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Literature Review On The Impact Of Inventory Models With Varied Costs

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ABSTRACT

This article provides a current analysis of recent developments in inventory management for perishable commodities, specifically focusing on things that degrade over time. Although the previous extensive reviews, such as the study conducted by Goyal and Giri in 2015, provide useful insights into the decline of inventory modelling, the ever-changing nature of this subject requires a new evaluation. The assessment conducted by Bakker, Riezebos, and Teunter on inventory management systems after 2001, together with Janssen, Claus, and Sauer's examination of deteriorating inventory models from 2012 to 2015, has established a foundation for comprehending the changing patterns in this field. Nevertheless, the significant increase of more than three hundred subsequent papers highlights the necessity for a revised analysis. This article focuses on recent research that emphasizes important themes and contributions in inventory management. It draws upon Goyal and Giri's categorization methodology, classifying inventory management approaches based on shelf-life and demand characteristics. Primary areas of emphasis encompass managing partial backlogging or missed sales, evaluating salvage value, and assessing the influence of inflation on inventory control systems.

This review offers a thorough comprehension of the current state of declining inventory management by combining and analyzing various literature sources. This resource is highly important for scholars, practitioners, and policymakers looking for insights into effective ways to control the inventory of perishable items.

1. Introduction: An item that depreciates in worth as time passes is classified as perishable. The perishable products include vegetables, fruits, baked goods, bread, milk, meat, seafood, blood, radioactive and chemical materials, medications, Christmas trees, winter clothes, high-fashion garments, and high-tech devices such as computers and cell phones. In the current worldwide economy, it is evident that items are increasingly perishable due to evolving customer expectations, intense rivalry, shortened product life cycles, and frequent technological advancements. Efficient management of perishable product inventory is crucial as it directly affects sales, pricing, inventory levels, costs, spoilage, degradation, logistics, and product availability, all of which ultimately affect profitability. Managers, academicians, and researchers are currently working to comprehend and formulate models for inventory issues related to perishable items. This involves considering factors such as product characteristics, competition levels, internal and external limitations, the influence of price on demand, product availability, and the nature of demand within a particular setting. Consequently, numerous inventory models have been documented in the literature for the purpose of modeling, primarily tailored to specific contexts. The mathematical modeling of systems of inventory originated from the Economic Order Quantity Model (EOQ) introduced by Harris [1] in 1913. This model helps determine the most efficient quantity of units to order in order to minimize the overall cost of purchasing, shipping, and storing the product. Nevertheless, within the given context. The EOQ model's fundamental assumptions are largely disconnected from real-world applications. When deterioration has a substantial economic influence on inventory systems, the assumption of indefinite shelf life for determining lot sizes becomes highly erroneous. One difficult aspect of managing this group of things is to ensure that there is enough product available for customers to purchase while also minimizing the amount of product that is lost or wasted. This is important in order to effectively manage inventory. The study of inventory systems dealing with decaying products is a significant research subject that arose from the first EOQ model, as it poses a difficult task for academics and practitioners in achieving efficacy.

