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Inventory Optimization of Deteriorating Items: A Comprehensive Review of Carbon-Control Policies and Their Impact on Shelf Life, Greening Effects, and Rework Policies

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Abstract

This study examines the deteriorating inventory management problem for items with short shelf life, considering alternative carbon control strategies from 2018 to 2023. These policies include carbon cap and trade, trade and credit policy, carbon-emission control, and others. The study takes into account critical elements such as shelf life, optimal policies, modelling approaches, greening effects, subsidies, and rework policies. The analysis started with a search for 'EOQ Model' in the Science Direct database, which generated 788 items. For a comprehensive evaluation, were restricted our resources to 329 scientific publications, including deterioration. Following that, it was limited to carbon emissions, obtaining 123 results. The papers referenced above cover a wide range of issues, including remanufacturing and rework, as well as carbon caps and trade-credit systems for data collection, yielding 45 and 32 research articles, respectively. The review prioritizes respected publications of peer-reviewed journals papers for reliable results were examined. A review of the literature suggested that future research should concentrate on stochastic modelling. The emphasis has been placed on identifying future study gaps that will aid in the development of most relevant models. The current work will serve as a guideline for selecting the suitable mathematical technique(s) and methodology(s) in various situations involving deteriorating items. The current analysis examined 42 research papers on deteriorating inventory modelling accessible in the literature to characterize its current state and indicate probable future directions. Future research needs have also been identified. This comprehensive study is firmly believed to fill a knowledge gap on deteriorating inventory and support in the formulation of appropriate methods for the creation of a successful and effective inventory control system for deteriorating products.

Keywords: Carbon emissions; EOQ model; carbon cap and trade policy; deteriorating products; remanufacturing.

1. Introduction

The products which losses its worth over time is believed to be deteriorating items. The items such as perfumes, fruits, vegetables, chemicals, pharmaceuticals, foods, radioactive substances and electronic equipments, etc., (i.e. cell phones and computers) are deteriorating in nature. Products are seen to be degrading in today's worldwide economy because of shifting customer expectations, intense rivalry, shortened product life cycles, frequent technological advancements, etc. The management of deteriorating product inventories is crucial because it affects profitability directly through sales, pricing, spoilage cost, inventory level and cost, deterioration cost, product availability and logistics cost. In the last five years, deteriorating inventories have been investigated. A lot of money was lost because of the items' deterioration, so efforts were made to preserve foods that decayed quickly, including fruits and vegetables, for a brief period. The implementation of preservation technology (PT) to slow down the rate of deterioration, however, hasn't received much attention in recent years. The rapid social changes and the fact that preservation technology may significantly decrease the deterioration rate make it essential to take it into consideration. Additionally, sales, inventory, and order numbers are very dependent on the rate of deterioration, particularly for quickly deteriorating products. To do this, preservation technology was employed. The adoption of preservation technology also brought forward new issues, such as carbon emissions by which on the ecosystem, human health, and the global climate, carbon emissions have a number of important drawbacks or negative impacts like climate change, air pollution, loss of biodiversity, ocean acidification, economic impacts, energy security concerns, global water scarcity, to reduce life expectancy etc. Climate change is mostly caused by carbon emissions, mainly carbon dioxide (CO2). Global warming is brought on by too much CO2 in the atmosphere, which traps heat and raises Earth's temperature. This has a variety of unfavorable consequences, such as changing weather patterns, extreme weather occurrences, and increasing sea levels. Another factor in air pollution is the burning of fossil fuels, which produces carbon emissions. Pollutants such as nitrogen oxides; sulfur dioxide, volatile organic compounds and particulate matter are consequently released. These pollutants have a negative impact on human health, causing respiratory and heart difficulties as well as increasing existing medical conditions. Water supply for consumption, agriculture, and manufacturing can be impacted by climate change carried on by carbon emissions, which can also increase shortages of water in many locations. To minimize carbon emissions and their effects, various strategies have been used, including carbon cap and trade policies, carbon taxes, trade and credit policies, simple taxes, and green technologies. The remanufacturing process was initiated; however, there was little improvement in the degrading products. Remanufacturing decreases the requirement for fresh raw materials, conserving energy and resources. The effect of extracting, processing, and shipping raw materials is lessened as a result. Remanufacturing uses fewer resources and uses less energy than new product production, which results in lower greenhouse gas emissions. Most articles published in the last five years have used the remanufacturing method, including those by (Hu et al., 2020), (Sarkar et al., 2020), (Dey et al., 2023) and others.

It’s a well-known fact that writing a review paper is a crucial part of the research process as it helps in identifying research gaps, consolidate existing knowledge, guide future investigations, and contribute to the overall advancement of a particular field. The advantages from this review paper include professional and personal development, guiding future research, educational contribution and making a lasting impact on the academic community.

