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Effect of Trade Credit and Green Technology Investment on a Sustainable Approach to Perishable Inventory Control under Inflation

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Abstract: People are getting more worried about the environment. They want to save money too. So, researchers are trying to come up with ways to manage inventory that are good for the earth and do not cost too much. This study is about a way to manage inventory for perishable items. It looks at how giving customers credit to buy things and investing in technology can help in a time when prices are going up. Things that can go bad lose their value after some time because they get worse. It is harder to manage inventory when the economy is changing. In this paper we develop a sustainable inventory model with the effect of trade credit and green technology investment on sustainable perishable inventory model. Numerical illustrations is carried out by using the software Mathematica12.0. The finding shows that we obtained the optimal cost when the trade credit period is greater than the cycle length. Sensitivity analysis further illustrated the importance of key parameters such as the inflation rate, deterioration rate, and preservation technology investment cost on the overall system performance.

Keywords: Trade credit, inflation, green technology, perishable inventory

1. Introduction

In todays business world managing inventory is crucial for companies to stay profitable and run efficiently. Inventory system becomes a part of supply chain systems. Companies are always looking for inventory policies that can reduce total costs meet customer demand and address environmental concerns. Managing inventory is more challenging when products are perishable, like food, medicine and high-tech goods. These items deteriorate over time losing quality, usefulness or market value. This directly affects inventory decisions and overall system performance.

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Recently sustainable practices have become more important due to concerns, government regulations and social awareness. Investing in technology is an effective strategy for reducing carbon emissions improving energy efficiency minimizing waste and supporting environmentally responsible production and inventory systems. Such investments help the environment. Can also improve operational performance and long-term profitability.

Financial aspects also play a role in inventory decisions. Trade credit is a business practice where suppliers let buyers delay payments. This arrangement offers flexibility reduces immediate capital requirements and improves cash flow management. Trade credit policies influence replenishment strategies and purchasing decisions. Inflation is another economic factor that affects inventory systems. Goyal (1985) introduced the concept of trade credit.

Inflation throws a wrench into the works. Unpredictable cost fluctuations disrupt inventory control, impacting production costs, holding costs, and purchasing power. For perishable products, inflation-induced price variations and deterioration rates demand effective preservation methods to prevent spoilage and maintain quality. Buzacott (1975) introduced the concept of inflation.

It influences purchasing costs holding costs and operational expenses over time. Ignoring inflation can lead to assumptions and less effective inventory decisions.

This study develops an inventory control model for perishable items. The model integrates the effects of trade credit and green technology investment under an environment.

The goal is to determine an inventory policy that minimizes the total system cost. The policy must balance efficiency and environmental sustainability. The proposed model provides insights, for managers seeking sustainable inventory practices.

2. Literature Review

The way people think about inventory and supply chain management has changed a lot over time. It used to be about making sure you had the right amount of stuff in stock. Now people also think about how to be kind to the environment and reduce waste. Toptal and Çetinkaya (2017) developed a model considers how working together with companies in the supply chain can help reduce the bad effects on the environment. They found out that when companies work together, they can make decisions and be more sustainable.

In 2018 some other researchers did studies on sustainable inventory. Sanjib Tiwari and his team made a model for managing inventory that takes into account products that go bad quickly and are not perfect. They showed that it is important to think about quality and the environment when making decisions about inventory. Taleizadeh *et al.* developed a model that helps companies make decisions that're good for the environment and the economy. Sheng Tang and his team looked at how transportation affects the environment. Found ways to reduce the harmful effects. Tao Wu and his team made a model for managing inventory that uses technology.

In 2019 Shailesh Tiwari and his team did a study on how to make decisions about ordering products that go bad quickly. They found out that money and the environment are both important when making these decisions. Xu et al. reviewed of all the research on green supply chains and found out what still needs to be studied.

In 2020 researchers started to focus on inventory systems that are controlled by carbon emissions. Mishra *et al.* formulated a model for managing production and inventory that takes into account carbon emissions. Yong Shi and his team looked at how to make decisions about replenishing products that go bad quickly. Wangsa *et al.* made a model for working with vendors and buyers in a way. Cheng et al. formulated a model for managing inventory that takes into account products that go bad quickly and carbon emissions.

In 2021 researchers started to think more about pricing and sustainable supply chains. Mishra *et al.* developed a model for managing inventory in a way. Sepehri *et al.* developed a model for pricing and inventory that takes into account carbon emissions. Liang *et al.* made a model that integrates pricing, production, advertising, inventory and investment decisions. Sarkar *et al.* looked at how carbon emissions and quality affect products. Sepehri also formulated a model for optimizing replenishment cycles and selling prices. Yadav and Khanna developed a model for managing inventory that takes into account carbon tax policies. Pattnaik *et al.* reviewed all the research on inventory models and found out what is new and exciting.

In 2022 Thomas and Mishra made a model for a supply chain that uses circular economy principles. In 2023 researchers started to think about circular economy concepts and preservation technologies. Mridha *et al.* looked at how to improve biofuel production and reduce carbon emissions. Nobil *et al.* made a model for managing production that takes into account products. John and Mishra made a model for production systems that reduce emissions. Rana *et al.* made a model for managing inventory that takes into account dynamic fuel pricing. Ruidas *et al.* developed a model for managing inventory that uses technology. Sepehri and Gholamian formulated a model for managing inventory that takes into account products.

In 2024 researchers started to think about advanced regulations and emerging sustainable technologies. Sebatjane made a model for managing inventory in a chain that uses green technology. Xu *et al.* reviewed all the research, on supply chain system.

3. Assumptions and Notations

Following are the assumptions and notations used in the whole chapter

3.1 Assumptions

The below-mentioned assumptions are taken in the festive-sweets production inventory model.