The objective of this research is to acquire a comprehensive understanding of the current state of the literature on inventory modeling for degrading products. This addresses the requirement to assess the overall achievements of the lot-sizing theory when applied to perishable products and identify potential areas for future research. Overall, the process of literature review involves the crucial task of identifying, evaluating, and interpreting existing knowledge, which is fundamental to all types of research. This is commonly emphasized in research methodology textbooks [2-4], as well as in methodological articles published in high-impact journals [5, 6]. Since the past literature studies on degrading inventory modeling [7-8], over 300 works have been documented in recent years. This not only raises concerns over the current condition of this research field, but also emphasizes the necessity of establishing a foundation for further research by finding patterns, themes, and issues from the existing collection of recorded records. Since the initial research on deteriorating inventory modeling in the 1950s and 1960s [9-10], numerous papers have been published annually. The initial survey of this scientific field was conducted by Nahmias [11] in 1982. This review examined the pertinent literature about the inventory challenge of determining appropriate ordering procedures for objects with either fixed or unpredictable lifetimes. Subsequently, after a span of nine years, Raafat [13] conducted an assessment of the progress made in the field of deteriorating inventory, based on the classification system established by Silver [12]. However, Raafat's study specifically focused on research that examined the impact of deterioration in relation to the quantity of inventory available. In 2001, Goyal and Giri expanded on Raafat's work by incorporating inventory models that involve goods with defined lifetimes [14] [13]. In 2012, Bakker and Riezebos [7] revised the work of Goyal and Giri [14] by presenting a comprehensive review and classification that closely resembled Goyal and Giri's. This was done to make it easier to compare the two. Janssen and Claus [17] conducted a comprehensive analysis of recent publications published between 2012 and 2015, building upon the work of Bakker and Riezebos [7]. They also explored new themes in their discussion. In contrast to the prior studies, these reviews incorporated newsvendor and transport models. In addition to these surveys, there are more studies that have been documented in the literature. However, a subset of these studies concentrated solely on particular aspects of declining inventory models [25-30], while others adopted other categorization and/or analysis methods [16, 25]. The allocation of reviewed literature to these categories, along with other relevant model characteristics, is critically analyzed. A comprehensive examination of the solution methodologies. The conclusion and future research directions are stated.

2. **Objective**: This article examines current inventory management trends for perishable products, focusing on degrading items. It assesses recent trends since 2015, using Goyal and Giri's shelf-life and demand categorization framework. Key themes include partial backlogging, lost sales, salvage value, and inflation's impact on inventory control. The study synthesizes and contextualizes the material to provide a comprehensive understanding of deteriorating inventory management, aiming to inform academics, practitioners, and policymakers.

3. There are two types of inventory models that are classified based on deterioration and demand.

3.1 Deterioration

Deteriorating inventory models can be classified based on the lifespan of products and demand factors. Three categories are classified according to the characteristics of their shelf life:

(1) Fixed lifetime refers to a preset and deterministic lifespan, such as two days or one season.

(2) The rate at which anything deteriorates varies depending on its age, and this means that its lifetime is distributed probabilistically, for example, according to the Weibull distribution.

(3) Deterioration rate that is based on time or inventory, but not age. It should be noted that models belonging to class 3 have a constant degradation rate per stocked item, meaning that the rate of deterioration is not based on the age of the item but only on the inventory.

3.2 Market demand

Demand can be represented as either random or predictable. From a practical perspective, a demand distribution that involves randomness is more realistic, although only a small fraction (less than 20%) of the models examined in this work fall into this category. Building upon the work of Goyal and Giri, the stochastic demand models differentiate between a particular type of probability distribution and a general probability distribution. Out of all the publications reviewed, only 10 of them present models that incorporate an arbitrary probability distribution for demand. Additionally, two of the studies introduce models that consider demand as a fuzzy number. For deterministic demand, it can be further classified as follows:

(a) Uniform demand, which refers to a constant and fixed quantity of things.

(b) Demand that is directly influenced by the availability of stock.

(c) Fluctuating demand over time.

(d) Demand that is influenced by price. It is important to acknowledge that a combination of the aforementioned options is also feasible.

4. Factors Influencing Deteriorating Inventory Analysis

4.1 Demand

Demand is the quantity of products or services that customers are willing and able to purchase at a specific price within a specified time frame. It is essential for the operation of inventory systems. Demand can be either deterministic, in which the size of the order is predetermined, or stochastic, in which it is unpredictable, presenting obstacles such as inventory management and customer satisfaction.