An extensive review on this topic dates to 2001 has been done by Goyal and Giri in 2001. Bakker et al review the paper of deteriorating items from the years 2001 to 2011. A thorough literature review of deteriorating models segregated by key topics for the years 2012 to 2015 has been published by Janssen et al. (2016). Recently Shekhawat et al. (2021) analyses the work of inventory model of deteriorating items from the years 2016 to 2019. Since then, over three hundred articles on this subject have been published in the major journals on inventory control, indicating the need for a new review. In this review we include the paper from January 2018 to July 2023. Working on this review paper will give the readers the advantage of learning how much work has already been done in inventory model of deteriorating item of Carbon-Control Policies and Their Impact on Shelf Life, Greening Effects, and Rework Policies and, concurrently, identifying areas that require further research in the future. Deteriorating products, carbon emissions, remanufacturing, EOQ model, carbon cap and trade policy, there has been a lot of study done on these keywords in the last five years. This is one of the reasons for inclusion of papers from 2018 to 2023.

The following is how the rest of this paper is structured: Section 2 explains the methodology used to collect for this review literature, whereas the categorization of deteriorating items based on, Section 3 analyzes the classification of the carbon emission, carbon cap and trade policy, carbon tax policy, trade and credit policy, green technology, multi echelon logistics system including the distribution of revised the literature related to these classes as well as relevant extra model properties. Section 4 clarifies deterministic and stochastic demand, while Section 5 provides an outline of the solution approach. Section 6 contains a detailed classification of the existing work, not only in terms of the study's purpose, but also by the EOQ model, remanufacturing, carbon control, green technology, and imperfect items. Sections 7 and 8 discuss the conclusion and future study directions, respectively.

Literature Review

2. Methodology

This section provides information on the approach used for the literature review three parts make up the methodology the relevant papers, the classification phase and search phase and the source statistics.

2.1. Search phase

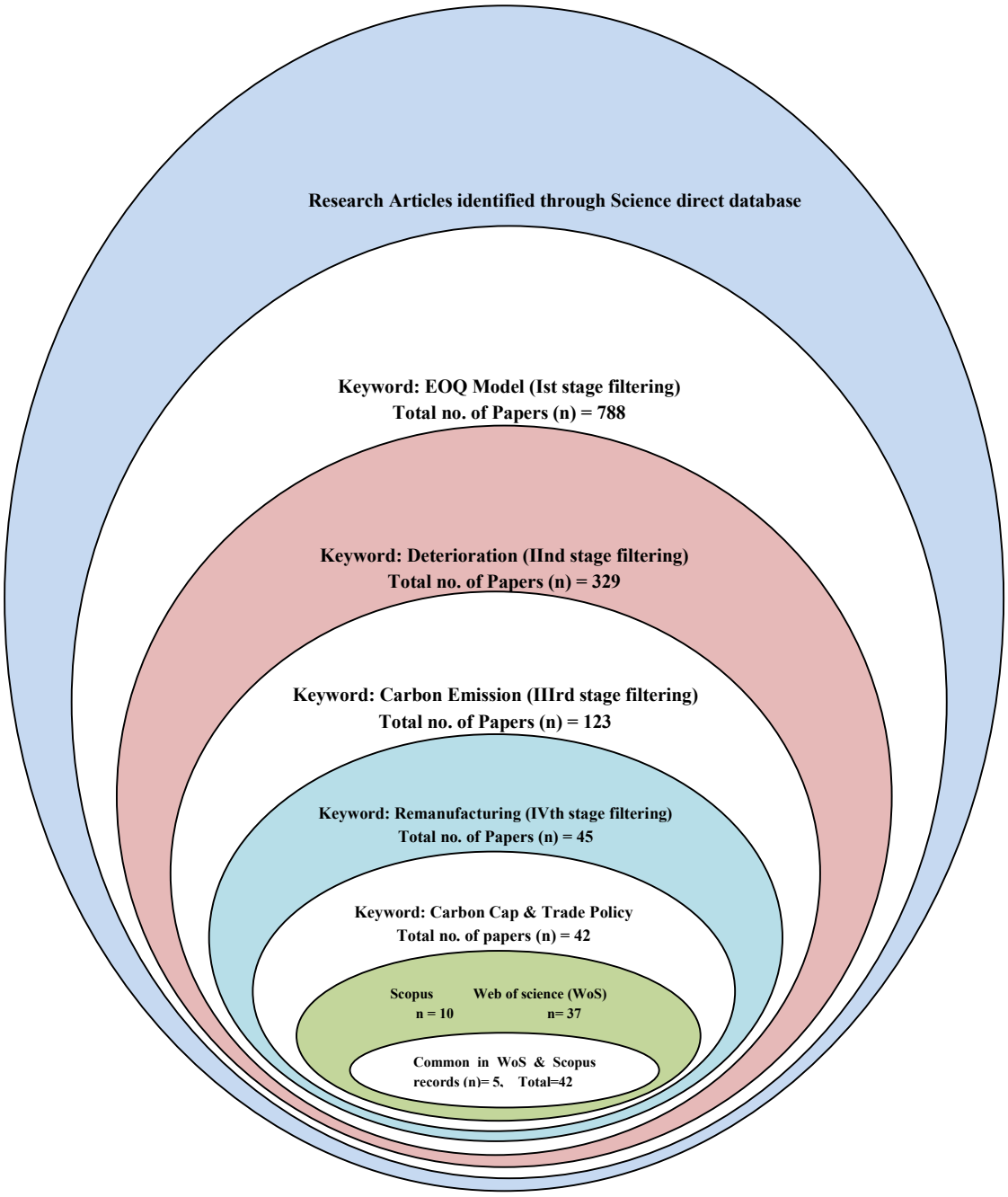
The relevant research on inventory models of deteriorating items that have been published between 2018 and 2023 are investigated and acquired for the analysis. For the purpose of choosing the most important journal articles, a keyword-based search algorithm was used**. Table I** a list of these topics published research articles is provided. In the advanced search field, "inventory" was put along with a variety of different pairs of relevant words. The subsequent keywords (Carbon cap and trade policy, carbon emissions, EOQ model, Deteriorating Products, Remanufacturing) the authors list of keywords is taken into account in this title abstract.

