Communications on Applied Nonlinear Analysis
ISSN: 1074-133X
Vol 32 No. 9s (2025)

A Reverse Logistics Model for Green Products with Carbon Emission under Green Technology and Consumer Concern

[1]Ashok Kumar, [2]Jitendra Kumar, [3]Arvind Kumar*

[1]Department of Mathematics, Meerut College, Meerut; Email- drakkashyap@hotmail.com

[2]Department of Mathematics, Marwari College, L.N. Mithila University, Darbhanga; Email- jitte.dm@gmail.com

[3]Department of Mathematics, Meerut College, Meerut; Email- arvind.mcat@gmail.com

Article History:

Received: 12-11-2024

Revised: 17-12-2024

Accepted: 06-01-2025

Abstract:

In the prevailing global scenario, characterized by heightened carbon concerns and inadequate waste management, a systematic approach to product lifecycle management is essential. This proposed model tackles the challenge by methodically handling used products through collection, disassembly, and distribution based on their intrinsic value. With a primary focus on minimizing waste at the end of the cycle and considering carbon emissions, the model seamlessly integrates production and remanufacturing while accommodating fluctuating inflation rates over time. Crucially, it ensures that remanufactured items maintain parity with their original counterparts, accounting for the natural degradation of stored items. Numerical verification enhances the theoretical framework, providing a visual representation of anticipated results, and sensitivity analyses explore various parameters, contributing to a comprehensive understanding of the intricate dynamics between production, remanufacturing, and waste reduction.

Keywords: Imperfect production, Time dependent demand, Reverse- Logistics, Inflation.

1. Introduction

In recent years, the imperative for sustainable business practices has become increasingly apparent, driven by growing awareness of environmental issues and a heightened sense of corporate responsibility. Central to this movement is the concept of reverse logistics, which encompasses the management of product returns and end-of-life disposal in a manner that minimizes waste and maximizes resource efficiency. Reverse logistics, a term subject to varying interpretations among scholars, as per Kokkinaki et al. (2001), encompasses all operations associated with the reuse, refurbishment, and recycling of products and materials. Reverse logistics refers to the process of managing the flow of products and materials backward through the supply chain, from the end consumer to the point of origin, for purposes such as recycling, refurbishment, or disposal. This aspect of supply chain management focuses on optimizing resource utilization, minimizing waste, and promoting sustainability by ensuring that products reach their maximum potential value before being discarded. Reverse logistics plays a crucial role in reducing the environmental impact of consumption by diverting items from landfills and facilitating their reuse or recycling.

Moreover, as companies strive to adopt greener practices, the consideration of carbon emissions has emerged as a critical factor in assessing the environmental impact of supply chain operations. Carbon emissions, largely stemming from industrial activities and transportation, contribute significantly to climate change and environmental degradation. Addressing carbon emissions requires the adoption of green technologies and sustainable practices throughout the supply chain. Green technology encompasses a range of innovative solutions aimed at reducing resource consumption, minimizing waste generation, and lowering carbon emissions. These technologies play a pivotal role in promoting environmental sustainability and mitigating the ecological footprint of business operations.

In response to mounting environmental concerns, manufacturers and suppliers are increasingly investing in green technologies to develop eco-friendly products and optimize production processes. Green technology encompasses a range of innovations aimed at reducing resource consumption, minimizing waste generation, and lowering carbon emissions. These efforts align with consumer demand for sustainable products, driven by a heightened sense of environmental consciousness and a desire to support businesses that prioritize eco-friendliness. Consumer concern for the environment has catalyzed the emergence of green marketing strategies, which aim to promote the environmental benefits of products and encourage sustainable consumption habits.

Against this backdrop, this study introduces a two-tier inventory model involving a manufacturer, a remanufacturer, and a supplier, with a focus on the production and distribution of green products. By analyzing price-sensitive demand patterns within this supply chain framework, the study seeks to elucidate optimal strategies for sustainable business operations. In doing so, it aims to contribute to the growing body of literature on reverse logistics, carbon emissions reduction, green technology adoption, and consumer-driven sustainability initiatives within the context of modern supply chain management.

Schrady (1967) was the first to investigate remanufactured items and their stockpile in the 1960s. Based on the assumption of instantaneous repairs and manufacturing with no disposal costs, he developed an EOQ model for repairable items, considering a single batch of manufacturing and the creation of multiple repair systems. Goyal and Giri (2003) highlighted Richter's earlier work on a production-inventory problem, which theorized time-varying demands, productions, and degradations for a product. Teunter (2001, 2004), Inderfurth et al. (2005), and Dobos and Richter (2006) developed models considering the quality of returned items, exploring two collection management strategies: either buying used items back and reusing as much as possible or buying only a fraction back and determining the reusable quantity. In terms of quality, repaired products are inferior compared to remanufactured and reconditioned ones, as defined by King, Burgess, Ijomah, and McMahon (2006), who describe repair as addressing faults in a product. The paper discusses optimal production quantity, remanufacturing, and waste disposal when a manufacturer meets stationary demand with both manufactured and repaired products.