1. Trade credit policy is applied.
2. Effect of inflation is taken into consideration.

3. δ indicates the number of non-diabetic individuals who catch diabetes and $\delta > 0$ because non-diabetic individuals are more than diabetic individuals.
4. The demand for sweets is $R\ (t) = \mu J\ (t)$.
5. When green investment is considered, e^{-aG} times carbon emission cost is reduced where $0 < a < 1$ is the sensitivity of green investment.
6. Production rate is greater than the demand rate.
7. In one case the preservation technology is considered and the deterioration cost, in that case, is represented as$= C_d\theta e^{-\omega u}$, where $0 < \omega < 1$ is preservation cost sensitivity, Gautam et al (2021)
8. The reduced deterioration rate is taken as $f(u) = 1 - \frac{1}{1+\gamma u}$, $\gamma > 0$ which is increasing, continuous and concave function of preservation technology

3.2.2 Notations

The below-mentioned notations are used in the proposed festive-sweets production inventory model

J(t) Diabetic population size at time t (number of individuals)

q_0 Initial diabetic population (number of individuals)

α Rate of increase of diabetic population ($0 < \alpha < 1$)

δ Number of non-diabetic individuals who catch diabetes (number of individuals per annum)

μ Average consumption of sweets per individual (Quintal per annum)

I(t) Amount of sweets produced at time t

R Demand rate (Quintal per annum)

θ Deterioration rate ($0 \leq \theta < 1$)

f(u) cost parameter

Proportion of decreased deterioration rate, where $0 \leq f(u) \leq 1$

r Rate of inflation

M Trade Credit period

I_e Rate of interest earned

I_c Rate of interest paid

A	Set-up cost($ per order)
C_d	Deterioration cost ($ per unit per annum)
F	Transportation cost ($ per unit per annum)
C_{p0}	Fixed Production cost ($ per unit per annum)
C_{pv}	Production cost ($ per unit per annum)
	Cost parameter associated with carbon emissions
h	Holding cost ($ per unit per annum)
C_{dce}	Deterioration cost associated with carbon emission ($ per unit per annum)
C_{pvce}	Production cost associated with carbon emission ($ per unit per annum)
h_{CE}	Holding cost associated with carbon emissions ($ per unit per annum)
C_{TCE}	Transportation cost associated with carbon emissions ($ per unit per annum)
C_T	Carbon tax ($ per unit per annum)
G	Investment in Green technology ($ per annum)
u	Preservation technology investment (PTI) ($ per annum)
T	Cycle time (in months)
P	Production rate (Quintals per annum)

4. Mathematical Modeling

4.1 Population Model

During the time interval $[0, T]$, the growth of the diabetic population size is represented as $\frac{dJ(t)}{dt} = \alpha J(t) + \delta$ with the initial condition $J(0) = q_0$. Hence, the size of the diabetic population at the time t is $J(t) = q_0 e^{\alpha t} + \frac{\delta}{a}(e^{\alpha t} - 1)$. Let μ represents the average rate of sweet consumption per individual per time unit t, then the total consumption of sweets by the total diabetic population is $R(t) = \mu J(t)$ for $t \in$

[0, T]. Therefore, the demand for sweets at a time t for the total diabetic population is stated as $R(t) = \mu\left[q_0 e^{\alpha t} + \frac{\delta}{a}(e^{\alpha t} - 1)\right]$. (Shah *et al.* (2023)

4.2 Production Model

During the time interval $[0, T\ ]$ the inventory model for production is represented in terms of differential equation.

$$\frac{dI(t)}{dt} + \theta I(t) = P - R(t)$$

$$\frac{dI}{dt} + \theta I(t) = P - \mu[q_\circ e^{\alpha t} + \frac{\delta}{a}(e^{\alpha t - 1})$$

$$I(t) = (\frac{P}{\theta} - \mu\left[\frac{q_\circ e^{\alpha t}}{(\theta+\alpha)} + \frac{\delta}{a}\left(\frac{e^{\alpha t}}{(\theta+\alpha)} - \frac{1}{\theta}\right)\right] + \mu q_\circ e^{\alpha t} - \frac{P}{\theta}e^{\alpha t} + \{\mu\left[\frac{q_\circ}{\theta+\alpha} - \frac{\delta}{a(\theta+\alpha)} - \frac{1}{\theta}\right) e^{-\theta t}]$$

$$Ordering\ Cost\ OC = A$$

$$Deteriorating\ Cost\ \ DC = C_d\theta\int_0^T I(t)e^{-rt}\,dt$$

$$Deterioation\ cost\ DC = c_d\theta\,{}_0^T[\frac{Pe^{-rt}}{-\theta r} + \frac{P}{\theta r} - \mu\left[\frac{q_\circ e^{(\alpha-r)t}}{(\theta+\alpha)(\alpha-r)} + \frac{\delta}{a}\left[\frac{e^{(\alpha-r)t}}{(\theta+\alpha)(\alpha-r)} + \frac{e^{-rt}}{r\theta}\right] + \mu[\frac{q_\circ}{(\theta+\alpha)(\alpha-r)} + \frac{\Delta}{a}\left[\frac{1}{(\theta+\alpha)(\alpha-r)} + \frac{1}{r\theta}\right] - \frac{\mu q_\circ e^{-(\theta+r)T}}{-(\theta+r)} + \frac{\mu q_\circ}{(\theta+r)} + \frac{P}{\theta}\frac{e^{-(\alpha+\theta)t}}{(\theta+r)} - \frac{\mu}{r}\left[\frac{q_\circ}{(\theta+\alpha)} - \frac{\delta}{a}\frac{1}{(\theta+\alpha)} - \frac{\delta}{\theta}\right]e^{-rt} + \frac{\mu}{r}\left[\frac{q_\circ}{(\theta+\alpha)} - \frac{\delta}{a(\theta+\alpha)} - \frac{\delta}{\theta}\right]\right]$$

$$\mathrm{P}roduction\ Cost = C_{P^\circ}PT + \frac{C_{PV}}{P}\int_0^T e^{-rt}R(t)dt$$

$$PC = C_{P^\circ}PT + \frac{C_{PV}}{P}\mu[\frac{q_\circ e^{(\alpha-r)T}}{(\alpha-r)} + \frac{\delta}{\alpha}(\frac{e^{(\alpha-r)T}}{(\alpha-r)} + \frac{e^{-rT}}{r} - \frac{q_\circ}{(\alpha-r)} - \frac{\delta}{\alpha(\alpha-r)} - \frac{\delta}{r}]$$

$$Transposition\ Cost\ FC = F\int_0^T R(t)\, e^{-rt} dt$$

$$FC = f\int_0^T e^{-rt}\,\mu\left[q_\circ e^{\alpha t} + \frac{\delta}{\alpha}(e^{\alpha t} - 1)\right] dt$$

$$= \mu f [\frac{q_\circ e^{(\alpha-r)T}}{(\alpha - r)} + \frac{\delta}{\alpha}(\frac{e^{(\alpha-r)T}}{(\alpha - r)} + \frac{e^{-rT}}{r} - \frac{q_\circ}{(\alpha - r)} - \frac{\delta}{\alpha(\alpha - r)} - \frac{\delta}{r}]$$