Table I: Journals that published pertinent articles between 2018 and 2023.

Journal	Keyword			
	CC&TP	CE	DP	R
Journal of cleaner production	6	14	12	7
Computers & Industrial Engineering	4	7	7	5
Expert Systems with Applications	1	3	2	_
Materials Today: Proceedings	_	1	1	1
Journal of king Saud University - Science	1	1	_	_
Applied Mathematical Modeling	_	1	1	1
Transportation Research Part E	2	2	2	2
Chaos, Solitons & Fractals	1	1	1	1
European J. of operational Research	_	_	1	1
Operations Research Perspectives	1	1	1	1
Cleaner Logistics & Supply Chain	_	2	2	2

Notes: Carbon cap & Trade Policy (CC&TP), Carbon Emission (CE), Deteriorating Products (DP), Remanufacturing (R).

Figure 1. The Keywords Based Searching from 2018-2023.



The research articles were found by using keywords such as "EOQ Model," "deterioration," "carbon emission," "remanufacturing," and "carbon cap and trade policy" to search in the Science Direct database. After the first step of filtering the EOQ model, the findings were applied to 788 papers. Deterioration, carbon emission, remanufacturing, carbon cap and trade policy were found to be 329, 123, 45, and 42 in the second, third, fourth, and fifth filtering stages, respectively. According to this authors like (Robles-Santana et al., 2023) and (Alvarez & Maheut, 2022), after removing duplicate entries, the total number of publications found during the information search was 42 (10 in Scopus and 37 in Web of Science) in figure 1.

2.2. Classification phase and relevant papers

The 42 publications that were gathered were classified into groups based on deterministic, stochastic among other categories, as well as other dimensions. Information about the studies that appeared in various journals between 2018 and 2023 is provided in **Table II.**

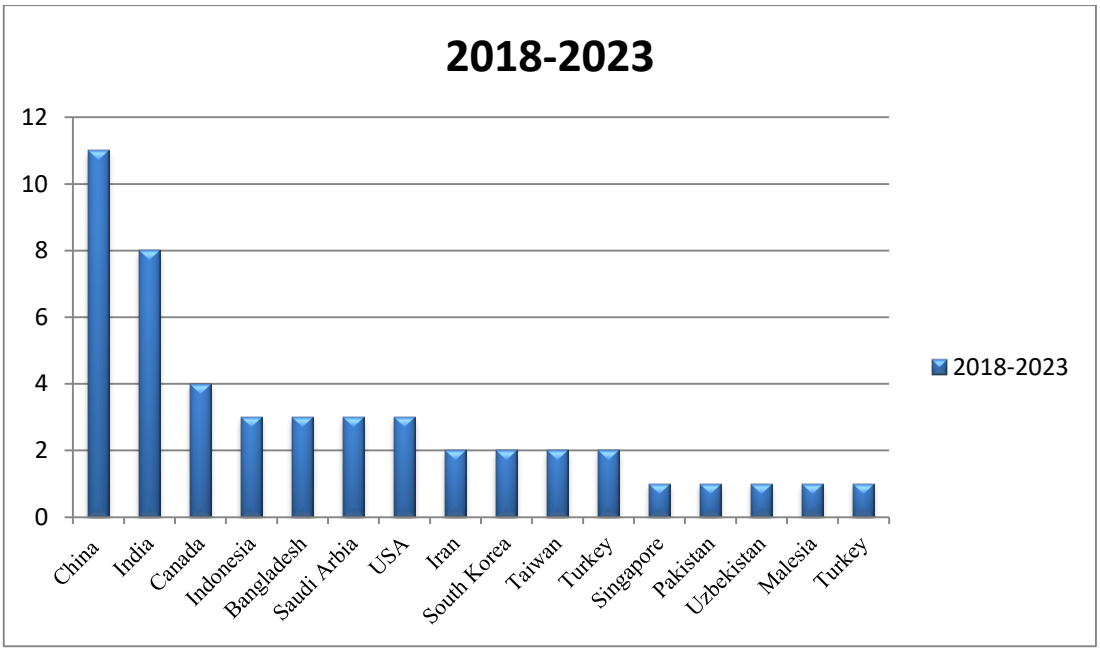
Table II. Relevant research paper published in various journals during a six year periods.