Moreover, researchers have examined a production/recycling system with constant demand (El Saadany and Jaber, 2008). This system involves the constant production of a single batch of repair and original parts through non-instantaneous production and recycling. Rahbar and Wahid (2011) presented research on the effects of green marketing tools on consumer behavior. Singh and Saxena

(2013) introduced a closed-loop remanufacturing system for decaying items, considering a single item with two different quality standards in the model. During production, shortages and excess demand led to a backlog, and a model has been provided to estimate pricing, market coverage, and capacity based on the research by Yenipazarli and Vakharia (2015). Moghaddam (2015) developed a fuzzy multi-objective model to select suppliers and allocate orders within a reverse logistics system with uncertainty in supply and demand. This model proposes a continuous-review inventory model, as suggested by Malik and Sarkar (2018), incorporating uncertainties in demand, quality enhancements, setup cost savings, and lead-time variability control. Mashud et al. (2020) proposed the concept of a sustainable inventory based on imperfect products, depreciation, and controllable emissions. Using the remanufacturing/production cycle model, Saxena et al. (2020) developed a perspective on waste management through the selection of remanufacturing/production cycles in an alternative market.

The proposed model for waste reduction and efficient product lifecycle management draws on a comprehensive literature review spanning various dimensions of sustainable and eco-efficient practices. Saxena et al. (2020) shed light on the selection of remanufacturing/production cycles in the context of an alternative market, emphasizing waste management in the Journal of Cleaner Production. Trochu et al. (2020) contribute a carbon-constrained stochastic model for eco-efficient reverse logistics network design under environmental regulations. An integrative inventory system incorporating degradation was published by Tyagi et al. (2020) where consumption is regarded as being price-based and production rate as being market-dependent.

The rate of recovery is thought to be linearly time-sensitive in a framework developed by Handa et al. (2021) in which the end user receives repurchase goods. Meng et al. (2021) present a pricing policy for dual-channel green supply chains, considering government subsidies. Mishra and Sarkar (2021) study the optimal inventory management strategy considering backorders and deterioration effects. Sarkar et al. (2021) explore the effects of carbon reduction and improved product quality on fixed life cycle products in sustainably managed supply chains. Kumar et al. (2021) present a fuzzy reverse logistics inventory model considering carbon emissions, while Motla et al. (2021) explore a fuzzy integrated inventory system with end-of-life treatment in the sports industry. Rana et al. (2021) investigate a growing items inventory model for carbon emissions, and Hashemi (2021) introduces a fuzzy multi-objective optimization model for sustainable reverse logistics network design An approach for degrading supplies was developed by Singh et al. (2022) based on the supposition that the deteriorating things have an optimal lifespan and that learning-forgetting has a direct effect on purchasing expenses. Yadav et al. (2022) examine an integrated model, recognizing that the profit of the centralized system grows due to the influence of learning-forgetting on its initial cost. Mondal et al. (2022) present the impact of deteriorating prevention technology and trapezoidal demand in Interval Uncertainty under Backlogging. Alamri et al. (2022) develop an ecologically objective quality model with carbon emissions and inflation resulting from deteriorating unreliable production processes. Sarkar et al. (2022) find the remanufacturing industry negatively impacting both the economy and the environment. Karim and Nakade (2022) conduct a literature review on the sustainable EPQ model, focusing on carbon emissions and product recycling. Bhardwaj et al. (2023) proposed a three-tier environmental distribution approach to inventory that takes into account stock-based demand, retailer-permitted shortages of goods, and emission levels in order to save crucial time and reduce comprehensive costs. Letunovska et al. (2023) delve into the effect of procurement sustainability on reverse logistics in Green Supply Chain Management. Saxena et al. (2023) contribute to the field with a reverse logistics model under the Stackelberg-Nash equilibrium and centralized framework, and further explore random misplacement and production process reliability as sustainable industrial approaches. Ullah (2023) investigates the impact of transportation and carbon emissions on reverse channel selection in closed-loop supply chain management. Motla et al. (2023) optimize inventory in a green environment with two warehouses, while Saxena et al. (2023) explore how the retailing industry decides the best replenishment strategy using technological support through blockchain. Moreover, Saxena et al. (2023) present a sustainable production model with stochastic machine breakdown using smart manufacturing under circular economy principles. The recent work by Saxena et al. (2024) investigates retail strategies for shelf-life products to satisfy consumers under game policy in the Journal of Retailing and Consumer Services. This extensive body of literature provides a robust foundation for the proposed model, integrating insights from diverse studies focused on sustainability, waste reduction, and efficient production processes. Yang et al.'s (2024) article investigates how reverse logistics and sustainable supply chain initiatives impact sustainability performance in manufacturing, highlighting the moderating role of organizational learning capability.