$$Holding\ cost = h\int_0^T I(t)e^{-rt}\, dt$$

$$HC = h[\frac{-Pe^{-rT}}{\theta r} + \frac{P}{\theta r} - \mu\left[\frac{q_{\ 0}\, e^{(\alpha-r)T}}{(\theta+r)(\alpha-r)} + \frac{\Delta}{a}\left[\frac{e^{(\alpha-r)T}}{(\theta+r)} - \frac{e^{-rT}}{r\theta}\right]\right] + \mu\left[\frac{q_\circ}{(\theta+\alpha)(\alpha-r)} - \frac{\delta}{a(\theta+\alpha)(\alpha-r)} - \frac{1}{\theta r}\right] +$$
$$\frac{-\mu q_\circ}{(\theta+r)} e^{-(\theta+r)T} + \frac{\mu q_\circ}{(\theta+r)} + \frac{P}{\theta(\theta+r)} e^{-(\theta+r)T} - \frac{\mu}{r}\left[\frac{q_\circ}{(\theta+\alpha)} - \frac{\delta}{a(\theta+\alpha)} - \frac{\delta}{\theta}\right] e^{-rT} + \frac{\mu}{r}\left[\frac{q_\circ}{(\theta+\alpha)} - \frac{\delta}{a(\theta+\alpha)} - \frac{\delta}{\theta}\right]\Bigg]$$

The cost associated with carbon emission from holding inventory

$$HC_{CE} = h_{ce}\int_0^T I(t)dt$$

$$= h_{ce}[\frac{-Pe^{-rT}}{\theta r} + \frac{P}{\theta r} - \mu\left[\frac{q_\circ\, e^{(\alpha-r)T}}{(\theta+r)(\alpha-r)} + \frac{\delta}{a}\left[\frac{e^{(\alpha-r)T}}{(\theta+r)} - \frac{e^{-rT}}{r\theta}\right]\right] + \mu\left[\frac{q_\circ}{(\theta+\alpha)(\alpha-r)} - \frac{\delta}{a(\theta+\alpha)(\alpha-r)} - \frac{\delta}{\theta r}\right] +$$
$$\frac{-\mu q_\circ}{(\theta+r)} e^{-(\theta+r)T} + \frac{\mu q_\circ}{(\theta+r)} + \frac{P}{\theta(\theta+r)} e^{-(\theta+r)T} - \frac{\mu}{r}\left[\frac{q_\circ}{(\theta+\alpha)} - \frac{\delta}{a(\theta+\alpha)} - \frac{\delta}{\theta}\right] e^{-rT} +$$
$$\frac{\mu}{r}\left[\frac{q_\circ}{(\theta+\alpha)} - \frac{\delta}{a(\theta+\alpha)} - \frac{\delta}{\theta}\right]\Bigg]$$

$The\ cost\ associated\ with\ carbon\ emmission\ from\ transporting\ inventory$

$$FC_{CE} = C_{T_{CE}}\int_0^T R(t)e^{-rt}\, dt$$

$$= C_{T_{CE}}\mu\left[\frac{q_\circ e^{(\alpha-r)t}}{(\alpha - r)} + \frac{\delta}{\alpha}\frac{e^{(\alpha-r)t}}{(\alpha - r)} + \frac{e^{-rt}}{r} - \frac{q_\circ}{(\alpha - r)} - \frac{\delta}{\alpha(\alpha - r)} - \frac{\delta}{r}\right]$$

$the\ cost\ associated\ with\ carbon\ emmission\ from\ producing\ inventory$

$$PC_{CE} = C_{P_\circ}.PT + \frac{C_{P_{V_{CE}}}}{P}\int_0^T R(t)dt$$

$$= C_{P_\circ}.PT + \frac{C_{P_{V_{CE}}}}{P}\mu\left[\frac{q_\circ e^{(\alpha-r)t}}{(\alpha-r)} + \frac{\delta}{\alpha}\frac{e^{(\alpha-r)t}}{(\alpha-r)} + \frac{e^{-rt}}{r} - \frac{q_\circ}{(\alpha-r)} - \frac{\delta}{\alpha(\alpha-r)} - \frac{\delta}{r}\right]$$

$$The\ cost\ associated\ with\ carbon\ emission\ from\ deteriorating\ inventory$$

$$= C_{d_{CE}}\theta[\frac{-Pe^{-rt}}{\theta r} + \frac{P}{\theta r} - \mu\left[\frac{q_{\circ_{e}(\alpha-r)t}}{(\theta+r)(\alpha-r)} + \frac{\delta}{a}\left[\frac{e^{(\alpha-r)T}}{(\theta+r)} - \frac{e^{-rT}}{r\theta}\right]\right.$$
$$+ \mu\left[\frac{q_\circ}{(\theta+\alpha)(\alpha-r)} - \frac{\delta}{a(\theta+\alpha)(\alpha-r)} - \frac{1}{\theta r}\right] + \frac{-\mu q_\circ}{(\theta+r)}e^{-(\theta+r)t}$$
$$+ \frac{\mu q_\circ}{(\theta+r)} + \frac{P}{\theta(\theta+r)}e^{-(\theta+r)T} - \frac{\mu}{r}\left[\frac{q_\circ}{(\theta+\alpha)} - \frac{\delta}{a(\theta+\alpha)} - \frac{\delta}{\theta}\right]e^{-rT}$$
$$\left.+ \frac{\mu}{r}\left[\frac{q_\circ}{(\theta+\alpha)} - \frac{\delta}{a(\theta+\alpha)} - \frac{\delta}{\theta}\right]\right]$$

Green technology investment is taken into account to reduce carbon emission from four carbon emitting sweets as transporting, holding, producing, and deteriorating sweets the investor will invest in green technology after investing in green technology reduced carbon emission cost is calculated as

