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# OPTIMIZATION OF AN INVENTORY MODEL CONSIDERING THE COSTS OF TRANSPORTATION AND ITS ASSOCIATED EMISSION IN STEEL INDUSTRIES

**R. YOGA RANI[1] AND NIVETHA MARTIN[2]**

[1,2]Department of Mathematics,
Arul Anandar College (Autonomous), Karumathur, India.

***ABSTRACTS***

*Industries play an imperative role in the economic intensification; in particular the steel industries occupy a significant position in contributing to the industrial growth of our country. The production pattern and its related activities cause environmental impacts which have to be investigated in a profound manner so as to devise suitable strategies for enhancing the economic profit and minimizing the environmental effects. Locomotion of raw materials from the source to the production place; finished steel products from the manufactured zone to the markets requires transportation. The steel industries have to be cautious in selecting the suitable mode of transportation not only to minimize the costs of transportation but also its environmental effects. This paper strongly focuses on the needs of environmental concern in steel industries. This research work aims in formulating a new inventory model encompassing the costs of transportation along with the associated costs of mitigating the environmental effects.*

## INTRODUCTION

The logo 'Go Green' is echoing in every corner of our country to conserve the natural resources. The diminution of these reserves will end in day zero, just as in Cape Town. One of the reasons for such drastic effects is global warming which occurs due to the emission of green house gases out of transportation. Integration of the costs of transportation along with the costs of mitigating its emission with an inventory model is a novel step in developing a socially responsible inventory model reflecting the environmental concerns. Industrial sectors especially the steel industries are in need of wide range of transportation facilities. This research work brackets together the costs related to transportation and the costs bonded to the emission mitigation with the conventional costs of economic production quantity model. This paper also emphasizes much on the inclusion of the external costs comprising of emission costs which accounts to total costs.

The origin of EOQ (Economic order quantity) & EPQ inventory models dates back almost to a century. Several researchers developed these two basic models and currently there are millions of inventory models catering to the needs of the industrial sectors. Still the pollsters are continuing their contributions by relating the contemporary issues and concepts in terms of monetary terms with the existing inventory models. To mention a few, the inventory modeling experts such as Richter, Schrady, Jaber, Marris Boney have formulated a wide range of inventory models encompassing varied facets of industrial sectors.

The paper is organized as follows: section 2 presents the model formulation; section 3 validates the proposed model and the last section concludes the paper.

## 2. MODEL FORMULATION

The following assumptions and notations are used throughout the paper.

### 2.1 Assumptions

1. The demand is continuous.
2. Shortages are not allowed.



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**2.2 Notations**

| | |
|---|---|
| D | demand per unit time |
| P | production per unit of time |
| x | D/P |
| 1-x | the fraction of time the production process spends actually idling |
| A | fixed ordering cost/ set up cost per production run |
| h | holding cost per unit per unit of time. |
| $EEC_{TS}$ | External Environmental costs of Transportation services |
| $EEC_{TE}$ | External Environmental costs of Transportation Equipment |
| $EEC_{TM}$ | External Environmental costs of Transportation Materials |
| $V_R$ | Vehicle Repair cost |
| $V_M$ | Vehicle Maintenance cost |
| $V_S$ | Vehicle Insurance cost |

The EPQ cost per unit of time

$$C(Q) = \frac{AD}{Q} + \frac{hQ(1-x)}{2}$$

The external environmental costs pertaining to transportation with the inclusion of air emission costs is

$$EEC(Q) = (EEC_{TS} + EEC_{TE} + EEC_{TM})/T$$

The costs related to vehicles used for transportation is

$$V(Q) = (V_R + V_M + V_S)/T$$

where $T = Q/D$

The total cost per unit of time

$$\Psi(Q) = C(Q) + EEC(Q) + V(Q)$$

$$\frac{AD}{Q} + \frac{hQ(1-x)}{2} + \frac{(EEC_{TS} + EEC_{TE} + EEC_{TM})D}{Q} + \frac{(V_R + V_M + V_S)D}{Q}$$

$$\frac{\partial\Psi(Q)}{\partial Q} = \frac{\partial}{\partial Q}\left[\frac{AD}{Q} + \frac{hQ(1-x)}{2} + \frac{(EEC_{TS} + EEC_{TE} + EEC_{TM})D}{Q} + \frac{(V_R + V_M + V_S)D}{Q}\right]$$

$$= -\frac{AD}{Q^2} + \frac{h(1-x)}{2} - \frac{(EEC_{TS} + EEC_{TE} + EEC_{TM})D}{Q^2} + \frac{(V_R + V_M + V_S)D}{Q^2}]$$

The optimal order quantity is $Q=\sqrt{\frac{2D[A+(EEC_{TS} + EEC_{TE} + EEC_{TM}) + (V_R + V_M + V_S)]}{h(1-x)}}$

## 3. NUMERICAL EXAMPLE

Consider an inventory system with the following secondary data

A = \$100 / cycle, h = \$5/ unit/ cycle, D = 50,000 units/ year, P = 75,000 units / year, $EEC_{TS}$ = \$60, $EEC_{TE}$ = \$70, $EEC_{TM}$ = \$ 80, $V_R = \$50$. $V_M = \$40$, $V_S$ = \$55. The optimal order quantity is 5251 units.

## CONCLUSION

This paper primarily focuses on the aspects of external environmental costs of transportation which includes the air emission costs. The formulated deterministic inventory model reflects the existing monetary expenditure of the steel industries. This paper also stresses on weakening the environmental aberrations caused by the transportation. The formulated inventory model can be extended with the incorporation of several associated factors.

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