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An Integrated Inventory Model with Price Negotiation and Two-Level Credit Policy under Price-Sensitive and Stock-Dependent Demand

[1]Awanish Kumar, [2]Dr. Pinky Pandey
[1]Research Scholar, University Dept. of Mathematics, Ranchi University, Ranchi
[2]Asst.. Professor, Dept. of Mathematics, Nirmala College, Ranchi University, Ranchi

Abstract - This paper formulates a joint inventory model, which considers the realities of today's supply chain system through considering three main features: price-sensitive and stock-dependent demand, a vendor–buyer price bargaining policy, and bi-level credit. The nature of the proposed model is unlike those used in previous inventory models with fixed price and simple credit which do not consider situations reflecting real life where consumer behaviour along financial constraints plays a crucial role on the demand. The model incorporates a weighted bargaining factor (α) to account for dealing power in transfer pricing and combines a distributed credit policy (T_1 and T_2) to coordinate order-taking and payment leverage. Inventory dynamics are further extended to deterioration by which the model becomes valid for industries processing perishable, and quick obsoleted products. The total cost per cycle is minimized over an integral cost structure, which includes holding/stockout costs, ordering costs, purchasing costs and deterioration and interest costing. Gui simulations programmed in MATLAB show how the negotiation results, credit terms and deterioration rates affect demand, cost and inventory level together. The results highlight the need for a balance between operational efficiency and financial strategies and offer practical implications for vendor-managed inventory systems, wholesale distribution networks, and long-term B2B relationships.

Keywords - Integrated Inventory Model, Price-Sensitive Demand, Stock-Dependent Demand, Price Negotiation Scheme, Two-Level Credit Policy, Inventory Deterioration, Supply Chain Optimization.

I. INTRODUCTION

Inventory management has been established as one of core operation for ensuring an efficient and profitable operations in manufacturing and retail firms alike. In previous literature, inventory models were established in a very simple framework where demand was assumed constant or deterministic, prices are constant and payment policy is the same. These were assumed to enable succinct mathematical representations but their oversimplifying nature typically could not be applied in a real supply chain. Supply chains are competitive, fluid systems in which firms have to manage both their logistics flows and the financial and strategic deals that set the tone for long-term relationships between purchasers and vendors. In this context, the integrated inventory models become more popular as they deal with multi-aspect aspects of the inventory problem. This paper offers an integrated inventory model, which considers two important and practical effects of the real world; price negotiation policy between buyer and supplier, a two-level permissible delay in payment. This policy is proposed in the face of price-sensitive and stock-dependent demand, a practice often observed in markets such as consumer electronics, fashion, FMCG (fast-moving consumer goods), and perishables. In these industries, the demand of customers is not just responsive to price increases but also for product availability. Customers usually link high levels of supply with reliability, the possibility to provide increased service and a higher level of trust in the supplier, thus generating stock-dependent demand [1]. Thus, a contemporary inventory model has to consider not only consumer behaviour but also vendor-buyers' interactions along with credit policy that induce direct impact on the purchase and holding decisions.

Rationale for an Integrated Approach

The unification of price negotiation and credit policy within an inventory structure is motivated by the fact that contemporary supply chains are not linear supply-and-demand systems in which suppliers dictate prices and buyers accept without a say. Instead, supply chain relationships are based on collaboration, negotiation and financial arrangements in which the interests of both parties are taken into account. Suppliers, in order to remain competitive, are willing to offer pricing concessions for volume or long-term purchases. For buyers, on the other hand, credit facilities are necessary to achieve cost benefits and synchronize their input and sales cycles.

By extension, other decisions concerning price and credit timing are not at the periphery of inventory control but inextricably related to cost systems and profitability. And the demand of consumers itself is also getting more and more volatile due to market competition, promotions and sensitivity to prices. Minor differences in price can have large impacts on demand and retail visibility (in fact, discovered stock at the retailer level may actually stimulate or inhibit consumer purchase). In e-commerce and retail, "stock-out" signals have often disappointed buyers and drove them to rivals but visible abundance may relieve them by encouraging trust [2]. An inventory model that aims to be applied in practice should therefore take into account the interaction between price and stock visibility [3].

Price-Sensitive and Stock-Dependent Demand

The demand context considered in this study recognizes two fundamental drivers of consumer buying behaviour: Price Sensitivity: Consumers in general are sensitive to firm's price changes. "The more the price goes up, the less people want it, and conversely for a lower price." This elasticity differs between industries and customer segments, but it is always present in some shape or form.

