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Overview of Advancement of Inventory Models for Deteriorating Items with Time Based Uniform Price

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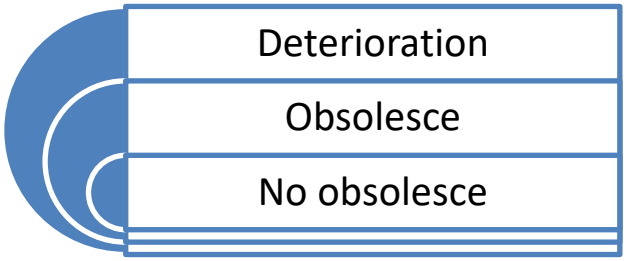
Abstract: *A Inventory control describes the items, products, or stocks kept indefinitely to meet the anticipated demand. In reality, however, the shelf's life span is impossible due to deteriorated items. The quality of the items (like fruits, vegetables) improves each day, and after a specific time, customers aren't inclined to purchase the items to consume. The decrease in the standard of the product is referred to as deterioration. Different researchers such as Gregory P.[1] Fred Raafat[2], S. K. Goyal[3]& B. C. Giri, N. Khanlarzade[4] et.al, L. Janssen, T. Claus & J. Sauer[5], J. Kaushik[6] with A. Sharma have been involved in inventory modeling, using an alternative method of calculating demands, functions as well as assumptions. Deterioration is a frequent cause of loss for retailers, and we present an exhaustive review of constant order and time-dependent requests in inventory models for deteriorating items. We focused on models for inventory with various demand patterns, such as ramp type, linear trapezoidal, etc., in our current research. A comprehensive list of references is included to assist readers in exploring the subject of their interest.*

Mathematics Subject Classification(MSC2022): *90B05*
Key Word: *inventory model; deteriorating item; price; stock; price-dependent demand;*

I.INTRODUCTION

Inventory refers to the stock of a finished product and raw materials in the pipeline to meet the anticipated demand. Inventory management and control are essential in every trade or business since it requires significant capital expenditure. It is vital for the maximization of profits for any business. Customers could choose to go to a different vendor instead of waiting for fulfillment for inventory products, as a result in a capital loss for the business. So, companies must control their inventory to ensure the availability of goods, reduce costs, and maximize profits. Because of the anticipated demand for the future, a list of perishable products is maintained; however, because of the passage of time storage, the quality of items decreases when contrasted with fresh goods such as fruits, vegetables, meat, and seasonal goods. The decline in the quality of the items is known as degradation. Deterioration is the term used to describe product dryness, damage, spoilage, and decay. That means we must consider the effects of deterioration on the inventory model; therefore, inventory can be classified into three categories.



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Obsolesce: means an improvement in the value of an item due to changes in time or technology. Similar to Mig Aircraft replaced by F12 in the Indian Army. Examples: Mobile phones on marketplaces are replaced with newer models due to shifts in time or technology. Old mobiles are replaced with the latest technology. Deterioration refers to degradation in quality, spoilage, or drying of the product, such as fruits or vegetables, blood, or even blood. Products with an established shelf life (e.g., fruits) are called perishable goods. However, when shelf life is not fixed, these items are referred to as no obsolesce degrading products. Certain products have an indefinite shelf life and will fall under obsolesce degradation.

II.CHALLENGES IN DETERIORATION

Different kinds of products are affected by deterioration, each with distinct characteristics. A few items are under immediate declines, like milk. Fruits and vegetables have various types of lives. So, the degrading of such things must be handled differently. The product's shelf life differs; for example, the shelf life of electronic products and the shelf lives of food products are distinct. The shelf lives of medicine and fruits are different; therefore, it is necessary to employ another strategy before deciding the rate of deterioration. It has been observed that certain products change when they are deteriorating (e.g.,

radioactive items). There are times when fashions change, new technologies are introduced, and often deterioration is time-or concerning price. These types of issues were encountered at the time when the first signs of degradation. Our research focuses on Uniform demand, price-dependent demand, and time-dependent demand of an inventory model.

III. INVENTORY MODELS THAT CONSIDER THE UNIFORM DEMAND

The optimal policy for deteriorating items was proposed by G. Ghare[7] with P. Schrader, and R. P. Covert[8]& G. C. Philip came up with an inventory model for degrading things based on the assumption of an exponential decline. This EOQ model was developed to satisfy deterministic demand, where shortages were not permitted to increase, while G. Philip[9] introduced the Weibull distributions for deteriorating items with no poverty. The first-time deficit was accepted by Y. K. Shah[10]. Then K. V. Sarma[11] presented an inventory model to deal with individual deterioration using two warehouse concepts. The fundamental idea was that taking on the burden of surplus inventory is more effective than having a warehouse hold more stock since it will reduce the deterioration cost; as a result, organizations earn greater profits from this method. Then S. K. Goyal[12] proposed the concept of "EOQ" to provide optimal value based on constant demand and no shortage.

