Optimal Control Theory Approach to Solve Constrained Production and Inventory System

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Abstract: This paper proposes an optimal control of production inventory system. The production and inventory system is solved using optimal control theory. We present finite continuous time linear optimal control model to control dynamic price and production flow rate to maximize total revenue minus total cost. Where the demand is linear with price, the production flow rate of the product not exceeds the maximum production capacity rate. Total cost consists of the manufacture holding cost, buyer holding cost and production cost. Pontryagin Maximum Principle is applied to find the controllers of the model.

Keywords: Production Inventory System, Optimal Control, Pontryagin Maximum Principle

I-Introduction

Recently the optimal control theory is used to solve problems of inventory and production systems. Researchers are focusing on estimating the effect of the changes in the demand with time in logistics. Continuous time optimal control models provide a convenient way for awareness the behavior of systems where system dynamic plays a significant role. A lot of research is focusing on models considering all features of these problems. In particular the most attractive feature of these models is to provide good scheduling production and inventory polices in diversity of settings. Moreover they approximate well the fundamental stochastic of problems in a deterministic way. A continuous time method has an excellent feature which is not introducing any approximation to the real setting; it provides the accurate solution of the system.

Literature Review: S.P.Sethi, G. L. Thompson, (2000) presented a model in which the factory produces a single homogenous product and has a finished goods store. They assumed that the model is similar to HMMS model. The model is formulated and completely solved using optimal control theory .The steady state solution is obtained when horizon is infinity. The optimization problem is to minimize total cost of the model. M. A. Baten , A. A. Kamil. (2009) presented a model in which the inventory –production system with two parameters Weibull distributed deterioration items in which the inventory model is considered as linear optimal control problem and the model is solved by pontryagin maximum principle, the solution of the optimal control problem is solved analytically. Yinkuan Gu, Hongxia Zhang, 2011, present a model to control supply Chain. The main aim of the model is to make the total cost of the supply chain minimum. Ghodrat Allah Emamverdi, et al (2011) presented optimal control of production inventory system considering deteriorating items. The main objective of this study is to determine minimum total production and inventory costs. D. Ivanov ,B. Sokolov (2013) present a model to analyze and to achieve designed economic performance in a actual time uncertain and disturbance execution environment is vital and modern issue in many supply chains. This study is the first papers addressing the operative perspective of the supply chain dynamic domain.

II- Assumptions and Notations

To establish the model the following notations and assumptions are used. Consider a factory producing a certain product and having homogenous finishing goods warehouse. The factory distributes the product to a buyer which sells some and stores the rest. The objective is to determine the optimal price and optimal production rate to maximize the total profit of both the buyer and the vendor.

Inputs

T : Time horizon
Q : Vendor production capacity
h_b : Buyer holding cost.
h_v : Vendor holding cost.
c : The production cost coefficient

Inventory Production Theory A Linear Policy Approach

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Inventory Production Theory A Linear Policy Approach:

Inventory-Production Theory C.A. Schneeweiss,2012-12-06 The term inventory production theory is not well defined It com prises e g such models like cash balance models production smoothing models and pure inventory models We shall here mainly be concerned with stochastic dynamic problems and shall give exact definitions in the next section Most of our work will concentrate on cash balance models However production smoothing situations and pure inventory problems will also be investigated Since we are faced in principle with dynamic stochastic situa tions a dynamic programming approach would be appropriate This approach however due to computational restraints is limited to only but the simplest models Therefore in practice one ruduces stochastics just in taking forecasts of demand and then treating the problem as a deterministic optimization problem In addition one often introduces certain safety stocks to safeguard the system from possible forecasting errors In general this proce dure is suboptimal However there exists one particular situa tion when a separation in a forecasting procedure and a subse quent optimization of the remaining deterministic model is not suboptimal This is known as the linear quadratic model i e a model having linear system equations and a quadratic cost crite rion For this type of model H A Simon 3J and later H Theil 25J have shown that the above separation property holds In fact Simon s and Theil s results are nothing else but what has later and more generally become known to control engineers as Kalman s famous separation principle   *Inventory-production theory* Ch Schneeweiss,1977   **Inventory Control** Dieter Bartmann,Martin F. Bach,2012-12-06 Experts in operations research and developers of software application systems have been treading separate paths for many years It is urgently necessary to reset this course so that the demanding requirements of variousCIM concepts can be realized This is specially relevant for computer based stock management Both authors with a number of years of practical experience behind them have written this book with this objective in mind The book shows how modern inventory control can be rationally structured with the help of OR Two aspects are given importance 1 the necessary mathematical derivations are completely explained in detail so that the reader will be able to optimally handle a given situation with the help of the methods learned in this book and 2 aside from the models strong emphasis is given on numerical methods Suitable algorithms are thoroughly explained for the more important cases   **Journal of Economic Literature** ,1978   **Quantitative Approaches to Management** Richard I. Levin,Charles Atkinson Kirkpatrick,David S. Rubin,1982   *Design and Engineering of Production Systems* Farhad Azadivar,1984   *Catalog of Copyright Entries. Third Series* Library of Congress. Copyright Office,1979   **Process Control and Management** P.L. Lee,R.B. Newell,I.T. Cameron,1998 The purpose of this book is to provide a balanced introduction to process control and management aimed at the general process engineer Rapid changes have occurred in process control over the past decade mainly because of the deployment of robust and effective digital control equipment and the development of the models which underpin the area Historically process control was seen as simply the maintenance of particular process variables at appropriate setpoints This

