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Supply Chain Engineering

Useful Methods and Techniques

 Springer

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Preface

Supply chain engineering is an emerging field based on analysis and comprehension of the essential principles of production and distribution systems. This scientific domain concerns the methodical evaluation and optimization of production systems, logistics networks, and their management policies to increase the effectiveness of multifaceted demand and supply chains.

Worldwide competition has grown ever stronger since the beginning of the 1980s. The pressure of the competitive global market has intensely affected the production systems, calling for:

- integration of the activities that cover the whole production spectrum from customers' requirements to payment;
- flexibility in the face of customer-demand changes;
- drastic reduction of production costs.

To reach these objectives, radical changes have been introduced in production systems, thanks to new manufacturing technologies that increase efficiency and IT technologies that improve system organization and management.

Furthermore, dynamical pricing and revenue management, which proposes approaches that define the price of the products based on market situations, attracts more and more researchers and practitioners. Pricing stresses the return on the investment.

Supply chains are emblematic examples of the renewal of production systems in recent decades. It is through this new paradigm that cost reduction and service enhancement can be achieved. To make this easier to implement, new types of manufacturing systems have been introduced, for example: reconfigurable manufacturing systems (RMS), assembly lines with worker's flexibility, bucket brigades or U-shaped assembly lines. Over the same period, new technologies arose to monitor the state of systems in real time. We can mention radio-frequency identification (RFID), Internet applications or "intelligent" storage facilities, to name just a few. These technologies favor one of the most important objectives of production systems management: the ability to make a decision almost immediately.

Radical changes in the criteria that express the new objectives of production systems in the face of competition are another important aspect. The introduction of some new criteria reflects the just-in-time (JIT) requirements. For instance, conventional scheduling optimization is now restricted, in the best case, to decid-

ing the order products are launched in production. In other words, the conventional scheduling activity migrated from the tactical to the strategic level. In actual production systems, this is replaced by a real-time scheduling, also called real-time assignment. Other criteria are used to reflect quality, flexibility and work-in-progress (WIP): adequate quality is now unavoidable to meet customers' satisfaction; flexibility is a necessary condition to remain competitive in an ever-changing market; and reduction of WIP is a factor to minimize the production cost and the probability of obsolescence.

The authors of this book collaborate closely with companies. They have been charged with numerous contracts covering a wide range of industrial activities, including steelmaking, aerospace research, car manufacturing, microelectronics, and in the machining industry. In these areas, the authors worked on design and management problems. They reached the following conclusions:

- The difficulty for companies lies much more in determining the exact nature of a problem and defining the criteria to be taken into account, than in solving the problem itself.
- The models available in the literature are often difficult to apply in real life, due to the assumptions that were made in order to have a treatable model.
- To be acceptable to companies, models must be simple, easy to apply and adjustable to the systems under study.

These conclusions are also taken into account in this book.

This reference work presents a general view of new methods, techniques, resources and organizations that have erupted in the production domain during the past two decades. The objective of the authors was to furnish the best applied approaches. Of course, if a theoretical approach is more convenient to provide the essentials of the system under study, then it was included. Furthermore, when a simple and efficient model exists to represent an industrial situation, we discard more complicated models that do not provide significantly better results, even if they are widely cited in the literature.

The book is organized into 11 chapters with 5 appendices. The following topics are covered.

Chapter 1 should be considered as an introduction to pricing. After outlining the importance of pricing to increase revenue, and providing the most common definitions in use in the field, pricing strategies are presented. The mechanisms that link costs, price and margin are analyzed. The selling curve is introduced and several methods to find the characteristics of importance to customers are developed. This chapter ends with price strategy in the oligopoly market.

Chapter 2 has as a main goal to introduce stochastic dynamic pricing models with salvage values. The constraints to apply to make this model manageable are given. Pricing models for time-dated items, with no supply option, in a monopolistic environment, and with myopic customers are presented in detail.

Chapter 3 concerns outsourcing, which is little studied academically in spite of its importance in the actual global market place. After defining the main notions, the most common benefits that may be expected from outsourcing are presented.

The steps that lead to outsourcing are detailed. In particular, a vendor selection and evaluation model is developed and several approaches to solve this multicriteria problem are proposed. The strategic outsourcing in the case of a duopoly market is then developed exhaustively. The arguments of the pro and cons are explored. One of the original aspects of this chapter lies in the analysis of offshoring in China. Some arguments in this discussion are quite different from those usually used in the literature. The reason may be that the effects of offshoring on workers in developed countries are taken into account.

Chapter 4 considers inventory management in supply chains. The advantages of sharing information among the different levels of a supply chain are discussed. Particular attention is given to the bullwhip effect and the actions to be taken in order to reduce this undesirable phenomenon. Some usual and robust models are highlighted, such as the newsboy (or newsvendor) model, finite-horizon model with stochastic demands and the well-known (R, Q) and (s, S) models. For the last two models, we show how simulation can be used to find the “optimal” values for their parameters. Echelon stock policies, which are tools that meet supply chain requirements, are analyzed along with their complimentary tools, such as material requirements planning (MRP) and manufacturing resources planning (MRP2). Due to the importance of the subject (mainly at the design level), we also review the most common lot-sizing models.