Stock Dependence: Demand for a product is affected by consumer perception of the availability of that product. Second, the quantity of inventory listed in physical or virtual markets provides a visual signal about abundance and reliability (or lack thereof), which encourages increased purchasing. We can witness such an instance in seasonal products, promotions and even impulse purchase scenarios where the stock visibility has a psychological connotation. Since the consumer purchasing decisions are not one-dimensional, two factors have been incorporated in the demand function as following.

It gives a more realistic reflection of demand in the behavioural sense, and allows firms to forecast how customers would react under different pricing and stock situations [4].

Price Negotiation in Inventory Systems

A notable innovation of this model is the inclusion of a price bargaining process between the vendor and buyer. In A lot of real-world business-to-business (B2B) scenarios, the prices are not fixed and dependent on negotiation. Purchasers and suppliers bargain to reach a final price, the bargaining stance is affected by the size of order, long-term business relation, buyer-supplier power situation and current market state.

In this model, the weighted negotiation factor (α) is proposed to indicate the strength of bargaining power between vendor and buyer. Higher values of α indicate protection for the vendor to price up, and lower α means control resides in favour of the buyer. Such a definition enables the model to emulate various levels of bargaining outcomes, that range from seller-determined price levels to buyer-dominated ones. Most notably, the outcome of this bargaining determines demand and hence procurement cost and each party's profit. By including negotiation within the inventory model, the research captured the strategic link between buyers and suppliers in competitive supply chains [5].

II. LITERATURE REVIEW

Integrated inventory models have developed to model complex supply chain dynamics, especially for systems where demand is related to pricing and credit policies. Its objectives best known inventory level with the proper pricing decision and credit terms in order to maximize profitability.

Integrated Inventory Models with Price Negotiation and Two-Level Credit Policies Range of other inventory Chen and Kang [2010] diversified inventory models that based on the allowable delay payment, where customer demand depends on the buyer's price. The two-level trade credit policy (vendor to buyer and buyer to customer chain) is integrated with their models in order to optimize the pricing and ordering policies.

Shah, Patel and Soni (2013) generalized this model by taking price negotiation model in to consideration where dynamic pricing according to market condition and negotiation outcomes can be carried out. Such a configuration permits an inventory management system which is more sensitive and adaptive to circumstances.

Stock-Dependent Demand and Credit Policies
Yang et al. (2020) studied a two-echelon supply chain model with price and the customer's credit period. They studied an inventory model under a two-level trade credit policy, and investigated the optimal credit periods and pricing strategies in the situations.

Shaikh et al. (2021) studied the inventory models with deteriorating items and stock-dependent demand under two-level trade credit. By contrast, their work studied nonzero inventory and partially backlogged shortages cases focusing on the role of credit policies in managing inventory efficiently.

Price Sensitivity and Inventory Management
Pervin et al. (2018) considered multi-item deteriorating inventory models under two-echelon supply chain policies with stock-dependent and price-dependent demand functions. The results provide an indication of the importance of pricing policies to control inventory on deteriorating items.
Thangam and Uthayakumar (2015) presented an Economic Production Quantity (EPQ)/Quality model in the case of deteriorating items subject to two-level trade credit policy under demand which depends on selling price and credit period. Their research lays the groundwork for the trade-off between pricing, credit conditions and stock levels.

Optimization Techniques and Managerial Insights
Liao et al. (2013) developed an inventory model for the deteriorating items under stock-dependent demand and two-level trade credit, demanding optimization methods for obtaining best possible ordering policies. Their analysis provides operational insights into the inventory problem in such environments.

Teng et al. (2012) developed an EOQ model for stock-dependent demand with supplier's trade credit when payment is made by instalment. Their work has shown the challenges concerning different credit term and the needs for joint models to obviate them.

III. METHODOLOGY

Modern supply chains are not simple one-dimensional systems based on fixed prices and inflexible financial agreement. They are rather the result of complex negotiations, co-operative-driven strategies and credit mechanisms that reconcile operational imperatives with financial interests. In this study, we develop an integrated inventory model for the buyer paying delay in the finite horizon under two important policies of trade credit: price negotiation and two-level credit policy, which profoundly affect decision making of inventory management.

The model is most suitable for the cases where the goods have sensitive demand and stock, buyers and vendors take price stratification measures to increase their profits and use credit sale and purchase methods. While the inventory decisions in these environments are based on classical (physical) inventory costs such as ordering, holding and deterioration cost, they are also affected by financial factors such as delayed payments, interest rate losses and discounted purchase prices [6]. These three factors are often interconnected, making a need for the model that reflects their interactions comprehensively. The mathematical modelling proposed in this paper is grounded in realistic assumptions and designed to generate managerial insights for making optimal decisions under uncertainty and competition.