$$CT_{CE} = C_T CT_{CE} = C_T e^{-aG}[C_{d_{CE}}\theta\left[\frac{-P}{\theta r}e^{-rt} + \frac{P}{\theta r} - \mu\left[\frac{q_\circ e^{(\alpha-r)T}}{(\theta+r)(\theta-r)} + \frac{\delta}{a}\left[\frac{e^{(\alpha-r)T}}{(\theta+r)(\theta-r)} + \frac{e^{-rt}}{r\theta}\right]\right] +\right.$$
$$\mu\left[\frac{q_\circ}{(\theta-r)(\theta-r)} + \frac{\delta}{a}\left[\frac{1}{(\theta+r)(\theta-r)} + \frac{1}{r\theta}\right]\right] - \frac{\mu q_\circ e^{-(\theta+r)T}}{(\theta+r)(\theta-r)} + \frac{\mu q_\circ}{(\theta+r)} + \frac{Pe^{-(\theta+r)T}}{\theta(\theta+r)} - \frac{\mu}{r}\left[\frac{q_\circ}{(\theta+r)} - \frac{\delta}{a(\theta+r)} - \frac{\delta}{\theta}\right]e^{-rt} +$$
$$\left.\frac{\mu}{r}\left[\frac{q_\circ}{(\theta+r)} - \frac{\delta}{a(\theta+r)} - \frac{\delta}{\theta}\right]\right] + h_{ce}\left[\frac{-P}{\theta r}e^{-rt} + \frac{P}{\theta r} - \mu\left[\frac{q_\circ e^{(\alpha-r)T}}{(\theta+r)(\theta-r)} + \frac{\delta}{a}\left[\frac{e^{(\alpha-r)T}}{(\theta+r)(\theta-r)} + \frac{e^{-rt}}{r\theta}\right]\right] +\right.$$
$$\mu\left[\frac{q_\circ}{(\theta-r)(\theta-r)} + \frac{\delta}{a}\left[\frac{1}{(\theta+r)(\theta-r)} + \frac{1}{r\theta}\right]\right] - \frac{\mu q_\circ e^{-(\theta+r)T}}{(\theta+r)(\theta-r)} + \frac{\mu q_\circ}{(\theta+r)} + \frac{Pe^{-(\theta+r)T}}{\theta(\theta+r)} - \frac{\mu}{r}\left[\frac{q_\circ}{(\theta+r)} - \frac{\delta}{a(\theta+r)} - \frac{\delta}{\theta}\right]e^{-rt} +$$
$$\left.\frac{\mu}{r}\left[\frac{q_\circ}{(\theta+r)} - \frac{\delta}{a(\theta+r)} - \frac{\delta}{\theta}\right]\right] + C_{T_{CE}}\mu\left[\frac{q_\circ e^{(\alpha-r)T}}{(\alpha-r)} + \frac{\delta e^{(\alpha-r)T}}{\alpha(\alpha-r)} + \frac{e^{-rt}}{r} - \frac{q_\circ}{[\alpha-r]} - \frac{\delta}{\alpha(\alpha-r)} - \frac{\delta}{r}\right] + C_{P_\circ}PT +$$
$$\frac{C_{P_{VCE}}\mu}{P}[\left[\frac{q_\circ e^{(\alpha-r)T}}{(\alpha-r)} + \frac{\Delta e^{(\alpha-r)T}}{\alpha(\alpha-r)} + \frac{e^{-rt}}{r} - \frac{q_\circ}{[\alpha-r]} - \frac{\delta}{\alpha(\alpha-r)} - \frac{\delta}{r}\right]$$

Thus the total average cost per unit of time is calculated as

$$TC_4 = \frac{1}{T}[OC + DC + HC + FC + TC + CT_{CE} + G]$$

Model 2 Preservation Technology investment without carbon emission is taken into account

$$\frac{dI_2(t)}{dt} + \theta\big(1 - f(u)\big)I_2 = P - R(t)$$

$$I.F = e^{\theta(1-f(u))t}$$

$$I_{2(t)} = [\frac{P}{\theta(1-f(u))} - \mu\left[\frac{q_{\circ}e^{\alpha t}}{(\theta(1-f(u)+\alpha)} + \frac{\delta}{a}\left[\frac{e^{\alpha t}}{(r+\theta(1-f(u))} - \frac{1}{\theta(1-f(u)}\right]\right] + \mu q_{\circ}e^{-\theta(1-f(u))t} - \frac{Pe^{-\theta(1-f(u))t}}{\theta(1-f(u)} + \mu\left[\frac{q_{\circ}}{(\theta(1-f(u))} - \frac{\delta}{(\theta(1-f(u)+\alpha)} - \frac{1}{\theta}\right]e^{-\theta(1-f(u))t}\right]$$

$$Deterioation\ cost\ Dc_2 = C_d\theta e^{-\omega u}\int_0^T e^{-rt}dt$$

$$= C_d\theta e^{-\omega\pm*u}[\frac{-Pe^{-rt}}{\theta(1-f(u))} + \frac{P}{\theta(1-f(u))r} - \mu\left[\frac{q_{\circ}e^{(\alpha-r)t}}{(\theta(1-f(u)+\alpha)} + \frac{\delta}{a}\left[\frac{e^{(\alpha-r)t}}{(\theta(1-f(u)+\alpha)(\alpha-r)} - \frac{e^{-rt}}{r\theta(1-f(u)}\right]\right] + \mu\left[\frac{q_{\circ}}{(\theta(1-f(u)+\alpha)(\alpha-r)} + \frac{\delta}{a}\left[\frac{1}{(\theta(1-f(u)+\alpha)(\alpha-r)} - \frac{1}{r\theta(1-f(u)}\right]\right] - \left[\frac{\mu q_{\circ}e^{-(\theta(1-f(u))+r)t}}{(\theta(1-f(u)+\alpha)} + \frac{\mu q_{\circ}}{(\theta(1-f(u)+\alpha)} + \frac{Pe^{-(\theta(1-f(u))+r)t}}{\theta(1-f(u))(\theta(1-f(u)+r)} - \frac{\mu}{r}[\frac{q_{\circ}}{(\theta(1-f(u)+\alpha)} + \frac{\delta}{a}\left[\frac{1}{(\theta(1-f(u)+\alpha)} - \frac{\delta}{r\theta(1-f(u)}\right]\right]e^{-rT} + \frac{\mu}{r}[\frac{q_{\circ}}{(\theta(1-f(u)+\alpha)} - \frac{\delta}{a}\left[\frac{1}{(\theta(1-f(u)+\alpha)} + \frac{\delta}{r\theta(1-f(u)}\right]$$