In 2019, a variety of studies investigated various aspects of inventory and demand management. An inventory model that takes into account shortages and deterioration with three demand rates was devised by Shalini Singh and G. C. Sharma. Kaushik and A. Sharma [26] concentrated on procurement and pricing decisions that were associated with trapezoidal demand patterns and variable rates of deterioration over time. In order to enhance decision-making in the face of uncertain demand, Dehghani et al. investigated proactive transhipment in the blood supply chain. Deng et al. investigated the strategies for risk transmission and mitigation in sustainable supply chains for perishable products [27]. Gong et al. examined the influence of carbon emission reduction on the coordination of supply chains that involve disintegrating products [28]. Li et al. investigated the decision-making process for the investment in preservation technology, replenishment, and pricing for commodities that exhibit non-instantaneous degradation [29]. In a duopoly market with linear demand and deteriorating products, Mahmoodi examined the price and inventory management of competing stores [30]. Under the constraints of fluctuating demand and fill rate, Pauls et al. examined the most effective order strategies for perishable inventory [31]. Raut et al. suggested the implementation of refrigerated third-party logistics to mitigate food losses in the supply chains of fruits and vegetables [32]. Tai et al. investigated the joint inspection and inventory management of decaying items with variable maximal lifespans [33]. Timajchi et al. examined the challenges of inventory and routing for hazardous and degrading commodities, taking into account accident risks and transshipment solutions [34].

An inventory model for items that deteriorate over time was devised by J. Kaushik and A. Sharma (2020). The model assumes that demand is influenced by both price and time in a trapezoidal pattern. The objective of their research is to enhance inventory management by taking into account these distinctive demand characteristics [35]. Sharma and Kaushik (2021) developed an additional model that concentrated on commodities that are susceptible to degradation. This model is designed to improve inventory strategies by addressing ramp-like demand patterns and payment delays by incorporating a demand pattern that increases progressively over time. It also allows for delayed payment [36]. Kaushik and Sharma (2021) conducted an additional analysis of preservation technology in their inventory model for items with Weibull deterioration rates. The research examines the impact of preservation technologies on the decisions made regarding inventory management [37]. Jitendra (2022) suggested an inventory model for perishable commodities that accounts for deterioration, preventive technologies, and progressive demand increases in accordance with the Weibull distribution. The goal is to optimize inventory policies by taking into account the unique characteristics of perishable products [38].

These works make a valuable contribution to the field of inventory management by presenting models that specifically tackle different demand patterns, rates of deterioration, and technology interventions. These models aim to improve inventory policies specifically for commodities that are prone to deterioration.

4.2 Deterioration

Deterioration is pervasive and affects a diverse array of products, each with its own unique attributes. Milk is among the few items that are susceptible to accelerated decay. Fruits and vegetables exhibit distinct modes of existence. As a result, it is necessary to address the degradation of these products in a unique manner. The product's durability is subject to variation; for example, electronic items have a distinct lifespan in comparison to perishable items. It is imperative to implement an alternative methodology when evaluating the rate of deterioration, as medicines and fruits have variable shelf lives. Gong, Jin, and Xu (2019) investigated the influence of carbon emission reduction on supply chain coordination, with an emphasis on the management of inventory of disintegrating products [39]. They evaluated the operational efficiency and sustainability implications. In order to enhance inventory planning and improve demand forecasting accuracy, Jing and Mu (2019) [40] investigated dynamic lot-sizing models that incorporate perishable inventories and product substitution. Li, He, Zhou, and Wu (2019) [41] conducted an investigation into the decisions made by manufacturers regarding the investment in preservation technology, replenishment, and pricing of products that degrade over time. To improve the quality and expiration life of their products, they evaluated technological advancements. The inventory and pricing decisions in a three-tier supply chain that deals with degrading commodities under uncertain conditions were analyzed by Maihami, Govindan, and Fattahi (2019) [42]. Their primary objective was to effectively manage risks and coordinate the supply chain. Sazvar and Sepehri (2019) suggested a replenishment-recruitment strategy for a sustainable retail system that manages declining products [43]. Their strategy was to achieve a harmonious equilibrium between the objectives of economic, environmental, and social sustainability. Inventory models that incorporate shortages and deterioration were introduced by Singh and Sharma (2019) and Kaushik and Sharma (2019a, 2019b) [44]. To improve the efficiency of inventory management, these models incorporated a variety of demand rate patterns and payment delay options.