Demand Behaviour: Price and Inventory Dependency

The model begins by formulating a demand function that captures how customer demand responds to changes in both price and inventory availability. Let the instantaneous demand at time t be represented as:

$D(t)=a+bI(t)-cp$

where is the part of demand not depending on inventory and price, is a stock dependence parameter: the more available an item is, the faster it attracts views and demand, describes how sensitive demand is to price changes (in addition, ttt denotes time, ccc represents). The addition of incorporates promotional effects, the effect of impulse and higher trust in sellers that can fulfil good inventories, while represents negative price-quantity demanded relationship. So, the demand function simulates reality where availability and affordability act together in a purchase decision.

Price Negotiation Scheme Between Vendor and Buyer

One major feature of this model is the addition of a negotiated pricing contract. However, in most real life settings, sellers, as well as buyers, may negotiate for prices instead of based on static contracts. This is particularly prevalent in B2B, long-term relationships or bulk buys.

Let pv be the vendor's asking price and pb the buyer's bid. The final agreed price p is determined using a weighted negotiation factor $\alpha \in [0,1]$, were

$p=\alpha pv+(1-\alpha)pb$

The parameter α measures the bargaining power of the seller. A greater α indicates that vendors have more power, whereas a lower 1α implies that buyers are the dominant party. This equation introduces a degree of leeway, allowing the model to represent other dependent negotiation results. For example, when $\alpha=0.5$ it means equal bargaining power. For $\alpha=0.8$, most of the pricing decision is made by the vendor. Such negotiated price affects directly total demand, the inventory valuation and buyer's cost structure [7].

Inventory Dynamics and Deterioration

The dynamics of the stock are controlled by demand satisfaction and product decay. Loss also presents a significant problem in fields such as food, pharmaceuticals or electronics not only because of decay, but also due to obsolescence. 36 The equation representing the dynamic inventory is expressed as:

$(dI(t))/dt=-D(t)-\theta I(t)$

Substituting the demand function yields

$(dI(t))/dt=-a-bI(t)+cp-\theta I(t)$

$\Rightarrow (dI(t))/dt==-a+cp-(b+\theta)I(t)$

where θ is the constant rate of decay. The inventory level I(t) over the finite horizon [0, T] is given by the solution of this differential equation. This ongoing representation enables us to investigate the profiling process of inventory that shrinks due to a combination of customer demand and decay, which contributes to better estimations of average inventory frequency and cost components.

Two-Level Credit Policy: Delayed Payment Structure

The second novelty of the model is two-level credit policy, very practical. Sellers frequently give customers credit to encourage sales, subject to the right to charge interest on any balance after a certain date.

Let be the smallest credit period without interest. It is something that is often provided as a net discount to settle early. The second term of credit period 12, spanning from T1 to T1+T2, is charged interest at a rate rrr. The purchasing party has to pay for anything left-over inventory after T1 with interest on this surplus remainder. Since it is total procurement costs that are influenced by this policy, the optimal ordering decision could not fail to be affected.

The interest cost is calculated as:

IC=r·∫_T1^(T1+T2)▒〖I(t)·pdt〗

Such a formulation discourages holding inventory for time beyond the initial credit window, and Favors just-in-time or optimal ordering intervals.

Cost Structure and Optimization Objectives

The total cost per cycle comprises the following components

Holding Cost (HC): Based on average inventory:

HC=H·1/T ∫_0^T▒〖(t)dt〗

Ordering Cost (S): A fixed cost incurred each time a replenishment is made.

Purchase Cost (PC): Dependent on the negotiated unit price and order quantity

PC=Q·p

Deterioration Cost (DC): Calculated from the cumulative deterioration

DC=Cd·∫_0^T▒〖θI(t)dt〗

Interest Cost (IC): As defined above for the second credit period.

The total cost function is thus:

TC=HC+PC+S+DC+IC

The total cost, which is the sum of these costs, should be minimized by choosing best values of order quantity Q, negotiating factor α, and credit periods T1 and T2. To arrive at an appropriate valve control, the following constrained optimization problem is addressed taking into account financial and operational trade-offs together [8].

Managerial Implications and Strategic Decisions

This model provides several important implications for the suppliers and buyers:

Negotiation Flexibility: In this context, customers are able to affect pricing outcomes through bulk purchase or long-term contracts and vendors may protect margins by fine tuning α\alphaα and by granting limited credit.

Credit Policy Optimization: The two-tier policy motivates the buyer to sell-off stock during T1, thus cutting down on financial liability. T2 and rrr can help reduce such payment risks for suppliers.