A study conducted by the G. Padmanabhan[13] and P. Vrat introduces an inventory model for perishable goods in which the rate of deterioration was exponential, and the cost of holding and purchase cost was also included in the model. Fred introduced an inventory model that can meet the ongoing demand for degrading products with a fixed replenishment rate. T. P. M. Pakkala& K. K. Achary[14] introduced an inventory model that incorporated two warehouse models with different degradation rates. Replenishment rates were allowed in the event of the possibility of a shortage. On the other hand, in a parallel study, the authors A. Gowami& K. S. Chaudhuri[15] provided an inventory model that explains the time-dependent deterioration rate, with no shortage being allowed. In addition, S. Sana[16], S.K.Goyal and K.S.Chaudhari expanded the work of G. Padmanabhan and P. Vrat[13]. They examined lead time in the drought, which needed to take longer than expected and was followed by a low cost. In this manner, the time of drought has been reduced from a long time into a cycle. C. T. Chang[17] came up with a novel concept of a permissible delay when a buyer ordered large quantities. This controlled the effects of inventory inflation because the delayed payment was used to make retailers more money. In addition, H.L.Yang[18] introduced the concept of inflation and shortage in two warehouses to ensure control of the degrading inventory of items. This model regarded shortage as beginning at the beginning of a cycle and is finished when there are no shortages. This model shows the old warehouse's higher price than the models presented. Thus, the model presented was less expensive than the previously used model in the context of inflation. H. L.Yang[19] presented as an inventory management model designed to maximize the earning function and achieve the best replenishment strategy for the constant demands of degrading products. In the earlier research, the focus was on minimizing costs when designing the inventory models to discover the optimal replenishment strategy, but maximizing earnings needed to be included. In addition, H. L.Yang[20] introduced partial backlogging to evaluate two warehouses to reduce costs. In this model, he expanded his work from H.L.Yang[18]. Then, C. C. Lee[21] changed the model from T. P. M. Pakkala& K. K. Achary[14] by working on a FIFO policy for controlling inventory across two warehouses; however, C. C. Lee[21] also introduced the LIFO method for managing inventory in two warehouses. Interestingly, the LIFO method is not used in the real world because fresh, perishable items are given preference. In this manner, research suggests that the FIFO model's costs are lower than the LIFO method. The price for holding the rented warehouse is lower when compared to the company's warehouse. C. Y. Dye[22] presented an inventory model that uses an approach to maximize profits per item. The concept is that there are two different warehouses incorporated. A rented and owned warehouse concept was introduced when the supplier received more orders than the capacities of its warehouse. The rate of deterioration was different for the two warehouses. The amount of space available at the primary warehouse and backlog demand are based on empty space within the warehouse. B.Niu and J.Xie[23] Extending his work from C. C. Lee[21] established it needed to be corrected and suggested a new method of calculation for items that are deteriorating. C. C. Lee[21] was working with two warehouses. They expanded the model of T. P. M. Pakkala& K. K. Achary, only to prove that it needed to be corrected by B.Niu and J.Xie[23]. L. Y. Ouyang[24]expands on the work of S. K. Goyal and develops an inventory control model that allows for degrading items with an allowable payment delay. The selling price per unit is greater than the purchase cost per unit. The assumption for interest earned must be greater than the interest charged in their research. In this study, the payment delay is permitted up to a predetermined period, which means that the retailers' purchasing power increases and they can buy more products. As a result, retailers complete orders in large quantities that result in additional sales. This method increases the profits of both retailers and suppliers because of the increased sales permitted by the permissible delay in the payment. H.Pandey&Ashutosh Pandey[25]created two warehouse models of inventory for perishable products. Sometimes, the item's production is limited to a particular season (e.g., wheat). Self-storage capacity is limited, so we need to rent a second facility on rent for storage, which is not enough. Their rate of deterioration is higher than that of the rented warehouse because of the use of a more effective preservation technique. The shortfall can be accommodated with the whole backlog. The rate of deterioration was constant with an even demand. Then, A. A. Sheikh[26] introduced an inventory model that included the assumption that there were two warehouses, one for its warehouse and the other on lease. The permissible payment delay was permitted for the warehouse that the owner owned. Backlogs with partial shortfalls were permissible in the case of an even demand.

IV.INVENTORY MODELS THAT CONSIDER PRICE DEPENDENT DEMAND

The cost of products and retailers' demand is in direct correlation with one another. If the price is lower and retailers are in demand, they influence the surplus lot size, and the reverse is true. H. M. Wee[27] Working on replenishment policies and pricing on the control of inventory for perishable products. If demand dropped exponentially concerning price, they viewed it as a steady degradation rate with a partial backlog. Additionally, H. Wee[28] extended his model and found significant variations