J. K. and A. Sharma (2020): Created a trapezoidal-shaped inventory model for perishable items with fluctuating demand over time. In order to optimize profitability, the model takes into account the temporal character of demand and its reliance on price fluctuations, as well as inventory levels and pricing strategies [45]. An inventory model specially designed for commodities with ramp-type demand was introduced by Sharma and Kaushik in 2021. In an effort to optimize the ordering procedures for perishable products by balancing inventory costs with financial constraints, this study underscored the influence of payment delays on inventory management. The role of preservative technology in reducing deterioration for perishable items characterized by a Weibull deterioration rate was investigated by J. Kaushik and A. Sharma in 2021 [47]. Their research incorporated preservative technologies into the inventory model to reduce waste, prolong the expiration life, and improve effectiveness. K. Jitendra (2022): Investigated ramp-type demand and the application of preservative technologies for perishable items that are experiencing Weibull degradation, building upon previous research. The objective of this research is to enhance inventory management strategies by taking these specific characteristics into account [48].
The collective objective of these studies is to enhance inventory management strategies for perishable products by leveraging technological advancements to extend shelf life, optimize operational efficiencies, and address unique demand patterns.

4.3 Shortages and backorder

Backorders and shortages are essential concepts in inventory management, emphasizing the precarious equilibrium between supply and demand dynamics. It is imperative for businesses that are striving to improve customer satisfaction, reduce revenue loss, and optimize operational efficiency in the current competitive market to effectively manage these challenges. Singh et al. (2019) suggest an inventory model that is specifically designed for items that are deteriorating, with an emphasis on partial backlogging and incremental holding costs. The study addresses the challenge of managing inventory for objects that are susceptible to deterioration, where the cost of holding increases over time as a result of the item's ageing [49]. An inventory model that is specifically designed for non-instantaneous deteriorating items, as well as those that are characterized by multivariate demand and backlogging, is presented by Sundararajan et al. (2019) and takes inflation into account. The inclusion of inflationary effects in inventory management adds a layer of realism, as it reflects economic conditions that influence procurement and pricing decisions [50].
A probabilistic deterioration, negative exponential demand, and imprecise lead times inventory model were introduced by Sen and Saha (2020), which also includes partial backlogging for deteriorating objects [51]. This study investigates the intricacies that result from unforeseen demand, deterioration, and lead times, providing valuable insights into effective inventory management strategies. Rout et al. (2021) developed a production inventory model that takes into account deteriorating products and backlog-dependent demand. The objective of the study is to optimize inventory levels in the face of fluctuating demand conditions by examining the relationship between production planning and variable demand patterns [52]. Sharma et al. (2022) introduced an inventory control model that accounts for deteriorating items, demand-dependent production, and time and stock-dependent demand. The dynamic interactions among inventory management, demand variability, production decisions, and adaptive control mechanisms are the focus of this research [53]. Mashud (2020) developed an inventory model that accommodates a variety of demand types and wholly backlogged shortages, with an emphasis on EOQ deterioration. The research contributes to the comprehension of inventory optimization in situations where fluctuations in demand may result in shortages, offering valuable insights into effective inventory management practices [54].
Introduction of a multi-cycle inventory control model for deteriorating items with partial backlogs and utilization of trade credit by Mo, Chamchang, Niu, and Li et al. (2022). The objective of the research is to comprehensively optimize inventory policies and enhance cash flow management by assessing the influence of trade credit on inventory decisions [55] .

In general, the literature that has been examined illustrates the wide range of methodologies and factors that must be taken into account when creating inventory models for objects that are deteriorating. These studies make a valuable contribution to the advancement of knowledge regarding inventory management strategies that are customized to address the unique attributes and difficulties associated with declining inventory items. As a result, they assist in making more informed decisions regarding supply chain operations.

