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www.elsevier.com/locate/omega

PII: S0305-0483(16)30117-7
DOI: http://dx.doi.org/10.1016/j.omega.2016.04.004
Reference: OME1668

To appear in: *Omega*

Received date: 1 April 2015
Revised date: 27 February 2016
Accepted date: 10 April 2016

Cite this article as: Wenchao Wei, Luis Guimarães, Pedro Amorim and Bernardo Almada-Lobo, Tactical production and distribution planning with dependency issues on the production process, *Omega* http://dx.doi.org/10.1016/j.omega.2016.04.004

Tactical production and distribution planning with dependency issues on the production process

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Abstract. Tactical production-distribution planning models have attracted a great deal of attention in the past decades. In these models, production and distribution decisions are considered simultaneously such that the combined plans are more advantageous than the plans resolved in a hierarchical planning process. We consider a two-stage production process, where in the first stage raw materials are transformed into continuous resources that feed the discrete production of end products in the second stage. Moreover, the setup times and costs of resources depend on the sequence in which they are processed in the first stage. The minimum scheduling unit is the product family which consists of products sharing common resources and manufacturing processes. Based on different mathematical modelling approaches to the production in the first stage, we develop a sequence-oriented formulation and a product-oriented formulation, and propose decomposition-based heuristics to solve this problem efficiently. By considering these dependencies arising in practical production processes, our model can be applied to various industrial cases, such as the beverage industry or the steel industry. Computation tests on instances from an industrial application are provided at the end of the paper.

Keywords: tactical integrated production-distribution planning, two-stage production process, sequence dependent setup times and costs, MILP based heuristics.

1. Introduction

In many industrial supply chains, raw materials are gradually transformed into end products through a series of production stages, and then delivered to scattered clients to meet their demands. With market globalisation and international trade expansions, many firms have been trying to optimise their production and distribution systems simultaneously in the most efficient and economical way possible, such that the overall costs are minimised and all client requirements are met. For example, the production sites are usually geographically close to clients and are dedicated to few types of products in order to reduce the distribution and production costs, respectively. In an environment where demands are seasonal, the production rates and the inventory levels of some products are kept in a systematic way to balance inventory costs and customer satisfaction. Moreover, some groupings of products of different types and amounts over a large time scale for a one-off delivery may increase the usage of the transportation capacities, and thus decrease the total delivery costs. The integrated production-distribution models consider all the factors above throughout the decision-making process, thus providing the tools to investigate the supply chains in a more macroscopic way than in a dissolved model (Chandra & Fisher, 1994).

Following the hierarchical supply chain management, company practitioners perform strategic, tactical and operational oversight to monitor and improve the integrated production-distribution process. The strategic level decisions are usually the first step in developing such a process, for instance, by choosing the site and functionality of factories or creating a reliable transportation network. The process itself is substantially defined at tactical level, where issues about demand satisfaction, cost control and risk management are addressed. Common concerns in the tactical level include production schedules, transportation and warehousing solutions, or inventory logistics. Operational level refers to day-to-day processes, such as detailed management of good-in-process, or managing incoming and outgoing products. In this study, we investigate the production and distribution planning in a tactical level by considering the dependency constraints arising at operational level. The motivation is to provide the

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