In this paper, we propose an integrated inventory model for green production/remanufacturing processes that incorporates GHG emissions and multivariate demand. Demand rate depends on price, green degree of the product and the consumer's concern toward green products. Production rate and remanufacturing is dependent on demand rate. The remaining portion of this paper is structured as follows. Section 2 of this chapter will identify the assumptions, notations, and description of the system that will be used to evaluate the production/remanufacturing inventory that will be discussed throughout. The mathematical modeling can be found in Section 3. Finally, the discussion of the results and the examples are listed in Section 4. At the end of this paper, the results and the examples summarise and conclude the paper.

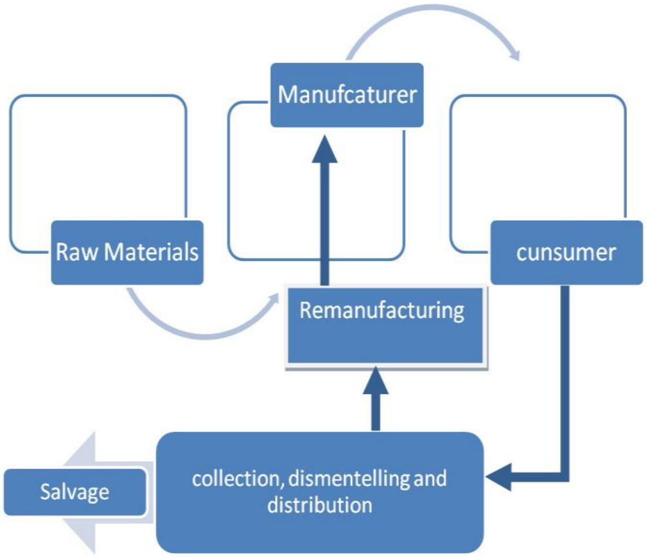

Figure 1: Material flow the closed loop supply chain system

2. Assumptions

This section discusses the assumptions used throughout the paper.

- The multivariate demand rate has been considered as $D(p,j) = a - p + ej$ where a is the potential market demand, p is the selling price, j is the consumer preference for the green product and e is the green degree of the product.
- The production rate P_m = bD = $b(a - p + ej)$ is demand dependent and $P_m > D$.
- The remanufacturing rate P_r is also demand dependent i.e. $P_r = c(a - p + ej)$ and $P_r > D$.
- The return rate of the used items, R, is proportional to the demand rate i.e. $R = kD$, where $0 \leq k \leq 1$.
- Used items are collected and remanufactured as good as new ones.

3. Notations:

The following notations also need to be taken into consideration in order to create the model.

C_P	the setup cost of the production run (cost/setup)
C_R	the setup cost of the repair run (cost/setup)
C_1	the ordering cost of raw material 1 (cost/order)
h_P	the inventory holding cost of finished items (cost/unit/time)
h_R	the inventory holding cost of used items (cost/unit/time)
h_1	the inventory holding cost raw material 1 (cost/unit/time)
r	the inflation rate
δ	the rate of imperfect production
l	inspection cost
i	remanufacturing cost
q_1	the quantity of raw material 1 required to produce one unit of the finished product.

4. Mathematical Formulation

The manufacturing of finished product from raw materials, it may be possible to reuse the collecting used products which are collected from the customers. The stock behaviour has been depicted in the figure 2 and the differential equations are as follows:

