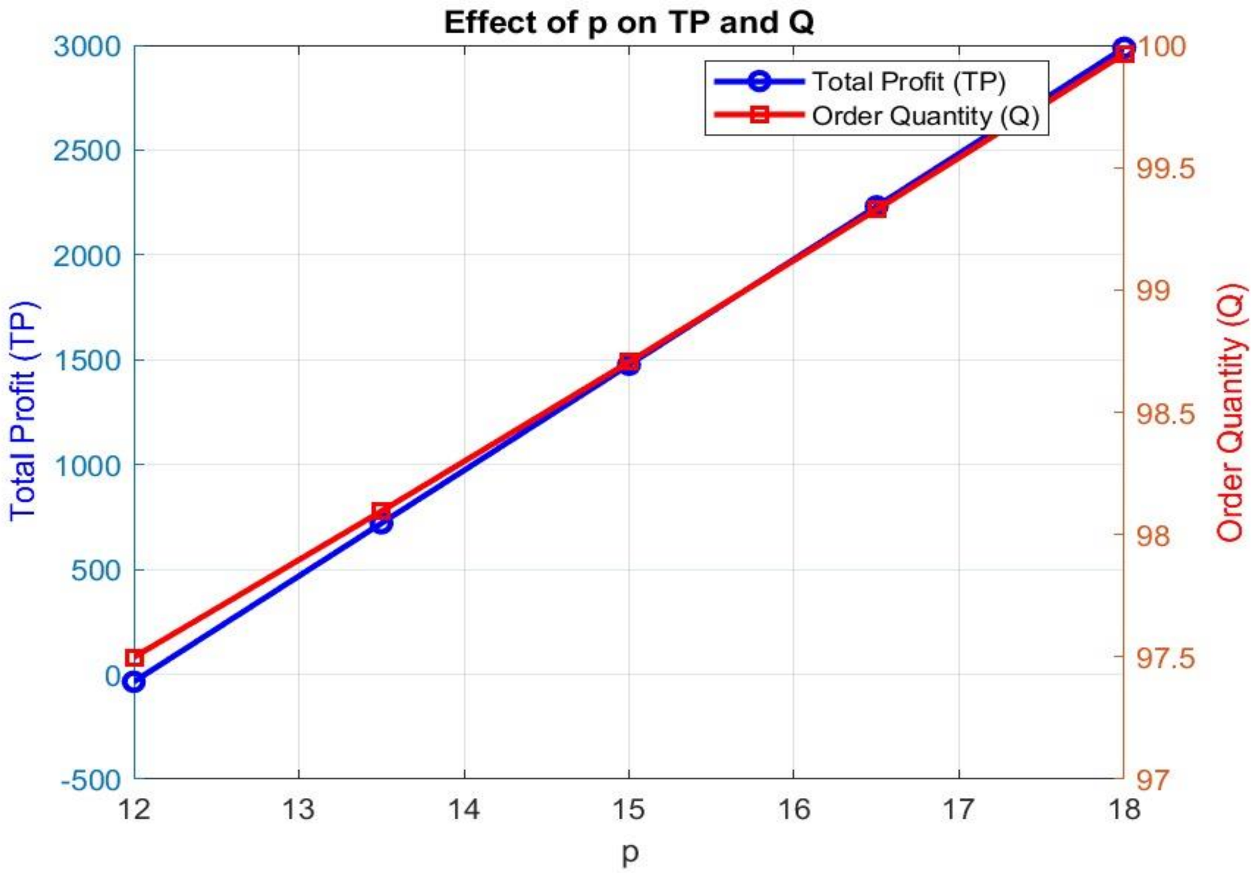
Effect of p on TP and Q
Total Profit (TP)
Order Quantity (Q)
3000
2500
2000
1500
1000
500
0
-500
100
99.5
99
98.5
98
97.5
97
12
13
14
15
16
17
18
p

