ASSESSING SERVICE QUALITY IMPROVEMENT THROUGH HORIZONTAL COOPERATION IN LAST-MILE DISTRIBUTION

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ABSTRACT

Horizontal cooperation is a relevant strategy that logistic service providers can follow in order to achieve greater efficiency. While literature has mainly focused on economic benefits, this article discusses the impact of horizontal cooperation on service quality in last-mile distribution. An agent-based simulation model is introduced to assess savings in lead times due to various horizontal cooperation agreements under consideration of trust related factors. Results of computational experiments show that cooperation enables companies to reduce lead times substantially, which increases service quality and competitiveness.

Keywords: Horizontal Cooperation, Coalition, Service Quality, Simulation, Last-mile Distribution

1. INTRODUCTION

Companies are facing significant challenges in their logistics activities. Growing competition due to globalization as well as increasing customer expectations on service quality require firms to be more efficient and competitive in the management of distribution operations. These issues are especially important for small and medium-sized enterprises (SME) that usually do not have the economic, human and technical resources needed to solve complex mathematical models related to logistics optimization. Additionally, in Europe, the logistics service providers (LSP) sector is often highly diverse, being mainly made of small companies, which are often family-owned (Cruijssen et al. 2007). Thus, unlike large companies, SME can only take limit advantage of economies of scale and, therefore, require innovative concepts in order to stay competitive.

In order to facilitate competitiveness, SME can follow cooperation strategies with other companies. Interfirm agreements imply, on the one hand, maintaining an independent legal personality and, on the other hand, the establishment of processes, protocols, or frameworks that enable the cooperation in business-related projects such as logistics activities. When cooperation takes place between companies that belong to the same echelon of the supply chain, it is commonly denoted as horizontal cooperation (e.g., Lambert et al. 1996, European Union 2001, Cruijssen et al. 2007). Therefore, horizontal cooperation is a particular typology of interfirm collaboration, in contrast to vertical collaboration where agreements take place among different stages of the supply chain, i.e., between suppliers, manufacturers and retailers. Supply Chain Management (SCM) aims to efficiently integrate the actors that are active within a particular supply chain in order to provide products in the right quantity as well as at the right time and location in such a way that total costs of all actors are minimized and service level is satisfied (Chopra and Meindl 2016). While numerous work on SCM is found in the literature, horizontal cooperation is still in its early stages (Leitner et al. 2011).

Concerning horizontal cooperation, last-mile distribution, the link between the supply chain and the final destination, is of particular interest as it is responsible for up to 28% of total logistics costs (Roca-Riu et al. 2012). This delivery often takes place in urban environments, in which case it is commonly denoted as urban freight distribution. Even though urban distribution has a key role in the economic development of cities, it has many challenges to cope with (Taniguchi et al. 2016) as urban areas are growing rapidly. According to the United Nations (2014), 54 % of the world's population was living in urban areas in 2014 and 66 % are expected to do so by 2050. Additionally, the rapid development of information and communication technologies have led to new sales channels such as e-commerce (Deloto and Chen-Burger 2015), further increasing urban freight distribution. Thus, efficiency in urban distribution, i.e. enabling higher frequency in deliveries and shorter times, is a key factor for the competitiveness of urban LSPs.

To support last-mile distribution and to investigate the impact of horizontal cooperation, this article evaluates benefits derived from the implementation of various horizontal cooperation agreements from a customer point of view. Therefore, the objective is to reduce lead times and the focus is set on a medium-term time frame of up to 90 days. To consider agents behavior and interdependencies between various actors, an agent-based simulation is presented. Therefore, the contribution of this work is two-fold: it introduces a methodology to model horizontal cooperation in last-mile distribution and discusses potentials and impacts on service quality. The remainder of this paper is structured as follows: Section 2 introduces related literature. The agent-based simulation is presented in Section 3 and results of the computational experiments are presented and discussed in Section 4. Concluding remarks are given in Section 5.

2. LITERATURE REVIEW

In literature, different definitions of horizontal cooperation exist. Lambert et al. (1996) define horizontal cooperation as a tailored relationship that it is based on trust and openness with the aim of obtaining a competitive advantage in such a way that conjoint performance is greater than the one that the individual actors would achieve individually. In contrast, the European Union (2001) defines horizontal cooperation as concerted practices between companies that operate at the same level in the market. In Cruijssen et al. (2007), it is seen as an interesting approach to decrease costs, improve service quality or protect market positions. Moreover, Bahinipati et al. (2009) denote horizontal collaboration as a business agreement between two or more firms at the same level in the supply chain in order to achieve a common goal.

