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Determining collaborative profits in coalitions formed by two partners with varying characteristics

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ABSTRACT

Horizontal logistic collaboration offers a great opportunity for companies to reduce their distribution costs. By forming a coalition and carrying out a joint operational plan, companies are able to achieve a larger profit. The extent of this profit is, however, highly dependent on the partners that form the coalition and the characteristics of their operations. Different companies might have different requirements and could enforce different restrictions on the joint operational plan. In this paper, we discuss a simulation study carried out to analyse the effects of different partner characteristics on the coalition's performance. We evaluate coalitions formed by partners with different characteristics, and analyse how these complement each other. In this way, we are able to identify opportunities for very profitable collaborations that are missed by other studies.

1. Introduction

The freight transportation sector accounts for a major percentage of the global economy. According to the Organization for Economic Co-operation and Development (OECD, 2006), the transportation of goods and services contributed 1156 billion dollars to the US economy during 2003 (around 11% of that year's GDP). Transportation was ranked the fourth most demanded sector in the US economy (after housing, healthcare and food). During that year only, the EU and the US combined transported around 7707 billion tonne-kilometres. Such a vast economic activity has had a strong environmental impact. In the EU only, this sector accounts for 30% of the total energy consumption and is responsible for 19% of the total greenhouse gas emissions (Campbell, 2007). Figures like these show the importance of the transportation sector, and motivate the enormous effort invested in improving its efficiency and sustainability.

A large fraction of the freight volume is carried via the road network. In the EU, for example, this mode accounts for around 72% of the total freight transportation (Campbell, 2007). One of the main challenges that companies in this sector face is related to the efficiency of their operational plans. These companies need to decide, on a daily basis, which truck delivers which orders and in which sequence. This optimization problem, known as the *vehicle routing problem* (VRP), was proposed by Dantzig and Ramser (1959) and has been widely studied by the operations research community. The development of advanced optimization methods has allowed companies to improve their operational plans considerably. These methods provide the means for companies to reduce their operating costs and become more profitable, as well as more environmentally friendly (Lin et al., 2014; Demir et al., 2014).[1] Despite these important advances, the transportation sector still feels an

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[1] We refer the reader to the book by Toth and Vigo (2014) for a more thorough explanation of the VRP and an extensive review of the most recent optimization methods.

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increasing pressure to improve its operational efficiency while maintaining competitive service levels (Commerce Initiative and Capgemini, 2008). According to the official statistics of the EU, for instance, around 27% of the trucks in the road network are empty (de Angelis, 2011). The fact that such a large portion of the road-transportation capacity is underused shows that there is still room for improvement.

A recent trend in supply chain management, called *horizontal collaboration*, sees companies join forces to perform their distribution jointly. This kind of cooperation has received increasing attention not only in road transportation (Ergun et al., 2007; Cruijssen et al., 2007a; Hernández et al., 2011), but also in ship (Cruijssen et al., 2007c; Panayides and Wiedmer, 2011), rail (Kuo et al., 2008; Kuo and Miller-Hooks, 2012) and intermodal transportation (Groothedde et al., 2005; Li et al., 2015). The principle behind this trend is straightforward: companies can achieve higher efficiency levels by forming a *coalition* and carrying out a joint operational plan. One of the main motivations for companies to collaborate is, according to a study of EyeforTransport (2010-2011), that the total distribution cost of a coalition is lower than the sum of the stand-alone costs. The difference between these two costs is referred to as the *coalition gain* or *coalition profit*. Several studies show that the synergy achieved by horizontal collaboration can achieve coalition gains of up to 30% (Frisk et al., 2010; Vanovermeire et al., 2014; Lozano et al., 2013). The extent of these gains is, however, highly dependent on the partners that form the coalition and the characteristics of their operations. Different companies might have substantially different requirements, and could enforce different restrictions on the (joint) operational plan. One partner might, for example, require its orders to be delivered on specific days, whereas another partner could be willing to delay some of its orders for a few days. Such differences between the partners' characteristics have a large impact on the performance of the coalition. For that reason, it is important that companies take them into account when choosing the best partner(s) to collaborate with. What might be an ideal partner for a company, might not be so for another one with different characteristics. The task of choosing the best possible partner(s) therefore gives room to the following questions:

- Which partner characteristics have the largest influence on the coalition's performance?
- Which companies are more suitable to collaborate with each other? Or, in a more specific sense: which combinations of partner characteristics lead to a large coalition profit?

The purpose of this paper is to shed some light on the answers to these questions. We study the effects of different partner characteristics on the coalition's performance. To this end, we frame our study in a scenario where companies carry out an operational plan that involves a time horizon of several days. In this sense, the coalition needs to decide on two different levels: first, it needs to determine which orders are served in which days; and second, it requires to solve a VRP for each day in the time horizon. This extension of the VRP, introduced by Beltrami and Bodin (1974), is known as the *periodic vehicle routing problem* (PVRP). For this scenario, we carried out an extensive computational experiment to simulate the gains achieved by several coalitions (formed by partners with different operational characteristics). We then used the data generated to determine the characteristics that have the highest impact on the coalition's performance, and to identify the most promising coalitions.

The study carried out in this paper somehow extends the computational experiment reported by Cruijssen et al. (2007a). They also analyse the extent to which the coalition's performance depends on different operational characteristics of the partners. Their focus is, however, on a coalitional level: they mainly consider scenarios where all the partners have similar characteristics. Instead, we focus on an individual level: we evaluate scenarios where partners have different characteristics, and analyse how these complement each other. Additionally, we perform a case-by-case study to determine the characteristics that different companies (with different characteristics) should look for in a partner. By considering this thorough approach, we are able to identify opportunities for collaboration that are missed by the more general experiment of Cruijssen et al. (2007a). Such detailed analysis comes, however, with a limitation. In order to restrict the size of our computational experiment, we considered coalitions formed by only two companies. Nevertheless, despite this restricted scope, the results obtained provide useful insights for companies to better choose the partner to collaborate with.

The structure of this paper is as follows. Section 2 presents an overview of the research that has been done to evaluate or determine the benefits of horizontal logistics collaboration. Additionally, this section also reviews a wide range of real cases that serve as motivation for the present study. Section 3 explains the set-up of the computational experiment carried out. Based on the results of this experiment, Section 4 describes a statistical analysis carried out to identify the characteristics that have the strongest influence on the coalition's performance. It turns out that, by considering the interaction effects (i.e., modelling how the characteristics influence each other), the explanatory power of the analysis increases considerably. Section 5 extends the previous analysis by discussing a case-by-case study of the results: for different potential companies, it determines the characteristics of the most promising partners to collaborate with. Finally, Section 6 provides the concluding remarks of the study.

2. Creating collaborative gains

Most of the literature related to horizontal collaboration focusses on discussing its main benefits. Despite the fact that this practice offers other advantages (like improving the service levels and leading to a more environmentally-friendly supply chain), the coalition gain has received most of the attention. A large percentage of the literature discusses several case