very narrow view has been superseded by the view that process control involves the regulation of any given process in the context of a complete processing plant to maximise the economic return from the plant This wider definition brings into play a range of control regimes from basic regulatory control through advanced regulatory control to complex process management The organization of the book reflects this hierarchy and is thus split into 3 parts covering basic regulatory control advanced process control and finally process management The book is completed by the inclusion of several useful appendices covering mathematical modelling process optimisation and simulation *On Replenishment Rules, Forecasting, and the Bullwhip Effect in Supply Chains* Stephen M. Disney,Marc R. Lambrecht,2008 In this review we focus on supply coordination and use the bullwhip effect as the key example of supply chain inefficiency We emphasize the managerial relevance of the bullwhip effect and the methodological issues so that both managers and researchers can benefit

Operations Research (unclassified Title) Defense Documentation Center (U.S.),1962 *Subject Catalog* Library of Congress, Information Systems: Modeling, Development, and Integration Jianhua Yang,Athula Ginige,Heinrich C. Mayr,Ralf-D. Kutsche,2009-04-17 UNISCON 2009 United Information Systems Conference was the third conf ence in the series that is based on the idea to pool smaller but highly interesting scienti c events on information systems into one large conference Here people from di erent scienti c backgrounds can present their research results share their ideas and discuss future trends in these various areas UNISCON 2009 was held in Sydney Australia in the University of Western Sydney Campbelltown Campus In 2009 the following scienti c events were held under the umbrella of UNISCON 2009 th 8 International Conference on Information Systems Technology and Its Applications ISTA 2009 th 8 International Workshop on Conceptual Modelling Approaches for e Business eCOMO 2009 Second Workshop on Model Based Software and Data Integration MBSDI 2009 We received 115 papers for the three events Papers were submitted from over 25 countries After a rigorous review process 39 papers were accepted as full papers and 14 papers as short papers for presentation at the conference and published in these proceedings In addition to the above three events we also organized a Doctoral Cons tium to provide a forum for doctoral students to get feedback from experts in the area about their research projects **Subject Guide to Books in Print** ,1984 **Library of Congress Catalogs** Library of Congress,1980 Subject Catalog, 1978 Library of Congress,1978 **Paperbound Books in Print** ,1991 *Lagerhaltung* Dieter Bartmann,Martin J. Beckmann,2013-03-12 In dem vorliegenden Buch wird dargestellt wie Lagerhaltung nach den heutigen Erkenntnissen mit Hilfe von Operations Research rational gestaltet werden kann Es werden neben deterministischen Lagerhaltungsmodellen Produktionslager auch Modelle mit stochastischer Nachfrage Handelslager bei kontinuierlicher und periodischer Inspektion behandelt Das von den beiden praxiserfahrenen Verfassern geschriebene Lehrbuch befa t sich neben dem operationalen Aspekt der Losgr enoptimierung auch mit Fragestellungen auf h herer Managementebene Lager in Lizenz Wert des Bestandes Budget oder Raumknappheit Es ist das Ziel interessierte Studenten Systementwickler und Unternehmensberater

mit dem Basiswissen vertraut zu machen und sie zu bef higen einen gegebenen Fall mit Hilfe der erlernten Methoden eigenst ndig zu bearbeiten Zu diesem Zweck werden die verwendeten Techniken an den verschiedenen Modellen ausf hrlich vorgef hrt Alle ben tigten mathematischen Ableitungen werden vollst ndig und verst ndlich beschrieben In einem eigenen Kapitel wird eine Einf hrung in die f r die stochastische Lagerhaltung wichtigen Rechenverfahren der dynamischen Optimierung gegeben **Robust Control** Andrzej Bartoszewicz,2011-04-11 The main objective of this monograph is to present a broad range of well worked out recent theoretical and application studies in the field of robust control system analysis and design The contributions presented here include but are not limited to robust PID H infinity sliding mode fault tolerant fuzzy and QFT based control systems They advance the current progress in the field and motivate and encourage new ideas and solutions in the robust control area **Books and Pamphlets, Including Serials and Contributions to Periodicals** Library of Congress. Copyright Office,1977-07 *Perspectives on Operations Research* Martin Morlock,Christoph Schwindt,Norbert Trautmann,Jürgen Zimmermann,2007-10-31 This collection of essays is dedicated to Professor Klaus Neumann Head and Chair of the Institute for Economic Theory and Operations Research WiOR at the University of Karlsruhe On the occasion of his emeritation disciples colleagues scientific companions and friends coming from dif ferent fields have contributed their perspectives on Operations Research to form a broad view on the discipline The papers are organized in four parts on optimization OR in production and service management OR in logistics and interdisciplinary approaches We thank all the authors for their participation in publishing this volume Mrs Ute Wrasmann from Deutscher Universitats Verlag deserves credit for her interest and assis tance on this project Finally we would like to express our gratitude to PTV Planung Transport Verkehr AG in Karlsruhe and to numerous former WiOR colleagues for their financial support Klaus Neumann was born in Liegnitz Silesia in 1937 Prom 1955 to 1961 he studied mathematics at the Technical Universities of Dresden and Munich His first paper on analog computers and dynamic programming was published less than two years later In 1964 he obtained a Ph D in mathematics under the supervision of Josef Heinhold in Munich After a two year stay in industry he returned to his alma mater working on the fields of dynamic optimization and control theory

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