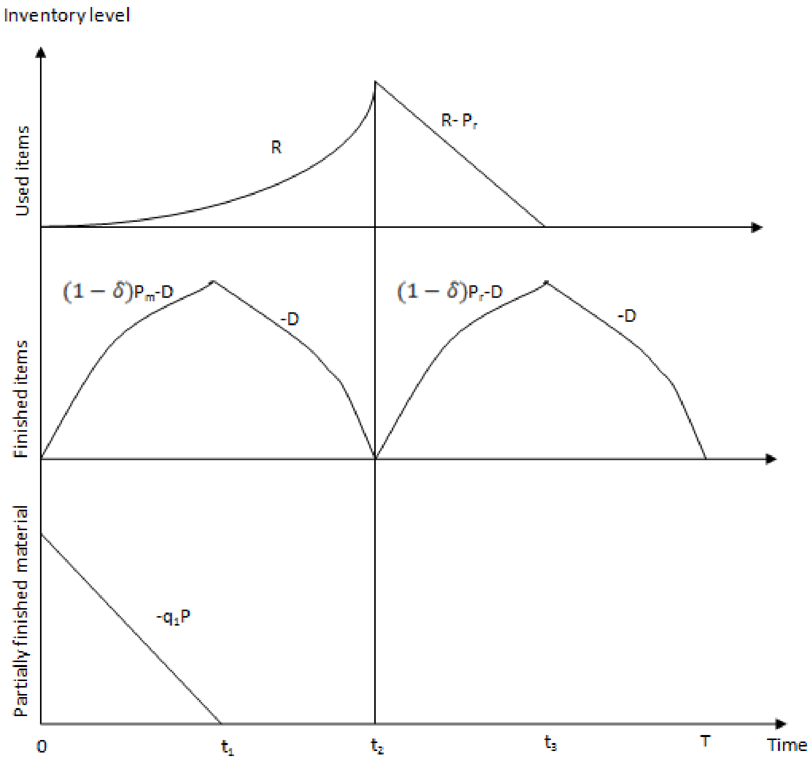

Figure 2: Status of inventory during the complete life cycle

$I_R'(t) = R, \qquad 0 \le t \le t_2 \qquad (1)$

$I_R'(t) = R - P_r \qquad t_2 \le t \le t_3 \qquad (2)$

$I_m'(t) = (1-\delta)P_m - D \qquad 0 \le t \le t_1 \qquad (3)$

$I_m'(t) = -D \qquad t_1 \le t \le t_2 \qquad (4)$

$I_r'(t) = (1-\delta)P_r - D \qquad t_2 \le t \le t_3 \qquad (5)$

$I_r'(t) = -D \qquad t_3 \le t \le T \qquad (6)$

With boundary conditions

$$I_R(0) = 0, I_R(t_3) = 0, I_m(0) = 0, I_m(t_2) = 0, I_r(t_2) = 0, I_r(\mathrm{T}) = 0$$

Solutions of these equations are:

$I_R(t) = Rt, \qquad 0 \le t \le t_2 \qquad (7)$

$I_R(t) = (P_r - R)(t_3 - t) \qquad t_2 \le t \le t_3 \qquad (8)$

$I_m(t) = \{(1-\delta)P_m - D\}t \qquad 0 \le t \le t_1 \qquad (9)$

$I_m(t) = D(t_2 - t) \qquad t_1 \le t \le t_2 \qquad (10)$

$I_r(t) = \{(1-\delta)P_r - D\}(t - t_2) \qquad t_2 \le t \le t_3 \qquad (11)$

$$I_r(t) = D(T - t) \qquad t_3 \le t \le T \qquad (12)$$

Cost components

Different costs are associated with the inventory management. These costs are calculated as below

To accomplish the demand of the consumer the manufacturer need to purchase the raw material and produce the items. The purchasing and production cost of the system can be calculated as

PC= $(C_P + C_m)P_m t_1$

R & D cost for green technology can be calculated as

GTC =$\frac{1}{2}Ke^2$

Items are buyback from the consumer and the accusation cost of the used products can be calculated as

AC = $A_s R t_3$

These returned items remanufactured and the cost of remanufacturing can be calculated as

RC =$C_r P_r (t_3 - t_2)$

Thereafter they need to hold the inventory and the holding cost of the returned items can be calculated as

$$H_R = h_R\left[\int_0^{t_2} I_R(t)dt + \int_{t_2}^{t_3} I_R(t)dt\right]$$

$$= h_R\left\{\frac{Rt_2^2}{2} + (P_r - R)\frac{(t_3 - t_2)^2}{2}\right\}$$

The holding cost of the manufactured items can be calculated as

$$H_m = h_m\left[\int_0^{t_1} I_m(t)dt + \int_{t_1}^{t_2} I_m(t)dt\right]$$

$$= h_m\left[\{(1-\delta)P_m - D\}\frac{t_1^2}{2} + D\frac{(t_2 - t_1)^2}{2}\right]$$

and the holding cost of the remanufactured items can be calculated as

$$H_r = h_r\left[\int_{t_2}^{t_3} I_r(t)dt + \int_{t_3}^{T} I_r(t)dt\right]$$

$$= h_r\left[\{(1-\delta)P_r - D\}\frac{(t_3 - t_2)^2}{2} + D\frac{(T - t_3)^2}{2}\right]$$

Total holding cost of the system can be written as

$$= h_R\left\{\frac{Rt_2^2}{2} + (P_r - R)\frac{(t_3 - t_2)^2}{2}\right\} + h_m\left[\{(1-\delta)P_m - D\}\frac{t_1^2}{2} + D\frac{(t_2 - t_1)^2}{2}\right] + h_r\left[\{(1-\delta)P_r - D\}\frac{(t_3 - t_2)^2}{2} + D\frac{(T - t_3)^2}{2}\right]$$

