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Expiry Based Dynamic Discount System – A Review

[1]Tej Save, [2]Aditya Nair, [3]Vighnesh Birru, [4]Shubham Chimkar, [5]Prof. Mohan Kumar

[1,2,3,4] Department of Data Engineering

[5] Professor, Department of Data Engineering Universal College Of Engineering, Kaman, India

Abstract - Food waste remains a persistent challenge in the retail sector, largely caused by fixed pricing systems that do not account for product freshness or expiry proximity. The *Expiry Based Dynamic Discount System* seeks to minimize this waste while maintaining retailer profitability by automatically adjusting prices according to predicted expiry dates and real-time demand. This review paper surveys ten key studies addressing dynamic pricing, expiry prediction, and inventory optimization for perishable products. Techniques such as ARIMA, LSTM, Q- learning, Genetic Algorithms, and Dynamic Shelf- Life modeling are compared to understand their roles in forecasting demand, optimizing stock rotation, and enabling sustainable retail operations. The findings indicate that integrating artificial intelligence and optimization models can significantly reduce waste and improve sales efficiency in perishable-goods management.

1. INTRODUCTION

The global food retail industry faces growing losses due to premature disposal of near-expiry products. Traditional fixed-price policies fail to capture the time-sensitive value of perishable goods, resulting in either unsold stock or unnecessary markdowns. Retailers therefore require a data-driven system capable of dynamically adjusting product prices based on expiry information, consumer demand, and inventory turnover.

An *Expiry Based Dynamic Discount System* offers such a solution by leveraging predictive models to forecast product freshness and compute appropriate discount levels automatically. Using machine- learning algorithms and real-time data analytics, the system aligns sales strategies with product shelf life, enabling optimal pricing decisions. This paper reviews the major research contributions that form the foundation for such systems, comparing methodologies and identifying technological trends useful for future development.

2. LITERATURE SURVEY

In this section we present the review of various blind sticks made by others.

Sathyabama, Raj, and Gukan [1] in their paper have proposed an AI-driven system named "Reviro" to manage perishable goods in the retail sector. The system uses ARIMA and LSTM models to more accurately predict product expiry dates and enable dynamic pricing strategies. Reviro is designed to integrate small local stores (kirana stores) and large supermarkets through an API, allowing retailers to dynamically adjust prices on near-expiry items to reduce food waste. Hence, in this paper, a scalable, AI-powered platform has been implemented to address food wastage, particularly in the Indian market, by combining predictive analytics with features for consumer engagement and food donation.

Bazrafshan, Emami, and Mashreghi [2] In their paper, propose a nonlinear mathematical model to optimize inventory and pricing for perishable products like cheese and mayonnaise.Their model accounts for demand that depends on both product age and price, and it uses Genetic Algorithms to determine the optimal order quantity and discount timing.The system is designed to maximize profit by creating a sales plan that clears inventory without shortages before the expiration date.

Buisman, Haijema, and Bloemhof-Ruwaard [3] developed a simulation-based optimization model to analyze strategies for reducing food waste in retail.The model compares the effects of a traditional Fixed Shelf Life (FSL) against a Dynamic Shelf Life (DSL) system, both with and without price discounting, using meat products as a case study. Their research demonstrates that combining DSL with discounting is the most effective strategy and, notably, that a DSL system alone can reduce more waste than an FSL system with discounts.

Syed T.A. & Aslam, H., Bhatti, et al. [4] introduce a

three-phase framework for implementing dynamic pricing in grocery retail, framing the process as a Data-Driven Digital Transformation (DD-DT). Their framework guides retailers through initiation (data collection), facilitation (algorithm integration), and strategic adaptation (continuous refinement). Hence, the paper provides a strategic roadmap for practitioners to bridge the gap between theoretical dynamic pricing models and their practical application in supermarkets.

Gallego and Hu [5] analyze dynamic price competition for perishable assets in a market with a few competing firms. Using game theory, their model shows that equilibrium prices can be determined by solving a one- shot game that accounts for "shadow prices," which measure how one firm's inventory capacity affects its competitors. Thus, the paper provides a simplified structure for understanding and managing revenue in complex, competitive environments.