Chapter 5 gives a brief description of the RFID (radio-frequency identification) technology. An analysis of the parameters of importance when selecting tags is conducted and a succinct guideline for RFID deployment is suggested. Some applications are reviewed and the importance of this technology for the efficiency of supply chains is outlined. The main domains where RFID is applied routinely are listed. The evaluation of this technology, and in particular the financial implication, is performed. A special section deals with privacy concerns that are an important problem of RFID in today’s situation. The last section raises the problem of authentication, which is especially significant for the case of counterfeit tags.

Chapter 6 presents an overview of manufacturing system organizations. This chapter is influenced by the heavy demands for flexibility and adaptability of manufacturing systems in the modern environments. The history of the idea of flexibility is presented and the majority of production system concepts are analyzed: dedicated manufacturing lines (DML), flexible manufacturing systems (FMS), agile manufacturing systems (AMS), reconfigurable manufacturing systems (RMS) and lean manufacturing systems (LMS). Each is defined, its advantages and drawbacks are studied and some illustrative examples are reported. Comparisons are made among them and their appropriateness to supply chains is highlighted.

Chapter 7 develops a complex and essential issue (particularly for lean manufacturing) of line balancing, which consists in minimizing the total idle time. The models examined in this chapter have deterministic times. The COMSOAL approach is analyzed comprehensively along with possible improvements. Other algorithms the most frequently mentioned in the literature, such as RPW, KW-like heuristic, B&B-based and mathematical programming approaches, are also pre-

sented and illustrated. The use of metaheuristics is shown in the third part of this chapter. Simulated annealing, tabu search and genetic algorithms are discussed. Then, the properties and evaluation of line-balancing solutions are underlined. We also go over the evaluation criteria for line balancing from the literature.

Chapter 8 generalizes assembly-line-balancing models presented in the previous chapter to stochastic operation times. The problems tackled in this chapter are examined from a practical point of view. In particular, probabilities are defined as is usually done in companies, i.e., by three parameters: minimum, most frequent and maximum values of the variable under consideration. This leads to the notion of triangular density. Problems are solved numerically. A powerful tool is proposed for computing the integration of functions: Tchebycheff's polynomial approach. Numerical examples are presented to illustrate these realistic solutions. Mixed assembly-line models with several types of products are also considered. Other interesting generalizations, such as line balancing with equipment selection, are introduced. Finally, the new concepts of dynamical work sharing are explained using the examples of the bucket brigades and U-shaped assembly lines.

Chapter 9 is devoted to the control reactivity, which is becoming a pivotal factor for competitiveness. We show that the static scheduling is slowly vanishing from the industrial environment. It is being replaced by dynamic scheduling and real-time assignment approaches that are able to provide an optimal or near-optimal solution in real time. The most popular priority (or dispatching) rules are presented first, followed by a second type of dynamic scheduling called the "repair-based approach" that consists of computing a static schedule at the beginning of the working period and adjusting it in the case of unexpected events.

Chapter 10 concerns facility layout design. Until the 1980s, the objective was to optimize the layouts assuming that the environment remained basically steady. This situation is referred to as static facility layout (SFL). Linear layouts, functional department layouts and cellular layouts are studied in the first part of this chapter, as well as tools and algorithms used to perform optimal layout designs. In the middle of the 1990s, the problem evolved toward dynamic facilities layouts (DFL) and robust layouts (RL) to meet the needs of enterprises manufacturing multiple products in a rapidly changing market. Most results in these areas concern only the location of manufacturing entities on the available factory surface at the design stage. Rapid advances in mechanical engineering and manufacturing organization may lead to the possibility of real-time rearrangement in the near future.

Chapter 11 presents warehousing. Certainly, warehouses are critical components of production systems. In this chapter, their usefulness is highlighted and various functions and equipment are analyzed. Recent advances such as the value-added services and their corresponding areas are covered. Special attention is paid to the warehouse management, in particular, to the main difficulties faced by their managers. The design stage is also extensively considered via developing storage algorithms for unit-load warehouse as well as examining warehouse sizing static and dynamic models. The last section of this chapter concerns the location of warehouses. Single- and multiflow location problems are put forth. Remember

that layout techniques, which also concern warehouses, were presented in Chapter 10.

Five types of optimization techniques are reported and illustrated at the end of the book in the *appendices*. Each of the approaches covered in these appendices has been used in at least one chapter to solve real-life problems:

- The first appendix explains the stimulated annealing method.
- The second is devoted to dynamic programming based on the optimality principle.
- The well-known branch-and-bound (B&B) approach is explained in the third.
- The fourth presents tabu search techniques.
- Genetic algorithms are presented in the last appendix.

We had several audiences in mind when this book was written.

In companies, the people in charge of management, production, logistics, supply chains, and those looking for suggestions to improve the efficiency of their systems, will be certainly interested in many of the advances covered in this book. They also will appreciate the way explanations are given by using basic examples, providing detailed algorithms, while discarding complex and unnecessary theoretical developments. This book is written for managers and engineers with analytical backgrounds, who are interested in capturing the potentials and limits of the recent advances in production and operations management.

The academic audience consists of the many researchers working in topics related to operations research, supply chain management, production system design, facility layout, scheduling, organization, etc. This book will also be useful to professors who teach industrial and systems engineering, management science, operations management as well as business management specifically because of the carefully chosen examples that are provided and the application oriented approach in which the notions are introduced.

To summarize, this book is within the comprehension of industrial managers having an analytical background and eager to improve the efficiency of their company, as well as researchers and students working in various related areas.

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France, February 2009

Alexandre Dolgui
Jean-Marie Proth

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