From continuity one can get

$$Rt_2 = (P_r - R)(t_3 - t_2)$$

$$\{(1-\delta)P_m - D\}t_1 = D(t_2 - t_1)$$

$$\{(1-\delta)P_r - D\}(t_3 - t_2) = D(T - t_3)$$

by which we get

$$t_2 = \frac{(1-\delta)P_m}{D}t_1$$

$$t_3 = \frac{P_r}{(P_r - R)}\frac{(1-\delta)P_m}{D}t_1$$

$$T = \frac{(1-\delta)P_r t_3 - \{(1-\delta)P_r - D\}t_2}{D}$$

Total Profitof the system can be written as

$$= \frac{1}{\mathrm{T}}\left[pDT - \left\{(C_P + C_m)P_m t_1 + A_s R t_3 + C_r P_r (t_3 - t_2) + \frac{1}{2}Ke^2 + h_R\left\{\frac{Rt_2^2}{2} + (P_r - R)\frac{(t_3 - t_2)^2}{2}\right\} + h_m\left[\{(1-\delta)P_m - D\}\frac{t_1^2}{2} + D\frac{(t_2 - t_1)^2}{2}\right] + h_r\left[\{(1-\delta)P_r - D\}\frac{(t_3 - t_2)^2}{2} + D\frac{(T - t_3)^2}{2}\right]\right\}\right] \quad (13)$$

Here the profit function is the function of the variable t_1, t_2, t_3 and T but by using the continuity one can observe that the value of t_2, t_3 and T depends on the parameter t_1 therefore the profit has only one decision variable t_1. To maximize total average profit per unit time (TP), the optimal values of $t_1$can be obtained by solving the equation $\frac{\partial TP}{\partial t_1} = 0$

The convexity of the function can be ensured by the condition as below

$$\frac{\partial^2 TP}{\partial {t_1}^2} < 0$$

5. Numerical Example

The provide model has been illustrated through the following numerical with suitable input parameters. To check the validity of the model, values of the parameters have been chosen from the previous studies.

Table 1: Input values of the Parameters

Parameters	**Input Values**	**Parameters**	**Input Values**
c_m	\$20 per unit item	k	2
c_P	\$50 per unit item	j	1
δ	0.05	e	250
A_s	\$10 per unit item	a	1000
c_r	\$45 per unit item	p	\$100
h_R	\$1.5 per unit per unit item	b	1.25
h_m	\$1.5 per unit per unit item	c	1.2
h_r	\$1.25 per unit per unit item	R	750

Table 2: Optimal values of decision parameters and total profit

t_1*	t_2*	t_3*	T*	TP
5.38	6.39	13.99	15.06	32418.1

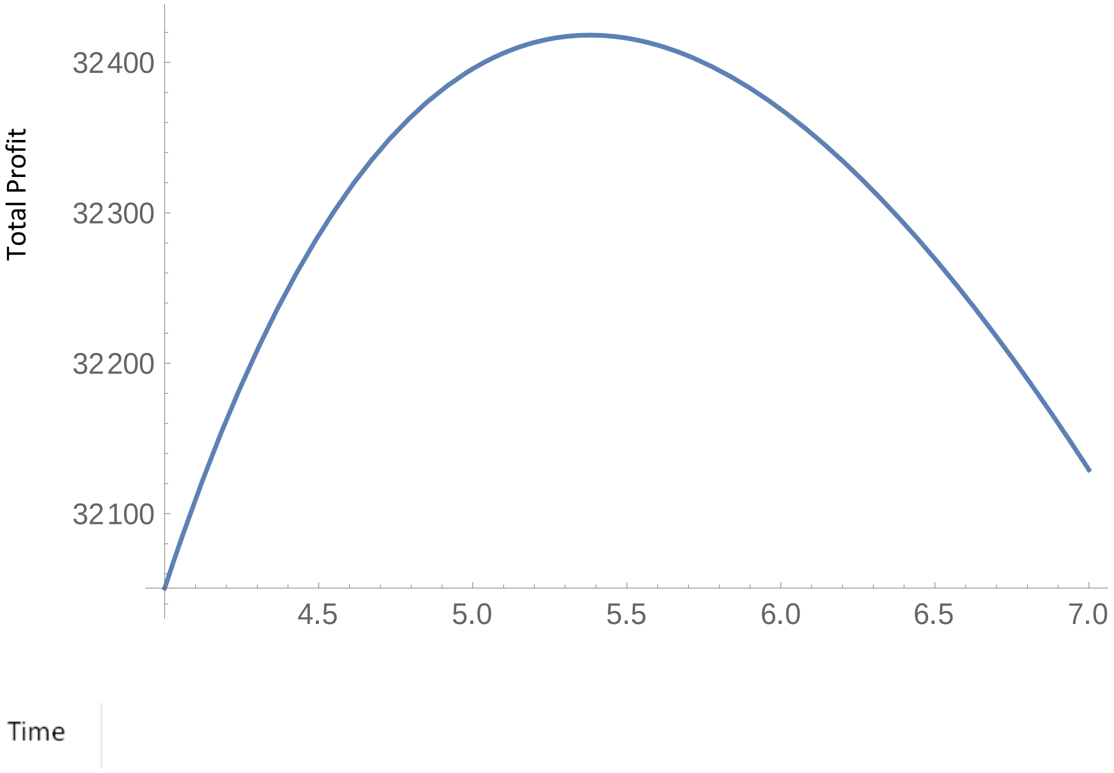

Figure 3: Concave Nature of Total profit w.r.t t_1

5.Sensitivity Analysis

A sensitivity analysis with respect to different associated parameters is carried out to observe the change in the profit function with the change in these parameters.

