

FUZZY PARAMETRIC GEOMETRIC PROGRAMMING WITH APPLICATION IN FUZZY EPQ MODEL UNDER FLEXIBILITY AND RELIABILITY CONSIDERATION

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Abstract. An economic production quantity model with demand dependent unit production cost in fuzzy environment has been developed. Flexibility and reliability consideration are introduced in the production process. The models are developed under fuzzy goal and fuzzy restrictions on budgetary cost. The inventory related costs and other parameters are taken as fuzzy in nature. The problem is solved by parametric geometric programming technique. The model is illustrated through numerical example. The sensitivity analyses of the cost function due to different measures are performed and presented graphically.

Keywords: parametric geometric programming technique; production process

1. Introduction

Since late 1960's Geometric Programming (GP) has been very popular in various fields of science and engineering. Duffin, Peterson and Zener [1] discussed the basic theories on GP with engineering application in their books. Peterson [2], Rijckaert [3], Jefferson and Scott [4] have presented informative surveys on GP. The parameter used in the GP problem may not be fixed. It is more fruitful to use fuzzy parameter instead of crisp parameter. In that case we introduced the concept of fuzzy parametric GP technique, where the parameters are fuzzy.

Application of GP can be observed in many aspects of inventory/production, there appears only few papers concerned with the solution of inventory problems using GP (Cheng [5, 6, 7]; Jung and Klein [8]; Kochenberger [9]; Lee [10]; Worrall and Hall [11]).

The determination of the most cost-effective production quantity under rather stable conditions is commonly known as classical economic production quantity (EPQ) inventory problem. Fabulous amount of research effort has been expended on topic leading to the publication of many interesting results in the literature ([Clark [12], Urgelleti [13], Velnott [14]).

A basic assumption in the classical EPQ model is that the production set-up cost is fixed. In addition the model also implicitly assumes that items produced are of perfect quality (Hax and Canada [15]). However, in reality product quality is not always perfect but directly affected by the reliability of the production process employed to manufacture the product. Thus a high-level of product quality can only be consistently achieved with substantial investment in improving the reliability of production process. Furthermore, while the set-up time, hence set-up cost, will be fixed in short term, it will tend to decrease in the long term because of the possibility of investment in new machineries that are highly flexible, e.g. flexible manufacturing system. Van and Putten [16] have addressed extensively the issue of flexibility improvement production and inventory management under various scenarios, while the issues of process reliability, quality improvement and set-up time reduction have been discussed by Porteus [17, 18], Rosenblatt and Lee [19]

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and Zangwill [20]. Cheng [5] proposed a general equation to model the relationship between production set-up cost and process reliability and flexibility. Cheng [6] also introduced demand dependent unit production cost in an EOQ model. Tripathy et al. [21] developed an EOQ model with imperfect production process and the unit production cost is directly related to process reliability and inversely related to the demand rate. Islam and Roy [22] developed an EPQ model with flexibility and reliability consideration in fuzzy environment and the model is solved by fuzzy geometric programming technique. Leung [23] considered an EPQ model with flexibility and reliability considerations using GP based on the arithmetic-geometric mean inequality.

In this paper we introduced the concept of fuzzy parametric GP technique. Here we have considered the coefficients of the problem are fuzzy and taken these in parametric form and solve it by GP technique which is formed as a fuzzy parametric GP. An economic production quantity model with demand dependent unit production cost in fuzzy environment has been developed. Flexibility and reliability consideration are introduced in the production process. The models are developed under fuzzy goal and fuzzy restrictions on budgetary cost. The inventory related costs and other parameters are taken as fuzzy in nature. The problem is solved by parametric geometric programming technique.

2. Mathematical model

Let a company produces a single product using a conventional production process with a certain level of reliability. The process reliability depends on a number of factors such as machine capability, use of on-line monitoring devices, skill level of the operating personal and maintenance and replacement policies. The process, thereby reducing the costs of scrap and rework of substandard products, wasted material and labor hours, more consistently produces higher reliability means products with acceptable quality. However, high reliability can only be achieved with substantial capital investment that will increase the cost of interest and depreciation of the production process.

A modern flexible production process that substantially reduces the production set-up time can produce the product more efficiently. It is thus economical to produce in smaller batch sizes with flexible process, thereby reducing the inventory holding cost. Also, substantial capital expenditure due to illustration of the new production process will give rise to might interest changes and great depreciation cost.

2.1. Notations

To construct a model for this problem, we define the following variables and parameters:

S	set-up cost per batch (a decision variable),
h	inventory carrying cost per item per unit time,
D	demand rate (a decision variable),
q	production quantity per batch (a decision variable),
r	production process reliability (a decision variable),
$f(S, r)$	total cost of interest and depreciation for a production process per production cycle,
$TC(D, S, q, r)$	total average cost,
P	unit production cost,
B	total budgetary cost.

2.2. Assumptions

The following assumptions are made for developing the mathematical production quantity model:

- 1) The rate of demand D is uniform over time
- 2) Shortages are not allowed
- 3) The time horizon is infinite
- 4) Total cost of interest and depreciation per production cycle is inversely related to a set-up cost and directly related to process reliability according to the following equation