Fig. 3.9

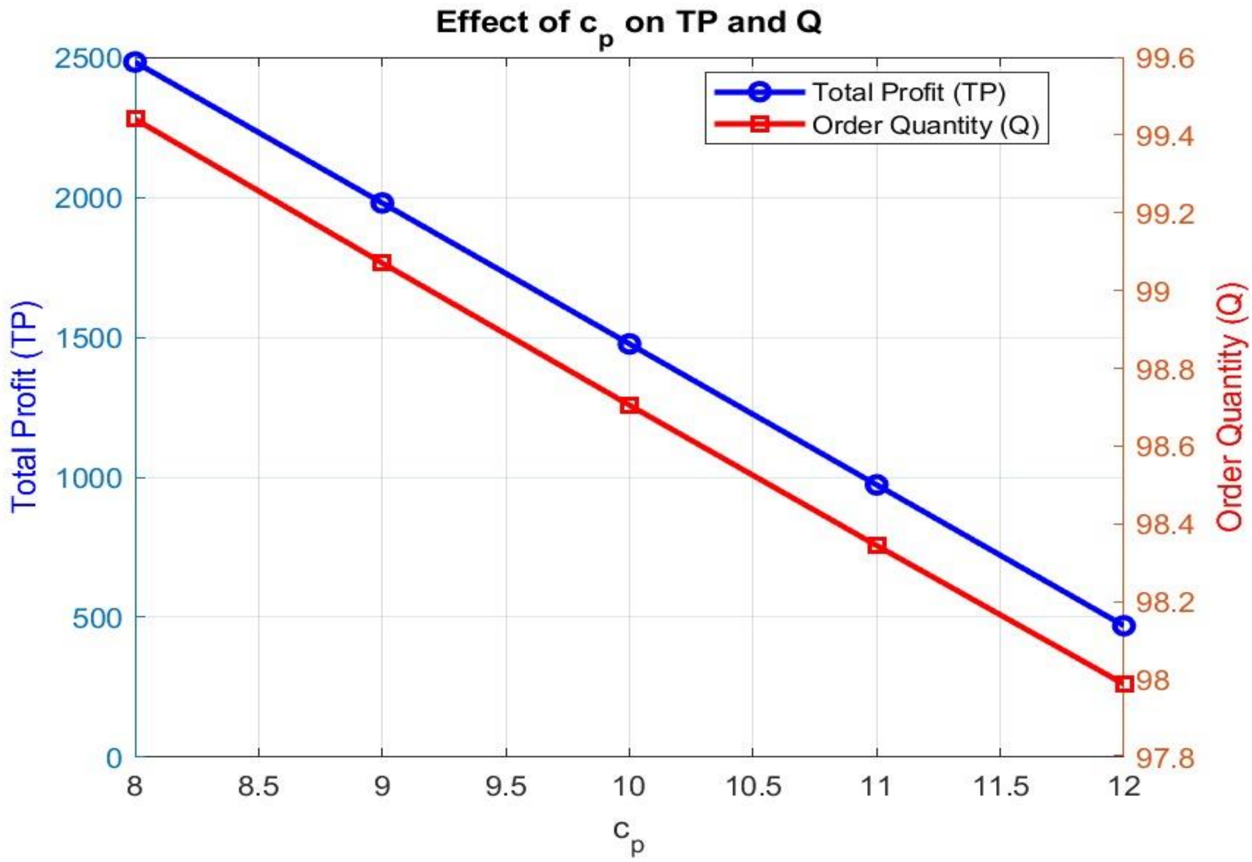

Fig. 3.10

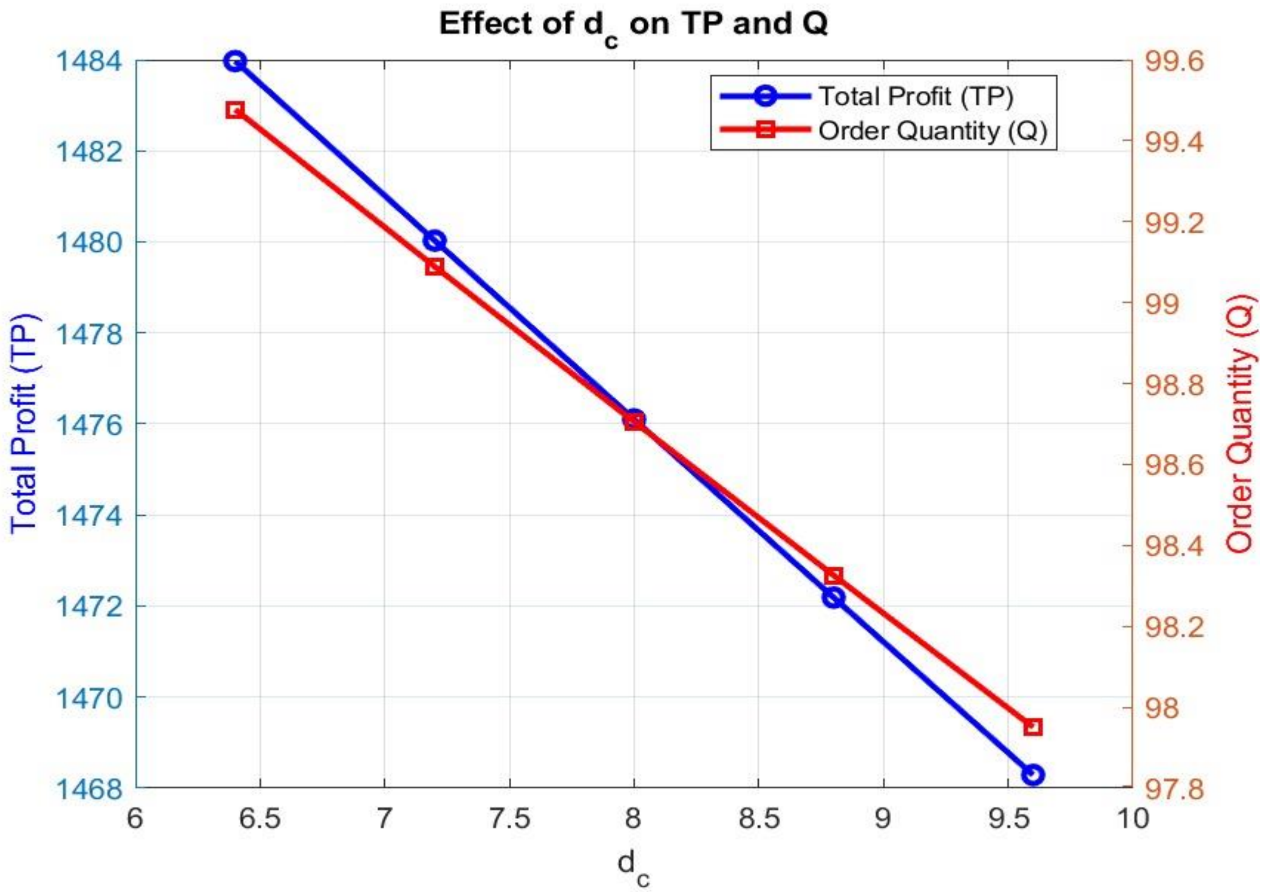

Fig. 3.11

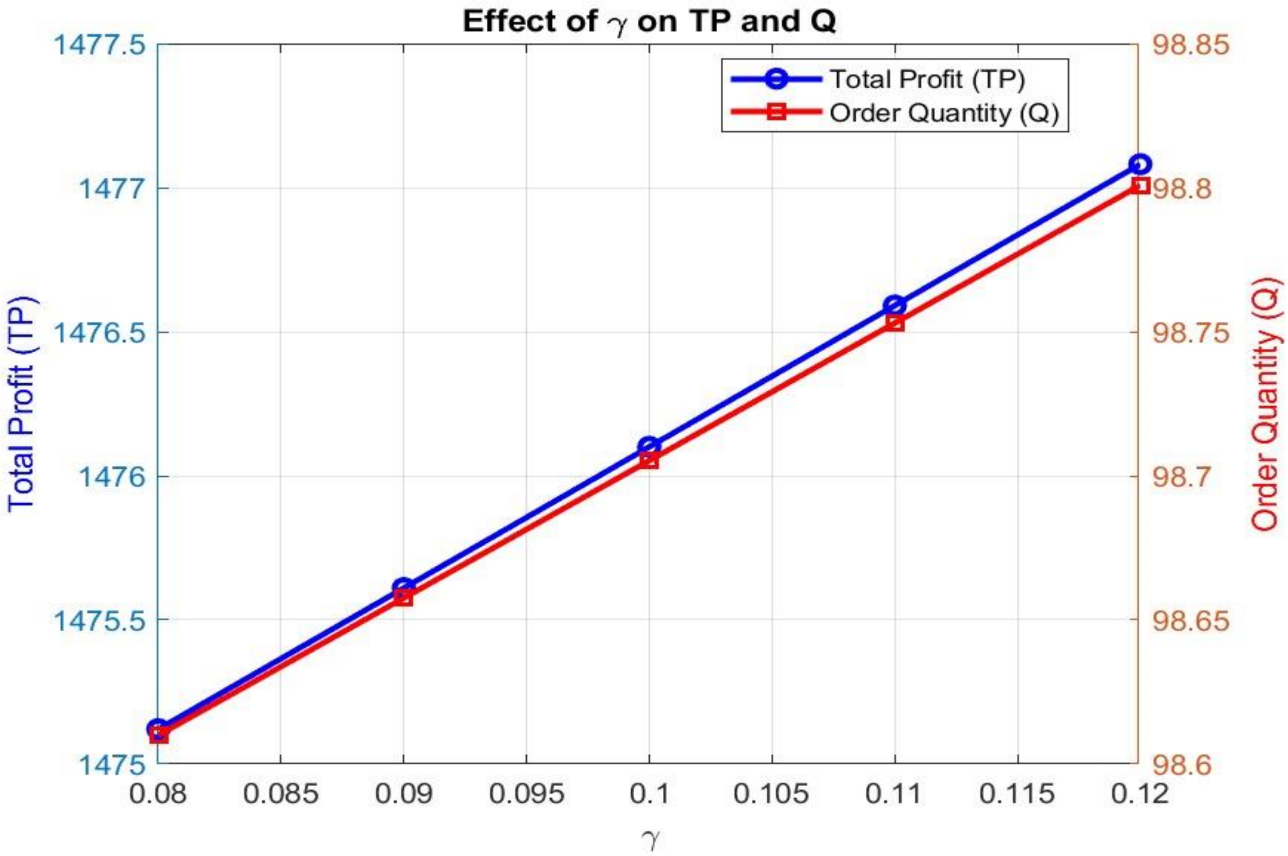

Fig. 3.12

8. Analysis and Interpretation

8.1. Effect of Demand Parameters (a, b, c, d, e)

The demand level parameter (a) shows a strong influence: an increase generally leads to larger order quantities and longer cycle times, but can reduce total Profit due to higher associated costs. In contrast, other demand parameters (b, c, d, and e) have only minor effects, keeping the system's performance largely stable despite small fluctuations.

8.2. Effect of Deterioration Rate (θ)

An increase in the deterioration rate lowers total Profit and shortens both cycle time and order quantity. This underlines the importance of managing deterioration effectively to sustain profitability.

8.3. Effect of Ordering Cost (OC)

Ordering costs have a notable impact: higher ordering costs lead to fewer, larger orders, increasing Profit and reducing cycle time. Lower ordering costs have the opposite effect, resulting in more frequent orders and longer cycles.