$$holding\ cost\ HC_2 = h\int_0^t I_2(t)e^{-rt}dt$$

$$= h[\frac{-Pe^{-rt}}{\theta(1-f(u))} + \frac{P}{\theta(1-f(u))r} - \mu\left[\frac{q_{\circ}e^{(\alpha-r)t}}{(\theta(1-f(u)+\alpha)} + \frac{\delta}{a}\left[\frac{e^{(\alpha-r)t}}{(\theta(1-f(u)+\alpha)(\alpha-r)} - \frac{e^{-rt}}{r\theta(1-f(u)}\right]\right] + \mu\left[\frac{q_{\circ}}{(\theta(1-f(u)+\alpha)(\alpha-r)} + \frac{\delta}{a}\left[\frac{1}{(\theta(1-f(u)+\alpha)(\alpha-r)} + \frac{1}{r\theta(1-f(u)}\right]\right] - \left[\frac{\mu q_{\circ}e^{-(\theta(1-f(u))+r)t}}{(\theta(1-f(u)+\alpha)} + \frac{\mu q_{\circ}}{(\theta(1-f(u)+r)} + \frac{Pe^{-(\theta(1-f(u))+r)t}}{\theta(1-f(u))(\theta(1-f(u)+r)} - \frac{\mu}{r}[\frac{q_{\circ}}{(\theta(1-f(u)+\alpha)} + \frac{\delta}{a}\left[\frac{1}{(\theta(1-f(u)+\alpha)} - \frac{\delta}{r\theta(1-f(u)}\right]\right] e^{-rT} + \frac{\mu}{r}[\frac{q_{\circ}}{(\theta(1-f(u)+\alpha)} - \frac{\delta}{a}\left[\frac{1}{(\theta(1-f(u)+\alpha)} + \frac{\delta}{\theta(1-f(u))}\right] e^{-rt} + \frac{\mu}{r}[\frac{q_{\circ}}{(\theta(1-f(u)+\alpha)} - \frac{\delta}{a}\left[\frac{1}{(\theta(1-f(u)+\alpha)} + \frac{\delta}{r\theta(1-f(u)}\right]$$

Investment in preservation technology $PIT = uT$

hence the total average cost per unit of time is represented as

$$TC_5 = [OC + DC_2 + HC_2 + FC + PC + PTI]$$

Model 3 Green Technology Investment and Preservation Technology both are taken into account

$$HC_{CE_2} = h_{CE}\int_0^T I_2\,(t)dt$$

$$= h_{CE}[\frac{-Pe^{-rt}}{\theta(1-f(u))} + \frac{P}{\theta(1-f(u))r} - \mu\left[\frac{q_{\circ}e^{(\alpha-r)t}}{(\theta(1-f(u)+\alpha)} + \frac{\delta}{a}\left[\frac{e^{(\alpha-r)t}}{(\theta(1-f(u)+\alpha)(\alpha-r)} - \frac{e^{-rt}}{r\theta(1-f(u)}\right]\right] + \mu\left[\frac{q_{\circ}}{(\theta(1-f(u)+\alpha)(\alpha-r)} + \frac{\delta}{a}\left[\frac{1}{(\theta(1-f(u)+\alpha)(\alpha-r)} + \frac{1}{r\theta(1-f(u)}\right]\right] - \left[\frac{\mu q_{\circ}e^{-(\theta(1-f(u))+r)t}}{(\theta(1-f(u)+\alpha)} + \frac{\mu q_{\circ}}{(\theta(1-f(u)+r)} + \frac{Pe^{-(\theta(1-f(u))+r)t}}{\theta(1-f(u))(\theta(1-f(u)+r)} - \frac{\mu}{r}[\frac{q_{\circ}}{(\theta(1-f(u)+\alpha)} + \frac{\delta}{a}\left[\frac{1}{(\theta(1-f(u)+\alpha)} - \frac{\delta}{r\theta(1-f(u)}\right]\right] e^{-rT} + \frac{\mu}{r}[\frac{q_{\circ}}{(\theta(1-f(u)+\alpha)} - \frac{\delta}{a}\left[\frac{1}{(\theta(1-f(u)+\alpha)} + \frac{\delta}{\theta(1-f(u))}\right]$$

the cost associated with carbon emission from deterioration inventory

$$DC_{CE_2} = C_{d_{CE}}\int_0^T I_2\,(t)e^{-rt}dt$$

$$DC_{CE_2} = C_{d_{CE}}\theta e^{-\omega u}\left[\frac{-Pe^{-rt}}{\theta(1-f(u))} + \frac{P}{\theta(1-f(u))r} - \mu\left[\frac{q_{\circ}e^{(\alpha-r)t}}{(\theta(1-f(u)+\alpha)} + \frac{\delta}{a}\left[\frac{e^{(\alpha-r)t}}{(\theta(1-f(u)+\alpha)(\alpha-r)} - \frac{e^{-rt}}{r\theta(1-f(u)}\right]\right] + \mu\left[\frac{q_{\circ}}{(\theta(1-f(u)+\alpha)(\alpha-r)} + \frac{\delta}{a}\left[\frac{1}{(\theta(1-f(u)+\alpha)(\alpha-r)} + \frac{1}{r\theta(1-f(u)}\right]\right] - \left[\frac{\mu q_{\circ}e^{-(\theta(1-f(u))+r)t}}{(\theta(1-f(u)+\alpha)} + \frac{\mu q_{\circ}}{(\theta(1-f(u)+r)} + \frac{Pe^{-(\theta(1-f(u))+r)t}}{\theta(1-f(u))(\theta(1-f(u)+r)} - \frac{\mu}{r}\left[\frac{q_{\circ}}{(\theta(1-f(u)+\alpha)} + \frac{\delta}{a}\left[\frac{1}{(\theta(1-f(u)+\alpha)} - \frac{\Delta}{r\theta(1-f(u)}\right]\right]e^{-rT} + \frac{\mu}{r}\left[\frac{q_{\circ}}{(\theta(1-f(u)+\alpha)} - \frac{\delta}{a}\left[\frac{1}{(\theta(1-f(u)+\alpha)} + \frac{\delta}{\theta(1-f(u))}\right]\right.\right.$$

$the\ reduced\ carbon\ emission\ cost\ is$

$$CT_{CE2} = C_T e^{-aG}[DC_{EC2} + HC_{CE2} + FC_{CE} + PC_{CE}]$$

$total\ average\ cost\ per\ unit\ of\ time\ in\ represented\ by$

$$T_{C_6} = \frac{1}{T}\ [OC + DC_2 + HC_2 + FC + PC + PTI + CT_{CE2} + GT]$$

Model 4: Model with trade credit policy

A model with trade credit policy in inventory management incorporates a financing arrangement where the supplier allows the buyer to delay payment for goods purchased. Trade credit influences the buyer's ordering decisions, holding costs, and profitability.

