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An economic production quantity model with random yield subject to process compressibility

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ABSTRACT

This paper develops a new model for determining economic production quantity in an imperfect production system that generates defective items randomly. The production system utilizes an inspection subsystem to identify defective items (including reworkable and non-reworkable items) from non-defectives. Among defective items, reworkable items could be reworked once, and again an inspection is carried out. Furthermore, the inspection is error-prone that can result in returned items from customers. The proposed model considers realistic conditions in order to provide an optimal production plan. For example, rates of main and rework processes, batch size and back-order are considered as decision variables simultaneously such that rates of main and rework processes are not the same and take different values due to amount of the money that producer invests in each process (contributed as process compressibility). The objective function consists of different cost terms including shortage, regular production, setup of regular production, inventory holding, rework, inspection, disposal of scarped items and returned items from customer. The model is proved to be a convex nonlinear program. As it is difficult to obtain exact closed-form relations for the optimal solution, a problem-specific algorithm is designed. Under certain conditions, the algorithm can achieve the global optimum within a single iteration; otherwise it can be achieved in a polynomial time. Finally computational experiences are reported.

1. Introduction

Considering different decision factors, real world production planning is a complicated issue for production managers. The basic economic production quantity (EPQ) is introduced to determine production quantity and backlog while minimizing total costs. This basic problem is developed further by considering different concepts and constraints in the literature. Most of the times, imperfect items are inevitable in the production system which could be detected by inspection procedures. Also, the inspection is imperfect in most cases. Furthermore, machines could also operate in different settings and production rates, which is contributed as process compressibility. These conditions increase the complexity of batch sizing. Different models are proposed in the literature that each of them considered different working conditions. This section provides a brief review of the progress in the literature and then detailed assumptions of the problem are provided in the next section.

Table 1 provides a comparative review of the problem structures in the literature in a chronological order. However, none of these papers considered variable rates for main and/or rework process in the terms of process compressibility.

As Table 1 shows most parts of the literature are dedicated to single product models when defective items are reworkable. Also, it seems that researchers are willing to consider models with imperfect rework processes. Clearly, this assumption is

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Table 1
A comparative analysis of the literature.

Authors	No. products		Type of defectives			Type of reworking			Type of inspection			Type of backlog		
	Single	Multiple	No defective	Reworkable	Scrapes	Not allowed	Imperfect	Perfect	Not used	Sampling	100%	Not allowed	Backorder	Lost sales
Lin [1]	✓		✓			✓			✓			✓		
Cárdenas-Barrón [2]		✓			✓	✓			✓			✓		
Salameh and Jaber [3]		✓			✓	✓			✓			✓		
Hayek and Salameh [4]	✓			✓				✓	✓				✓	
Goyal and Cárdenas-Barrón [5]		✓			✓	✓			✓			✓		
Goyal et al. [6]	✓				✓	✓			✓			✓		
Lin et al. [7]	✓			✓				✓		✓		✓		
Jamal et al. [8]	✓			✓				✓			✓		✓	
Goyal and Cárdenas-Barrón [9]	✓			✓			✓		✓			✓		
Lee [10]	✓				✓	✓			✓				✓	✓
Jaber [11]	✓			✓				✓	✓			✓		
Lee [12]		✓			✓	✓				✓		✓		
Lin and Kroll [13]	✓			✓				✓	✓			✓		
Cárdenas-Barrón [14]	✓			✓				✓			✓		✓	
Chiu et al. [15]	✓			✓	✓		✓		✓				✓	
Ojha et al. [16]	✓			✓				✓			✓	✓		
Cárdenas-Barrón [17]	✓			✓				✓			✓		✓	
Cárdenas-Barrón [18]	✓			✓				✓			✓		✓	
Cárdenas-Barrón [19]	✓			✓	✓			✓					✓	
Chung et al. [20]		✓		✓				✓			✓	✓		
Halim et al. [21]	✓				✓	✓			✓			✓		
Hsieh and Liu [22]	✓				✓	✓				✓		✓		
Liao et al. [23]	✓			✓			✓			✓		✓		
Maddah et al. [24]	✓				✓	✓			✓			✓		
Roy et al. [25]	✓			✓	✓		✓		✓			✓		
Yoo et al. [26]	✓			✓	✓		✓				✓	✓		
Chiu et al. [27]	✓			✓	✓			✓	✓			✓		
Geetha and Uthayakumar [28]	✓				✓	✓			✓				✓	✓
Khan et al. [29]	✓			✓				✓		✓			✓	✓
Sana [30]	✓			✓				✓	✓			✓		
Wahab abd Jaber [31]	✓				✓	✓			✓			✓		