Deterioration Management: Managers should be able to plan reorders by calculating θ (and so before stock becoming obsolete), particularly for items with high inherent risk.

Integrated Cost Awareness: The integration of the purchase, holding, deterioration and interest cost provides the data-based pricing versus intuitional decision.

The aims of the integrated inventory model are to: provide a holistic framework that incorporates dynamic pricing, financial collaboration and demand behaviour in a realistic operational setting. This captures the structure of today's supply chains that are complicated by such factors as inventory risk, sales level, price competition and financial situation. By incorporating a price negotiation mechanism and two-level credit policy into the modelling structure, this framework connects inventory optimization to financial decisions. These models are particularly useful in VMI systems, wholesale distribution and long-term B2B relationships.

The resulting insights can be help in strategic pricing, credit negotiations, and inventory timing. The direct application of the model is to ant simulations for negotiating in different scenarios with variety payment models helps decision-makers develop flexible, resilient and cost-effective supply networks.

Result and Discussion

The developed MATLAB-GUI system model was utilized to monitor and investigate the behaviour of inventory systems, under the effects of price-sensitive demand (PSD) or stock dependent demand (SDD), in which a two-level-credit policy in conjunction with bargaining was introduced. The model could be set up by users for various parameter settings in terms of the negotiation results, rate of deterioration and credit conditions. During simulation, the agreed-upon ×price is calculated as a function of the seller’s price (seller) and the buyer’s bid (buyer), adjusted by means of negotiation power parameter α. This method successfully illustrated the effect of bargaining power on purchasing cost and demand thereafter. For example, increased dominance of vendors (α →

1) negatively influenced demand and increasing prices - a greater percentage of buyer domination ($\alpha \to 0$), in turn decreased prices and increased demand, albeit potentially at the cost vendor profitability. That underscored the strategic trade-off of price give-ups and demand stimulation.

The inventory dynamics was described using a differential equation, and the "ODE45" solver was used to solve these equations. It was found that \inventory diminished over time for two reasons: (i) customer demand, which was positively associated with stock visible but negatively related to price, and (ii) deterioration, occurring at a constant rate considered independently of the request. The simulation diagrams showed that inventories decreased almost exponentially, with a steeper fall in inventories being noticed when the deterioration rate (θ) was higher. Basically, in perishables related industries, this means lots of rotation is required to prevent a loss.

The demand function was sensitive and realistic to price and stock. In the upswing of the cycle, when inventory was plentiful and demand was relatively higher because of stock visibility effects. With the depletion of inventory, demand levels also fell as they were closely related to both stock dependency and price sensitivity.

Holding, ordering, purchase, deterioration and interest costs were included in the cost analysis. The model showed that the mean inventory level influenced holding costs; higher deterioration rates noticeably led to more loss in value of deteriorating items. The price of purchases was highly correlated with negotiated prices, highlighting the relevance of fair negotiations.

The dual-credit policy served as a psychometric indicator. During the initial 1st term (T1), interest was not charged, to prompt early repayment. However, if payments were postponed into the subsequent credit window (T2), interest was charged, and the overall cost function escalated considerably. This practice demonstrated how offering payment on credit terms could be used as an incentive for prompt settlement and protection to suppliers against extended delays in payment.

The total cost function used in the simulation output demonstrated the relation between operational performance and financial aspects. Having extended T1, without increasing the interest rate r, buyers had to bear lower costs but vendors would have faced higher financial risk. In contrast, lower T1 and greater r discouraged late payments, passing more cost onto customers. This is in fact plausible, as the real-world vendors carefully design their credit rules according to a trade-off between competitiveness and risk.

Among the managerial implications, results of the simulations validated some important convergences which I initially hoped would emerge from such a complex model.

To begin with, flexibility of bargaining position is crucial to harmonising the interests of vendor and purchaser. Suppliers can cushion margins through greater bargaining power, but too much intransigence limits demand. Second, the design of credit policies is necessary for the stability: sellers need to calibrate the values of T1, T2 and r such that buyers make early payments but they are not deterred from paying. Third, deterioration management was identified as an important issue since greater diffusion of wastage over the set encountered a limit on the value of D beyond which profits declined.

Overall, the GUI-based simulation validated the theoretical framework by capturing realistic interactions between price negotiation, stock-dependent demand, and two-level credit policies. It provided a practical decision-support tool for analysing trade-offs between operational efficiency and financial terms, reinforcing the significance of integrated approaches in modern supply chains.