Case 1- when $M < T$

Case 2- when$M \geq T$

Now for case 1

Interest earned in this case is given by $= pI_e \int_0^M R(t)te^{-rt}dt$

$$= pI_e\mu[q_{\circ}\left(\frac{Me^{(t-r)M}}{(\alpha-r)} - \frac{e^{(t-r)M}M}{(\alpha-r)^2} + \frac{1}{(\alpha-r)^2}\right) + \frac{\delta}{2}\left[\frac{e^{(t-r)m}M}{(\alpha-r)} - \frac{e^{(t-r)m}}{(\alpha-r)^2} + \frac{1}{(\alpha-r)^2} + \left(\frac{Me^{-rm}}{r} + \frac{e^{-rm}}{r^2} - \frac{1}{r^2}\right)\right]$$

Interest Charge = $cI_c \int_M^T I_2(t)e^{-rt}dt$

$$Interest\ \ charge = cI_C\{\left[\frac{-Pe^{-rt}}{\theta(1-f(u)r} + \frac{Pe^{-rm}}{\theta(1-f(u))r}\right] - \mu\left[\frac{q_\circ e^{(d-r)T}}{\theta(1-f(u)+\alpha)(\alpha-r)} - \frac{q_\circ e^{(d-r)M}}{\theta(1-f(u)+\alpha)(\alpha-r)} + \frac{\delta}{a}\left[\frac{e^{(\alpha-r)T}}{(\alpha+\theta(1-f(u))(\alpha-r)} - \frac{e^{(\alpha-r)M}}{(\alpha+\theta(1-f(u))(\alpha-r)} + \frac{e^{-rt}-e^{-rm}}{r(\theta(1-f(u))}\right]\right] - \frac{\mu q_\circ e^{-[\theta(1-f(u)+r)T}}{(\theta(1-f(u)+r)} + \frac{\mu q_\circ e^{-[\theta(1-f(u)+r)M}}{(\theta(1-f(u)+r)} + \frac{Pe^{-[\theta(1-f(u)+r)T}}{\theta^2(1-f(u))(1-f(u)+r)} + \mu[\frac{q_\circ}{\theta(1-f(u))} - \frac{\delta}{a(\theta(1-f(u))} - \frac{1}{\theta}][\frac{-e^{-[\theta(1-f(u)+r)T}+e^{-[\theta(1-f(u)+r)M}}{(\theta(1-f(u)+r)}]\}$$

Case 2 when $M \geq T$

Interest Charged = 0

Interest Earned =

$$= pI_e(\mu(q_0(\frac{T\,e^{(\alpha-r)T}}{(\alpha-r)} - \frac{e^{(\alpha-r)T}}{(\alpha-r)^2} + \frac{Te^{-rT}}{r} + \frac{e^{(\alpha-r)T}}{r^2}) + \frac{\delta}{2}(\frac{Te^{(\alpha-r)T}}{(\alpha-r)} - \frac{e^{(\alpha-r)T}}{(\alpha-r)^2} + \frac{Te^{-rT}}{r} + \frac{e^{-rT}}{r^2})) - \mu(q_0(\frac{1}{(\alpha-r)^2}) + \frac{\delta}{2}(\frac{-1}{(\alpha-r)^2} + \frac{1}{r^2})) + (M-T)(\mu(\frac{q_0 e^{(\alpha-r)T}}{(\alpha-r)^2} - \frac{q_0}{(\alpha-r)}) + \frac{\delta}{2}(\frac{e^{(\alpha-r)T}}{(\alpha-r)} + \frac{e^{-rT}}{r} - \frac{1}{(\alpha-r)} - \frac{\delta}{r})))$$

5. Numerical Illustration

This section illustrates and verifies these models numerically. In our models, we have taken into account sweet makers and consumers of sweets during Indian festivals. It is estimated that some individuals are already diabetic and some are migrating from non-diabetic to diabetic status. The development of such a model has been very limited to date. Therefore, the model is based on hypothetical parameters.

Example 1 When $T \geq M$ The presented models are validated by considering the following example

$$q_0 = 10000, \alpha = 0.5, \mu = 0.05, \theta = 0.1, \delta = 120, c_T = 10, c_d = 2, h = 0.2, A = 100, a = 0.25, r = 0.1, \omega = 1, M = 1.5, F = 10, H = 0.03, C_{T_{c_E}} = 0.03, \gamma = 4, c_{p_0} = 15, C_{d_{c_E}} = 1.5, c_p = 5, p = 1, c = 0.5, I_e = 0.1, I_C = 0.2, u = 100, P = 500$$

Optimal Result

$$Total\ cost = 2406672.68\$\ , T = 10.2747 months\ , G = 49.47\ \$$$

Example 2 : When $M \geq T$ The presented models are validated by considering the following example $q_0 = 10000, \alpha = 0.5, \mu = 0.05, \theta = 0.1, \delta = 120, c_T = 10, c_d = 2, h = 0.2, A = 100, a = 0.25, r = 0.1, \omega = 1, M = 1.5, F = 10, H = 0.03, C_{T_{c_E}} = 0.03, \gamma = 4, c_{p_0} = 15, C_{d_{c_E}} = 1.5, c_p = 5, p = 1, c = 0.5, I_e = 0.1, I_C = 0.2, u = 100, P = 500$

Optimal Result

$$Total\ cost = 1044730.84\$\ , T = 9.3073 months\ , G = 58.64\ \$$$

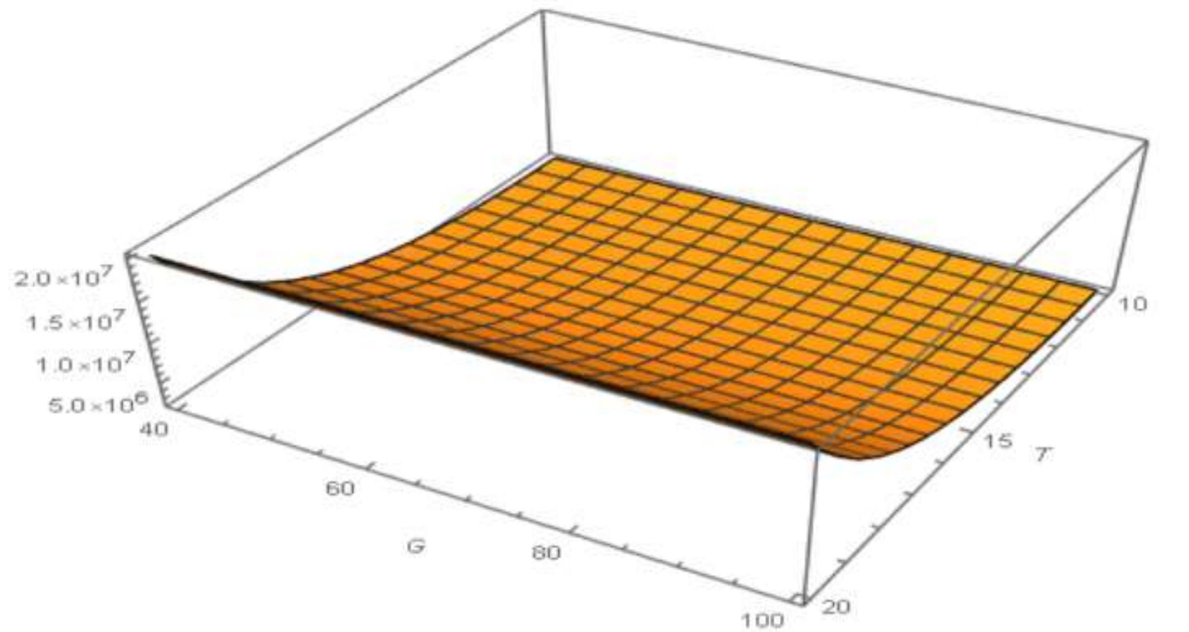

Figure 1 Convexity between cycle length T and Green Technology Investment in case 1