Journal	2018	2019	2020	2021	2022	2023	Total
Journal of cleaner production	2	1	3	3	4	1	14
Computers & Industrial Engineering	_	2	2	2	2	_	8
Expert Systems with Applications	_	_	_	_	_	1	1
Materials Today: Proceedings	_	_	_	_	1	_	1
Journal of king Saud University – Science	_	_	_	_	1	_	1
Applied Mathematical Modeling	1	_	_	_	_	_	1
Transportation Research Part E	_	1	_	_	_	_	1
Chaos, Solitons & Fractals	_	_	_	_	_	_	0
European J. of operational Research	_	_	_	_	_	_	0
Operations Research Perspectives	_	_	_	_	_	_	0
Cleaner Logistics & Supply Chain	_	_	_	_	1	_	1
Helicon	_	_	_	_	_	_	0

2.3. Source statistics

The previous literature reviews' foundation was employed to ensure continuity. On the basis of papers published in various journals and nations in various years, it was determined what the current trends in this sector were. It is displayed in **Figure 2 and table II**. Figure 2 shows the total number of research articles produced in various nations during a five-year period. The most important research publications come from China, then India, Canada, and Indonesia. In India, there was a sharp rise in the number of papers between 2018 and 2023.

Figure 2. The number of research papers produced by various nations, according to the authors.



3. Classification on the basis of deteriorating items

An effective modeling of inventory strategy should be utilized in a particular setting to model its external and internal environments taking into account the features of the product in order to achieve the inventory management of deteriorating products' goal of receiving optimal returns. In commemoration of the inventor of models of inventory. Ford Whitman Harris, the year 2014 was commemorated as the centennial celebration of the EOQ model. The papers published were briefly described by (Liao & Deng, 2018a) etc. The literature has also reported on a variety of strategies throughout the past five years for dealing with diverse environmental situations, including carbon cap and trade policy (CC&TP), carbon tax policy (CTP), trade and credit policy (TCP), green technology etc. policy of carbon trading, EOQ model, items that are degrading, remanufacturing. The majority of studies relating to this keyword from the past five years focus on deterministic models.

3.1. On the basis of Carbon Emission

In the past five years, a number of issues regarding carbon emissions have come to light, including those relating to the environment, the burning of fossil fuels, power generation, transportation, industrial processes, agriculture, etc. In most of the papers carbon emission has caused more damage to the environmental like (Shamayleh et al., 2019); (Wang et al., 2022); (Entezaminia et al., 2021) etc. The processes of cap and trade policy, carbon tax policy, and carbon credit policy are all designed to lower greenhouse gas emissions and lessen the effects of climate change. They have special characteristics and operate in various ways, though.

3.2. On the basis of Carbon Cap & Trade Policy

Human growth and survival are facing major challenges and deadlines as a result of the trend toward global warming. In this climate, numerous manufacturers organizations are altering their production methods by broadening the notions of sustainability and environmental protection (Qian et al. 2020). Reduced greenhouse gas (GHG) emissions have become more important as a result of the notion of sustainable growth receiving increased attention from academics, practitioners, and the government. GHG emissions can be decreased by a variety of environmental strategies. The Carbon Cap-and-Trade Policy (CC&TP) is thought to be the most successful of these regulations (Wangsa et al., 2020); (Entezaminia et al., 2021); (Roy & Mashud, 2022). As part of CC&TP, the government allots a certain quantity of carbon emissions (known as a carbon cap) to the manufacturers at the start of their operations. If their initial carbon emissions exceed the government-set carbon cap, they must purchase emission permissions from the carbon market for trading. Otherwise, either buy or sell (also known as trade) additional emissions depending on whether their original emissions are more or lower than the cap, emissions will be traded in the emission market. A market-based strategy for reducing pollution is cap and trade, sometimes referred to as emissions trading. It establishes a cap on the overall amount of greenhouse gases (GHG) that regulated entities, such as businesses or industries are allowed to emit. There is a market for emissions allowances since these corporations are issued permits that correspond to their permitted emissions, and if a company emits less than its allotted amount, it can sell its extra permits to other companies that would exceed their limits.