Table 3: effect of variation of different parameter on the optimum results

Parameter	Change in Parameter	t₁*	TC*
Δ	0.025	5.15	34403.51
	0.045	5.23	33622.1
	0.055	5.33	32823.8
	0.065	5.43	32007.9
K	1	3.81	34849.2
	1.5	4.65	33530.1
	2.5	6.01	31438.5
	3	6.58	30552.8
j	0.5	4.94	29685.4
	0.75	5.18	31037.5
	1.25	5.54	33822.7
	1.5	5.68	35245.9
e	150	3.02	33339.9
	200	4.18	32922.9
	300	6.61	31834.6
	350	7.88	31179.7
A	900	5.04	30222.4
	950	5.22	31311.5
	1050	5.51	33539.5
	1100	5.63	34673.
p	90	5.41	21041.
	95	5.39	26754.6
	105	5.37	38031.7
	110	5.35	43595.5
b	1.1	6.32	32691.1
	1.2	5.66	32500.5
	1.3	5.12	32342.7
	1.4	4.68	32209.8
c	1.1	5.28	33316.1
	1.15	5.32	32828.9
	1.25	5.17	31988.6
	1.3	5.21	31681.98
R	600	6.65	30321.8
	700	5.78	31699.1
	800	4.98	33157.2
	900	4.22	34697.3

6.Observations

1. From the table 1, one can see how the profit function changes as the value of demand parameter a varies, one can see that as the a slight increment in the value of demand parameter a resulted in the moderate increment in the production period while profit of the model is generally positive in response to a change in the demand parameter.
2. It is observed that the profit function is slightly negative sensitive to the change in the production parameter while the production period is highly negative sensitive to the change in the parameter b, which is quite obvious because if the rate of production will be high, we need less time to produce the material.
3. Similar results evident by the sensitivity of the remanufacturing parameter c. it is observed that the increment in the remanufacturing parameter resulted in slightly reduction in the production period while a moderate reduction in the profit function.
4. It is noticed that a slight increment in the return rate cause a great reduction in the product period because greater return resulted in more remanufacturing and less production, consequently a huge increment in the profit.
5. Results revel that that a positive variation in price can cause a reduction in total demand, consequently less production therefore a slight reduction in the production period however a slight increment in the price can resulted in a huge increment in the profit.
6. It is noticed that the profit function is highly negative proportional to the change in the δ, k and e green coefficient while highly positive sensitive for the consumer concern$j$

6. Conclusion

The presented model offers a nuanced perspective on the reverse logistics system, explicitly incorporating green products and consumer concerns. This innovative approach involves the collection and remanufacturing of used items alongside the production of new ones, with a dedicated focus on integrating green technology. Throughout the production process, careful consideration of consumer concerns regarding environmentally friendly practices has been maintained. The demand rate is intricately linked to price, green technology, and consumer concerns, highlighting the interdisciplinary nature of the model.

A distinctive contribution of this research lies in its comprehensive exploration of the reverse logistics system, specifically addressing the integration of green products and consumer sentiments. By incorporating green technology into the production process, the study offers insights into the intricate dynamics between consumer concerns, green coefficients, and the resulting profit function. The identification of parameters influencing the system's profitability contributes valuable knowledge to the evolving field of sustainable supply chain management.

While this research makes significant strides, it is essential to acknowledge certain limitations. The study focuses primarily on green coefficients, consumer concern, and pricing, potentially overlooking other influential factors. Additionally, the model assumes a simplified environment, neglecting the complexities introduced by external variables such as inflation and trade credit. These limitations underscore the need for cautious interpretation and highlight avenues for future refinement.

To advance the understanding of the reverse logistics system and enhance the model's applicability, future research should delve into the integration of additional parameters. Exploring the impact of inflation and trade credit could provide a more realistic representation of the system's dynamics. Furthermore, a deeper investigation into the interplay of various factors affecting consumer concern and its subsequent influence on the effectiveness of green technology integration is warranted. This expanded scope would contribute to a more comprehensive and robust understanding of sustainable inventory control systems, aligning with the evolving landscape of environmentally conscious supply chain management.