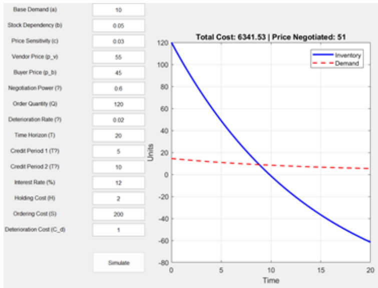

Fig. 1. Inventory with Price Negotiation & Two-Level Credit Policy

Figure 1 clearly shows how stock levels and demand interact on a planning horizon given the parameter set under consideration. The right-hand side two plots feature the inventory level (solid blue line) and demand rate (dashed red line). At time 1, the inventory level starts with 120 units = Q and decreases with time due to both demand and decay. The downward movement of the inventory curve reflects lack of supply due to consumption and product degradation, both acting together to lower the stock on hand. Sooner or later, all stock not only gets used up but becomes negative because there aren't enough in if you’re not on top of restocking.

On the other hand, the demand curve is almost constant along this period showing only a small fall. This is the behaviour of demand model which depends on the basic demand, inventory dependence and price dependent. Because the demand is not highly fluctuating, it keeps its value between about 15 and 10 units over the time horizon of 20 periods indicating that despite being sensitive to price and stock effects the customer needs are reasonably certain.

On the left side, Simulation inputs specify conditions of model operation. These include economic parameters (base demand, vendor and buyer prices; ordering cost, holding cost and deterioration cost) as well as operational parameters (order quantity, rate of deterioration and credit periods). The parameter power of negotiation is used to estimate the price that will then be negotiated between buyer and seller which in this case was 51. The model also gets the total cost of this policy by reference to 6341.53.

V. CONCLUSION

The proposed integrated inventory model, in this study, extends existing classic models by incorporating really financial and psychological worlds into inventory decision-making process. The findings support that the price bargaining has a significant impact on demand quantity and procurement cost, indicating that the policy of credit two-level provides an equal method for buyer's flexibility and seller's risk prevention. The findings from the simulations support that proper consideration of degradation should be made, if not, financial loss can arise due to the obsolescence or perishability. Managerial implications suggest that suppliers can strategically shift negotiation power and credit terms to preserve competitiveness at the expense of profit, while customers can best procure by reaping the benefits of lucrative credit windows. By combining price-sensitive stock-dependent demand with financial bargaining and credit policies this paper contributes to a practical decision model which improves both operating efficiency and financial viability. The flexibility of the model opens up its applicability to a wide range of industries and further substantiates its relevance in competitive and volatile supply chain contexts.

REFERENCES

1. Chen, L.-H., & Kang, F.-S. (2010). Integrated inventory models considering the two-level trade credit policy and a price-negotiation scheme. European Journal of Operational Research, 205(1), 47–58. https://doi.org/10.1016/j.ejor.2009.09.019
2. Liao, T. W., Lee, W. C., Huang, K. N., & Huang, Y. F. (2013). An inventory model for deteriorating items under stock-dependent demand and two-level trade credit. Applied Mathematical Modelling, 37(3), 1033–1043. https://doi.org/10.1016/j.apm.2012.04.004
3. Pervin, M., Giri, B. C., & Maiti, M. (2018). Multi-item deteriorating two-echelon inventory model with stock-dependent and price-dependent demand. Journal of Industrial & Management Optimization, 14(2), 533–552. https://doi.org/10.3934/jimo.2018.14.533

4. Shaikh, A. A., Cárdenas-Barrón, L. E., Manna, A. K., Céspedes-Mota, A., & Treviño-Garza, G. (2021). Two level trade credit policy approach in inventory model with expiration rate and stock dependent demand under nonzero inventory and partial backlogged shortages. Sustainability, 13(23), 13493. https://doi.org/10.3390/su132313493
5. Shah, N. H., Patel, A. R., & Soni, H. N. (2013). Optimizing inventory and marketing policy for non-instantaneous deteriorating items with generalized type deterioration and holding cost rates. Omega, 41(3), 421–430. https://doi.org/10.1016/j.omega.2012.09.003
6. Thangam, S., & Uthayakumar, R. (2015). Retailer's inventory system in a two-level trade credit policy. Journal of Industrial Engineering International, 11(4), 469–478. https://doi.org/10.1007/s40092-014-0052-z
7. Teng, J. T., & Chang, C. T. (2009). Retailer's inventory policy and supplier's delivery policy under two-level trade credit strategy. Asia-Pacific Journal of Operational Research, 24(3), 613–630. https://doi.org/10.1142/S0217595907001413
8. Yang, H., Zhuo, W., Zha, Y., & Wan, H. (2020). Optimal credit periods under two-level trade credit. Journal of Industrial & Management Optimization, 16(2), 543–561. https://doi.org/10.3934/jimo.2019027