3.3. On the basis of Carbon Tax Policy

A carbon tax is a fee that is directly assessed on the amount of carbon present in fuel or other emission-producing substances. It tries to internalize the external costs of carbon emissions by making polluters pay for the carbon they release. Typically, the tax amount is determined by the quantity of carbon emissions connected to a specific activity or good. A policy involving a carbon price has also primarily been utilized to cut greenhouse gas (GHG) emissions. Only a few persons, such as (Shamayleh et al., 2019); (Alegoz et al., 2021); (Gharaei et al., 2022), and (Yu et al., 2023), have used the carbon tax policy (CTP) in the recent five-year period.

3.4. On the basis of Trade and credit policy

A defined amount of emissions reductions is represented through trading permits called carbon credits. By carrying out activities that improve the storage of carbon or reduce emissions, such as forest products or renewable energy projects, one can earn them. Then, in carbon markets, these credits can be exchanged or sold. The government's trade and credit strategy are one tool it uses to cut greenhouse gas (GHG) emissions. Carbon cap and trade policies (CC&TP) have been employed to regulate carbon emission in the majority of articles during the last five years, but some authors have also used trade and credit policies (TCP), such as (Poswal et al., 2022); (Dey et al., 2023), etc.

3.5. On the basis of Green Technology

Green technology (GT) sometimes referred to as clean technology or sustainable technology refers to creative approaches and methods that seek to reduce adverse environmental effects and advance sustainable development. Adopting green technology (GT) has several benefits, including long-term sustainability, positive public perception, energy efficiency, environmental benefits, climate change mitigation, health and quality of life benefits, and economic benefits. Green technologies aid in lowering greenhouse

gas (GHG) emissions, which fuel global warming and climate change. This involves renewable energy sources, which operate with little to no greenhouse gas emissions, such as solar, wind, hydro, and geothermal energy. The main goal of green technology is to reduce carbon emissions or greenhouse gas (GHG). Very few authors have used green technology in the last 5 years reviewed related to these keywords (carbon emissions, carbon cap and trade policy, EOQ models, deteriorating products, remanufacturing), like (Jauhari et al., 2020); (Jauhari et al., 2021); (Kumar et al., 2023) etc.

3.6. The multi- echelon supply chain inventory

Inventory modeling of multiple levels in a supply chain is referred to as multi-echelon inventory modeling of the supply chain. It is becoming more important as all industrial organizations strive to reduce supply chain inventories while planning. When the item's deterioration is taken into account, the allocation method becomes even more complicated. Before reaching the end consumer, products move through numerous tiers or layers of suppliers, manufacturers, distributors, and retailers (Rout et al., 2021)

4. Classification of Deterministic and Stochastic Demand

Table III shows a classification of deterministic and stochastic demand based on a closed loop supply chain and a linear supply chain.

4.1. Deterministic Demand

A deterministic demand pattern or circumstance is one in which the total amount of an item or service which is going to be demanded or purchased can be determined with certainty. In this case, stability is no variation or unpredictability regarding the level of demand. This form of demand is regular and known, allowing businesses to confidently plan their manufacturing, inventory, as well as supply chain activities. Understanding deterministic demand is critical in business and supply chain management for a variety of reasons, including planning production, handling inventory, and resource allocation. Companies are able to organize their activities and allocate resources more efficiently when demand is predictable because they can correctly forecast what quantity of an item or service will be required. In the previous 5 years, most authors have worked on deterministic demand, such as (Wang et al., 2022); (Ruidas et al., 2021); (Yu et al., 2023)

4.2. Stochastic Demand

Stochastic demand is defined as demand for a product or service that is unpredictable and capable of random variations or variability. In other words, it is a form of demand which cannot be anticipated with precision and is impacted by a variety of uncontrollable causes. Stochastic demand is seen in a variety of businesses and circumstances, including retail, manufacturing, logistics, and finance. In these instances, organizations and decision-makers must account for the natural ambiguity in forecasting of demand and managing the supply chain. Businesses frequently employ statistical approaches, mathematical models for simulation, and other tools for forecasting to effectively manage unpredictable demand, that take historical data, market patterns, seasonality, and other important aspects into account. Companies can enhance their operations and better meet client needs by researching and comprehending the probabilistic nature of demand. Fewer people have worked on stochastic than deterministic in the previous 5 years, such as (Liao & Deng, 2018a); (Bai et al., 2020), etc.

