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Models for production planning under uncertainty: A review ☆

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Abstract

The consideration of uncertainty in manufacturing systems supposes a great advance. Models for production planning which do not recognize the uncertainty can be expected to generate inferior planning decisions as compared to models that explicitly account for the uncertainty. This paper reviews some of the existing literature of production planning under uncertainty. The research objective is to provide the reader with a starting point about uncertainty modelling in production planning problems aimed at production management researchers. The literature review that we compiled consists of 87 citations from 1983 to 2004. A classification scheme for models for production planning under uncertainty is defined.

Keywords: Manufacturing; Production planning; Uncertainty modelling

1. Introduction

Galbraith (1973) defines uncertainty as the difference between the amount of information required to perform a task and the amount of information already possessed. In the real world, there are many forms of uncertainty that affect production processes. Ho (1989) categorizes them into two groups: (i) environmental uncertainty and (ii) system uncertainty. Environmental uncertainty includes uncertainties beyond the production process, such as demand uncertainty and supply uncertainty. System uncertainty is related to uncertainties within the production process, such as operation yield uncertainty, production lead time uncertainty, quality uncertainty, failure of production system and changes to product structure, to mention some. In this paper, we will use this typology of uncertainty.

Along the years there have been many researches and applications aimed at to formalize the uncertainty in manufacturing systems (Yano and Lee, 1995; Sethi et al., 2002). The literature in production planning under uncertainty is vast. Different approaches have been proposed to cope with different forms of uncertainty. A brief general classification is shown in Table 1.

In an effort to gain a better understanding of the ways of managing uncertainty in production planning, and to provide a basis for future research, a broad review of some existing research on the topic has been presented.

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Table 1
Classification for the general types of uncertainty models in manufacturing systems

Conceptual models	*Analytical models*
Yield factors	Hierarchy processes
Safety stocks	Mathematical programming: (LP, MILP, NLP, DP, and MOP)[a]
Safety lead times	
Hedging	Stochastic programming
Overplanning	Deterministic approximations
Line requirements planning	Laplace transforms
Flexibility	Markov decision processes
Intelligence artificial based models	*Simulation models*
Expert systems	Monte Carlo techniques
Reinforcement learning	Probability distributions
Fuzzy set theory	Heuristic methods
Fuzzy logic	Freezing parameters
Neural network	Network modelling
Genetic algorithms	Queuing theory
Multi-agent systems	Dynamic systems

[a]LP = linear programming; MILP = mixed-integer linear programming; NLP = nonlinear programming; DP = dynamic programming; MOP = multi-objective programming.

Table 2
Classification scheme for models for production planning under uncertainty

Research topic	Number of citations
1. Aggregate planning	Artificial intelligence models [8] Simulation models [2]
2. Hierarchical production planning	Analytical models [3]
3. Material requirement planning	Conceptual models [9] Analytical models [6] Artificial intelligence models [4] Simulation models [10]
4. Capacity planning	Analytical models [4] Simulation models [1]
5. Manufacturing resource planning	Analytical models [7] Artificial intelligence models [5] Simulation models [2]
6. Inventory management	Analytical models [10] Artificial intelligence models [5]
7. Supply chain planning	Conceptual models [1] Analytical models [5] Artificial intelligence models [5]

In a general way, we have selected papers to include in this survey based on two main criteria:

(i) Midterm tactical models are the focus of our work. These models address planning horizons of 1–2 years and incorporate some features from both the strategic and operational models.
(ii) It is applied on real-world problems, and mainly, on manufacturing systems.

We describe briefly what each paper is but we do not describe with detail or formulate the models that have been considered. The motivation of this work is not to identify every bibliography and extended review of them rather it is intended to provide the reader with a starting point for investigating the literature on how best to manage with uncertainty in different production planning problems.

The objective of this paper is to (i) review the literature, (ii) classify the literature based on the production planning area and the modelling approach, and, (iii) identify future research directions. This paper is organized as follows. In next section, a classification scheme for models for production planning under uncertainty is introduced. Then, previous research on incorporating uncertainty in models for production planning is reviewed and classified. Finally, the conclusions and directions for further research are given in Section 4.

2. Classification scheme for models for production planning under uncertainty

Table 2 illustrates a classification scheme for the literature review on models for production planning under uncertainty. This classification scheme is based on two aspects: (i) the production planning area, and, (ii) the modelling approach. Seven major production planning categories are defined: aggregate planning, hierarchical production planning, material requirement planning, capacity planning, manufacturing resource planning, inventory management, and supply chain planning. Also, four modelling approaches are identified: conceptual, analytical, artificial intelligence, and simulation models. These four modelling approaches were originally defined by Giannoccaro and Pontrandolfo (2001).

A total of 87 citations on models for production planning under uncertainty were reviewed. The majority of the citations were found in journals (80.46%), proceedings, conferences and others (8.05%), books (10.34%) and published PhD Thesis