References

1. Alamri, O. A., Jayaswal, M. K., Khan, F. A., & Mittal, M. (2022). An EOQ Model with Carbon Emissions and Inflation for Deteriorating Imperfect Quality Items under Learning Effect. Sustainability, 14(3), 1365.
2. Bhardwaj, V., Kumar, S., & Tyagi, V. K. (2023, December). A Green Inventory Model for New and Revamped Decaying Products with Partially Backlogged and Stock Dependent Demand. In International Conference on Soft Computing: Theories and Applications (pp. 401-411). Singapore: Springer Nature Singapore.
3. Brindley, C. &Oxborrow, L. (2014). Aligning the sustainable supply chain to green marketing needs: A case study. Ind. Mark. Manag. 43, 45–55.
4. Dobos, I., & Richter, K. (2006). “A production/recycling model with quality considerations”. International Journal of Production Economics, 104(2), 571–579.
5. El Saadany, A. M. A., &Jaber, M. Y. (2008). “The EOQ repair and waste disposal model with switching costs”. Computers & Industrial Engineering, 55(1), 219–233.
6. Goyal, S. K. & Giri, B. C. (2003). The production-inventory problem of a product with time varying demand, production and deterioration rates. *Eur. J. Oper. Res.* 147, 549–557.
7. Handa, N., Kumar, S., & Kumar, J. (2021). Development of a closed-loop supply chain system with exponential demand and multivariate production/remanufacturing rates for deteriorated products. Materials Today: Proceedings, 47, 2560-2564.
8. Hashemi, S. E. (2021). A fuzzy multi-objective optimization model for a sustainable reverse logistics network design of municipal waste-collecting considering the reduction of emissions. *Journal of Cleaner Production*, *318*, 128577.
9. Inderfurth, K., Lindner, G., & Rachaniotis, N. P. (2005). “Lot sizing in a production system with rework and product deterioration”. International Journal of Production Research, 43(7), 1355–1374.
10. Jaber, M. Y., & Rosen, M. A. (2008). “The economic order quantity repair and waste disposal model with entropy cost”. European Journal of Operational Research, 188(1), 109–120.
11. Karim, R., & Nakade, K. (2022). A literature review on the sustainable EPQ model, focusing on carbon emissions and product recycling. *Logistics*, *6*(3), 55.
12. King, A. M., Burgess, S. C., Ijomah, W., & McMahon, C. A. (2006). Reducing waste: Repair, recondition, remanufacture or recycle? Sustainable Development, 14(4), 257–267.

13. Kokkinaki, A., Dekker, R., de Koster, R., &Pappis, C. (2001). *From e-trash to e-treasure: how value can be created by the new e-business models for reverse logistics* (No. EI 2000-32/A).
14. Kumar, S., Sarkar, B., & Kumar, A. (2021). Fuzzy reverse logistics inventory model of smart items with two warehouses of a retailer considering carbon emissions. *RAIRO-Operations Research*, *55*(4), 2285-2307.
15. Letunovska, N., Offei, F. A., Junior, P. A., Lyulyov, O., Pimonenko, T., &Kwilinski, A. (2023). Green Supply Chain Management: The Effect of Procurement Sustainability on Reverse Logistics. Logistics, 7(3), 47.
16. Malik, A. I., &Sarkar, B. (2018). Optimizing a multi-product continuous-review inventory model with uncertain demand, quality improvement, and setup cost reduction and variation control in lead time. IEEE Access, 6, 36176-36187.
17. Mashud, A. H. M., Roy, D., Daryanto, Y. & Ali, M. H. A sustainable inventory model with imperfect products, deterioration, and controllable emissions. *Mathematics* 8, 1–21 (2020).
18. Meng, Q., Li, M., Liu, W., Li, Z. & Zhang, J. (2021).Pricing policies of dual-channel green supply chain: Considering government subsidies and consumers' dual preferences. *Sustain. Prod. Consum.* 26, 1021–1030.
19. Mishra, U., Wu, J. Z., &Sarkar, B. (2021). Optimum sustainable inventory management with backorder and deterioration under controllable carbon emissions. *Journal of Cleaner Production*, *279*, 123699.
20. Moghaddam, K. S. (2015). Fuzzy multi-objective model for supplier selection and order allocation in reverse logistics systems under supply and demand uncertainty. *Expert Syst. Appl.* 42, 6237–6254.
21. Mondal, R., Shaikh, A. A., Bhunia, A. K., Hezam, I. M., & Chakrabortty, R. K. (2022). Impact of Trapezoidal Demand and Deteriorating Preventing Technology in an Inventory Model in Interval Uncertainty under Backlogging Situation. Mathematics, 10(1), 78.
22. Motla, R., Kumar, A., Saxena, N., & Sana, S. S. (2023). Inventory optimization in a green environment with two warehouses. *Innovation and Green Development*, *2*(4), 100087.
23. Motla, R., Kumar, A., Singh, S. R., & Saxena, N. (2021). A fuzzy integrated inventory system with end of life treatment: A possibility in sports industry. *Opsearch*, 1-20.
24. Pal, B. & Sarkar, A.(2021). Optimal strategies of a dual-channel green supply chain with recycling under retailer promotional effort. *RAIRO - Oper. Res.* 55, 415–431.
25. Rahbar, E. & Wahid, N. A.(2011). Investigation of green marketing tools' effect on consumers' purchases behavior. *Bus. Strateg. Ser.* 12, 73–83.
26. Rana, K., Singh, S. R., Saxena, N., & Sana, S. S. (2021). Growing items inventory model for carbon emission under the permissible delay in payment with partially backlogging. *Green Finance, 3*(2), 153-174.
27. Sarkar, B., Sarkar, M., Ganguly, B., & Cárdenas-Barrón, L. E. (2021). Combined effects of carbon emission and production quality improvement for fixed lifetime products in a sustainable supply chain management. International Journal of Production Economics, 231, 107867.