4.3. The Closed loop Supply Chain

A closed-loop supply chain is a system in which products, materials, or components flow in a circuit from the consumer back to the manufacturer or original source for recycling, refurbishment, remanufacturing, or proper disposal. It includes the transfer of goods from the customer or end-user to the producer, result in a "closed loop" of materials. The concept of a closed-loop supply chain differs from a typical linear supply chain. Where goods are produced, distributed, consumed, and often discarded as garbage. In a closed-loop system, the emphasis is on recovering value from end-of-life products or resources while minimizing waste are known as reverse logistics or closed-loop logistics, from the recent five years of publications evaluated here, it is discovered that only few authors have employed closed loop supply chain, such as (Bai et al., 2020); (Zhang & Zhang, 2022); (Ullah, 2023) and others.

4.4. The Linear Supply Chain

A linear supply chain, often known as an open-loop supply chain, is an established supply chain model, in which items move in a straight path from raw material suppliers to producers, then to distributors, retailers, and lastly to customers. This one-sided flow of goods and supplies is defined by a linear progression with a concentration on production, distribution, and consumption, but without a means for returning or recycling used products or materials. It's the inverse of a closed-loop supply chain. One-way Flow, Waste Generation, Limited Resource Recovery and so on is examples of open loop supply chains. After examining recent publications, majority of the authors employed Linear Supply Chain, such as (Halat & Hafezalkotob, 2019); (Sarkar et al., 2020); (Dey et al., 2023), and so on.

Table III. The relevant research papers published based on deterministic and stochastic demand.

Year	Authors	Deterministic Demand		Stochastic Demand	
		CLSC	LSC	CLSC	LSC
2018	(Liao & Deng, 2018a)	×	×	×	✓
	(Liao & Deng, 2018b)	×	×	×	✓
	(Tiwari et al., 2018)	×	✓	×	×
2019	(Nidhi & Pillai, 2019)	✓	×	×	×
	(Shamayleh et al., 2019)	×	✓	×	×
	(Halat & Hafezalkotob, 2019)	×	✓	×	×
	(Chen & Bidanda, 2019)	×	✓	×	×
	(Ben-Daya et al., 2019)	✓	×	×	×
	(Taleizadeh et al., 2019)	✓	×	×	×
2020	(Hu et al., 2020)	✓	×	×	×
	(Bai et al., 2020)	×	×	✓	×
	(Sarkar & Bhadouriya, 2020)	×	✓	×	×
	(Sarkar et al., 2020)	×	×	×	✓

	(Wangsa et al., 2020)	×	✓	×	×
	(Chen et al., 2020)	×	✓	×	×
	(Jauhari et al., 2020)	✓	×	×	×
	(Xiao et al., 2020)	×	✓	×	×
2021	(Ullah et al., 2021)	×	✓	×	×
	(Jauhari et al., 2021)	×	✓	×	×
	(Entezaminia et al., 2021)	×	✓	×	×
	(Ruidas et al., 2021)	×	✓	×	×
	(Alegoz et al., 2021)	✓	×	×	×
	(Rout et al., 2021)	×	✓	×	×
2022	(Wang et al., 2022)	×	✓	×	×
	(Wani & Mishra, 2022)	×	✓	×	×
	(Lu et al., 2022)	×	✓	×	×
	(Poswal et al., 2022)	×	✓	×	×
	(Roy & Mashud, 2022)	×	✓	×	×
	(Karmakar & Das, 2022)	×	✓	×	×
	(Gharaei et al., 2022)	×	✓	×	×
	(Priyan et al., 2022)	×	✓	×	×
	(Zhang et al., 2022)	✓	×	×	×
	(Zhang & Zhang, 2022)	✓	×	×	×
	(Jauhari, 2022)	✓	×	×	×
2023	(Kumar et al., 2023)	×	✓	×	×
	(Khan et al., 2023)	×	✓	×	×
	(Dey et al., 2023)	×	✓	×	×
	(Ullah, 2023)	✓	×	×	×
	(Yu et al., 2023)	×	✓	×	×
	(Lok et al., 2023)	×	✓	×	×
	(Chaudhary et al., 2023)	×	✓	×	×
	(Gautam et al., 2023)	×	✓	×	×

Notes: Closed loop Supply Chain (CLSC), Linear Supply Chain (LSC)

5. Mathematical programming

In the literature, many mathematical programming models for deteriorating inventory models may be identified. A food processing industry planning problem that takes product deterioration into account used mixed integer linear programming to solve, and the model's complexity was lowered to demonstrate that optimal production plans change when product deterioration is taken into account, (Zhang et al., 2022); (Nidhi & Pillai, 2019) developed mixed integer nonlinear programming models for jointly maximizing the production process for new and remanufactured goods. To solve mathematical papers, most authors use non-linear programming problems, such as (Wang et al., 2022); (Shamayleh et al., 2019) etc. However, some authors do not behave like such as (Zhang et al., 2022) aimed to solve the models by a Taylor series-based method through examining and utilizing the structural aspects of the models.