4.4 Deteriorating inventory with inflation and time value of money

A critical objective for organizations that wish to reduce expenditures and effectively satisfy consumer demands has been the efficient management of inventory. Various inventory models have been developed over the years to address the challenges that result from factors such as inflation and the deterioration of goods. This review provides a thorough analysis of the significant advancements in inventory modeling and influential research from the mid-20th century to the present. Wang et al. (2019) examined inventory strategies for a degrading item with fluctuating demand over time, taking into account trade credit and inflation. The study examined the effects of trade credit and inflation on inventory management, taking into account the changing demand patterns and the deterioration of items over time [56]. Handa, Singh, & Punetha (2021) investigated the influence of inflation on production inventory models characterized by changing demand and shortages.

The objective of the research was to comprehend the impact of inflation on inventory decisions when faced with fluctuating demand and shortages in order to offer valuable insights for the development of efficient inventory management techniques [57]. Mallick, Patra, & Mondal (2023) introduced a novel economic order quantity model for deteriorating items considering the combined impact of stock-dependent demand and inflation. The study presented an innovative model that takes into account the interaction between stock-dependent demand, deterioration, and inflation in order to optimize inventory decisions [58]. In their study, Singh & Sharma (2023) introduced an inventory model that considers degrading items with demand that is reliant on price and holding cost that varies with time, taking into account the impact of inflation. The study focused on the intricacies of inventory management, taking into account demand that is influenced by price, expenses that vary over time, the impact of deterioration, and the consequences of inflation. In general, the development of inventory models has been marked by a growing emphasis on dealing with the challenges of managing products that deteriorate with time and the impact of inflation [59]. This research has offered useful knowledge and techniques for firms to enhance inventory decisions and successfully adjust to evolving economic situations.

4.5 Salvage value

The forecasted residual value of an asset is determined by the anticipated amount a company will receive in exchange for the asset after its useful duration after depreciation has been fully accounted for. This is known as the salvage value. The depreciation schedule is significantly influenced by the anticipated salvage value of an item. Managing inventory for items that are failing and have salvage potential is a significant challenge for organizations that aim to optimize costs and prevent losses.

Kumar and Keerthika (2019) proposed an inventory control model that incorporates probabilistic degradation, salvage value, and time-linked holding costs. This model effectively mitigates uncertainties related to storage costs and deterioration patterns [60]. Mandal (2019): Developed an inventory management model that accounts for time-dependent demand, Weibull-distributed deterioration with salvage value, and shortages. This model improves inventory decisions by accounting for fluctuations in demand over time and the Weibull deterioration pattern [61]. Patel and Gor (2019) investigated the impact of salvage value and three variable Weibull degradation rates on items that exhibit non-instantaneous deterioration. Their research offered valuable insights into the optimization of inventory decisions by taking into account varying salvage values and deterioration rates [62]. Kumar (2019) conducted an investigation into inventory planning with a concentration on the optimization of decisions using time-varying linear demand, parabolic holding costs, and salvage value. The investigation provided valuable insights into the effective management of inventory in the presence of dynamic demand patterns and fluctuating holding costs [63]. A strategy for managing inventory of degrading items with time-dependent quadratic demand and salvage value was introduced by Singh et al. (2019). This method encompasses the potential to postpone payment, which can offer valuable insights for optimizing inventory decisions [64]. Pakhira, Ghosh, and Sarkar (2019) investigated the influence of memory on inventory management decisions in a model with quadratic demand rates and salvage values. Their research underscored the impact of memory on inventory strategies and decision-making processes [65]. Saha and Sen (2019): Created an inventory model that takes into account inflationary impacts, shortages, time and price-dependent demand, and item deterioration. In a dynamic economic environment, this paradigm provides practical advice for effective inventory management [66].

