Integrated production-distribution models: a state of the art

S. Moons[1], K. Ramaekers[1], and A. Caris[1,2]

[1]Hasselt University, Research Group Logistics
[2]Research Foundation Flanders (FWO),
{stef.moons,katrien.ramaekers,an.caris}@uhasselt.be

Abstract

Production and distribution have traditionally been studied as two independent problems. In reality these supply chain processes highly interact and combined decision support models are therefore needed. Production and distribution can be integrated at different decision levels. At the tactical level, the interdependence between production lot-sizing and routing decisions is explored. At the operational level, the combination of machine scheduling and routing is tackled. Coordination of both functions may lead to a relevant improvement of service level and to substantial savings in the total costs. In this research plan the topic of my PhD will be explained.

Keywords: production-distribution models, production routing problem, machine scheduling

A traditional supply chain consists of several functions, e.g. production and distribution. These functions are interrelated and influence each other. Historically, production and distribution functions are often optimized sequentially [5], i.e. using the output of one function as input of the next one [3]. However, ignoring the relationships between the functions may result in unnecessary incurred costs, waste of resources and poor overall behavior. Hence, it is important to optimize simultaneously these different aspects. Although, the literature on integrated production-distribution models is scarce [5]. More research on this topic can be useful for organizations in order to improve operational effectiveness and efficiency, and to gain a competitive advantage. Production and distribution can be integrated both at the tactical decision level and at the operational decision level.

At the **tactical decision level**, the integrated model between production lot-sizing and routing decisions is often called the Production Routing Problem (PRP). The PRP integrates the production, inventory, distribution and routing decisions of the supply chain [1, 2]. In the PRP a plant must decide in each period whether or not to produce and determine the corresponding lot-size, taking into account the production capacity. Products may be stored at the plant or at the customer's site. Products are delivered by a (homogeneous) fleet of vehicles to customers [1]. The outcome of a PRP is a production schedule, a replenishment schedule for the customers, and a distribution schedule consisting of several vehicle routes [2]. Combining these two problems makes the PRP hard to solve to optimality. As a consequence, historically most researchers used heuristics to find a (sub)optimal solution in reasonable computational time. Only a scarce amount of literature has focused on exact algorithms. For a review of past research, see [1].

The PRP integrates the production and distribution function at a tactical level. However, it is also important to coordinate these functions at the **operational decision level**. At this level, the combination of machine scheduling and routing is examined. During the scheduling process different jobs are assigned to the available resources, i.e. machines or people. Precedence requirements must need to be taken into account. As such, the production plan clearly indicates the timing of each job. The distribution of goods can only start after the completion of the last task of the production process [4]. Despite this link, the two problems are often solved independently. The integration of production scheduling and vehicle routing is an interesting and promising research field. This integration can result in significant savings and more on-time deliveries [6].

With my PhD research I aim to tackle some of the existing lacks in the literature on integrated production-distribution models. First, there is a need to study more realistic, but often also more complex, models. Some more realistic features that need to be considered are multiple products, multiple plants, restricted vehicle capacity [3], and time windows [1]. Second, the mathematical models of the integrated problem are often very hard to solve using exact algorithms. As a consequence to solve such complex problems, more effective heuristic procedures should be developed [1, 3].

References

[1] Adulyasak, Y., Cordeau, J.-F., Jans, R. (2015). The production routing problem: A review of formulations and solution algorithms. *Computers & Operations Research*, 55, 141-152.

[2] Ruokokoski, M., Solyali, O., Cordeau, J.-F., Jans, R., Süral, H. (2010). Efficient formulations and a branch-and-cut algorithm for a production-routing problem, GERAD Technical Report G-2010-66, HEC Montral, Canada.

[3] Sarmiento, A. M., Nagi, R. (1999). A review of integrated analysis of production-distribution systems. *IIE Transactions*, 31(11), 1061-1074.

[4] Schmid, V., Doerner, K. F., Laporte, G. (2013). Rich routing problems arising in supply chain management. *European Journal of Operational Research*, 224(3), 435-448.

[5] Thomas, D. J., Griffin, P. M. (1996). Coordinated supply chain management. *European Journal of Operational Research*, 94(1), 1-15.

[6] Ullrich, C. A. (2013). Integrated machine scheduling and vehicle routing with time windows. *European Journal of Operational Research*, 227(1), 152-165.