6. Multi-Criteria Categorization on the inventory model based on key parameters

The extant literature has been comprehensively categorized in this area based on several factors, such as the research purpose. Table IV shows the parameters associated with this keyword (Carbon Cap and Trade Policy, EOQ model, Carbon Emission, Deteriorating Products, Remanufacturing), as well as preservation technology, demand, green technology, defective items, and supply chain. Despite this, several research studies have investigated alternative types of objectives and substitute scenarios.

Table IV. Analysis of existing literature on modeling deteriorating products in terms of objective, carbon emission, remanufacturing

Authors	Deterioration		Remanufacturing	Carbon Emissions	Carbon Control	Preservation Technology	Demand	Green Technology	Imperfect items	Supply chain type
	Instantaneous	Non - Instanta-neous								
(Liao & Deng, 2018a)	×	✓	✓	×	Carbon cap & trade policy	×	Stochastic	×	×	×
(Liao & Deng, 2018b)	×	✓	✓	✓	×	×	Stochastic	×	×	×
(Tiwari et al., 2018)	×	✓	×	✓	×	×	Deterministic	×	✓	×
(Shamayleh et al., 2019)	×	×	×	✓	Carbon tax policy	×	Deterministic	×	×	×
(Nidhi & Pillai, 2019)	×	✓	✓	✓	Carbon policy & trading	×	Deterministic	×	×	Closed
(Halat & Hafezalkotob, 2019)	×	×	×	✓	Carbon tax & carbon trade	×	Deterministic	×	×	×
(Chen & Bidanda, 2019)	×	×	×	✓	Carbon cap & trade policy	×	Deterministic	×	×	×
(Ben-Daya et al., 2019)	×	✓	✓	×	×	×	Deterministic	×	×	Closed

(Taleizadeh et al., 2019)	×	✓	✓	✓	Carbon cap & trade policy	×	Deterministic	×	✓	Closed
(Sarkar & Bhadouriya, 2020)	×	×	×	×	×	×	Deterministic	×	×	×
(Hu et al., 2020)	×	✓	✓	✓	Carbon cap & trade policy	×	Deterministic	×	×	Closed
(Bai et al., 2020)	×	✓	×	✓	Carbon tax policy	×	Stochastic	×	×	Closed
(Sarkar et al., 2020)	×	✓	✓	×	×	×	Stochastic	×	✓	×
(Wangsa et al., 2020)	×	×	×	✓	Carbon cap & trade policy	×	Deterministic	×	×	×
(Chen et al., 2020)	×	✓	✓	✓	Carbon cap	×	Deterministic	×	×	×
(Jauhari et al., 2020)	×	✓	✓	✓	Carbon cap & trade policy	×	Deterministic	✓	×	Closed
(Xiao et al., 2020)	×	✓	✓	×	Carbon cap & trade policy	×	Deterministic	×	×	×
(Jauhari et al., 2021)	×	✓	✓	✓	Carbon tax	×	Deterministic	✓	×	×
(Ullah et al., 2021)	×	✓	✓	×	×	×	Deterministic	×	×	×
(Entezaminia et al., 2021)	×	✓	×	✓	Carbon cap & trade policy	×	Deterministic	×	×	×
(Ruidas et al., 2021)	×	×	×	✓	Simple tax policy etc.	×	Deterministic	×	✓	×
(Alegoz et al., 2021)	×	✓	✓	×	Carbon tax policy	×	Deterministic	×	×	Closed
(Rout et al., 2021)	×	✓	×	✓	Carbon cap & trade policy	×	Deterministic	×	✓	×
(Wani & Mishra, 2022)	✓	×	×	✓	×	×	Deterministic	×	×	×
(Poswal et al., 2022)	×	✓	✓	✓	Trade & credit policy	×	Deterministic	×	×	×
(Wang et al., 2022)	×	✓	✓	✓	Carbon tax legislation	×	Deterministic	×	×	×
(Roy & Mashud, 2022)	×	×	×	✓	Carbon cap & trade policy	✓	Deterministic	×	×	×
(Karmakar & Das, 2022)	×	✓	✓	✓	×	×	Deterministic	×	×	×
(Gharaei et al., 2022)	×	×	×	✓	Carbon tax policy	×	Deterministic	×	×	×
(Priyan et al., 2022)	×	✓	✓	✓	×	×	Deterministic	✓	×	×
(Zhang et al., 2022)	×	✓	✓	✓	Carbon cap & trade policy	×	Deterministic	×	×	Closed
(Zhang & Zhang, 2022)	×	✓	✓	✓	Carbon cap & trade policy	×	Deterministic	×	×	Closed
(Jauhari, 2022)	×	✓	✓	✓	Carbon tax policy	×	Deterministic	✓	×	Closed