Mandal (2020) proposed an inventory model for time-varying degrading commodities with cubic demand that addresses shortages and salvage value. It is the objective of this model to optimize inventory decisions by taking into account cubic demand patterns and salvage prices [67]. A two-warehouses EOQ inventory model for degrading items with exponential declining demand, restricted price fluctuations, and residual value was introduced by Sahoo, Paul, and Kumar (2020) [68]. This model provides valuable insights for the efficient management of inventory in multi-warehouse systems. Thirugnanasambandam and Sivan (2020) investigated inventory planning in the context of time-varying quadratic demand, cubic holding costs, advertising expenses, and salvage values. Their research offers valuable insights into the optimization of inventory decisions in dynamic environments [69]. Singh and Mallick (2020) conducted an analysis of time-dependent quadratic demand with optimal ordering policies that took into account salvage value, partial backlogging, time-proportional deterioration, and variable holding costs. Their research provides strategies for optimizing inventory decisions in dynamic environments [70]. Sahoo, Paul, and Sahoo (2021) proposed an EOQ model for the management of inventory of degrading commodities. The model incorporates cubic demand patterns and a three-parameter Weibull distribution for deterioration. The investigation emphasizes the optimization of inventory decisions by taking into account salvage value and scarcity [71]. (2021) Mandal proposed an inventory management model for commodities with both degrading and ameliorating characteristics. The model includes cubic demand patterns, salvage value considerations, and allowable payment delays. This model offers a comprehensive framework for the effective management of inventory in dynamic environments [72]. Pakhira et al. (2022) investigated the significance of salvage value in a memory-dependent EOQ model for non-decaying items, highlighting its significance even in the absence of deterioration [73]. Patel et al. (2022): Developed a profit-maximizing inventory management model that takes into account the influence of stock levels, salvaged products value, and delayed payments on demand. The research offers recommendations for optimizing inventory decisions to ensure profitability in deferred payment arrangements [74]. Paul, Sahoo, and Sarangi (2022): Developed an optimal inventory management policy that incorporates parabolic demand, scarcity, salvage value, and a three-parameter Weibull deterioration rate. In an effort to optimize inventory decisions in intricate operational scenarios, this model is designed [75].This approach takes into account various factors such as demand patterns, deterioration rates, and salvage values, providing a comprehensive framework for effective inventory management.

In their study, Wu, Chan & Chung (2022a) examined the impact of capital constraints on green supply chains. They specifically focused on the influence of time-varying salvage values. The study provides valuable insights into effectively managing environmentally sustainable supply chains by optimizing inventory decisions while taking into account financial constraints and salvage value considerations [76]. Wu, Chan & Chung (2022b) examined how positive and negative salvage values impact supply chain financing strategies. They offered valuable insights into optimizing supply chain finance decisions by taking into account different salvage value scenarios [77]. Ogundare & Onoja (2023) introduced a model for determining the salvage value from deterioration (SVD) in inventory management. This model utilizes a three-parameter Weibull distribution technique to provide valuable insights for improving inventory decisions, taking into account deterioration rates and salvage values [78].

These studies significantly enhance our comprehension of inventory management for things that deteriorate over time. They provide valuable insights into the most effective tactics, taking into account different patterns of demand and deterioration, as well as the consequences for salvage value.

5. Conclusion

Numerous methods, such as the examination of various demand patterns, pricing strategies, and operational challenges, are emphasized in the studies reviewed in order to improve inventory management systems for deteriorating items. They emphasize the significance of addressing complexities, including demand fluctuations, payment terms, and technological advancements such as advanced analytics and preservation techniques. These factors are essential for enhancing the efficacy and efficiency of inventory management strategies in dynamic supply chain environments.

In particular, the literature contributes to the comprehension of perishable inventory management by addressing critical factors, including financial implications, expiration management, capacity constraints, and variable demand. Researchers and practitioners can develop more effective strategies for optimizing supply chain efficiency and effectively managing perishable inventory by exploring these complexities. Additionally, the research underscores the necessity of incorporating components such as payment terms, back ordering policies, degradation rate control, and accommodation for shortages into comprehensive inventory management models. In order to meet customer demands in dynamic business contexts and minimize costs, this integrated approach is indispensable for informed decision-making.

In conclusion, these studies offer valuable insights into the development of effective inventory management strategies that reduce expenses and effectively meet customer needs. They demonstrate a variety of models and methods that are specifically designed to address the difficulties associated with managing deteriorating products with salvage value. Consequently, they contribute to our comprehension of effective inventory strategies in a variety of operational scenarios and industry contexts.

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