28. Sarkar, B., Ullah, M., &Sarkar, M. (2022). Environmental and economic sustainability through innovative green products by remanufacturing. Journal of Cleaner Production, 332, 129813.
29. Saxena, N., & Sarkar, B. (2023a). How does the retailing industry decide the best replenishment strategy by utilizing technological support through blockchain?. *Journal of Retailing and Consumer Services*, *71*, 103151.
30. Saxena, N., & Sarkar, B. (2023b). Random misplacement and production process reliability: A sustainable industrial approach to deal with the discrepancy and deficiency. *Journal of Industrial & Management Optimization*, *19*(7).
31. Saxena, N., Kumar, J., & Sana, S. S. (2023). Sustainable production model with stochastic machine breakdown using smart manufacturing under circular economy. *Green Finance*, *5*(4), 479-511.
32. Saxena, N., Sarkar, B., & Singh, S. R. (2020). Selection of remanufacturing/production cycles with an alternative market: A perspective on waste management. *Journal of Cleaner Production*, *245*, 118935.
33. Saxena, N., Sarkar, B., Wee, H. M., Reong, S., Singh, S. R., & Hsiao, Y. L. (2023). A reverse logistics model with eco-design under the Stackelberg-Nash equilibrium and centralized framework. *Journal of Cleaner Production*, *387*, 135789.
34. Saxena, N., Kumar, J., Mishra, U., Sarkar, B., & Kumar, K. (2024). Deterioration and age governed greenhouse gas emission from the product itself: An optimum inventory control problem. *RAIRO - Operations Research, 58, 2591-2620.*
35. Schrady, D. A. (1967). A Deterministic Inventory model for repairable items. Naval Research Logistics Quarterly, 14(3), 391–398.
36. Singh, M., Tyagi, V. K., Goel, R., & Kumar, S. (2022). The effect of lifetime on learning and forgetting in a supply chain inventory model with a service level constraint. Materials Today: Proceedings, 51, 201-206.
37. Teunter, R. (2004). Lot-sizing for inventory systems with product recovery. *Computers & Industrial Engineering*, *46*(3), 431-441.
38. Teunter, R. H. (2001). Economic ordering quantities for recoverable item inventory systems. *Naval Research Logistics (NRL)*, *48*(6), 484-495.
39. Trochu, J., Chaabane, A., & Ouhimmou, M. (2020). A carbon-constrained stochastic model for eco-efficient reverse logistics network design under environmental regulations in the CRD industry. *Journal of Cleaner Production*, *245*, 118818.
40. Tyagi, V. K., Goel, R., Singh, M., & Kumar, S. (2020). Modeling and analysis of a closed loop supply chain with uncertain lead time in the perspective of inventory management. Int J Sci Technol Res.
41. Ullah, M. (2023). Impact of transportation and carbon emissions on reverse channel selection in closed-loop supply chain management. *Journal of Cleaner Production*, *394*, 136370.

42. Yadav, D., Singh, S. R., Kumar, S., & Cárdenas-Barrón, L. E. (2022). Manufacturer-retailer integrated inventory model with controllable lead time and service level constraint under the effect of learning-forgetting in setup cost. Scientia Iranica, 29(2), 800-815.
43. Yang, K., Thoo, A. C., AbTalib, M. S., & Huam, H. T. (2024). How reverse logistics and sustainable supply chain initiatives influence sustainability performance: the moderating role of organisational learning capability. *Journal of Manufacturing Technology Management*, *35*(1), 141-163.
44. Yenipazarli, A. & Vakharia, A.(2015). Pricing, market coverage and capacity: Can green and brown products co-exist? *Eur. J. Oper. Res.* 242, 304–315.
45. Zhang, X., Xiu, G., Shahzad, F. &Duan, Y.(2021). Optimal financing strategy in a capital-constrained supply chain with retailer green marketing efforts. *Sustain.* 13, 1–19.