(Lu et al., 2022)	×	✓	×	✓	Carbon cap and trade policy	×	Deterministic	×	×	×
(Dey et al., 2023)	×	✓	✓	✓	Trade & credit policy	×	Deterministic	✓	✓	×
(Kumar et al., 2023)	✓	×	×	✓	×	✓	Deterministic	✓	×	×
(Ullah, 2023)	×	✓	✓	✓	×	×	Deterministic	×	×	Closed
(Khan et al., 2023)	×	✓	×	✓	×	×	Deterministic	×	×	×
(Yu et al., 2023)	×	×	×	×	Carbon tax policy	×	Deterministic	×	×	×
(Lok et al., 2023)	×	✓	×	✓	×	✓	Deterministic	×	×	×
(Chaudhary et al., 2023)	×	×	×	✓	×	×	Deterministic	×	✓	×
(Gautam et al., 2023)	×	✓	×	✓	×	✓	Deterministic	×	×	×

7. Result and discussion

Aside from carbon emission and damaging rate, additional elements such as carbon cap and trade policy, carbon tax policy, green technology, trade and credit policy, preservation technology, etc. are included in the deteriorating inventory models. Another essential component in the research of degrading items for modeling inventories is the degradation rate. In addition, different deterioration rates are considered in different conditions. Preservation strategies, such as a continuous deterioration rate, have been used to manage the deterioration rate as a linearly rising function of time. Although 9 percent authors used preservation technology, like (Kumar et al., 2023); (Roy & Mashud, 2022) etc. The problem began with carbon emissions as a result of the employment of preservation techniques. Carbon emissions have been causing climate change, air pollution, biodiversity loss, and other problems. 80 percent of authors utilized several ways to reduce carbon emissions (Hu et al., 2020); (Taleizadeh et al., 2019), such as carbon cap and trade policy, trade and credit policy, carbon tax policy, green technology, etc. 35 percent of authors (Chen &Bidanda, 2019) used carbon cap and trade policy to reduce carbon emissions and 14 percent used green technology (Jauhari et al., 2020). 90% of the authors worked on deterministic demand. There are extremely few studies that investigate deteriorating and non-deteriorating items. In the realm of imperfect production systems, where several failing objects are re-manufactured or reconstructed at the same time, research can be conducted. Transportation and inventory management are both problems in supply chain management. So, if both issues are resolved concurrently, the entire supply chain will be reduced to a bare minimum. A multi-warehouse choice issue, which can be solved like a multi-scale optimization problem, should also be used. Furthermore, a study should be conducted that considers both deteriorating and non-deteriorating products and can be utilized in the grocery store market. More research into deteriorating inventory management with a focus on sustainability, where environmentally friendly choices are made, and overall waste is decreased.

8. Conclusions

The important parameters for deteriorating inventory models (Carbon Emissions, EOQ model, Carbon cap and trade policy, Deteriorating Products and Remanufacturing) are identified and examined in detail. It was discovered that not every factor is treated equally weight. Because of the implementation of a supply chain with less vertical integration in today's cutthroat market, centralized decision making and information sharing for a multi echelon inventory has gained prominence. Multi-item models of inventory are complicated and computationally costly, and thus are underrepresented in the literature; thus, contributions in this field of research are needed. In practice, inventory information is not always correct; most of the time, it is unclear or inaccurate. As a result, stochastic, developing fuzzy and dynamic research methods is more logical; moreover, this is the future direction for the study on declining inventories. Many researchers have investigated inventory in uncertain conditions. It is advised that researchers capture and model the supply chain inventory concerns of deteriorating products using stochastic, fuzzy, and dynamic research methodologies while considering various objectives (including product accessibility). The authors believe that this work will provide a summary of the deteriorating inventory of goods in the past few years and will serve as a foundation for future study in this sector.

Authors Contributions

Poonam Verma (PV) and Vinod Kumar Mishra (VKM) formulated the search process for the review of the papers from the year 2018 to 2023 with five keywords: EOQ Model, Remanufacturing, Deteriorating Items, Carbon Emissions, Carbon Cap and Trade Policy. PV and VKM have done the literature review and carried out the conclusion. All authors read and approved the final manuscript.

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