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Tsan-Ming Choi
Editor

Handbook of EOQ Inventory Problems

Stochastic and Deterministic Models
and Applications

 Springer

Editor

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Preface

Inventory management is a critical factor which accounts for the success or failure of modern businesses in all kinds of industries. By far the best known inventory model is the classical “square root formula” of the economic order quantity (EOQ) model. The widely recognized first piece of research on the EOQ model appeared a century ago in Harris (1913) which describes “a very simple deterministic inventory planning model with a tradeoff between fixed ordering cost and inventory carrying cost.” Despite being simple, this model does capture the essence of inventory management and lays the foundation for all kinds of extensions and real-world applications (see Axsäter 1996; Huang et al. 2003; Khan et al. 2011; Pentico and Drake 2011). Nowadays, a search in the major research portals will find at least a thousand papers which carry the key words of “EOQ” in the paper title. In fact, tens to hundreds of related papers are still being published in major journals in operations research and management science every year. Despite the abundance of both classical and new research results, there is an absence of a comprehensive reference source that provides the state-of-the-art findings on both theoretical and applied research on EOQ and its related models. As a result, I organize this Springer’s handbook with a goal of consolidating many latest research findings and applications of the EOQ model into an edited volume. I believe that this handbook will be a pioneering text focusing on the EOQ model-related inventory and supply chain management problems. It also celebrates the EOQ model’s 100th anniversary.

The handbook contains papers which explore both the deterministic and the stochastic EOQ model-based problems and applications. It is organized into three parts: Part I presents the introduction and review papers. Part II includes technical analyses on single-echelon EOQ model-based inventory problems. Part III consists of applications of the EOQ model for multi-echelon supply chain inventory analysis. I am very pleased to see that this handbook has generated a lot of important insights and new research results on the EOQ model-related problems.

I would like to take this opportunity to show my hearty gratitude to Fred Hillier and Matthew Amboy for their kind support and advice along the course of carrying out this book project. I sincerely thank all the authors who have contributed their interesting research to this handbook. I am indebted to the anonymous reviewers who reviewed the manuscripts and provided me with very constructive and timely

review comments. I also acknowledge the editorial assistance of my Ph.D. student Ms. Hau-Ling Chan, and the funding support of the Research Grants Council of Hong Kong under grant number PolyU 5424/11H (General Research Fund). Last but not least, I am grateful to my family, colleagues, and students, who have been supporting me during the development of this important research handbook.

April 2013

Tsan-Ming Choi

References

- Axsäter S. Using the deterministic EOQ formula in stochastic inventory control. *Management Science* 42: 830–834, 1996.
- Harris F. How many parts to make at once. *The Magazine of Management* 10: 135–136 152, 1913.
- Huang W, Kulkarni VG, Swaminathan JM. Optimal EOQ for Announced Price Increases in Infinite Horizon. *Operations Research* 51: 336-339, 2003.
- Khan M, Jaber MY, Guiffrida AL, Zolfaghari. A review of the extensions of a modified EOQ model for imperfect quality items. *International Journal of Production Economics* 132: 1–12, 2011.
- Prentico DW, Drake MJ. A survey of deterministic models for the EOQ and EPQ with partial backordering. *European Journal of Operational Research* 214: 179–198, 2011.

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