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A PROFIT EPQ MODEL FOR BUYER–VENDOR COLLABORATION WITH SCREENING, DISPOSAL AND TRANSPORTATION COSTS

S. IMRAN BASHA[1] M. K. VEDIAPPAN[2,*] AND M. RAVITHAMMAL[3]

1.Research Scholar, Department of Mathematics, Vels Institute of Science, Technology and Advanced Studies, Chennai – 600117, Tamil Nadu, India.

2.Assistant Professor, Department of Mathematics, Vels Institute of Science, Technology and Advanced Studies, Chennai – 600117, Tamil Nadu, India.

*Corresponding author mail: mkvediappan@gmail.com

3. Assistant Professor, Department of Mathematics, The Quaide Milleth College for Men, Chennai – 600100, Tamil Nadu, India.

Email: imranaffan.1357@gmail.com, ravith_vahab1@yahoo.co.in

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ABSTRACT

A profit-based EPQ model is developed in this study, accounting for screening, disposal, and transportation costs to better reflect practical buyer-vendor interactions. In the proposed model, both the buyer and the vendor are jointly responsible for the production of goods. The buyer is tasked with screening the products and disposing of any defective items, while the vendor bears the transportation costs associated with delivering the products. The model further evaluates the total profit generated for both parties, providing a comprehensive view of cost-sharing and profit distribution. Finally, numerical examples are presented to illustrate the applicability and validate the effectiveness of the proposed model.

1. INTRODUCTION

The relationship between the buyer and vendor in manufacturing inventory models plays a pivotal role in determining the overall efficiency, cost-effectiveness, responsiveness, and competitive advantage of a supply chain. In well-structured manufacturing systems, this relationship often evolves from simple transactional exchanges to deeply integrated, strategic partnerships that prioritize collaboration, shared goals, and continuous improvement. In supply chain and inventory contexts, deterioration refers to the gradual loss of a product's value, quality, or usability over time, even if it remains unsold or unused. This is especially relevant for perishable goods, pharmaceuticals, chemicals, and high-tech products, where time-sensitive quality constraints must be managed proactively. As such, modern inventory models must account for deterioration to minimize waste, optimize order cycles, and ensure product availability without incurring unnecessary holding costs.

Chung and Wee (2003) developed an economic production quantity (EPQ) model that accounts for backordering and partial deliveries, laying an early foundation for practical EPQ applications in inventory management. Jauhari, Pujawan, and Suef (2023) expanded this foundation by proposing a sustainable inventory model for a hybrid production system that integrates investments aimed at reducing defects, emphasizing the environmental dimension of inventory control. Utama et al. (2023) introduced a multi-item lot sizing optimization model incorporating transportation costs and stochastic demand, solved using the Aquila optimization algorithm, thereby enhancing the model's relevance to uncertain and cost-sensitive supply chain environments.

Further contributions include Muniappan et al. (2020), who presented an integrated EOQ model considering inventory level and warehouse capacity constraints, and Ravithammal et al. (2019), who explored an EOQ model using algebraic methods under similar constraints. These models contribute to understanding space limitations and inventory levels in planning. Ravi and Banu (2010) addressed deteriorating items in a production inventory model with trade credit financing, highlighting how financial policies interact with inventory strategies. In a similar line, Sindhuja and Arathi (2023) modeled inventory for deteriorating products under preservation technology, focusing on quality demand that changes over time.

Sustainability in EPQ was further tackled by Taleizadeh, Soleymanfar, and Govindan (2018), who proposed a sustainable EPQ model for systems with shortages, integrating green logistics into classical inventory theory. Utama et al. (2024) followed this direction with an integrated production-inventory model involving exponential quality degradation in multi-item raw materials, demonstrated through a real-world case study. Lastly, Wijaya, Tarigan, and Siagian (2023) emphasized the role of top management commitment, employee empowerment, and total quality management in minimizing production waste and improving firm performance, reinforcing the link between operational practices and inventory efficiency.

2. ASSUMPTIONS AND NOTATIONS

The model use the following assumptions and notations

Assumptions

1. Demand rate is constant and known.
2. Vendor's production rate is finite but greater than the demand rate.
3. No stockouts allowed.
4. Lead time is fixed.
5. The buyer and vendor Costs includes Ordering/setup costs, Holding costs and production cost (for both buyer and vendor), Transportation (for vendor)

Notations

d Demand rate

P_1 Production cost for buyer

P_2 Production cost for vendor

k_1 Buyer's ordering cost

k_2 Vendor's setup cost

h_1 Buyer's holding cost

h_2 Vendor's holding cost

Q Economic Order quantity

F_2 Buyer's fixed transportation cost

V_2 Buyer's unit variable cost for order handling and receiving

m Vendor's multiples of order

x Percentage of defecting items

y Percentage of scrap items

c_1 Screening cost

c_2 Disposed cost

3. FORMULATION OF THE MODEL

The total cost for buyer can be written as

$$TC_b = \frac{k_1 d}{Q} + \frac{h_1 Q}{2}\left(1 - \frac{D}{P_1}\right) + \frac{c_1 Q}{2} + \frac{xyc_2 Q}{2} \quad (1)$$

The total cost for vendor can be written as

$$TC_v = \frac{k_2 d}{mQ} + \frac{h_2 mQ}{2}\left(1 - \frac{D}{P_2}\right) + F_2 + V_2 mQ \quad (2)$$

Equation (1) will be written as

$$TC_b = \left(\frac{h_1\left(1-\frac{D}{P_1}\right)+c_1+xyc_2}{2}\right)Q + \frac{k_1 d}{Q} \quad (3)$$

Equation (3) is of the form $a_1 Q + \frac{a_2}{Q} + a_3$

Q will be taken as, $Q = \sqrt{\frac{a_2}{a_1}}$

$$Q^* = \sqrt{\frac{2k_1 d}{h_1\left(1-\frac{D}{P_1}\right)+c_1+xyc_2}} \quad (4)$$

Total Profit for buyer and vendor is calculated ad follows

Buyer's total profit $B_P = \frac{TC_b}{TC_b+TC_v} \times 100$

Vendor's total profit $V_P = \frac{TC_v}{TC_b+TC_v} \times 100$

4. NUMERICAL EXAMPLE

Example 1. Let k_1=500; k_2=700; P_1 = 3000; P_2 = 10000, d=7000; h_1=2$; h_2=3$; c_1=2; c_2=3; F_1=5; F_2=2; V_1=0.2;V_2=0.4; m=3;x=0.1;y=0.2.

The optimal solution is $Q = 6257.560$,$\mathrm{TC_b} = 5.5672\, X\, 10^5$, $\mathrm{TC_v} = 8.3021\, X\, 10^5$, $B_P = 47\%$, $V_P = 53\%$.

5. CONCLUSION

This study developed a profit-oriented Economic Production Quantity (EPQ) model that integrates key real-world cost components, including screening costs, disposal costs, and transportation costs incurred by the vendor. In the proposed framework, both the vendor and the buyer share manufacturing responsibilities, with the buyer conducting the screening process and handling the disposal of defective items. The model focuses on calculating individual and total profits for both parties while enhancing the overall efficiency of the supply chain. By optimizing ordering frequency, lot sizes, inventory holding, and production schedules, the model aims to minimize total costs across the supply chain. Numerical examples validate the effectiveness of the model in practical settings. Furthermore, the proposed framework provides a foundation for future extensions, such as incorporating varied demand patterns, multi-item inventory systems, shortages, and other real-world operational complexities.

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