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Transport concept selection considering supplier milk runs – An integrated model and a case study from the automotive industry

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ABSTRACT

Efficient inbound transport networks in the European automotive industry rely on a set of different transport concepts: point-to-point services, area forwarding services and regular milk runs. For the tactical planning and the operational controlling of a mixed inbound network, a manufacturer needs decision support. We provide an integrated mathematical model and a simple, standard solver based solution approach for the transport concept selection considering milk runs. We show the potential of the approach based on a real world case study from the automotive industry. Furthermore, we introduce quick test and performance indicators and we discuss managerial insights.

1. Introduction

Transport processes, connecting a manufacturer with its remote suppliers, are an essential part of a supply chain (see Stadtler et al., 2015, p.225) and the "frequency of regular transports on the same relation is a key cost factor" (Stadtler et al., 2015, p.229). The frequency is determined on the tactical, mid-term level and the fundamental trade-off concerns inventory and transport cost. Due to the tremendous number of parts, in the automotive industry frequent, small-lot supply is preferred (see Boysen et al., 2015) compared to cheaper container load transports. For being able to provide such a frequent, small lot supply the selection of a suitable transport concept plays an important role.

In one of its recommendations, the German Association of the Automotive Industry (VDA) defines three *transport concepts* as the automotive standard for supply by road: point-to-point (P2P) transports, area forwarding (AF) services, and milk runs (MRs) (see Projektgruppe, 2008). In a *P2P transport*, a large shipment is brought by a freight forwarder directly without further consolidation from a supplier to a plant. In case of *AF services*, a special case of groupage services, a producing company gives all transport orders from a certain area to a certain location to a logistics service provider (LSP) and leaves it to the subcontractor to plan and execute these transports. The *MR concept* has its roots in the Toyota Production System emerged after World War II in Japan. The idea of this concept is to establish regularly scheduled tours between sources and sinks in order to guarantee a levelled and regular supply of parts resulting in highly reliable and predictable transport processes. MR schedules are planned by the manufacturer itself and executed by an LSP. They can be either planned as *round-trip MRs* between a cluster of suppliers and a plant or as an *open tour MR*, after which the LSP acquires return freight from third party customers.

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In the German automotive industry, the predominant transport concepts for inbound traffic are P2P transports and AF services while MRs do not play a significant role in Europe for inbound freight (see Queiser, 2007). The question is why advantages of MRs for supplier-plant relations are rarely taken in Germany (and Europe) while in Japan supplier round-trip MRs are the predominantly used concept for connecting regular suppliers with the corresponding plants.

According to Miemczyk and Holweg (2004) the structure or – as the authors also say the "gestalt" – of an inbound logistics subsystem is defined by two key factors: the number of suppliers per manufacturer and the average distance between suppliers and receiving plants. The difference between Japan and Europe in terms of the average distance is significant. Dyer (1996) determined in an empirical study the average distance of Toyota to its affiliated suppliers to 48 km, and to 140 km to its independent suppliers. In Europe, suppliers of a car manufacturer, or a first tier parts manufacturer like our case study partner Robert Bosch GmbH (Bosch), are spread all over the country and even the continent. Based on this network structure in Europe, MRs that cycle several times per day between clusters of suppliers and receiving plants with small trucks, as common in Japan, cannot be established cost-efficiently. However, MRs serviced for example several times per week following a strict pattern, such as Mon-Wed-Fri, still bring along the positive impact of regularity and might be operated cost efficiently depending on the geographical situation. Thus, European manufacturers can potentially benefit from a *mixed inbound network* combining different transport concepts such as P2P transports, AF services, and weekly MRs.

In order to be able to run such a mixed inbound network in Europe, the complexity of two tasks must be reduced for the manufacturer: the tactical transport planning and the operational monitoring. All transport concepts need to be considered during the tactical decision process, in which the frequency and the transport concept are assigned to each supplier-plant relation. Considering MRs in this decision phase increases the complexity considerably since the MR schedules must be determined by the receiving plant. For determining a MR schedule, a periodic version of a vehicle routing problem (VRP) has to be solved, while in case of AF and P2P transports all tour planning decisions are outsourced to the LSPs. Because of the general lack of decision support systems for tactical transport planning (see for example Stadtler et al., 2015, p.232) today a lot of manual effort for the determination of MR schedules is necessary.

Due to the static schedules of MRs, the efficiency of this transport concept is very sensitive to changes in demand: In case of a lower demand than expected, the vehicle utilization deteriorates. In case of a higher demand, the number of extra AF services rises. To support the operational process of the receiving plant, as well, the efficiency of a MR system should be measured continuously. An indicator typically used in practice is the weight/volume capacity usage of the MR vehicles. For relating the performance of the MR system to available alternative transport concepts, additional performance indicators need to be proposed. They need to give the manufacturer a quantitative base for deciding if MRs need to be rescheduled or if other transport concepts are more suitable.

Based on these observations, the contribution of this paper is threefold: (1) We develop a decision model for automotive manufacturers addressing the transport concept selection for mixed inbound networks including MRs. The model relies on an extension of a path based formulation for the periodic vehicle routing problem with service choice. (2) We show the potential of a mixed inbound network in Europe based on a real world case study. (3) Based on the results of the case study, we propose a new performance indicator for monitoring the execution of MRs taking into account the alternative transport concepts.

The paper starts in Section 2 with the introduction of the context and scope of the transport concept selection for mixed inbound networks in the European automotive industry. Based upon a short discussion of related models from literature in Section 3, we propose different modelling variants for the mixed inbound network design in Section 4 and give a brief overview about the solution procedure. Based on a real world case study for a production site of Bosch, one of the world's largest manufacturers for automotive parts, we show in Section 5, that the proposed approach is beneficial. In Section 6 we introduce an improved performance indicator and a quick test measuring the performance of an MR system in relation to alternative transport concepts and we discuss managerial insights of the case study results. We conclude with showing possible tracks of further research in Section 7.

2. Transport concept selection for mixed inbound networks

For describing the scope of the tactical decision in Section 2.2, we first provide an overview of the characteristics of the three standard transport concepts in Section 2.1. Section 2.3 summarises the necessary steps of the transport concept selection for mixed inbound networks including MRs.

2.1. Transport concepts

An overview of the VDA standard transport concepts is given in Table 1. Based on the criteria listed in the first column we discuss in the following section the characteristics of the transport concepts.

2.1.1. Type of regularity

The key difference between MRs and the other two concepts is that P2P transports and AF services are highly flexible in terms of shipping volumes and frequency: Usually, in these cases, the suppliers and the LSPs are informed one day before the pick ups are scheduled by the receiving plant. As a result, often the tours vary strongly on a daily basis. In contrast, supplier

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