in the degradation rate. P. L. Abad[29] worked on the size of the inventory of perishable goods to determine the price dependent on the availability of shortages and partial backlogs. Then H.Wee[30] expanded his Inventory model, H. M. Wee[28],which allowed an amount discount and partial backlog. The earlier study was founded on cost minimization, but he changed his approach to profit maximization. The study focused on pricing-dependent inventory control models for the size of the demand by retailers that suffers constant degradation in backlog demand. The price of the sale was set in the model. It was the first time that backlog rates were considered in the model before the study; rates of backlog were not thought of in prior studies. S. Papachristos and K. Skouri[32] Working on the study conducted by H.Wee[30]developed a price-dependent inventory model with constant degradation; however, S. Papachristos and K. Skouri[32] focused on the selling price's concave functions to maximize profits. This model ensured that the wait time for replenishment decreased. So in the model, inventory control was improved, and, as a result, the company earned greater profits. P.L.Abad[33]proposed price-dependent inventory model of perishable products is considered within this framework. The rate of deterioration was exponential and was increasing over time. The backlog was not complete and there was no shortfall permitted within this investigation. Another option for irritable customers. They could shift to a different supplier in the event that they aren't receiving the items they wanted on the proper date. In this situation, the supplier can arrange items from different production units when they receive them at a reasonable price. S. W. Shinn & H. Hwang[34] devised an inventory control system for a deterministic demand dependent on the sale price for damaged items. In this research, he simultaneously worked on an optimal pricing policy and the optimal size for the lot. He proposed the notion of permissible delay to retailers. The period of delay in credit in payment was contingent on the size of the bulk orders placed by retailer's amount. This quantity is delayed until the credit settlement date H.L.Yang[18]. He then developed an inventory-control model that incorporated determinate demand for prices dependent on item condition. In this research, he identified the best strategy for pricing and ordering as a combined profit for the seller and buyer. If the seller is making greater profits, he would be able to attract buyers with the discount rate offered to them. It is a matter of comparing two methods (the buyer in addition to the seller) to earn the same amount. This way the profit will be increased through more sales. A.K.Pal, A.K.Bhunia and R.N. Mukhrjee[35]developed the inventory model in order to calculate the amount of inventory needed for perishable goods with price and inventory dependent on shortage. The capacity for the shortage of the items was not significant based on this assumption. C. Y. Dye & L. Y. Ouyang[36]developed an 'EOQ' model that retailers can use to determine the best-selling prices and replenishment levels, which allows some backlog. The profit function is concave concerning the value P. Comparability has been demonstrated in J. T. Teng, L.Y. Ouyang ,L. H. Chen[37]. The model used in this study compares the model's deterministic lot size and price. In this research, the researcher extends the model from P. L. Abad[33] by incorporating the costs of a shortage and a loss cost. He then compares the model with the model from S. K. Goyal and B. C. Giri[38], the Y. Tsao and G. Sheen[39] model, considered to be a dynamic pricing issue in this study, to demonstrate the impact of advertising on buyers as well as the trade credit impact for the manufacturer. The aim of this study was to identify the optimal price for retailers. T. P. Hsieh and C. Y. Dye[40] Developed the inventory models for perishable goods dependent on price and under-inflation over a finite period. The study aimed to find out how to determine the amount of a lot and the price of sale for maximum profits for the business. Backlogging and partial shortages were permitted within this investigation. In addition, R. Maihami and I. Nakhai Kamalabadi[41] provided an inventory model that allowed for a partially backlogged inventory shortage. The study aimed to identify an optimal value for selling and determine the number of items to be sold to maximize profits. M. Rastogi, S. R. Singh, P. Kushwah and S. Tayal[42]analyzed the severe competition on the market as suppliers offer concessions discounts to retail stores in the form of the possibility of a delay in payment that increased demand according to their requirements. This type of bulk buying requires storage facilities that can attract inventory modeling. Our capacity in our warehouse was extremely restricted, and we needed to lease a second warehouse that rents. The cost of holding per unit was greater when a warehouse was rented as opposed to the warehouse we own. This model was developed to calculate the smallest possible cost. Furthermore, Shalini Singh and G. C. Sharma[43]designed an inventory-based model that could be used for nonperishable products. Three types of demand rates were evaluated using linear demand based on price, time, and a constant. . A.K.Sharma[44,45,46]discussed about inventory model with deteriorating items related to time constraints. Prior to it, one demand rate was thought of insufficient inventory due to the Development of Inventory Models for deteriorating items that include partial backlogging was given the same deterioration rate to be constant.

V. DISCUSSION AND CONCLUSION

Fred Raafat[2] discussed different kinds of inventory models during their study from 25 years ago. However, many demand models are built upon their research, including the ramp-type, exponential and trapezoidal demand, and so on. We will discuss the inventory models of perishable products with a uniform price, times, and time-dependent demand function. We have completed our literature review to date in our research. There are many subjects to choose from, such as permissible delay and advances in payment with trade credits, and also discussed within the community of inventory control. The discussion has already covered inventory models based on presumptions of the stochastic function of demand. However, there has yet to be any new work that has observed in inventory modeling in the past decade. If the researcher focuses on the stochastic method is a good thing for the community of researchers since real-world problems can be discussed in depth using the stochastic model. We also discussed deterministic demand on a weekly or monthly basis (Macro time). In reality, however, the order could change three times per day, similar to the inventory of a grocery store. Therefore, future models for merchandise at the micro level could address the decline of inventory items. People prefer fresh products like fruits and vegetables to their meals. Sometimes, the shelf life of deteriorating effects is more similar to the expiry date of the medication. Therefore, FIFO and LIFO policies can benefit inventory models' future. Thus, future researchers could create inventory models based on future requirements and aspects.

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