Chen, Liu, and Xu [6] explore a dynamic pricing strategy for perishable products using a Q-learning mechanism, a form of reinforcement learning.They created a competitive market using a multi-agent simulation where one retailer agent learns its pricing policy through experience, while other agents use traditional methods. The results show that the Q- learning approach allows a retailer to generate more revenue in a competitive environment with uncertain demand.

Scholz and Kulko [7] investigate dynamic pricing as a sustainable business model for perishable food. They conducted an online experiment to measure consumers' willingness to pay for strawberries of different freshness levels and used a Monte Carlo simulation to compare pricing strategies. The study finds that freshness is a key factor for consumers and that a dynamic pricing strategy can reduce food waste by up to 53.6% while increasing revenue by up to 10%.

Ashraf A. Afifi [8] proposes a novel data mining approach to forecast demand for short life cycle products that lack historical sales data. The system uses an incremental k-means clustering algorithm to group similar products and a RULES-6 classifier to generate forecasting rules based on product attributes. Hence, this paper implements a method to accurately predict demand trends for new products in sectors like IT e- commerce and retail.

Tromp & Rijgersberg, et al. [9] propose and simulate a Dynamic Expiry Date (DED) system as an alternative to the conservative Fixed Expiry Dates (FED) on fresh food.The DED is calculated based on a product's actual time-temperature history using a quality decay model, and a logistics simulation of a pork supply chain was used to quantify the benefits.The paper concludes that implementing a DED can reduce opportunity losses from waste and stockouts by nearly 80%.

R. Shi and C. You [10] formulate a strategy that jointly optimizes dynamic pricing and freshness-keeping efforts for perishable products.Their model considers demand to be dependent on price, freshness, and current stock levels, and it applies Pontryagin's maximum principle to find the profit-maximizing solution.The research finds that investing in freshness preservation is only optimal when the cost is low or the effect is significant, providing clear managerial guidelines.

Sr No.	Paper - Topic	Year	Technologies Used / Algorithms Implemented
1	"Inventory control and price discount policies for perishable products with age and price-dependent demand"	2020	Algorithms Implemented - Nonlinear Mathematical Modeling, Genetic Algorithm (GA), Particle Swarm Optimization (PSO)
2	"Discounting and dynamic shelf life to reduce fresh food waste at retailers"	2019	Algorithms Implemented - Simulation-Based Optimization Model
3	"Dynamic Pricing for Perishable goods: A Data-driven Digital Transformation Approach"	2024	Technologies Used - Multi-Case Study, Data-Driven Digital Transformation (DD-DT) Framework
4	"Dynamic Pricing of Perishable Assets Under Competition"	2014	Algorithms Implemented - Game Theory, Dynamic Price Competition Modeling
5	"Dynamic Pricing Strategies for Perishable Product in a Competitive Multi-Agent Retailers Market"	2018	Algorithms Implemented - Multi-Agent Simulation, Reinforcement Learning (Q-learning)
6	"Dynamic pricing of perishable food as a sustainable business model"	2021	Algorithms Implemented - Online Experiment, Monte Carlo Simulation, Regression Analysis
7	"Demand Forecasting of Short Life Cycle Products Using Data Mining Techniques"	2020	Algorithms Implemented - Data Mining, Incremental k-means clustering, RULES-6 rule induction classifier
8	"Retail benefits of dynamic expiry dates—Simulating opportunity losses due to product loss, discount policy and out of stock"	2012	Technologies Used - Logistics Simulation Modeling, Quality Decay Modeling
9	"Joint dynamic pricing and freshness-keeping effort strategy for perishable products with price-, freshness-, and stock-dependent demand"	2023	Algorithms Implemented - Pontryagin's maximum principle (Optimal Control Theory)
10	"AI-Driven Expiry Prediction and Dynamic Pricing System for Retail Inventory Management Utilizing ARIMA and LSTM Models"	2024	Technologies Used - AI, Flutter, Node.js, PostgreSQL, MongoDB. Algorithms Implemented - Autoregressive Integrated Moving Average (ARIMA), Long short-term memory (LSTM)

3. CONCLUSION

This paper is a comprehensive survey for Expiry Based Dynamic Discount Systems. The different approaches, ranging from mathematical optimization and simulation to advanced AI and data mining techniques, from recent studies and implementations in the domain were reviewed and analyzed. To this end, we found that there are improvements which can be made in the underlying technological infrastructure as well as the algorithmic and strategic frameworks.

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