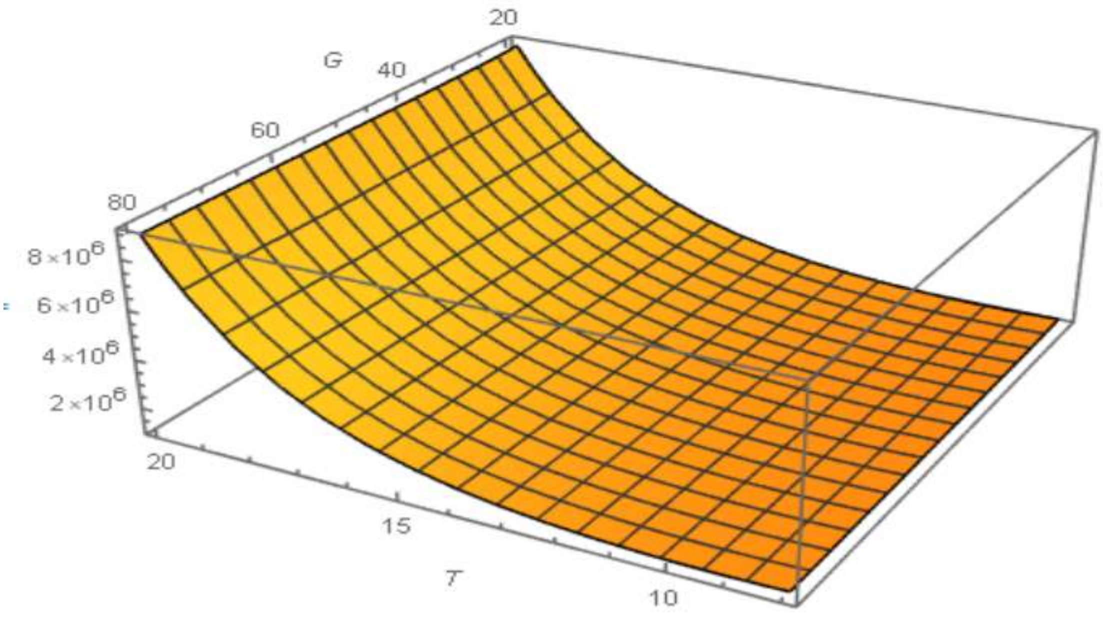

Figure 2. Convexity between cycle length T and Green Technology Investment in case 2

Table 1 Comparison of Result

Optimal Results	T	G	Total cost
Case 1 , $T \geq M$	10.27 months	49.47 $	2406672.68$
Case 2 $M \geq T$	9.3 months	58.64 $	1044730.84$

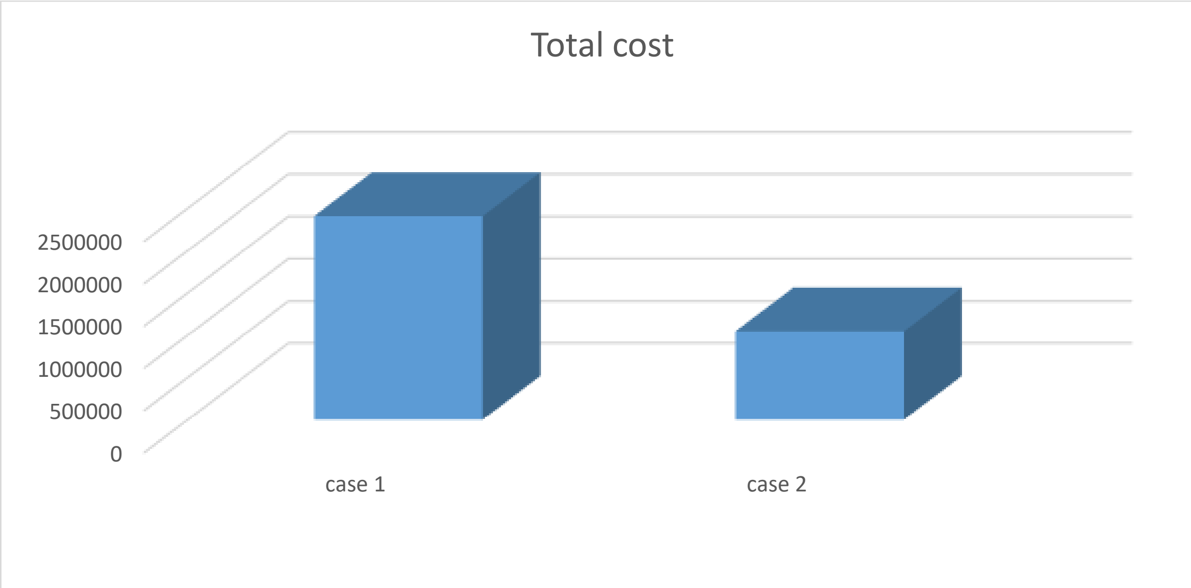

Figure 3. Comparison of the result

6. Sensitivity Analysis

The sensitivity analysis of various parameters are given in table 1.

Table 2 Sensitivity analysis of various parameters

Parameter	% Change	T	G	Total Cost
P	+20%	9.62404	59.0642	1163520
	+10%	9.47215	58.8606	1104740
	-10%	9.12706	58.4112	983323
	-20%	8.92807	58.161	920316
u	+20%	9.65799	59.244	1190460
	+10%	9.49032	58.9572	1118360
	-10%	9.10584	58.2979	969358

	-20%	8.88158	57.9125	891960
q_0	+20%	8.97603	58.7632	1099070
	+10%	9.13407	58.7059	1072580
	-10%	9.4989	58.5755	1015310
	-20%	9.71303	58.5003	984044
α	+20%	8.06959	59.157	1189610
	+10%	8.62034	58.9179	1120710
	-10%	10.1793	58.3257	961802
	-20%	11.3156	57.9515	871864
μ	+20%	8.99742	58.9751	1129660
	+10%	9.14451	58.8139	1087790
	-10%	9.48927	58.4628	1000270
	-20%	9.69504	58.2696	954126
θ	+20%	8.95828	58.0443	917706
	+10%	9.12456	58.33	976129
	-10%	9.51011	58.9911	1126630
	-20%	9.73779	59.3805	1226400
δ	+20%	9.32214	58.8598	1073520
	+10%	9.31498	58.7531	1059190
	-10%	9.29915	58.5311	1030150
	-20%	9.29045	58.4153	1154400
h	+20%	9.64562	58.5376	1191680
	+10%	9.48405	58.5874	1118920
	-10%	9.11234	58.7077	968915