8.4. Effect of Holding Cost (HC)

Rising holding costs reduce total profit and order quantity while shortening the cycle time. Conversely, lower holding costs extend the cycle and increase both profit and order quantity.

8.5. Effect of Selling Price (p)

Higher selling prices directly improve total Profit and lengthen cycle time by making each unit more profitable. Reductions in selling price decrease Profit and shorten the cycle.

8.6. Effect of Purchase Cost (p_c)

Increasing purchase costs lowers total Profit and cycle time, while a decrease in purchase costs raises Profit and extends the cycle. Effective cost control in procurement is thus critical for better performance.

8.7. Effect of Deterioration Cost (d_c)

Higher deterioration costs reduce profit and cycle time, whereas lower deterioration costs help increase them. This suggests that minimizing deterioration-related expenses benefits the inventory system.

8.8. Effect of Salvage Value (γ)

Changes in salvage value produce only slight variations in Profit, cycle time, and order quantity. The model's outcomes remain generally stable against these small changes.

9. Conclusion

The current study analyses the deteriorating items with a deterministic inventory model. The biquadratic demand pattern paves the way for a realistic and flexible representation of demand variations over time. Including such a pattern makes the model more appropriate for industries with signified demand fluctuations, ensuring a balanced approach to inventory cost management and revenue recovery from unsold items. The model has incorporated a constant deterioration rate and salvage value.

The numerical examples presented in the study validate the model's applicability and effectiveness in decision-making, which is highlighted through a sensitivity analysis, the impact of key parameters on inventory performance, offering valuable insights for inventory managers and decision-makers.

In order to enhance the model's applicability, future research could explore factors like time-dependent deterioration and demand, stochastic demand, partial and complete backlogging, price variations, dependent demand or inflation effects.

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