	-20%	8.89491	58.7818	891201
a	+20%	8.87678	49.4866	874303
	+10%	8.88502	53.722	881986
	-10%	8.90698	64.9365	902459
	-20%	8.92204	72.5905	916522
r	+20%	8.47161	58.3157	798657
	+10%	8.63688	58.5507	845629
	-10%	9.32493	58.9934	927458
	-20%	10.1811	59.1356	929416
ω	+20%	8.89491	58.7818	891201
	+10%	8.89491	58.7818	891201
	-10%	8.89491	58.7818	891201
	-20%	8.89491	58.7818	891201
F	+20%	8.71801	58.8442	1145850
	+10%	8.98625	58.7503	1097520
	-10%	9.7064	58.5193	985894
	-20%	10.2327	58.3694	918197
γ	+20%	9.65799	59.244	1190440
	+10%	9.49032	58.9572	1118350
	-10%	9.10584	58.2979	969368
	-20%	8.88158	57.9125	891980
	+20%	9.30732	58.65	1046230
	+10%	9.30732	58.6468	1045480

c_{p_0}	-10%	9.30732	58.6404	1043980
	-20%	9.30732	58.6372	1043230
p	+20%	9.69198	58.5236	988057
	+10%	9.48737	58.5864	1017220
	-10%	9.14663	58.6963	1070870
	-20%	9.0016	58.7451	1095850
c	+20%	9.30732	58.6436	1044730
	+10%	9.30732	58.6436	1044730
	-10%	9.30732	58.6436	1044730
	-20%	9.30732	58.6436	1044730
I_c	+20%	9.30732	58.6436	1044730
	+10%	9.30732	58.6436	1044730
	-10%	9.30732	58.6436	1044730
	-20%	9.30732	58.6436	1044730
I_e	+20%	9.69198	58.5236	988057
	+10%	9.48737	58.5864	1017220
	-10%	9.14663	58.6963	1070870
	-20%	9.0016	58.7451	1095850

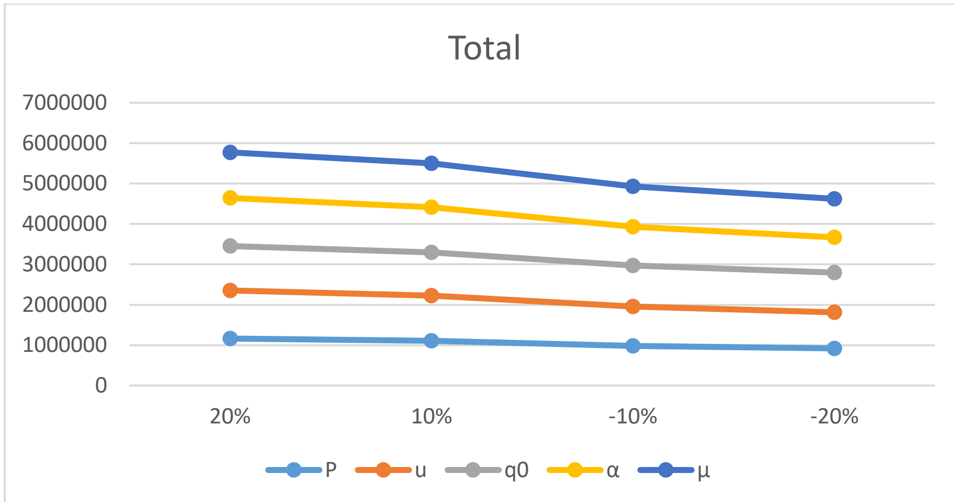

Figure. 4 Graphical representations of variation in the parameters $P, u, q_0, \alpha, and\ \mu$, o total cost.

7. Observations

Following assumptions are made from the sensitivity analysis table.

- As production rate P increases from -20% to 20% the cycle length T, Green technology investment G, and total cost all increases.
- As investment in preservation technology u increases from -20% to 20% the cycle length T, Green technology investment G, and total cost all increases.
- As q_0 increases from -20% to 20% the cycle length T decreases while the Green technology investment G, and total cost increases.
- As α increases from -20% to 20% the cycle length T decreases while the Green technology investment G, and total cost increases.
- As μ increases from -20% to 20% the cycle length T decreases while the Green technology investment G, and total cost increases.
- As θ increases from -20% to 20% the cycle length T and total cost decreases while the Green technology investment G slightly increases.
- As δ increases from -20% to 20% the cycle length T and Green technology investment G slightly increases while the total cost fluctuating .
- As h increases from -20% to 20% the cycle length T and total cost increases while the Green technology investment G slightly decreases.
- As a increases from -20% to 20% the cycle length T ,Green technology investment G and total cost all are decreases.
- As r increases from -20% to 20% the cycle length T ,Green technology investment G and total cost all are decreases.

- As $\omega, c\ and\ I_c$ increases from -20% to 20% no effect on the cycle length T , total cost and Green technology investment.
- As F increases from -20% to 20% the cycle length T decreases while the Green technology investment G, and total cost increases.
- As γ increases from -20% to 20% the cycle length T, total cost and the Green technology investment G all are increases.
- As c_{p_0} increases from -20% to 20% the cycle length T remains same, total cost and the Green technology investment G are increases.
- As p, I_e increases from -20% to 20% the cycle length T increases, while the total cost and the Green technology investment G decreases.

8. Conclusion

This paper investigated the optimization of green technology investment and trade credit policy in an inflationary environment for a perishable product inventory system. The analysis emphasized the complex interplay between sustainability initiatives, financial strategies, and the time-sensitive nature of perishable goods. By integrating inflation effects, green technology investment decisions, and trade credit terms into the inventory model, the research demonstrated how businesses can strategically manage costs while enhancing environmental performance. From the result analysis we obtained that we find the optimal cost in case 2 when trade credit period is greater than the total cycle length. Also, from the sensitivity analysis we find that purchasing price and interest charge have no impact on optimal solution. If the production rate and investment in preservation technology increases than the total cost also increases. Inflation rate positively impact on optimal solution. Future studies may extend this work by incorporating stochastic demand, multi-item systems, or real-time data analytics for dynamic decision-making.

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