As shown by the definition above, the main focus is on sharing activities or information in order to reduce costs. Therefore, the key is that through sharing information, it is possible to take advance of greater economies of scale by optimizing the overall systems instead of each partner individually. Nevertheless, sharing data and information requires a high degree of trust, which is, commonly, a major obstacle in corporate collaboration (Zeng et al., 2015). Expanding on these definitions, the following integrated definition of horizontal collaboration is considered in this work:

Horizontal cooperation is an agreement, tacit or not, which involves more than one company without vertical relationship between them (i.e. no supplier-customer relationship) based on trust and mutual commitment to identify and exploit win-win situations with the goal of sharing benefits (or risks) that would be higher (or lower) than each company would obtain if they acted completely independently.

Difficulties to ensure relationships, to find suitable partners and to allocate profits/risks as well as complexity resulting from information sharing are, among others, the major barriers to implementation of horizontal agreements (Cruijssen et al. 2007). A taxonomy to classify horizontal cooperation agreements in three different types depending on the degree of trust is presented in Lambert et al. (1999). Therefore, a ‘Type I’ cooperation denotes agreements in which the involved companies coordinate their activities on a limited basis for a very short time. A ‘Type II’ relationship, in contrast, indicates medium term agreements for an entire project duration and a greater level of coordination, while under a ‘Type III’ cooperation, organizations have a high level of integration for an unlimited duration. Within the simulation presented in this work, these different types of horizontal cooperation are implemented based on a modelled trust parameter.

In last-mile distribution, horizontal cooperation may occur from two perspectives: (1) unrelated, but horizontal, companies that aim to cooperate in their logistics processes and (2) LSPs cooperate to carry out joint activities. Therefore, reducing transportation cost is primarily the key enabler to start a coalition (Lehoux et al. 2014), while other factors receive little attention in the literature (Cruijssen et al. 2010; Schmoltzi and Wallenburg 2011). Nevertheless, some work focuses on the reduction of emissions. In Perez-Bernabeu et al. (2015) a reduction of about 20 % in emission costs as result of horizontal cooperation is recorded, while Schulte et al. (2015) lower emissions by reducing empty trips. The impact on service quality is rarely investigated. Ghaderi et al. (2016) study the impact on lead times of cooperation agreements. Therefore, the authors collected real-world data of various cooperations over a 14-month period. Results show significant reductions of 30.8 % in lead times as well as in the variance. In contrast to our work, no simulation is employed and the impact of trust is not investigated.

Additionally, the creation of business coalitions may be supported by game theory (Guajardo and Rönnqvist 2015). Being part of a coalition must imply the value of the coalition is at least as good as the sum of the values of its members individually, e.g., a coalition is not formed if not beneficial. Furthermore, in practice, many additional reasons might exist against forming a coalition. These reasons usually have to do with managerial complexity or legal issues that make the alliance difficult to coordinate and costly (Lozano et al. 2013). Additionally, according to the Treaty on the Functioning of the EU (European Commission 2007), anticompetitive behavior is forbidden in the cases of agreements and business practices which restrict competition and/or abuse dominant positions; however, some exemptions apply in rail, road and inland waterway transportation, e.g., if agreements look for technical improvements or to achieve technical cooperation (European Commission 2009).

3. METHOD

An agent-based simulation was developed using the software package Anylogic 7.3 (AnyLogic 2016) to study the introduced problem settings. Therefore, wholesalers, stores, i.e. customers, orders and vehicles are individually modelled as agents in geographic space. Wholesalers are the agents that may cooperate in order to improve service quality for their customers. In the initial scenario, a pure competitive setting is assumed in which no horizontal cooperation exists, i.e. no

information or customers are shared. Each wholesaler has its own customer base that is served if a product is requested.
Store agents are small shops in the study area with almost no stock- (micro enterprises). This kind of shops are typical in the urban environment and usually do not have access to complete information about the wholesaler market. In the simulation, stores are assumed to employ an (s,S) inventory policy (Arrow et al. 1951). Therefore, when the inventory level falls below a minimum value, denoted by 's', the store will generate a request for a replenishment order that will restore the inventory to a target value, denoted by 'S'. This is triggered by an event in the simulation. To initialize the simulation, each store is set up with a random value for both 's' and 'S'. Using a demand function constant in quantity but randomized in ordering time, inventory levels decrease during the day to simulate sales.
Transportation of products from wholesaler locations to store locations is performed by vehicle agents. Therefore, each wholesaler has its own and homogeneous vehicle fleet.
Vehicle motion is reflected in the Figure 1. Due to last-mile distribution and stores' characteristics, it is assumed that once an order occurs, it must be delivered as soon as possible. Starting at the wholesaler warehouse, each time a replenishment at a store is requested, an order is generated. These agent orders are processed in the wholesaler management office. Consequently, the products are loaded in the vehicles and moved to the costumer site. After unloading, vehicles return to the wholesaler location. Concerning information, we are using real data in roads and driving times because vehicles travel on the shortest path calculated with network data taken from OpenStreetMap (OpenStreetMap, 2016).

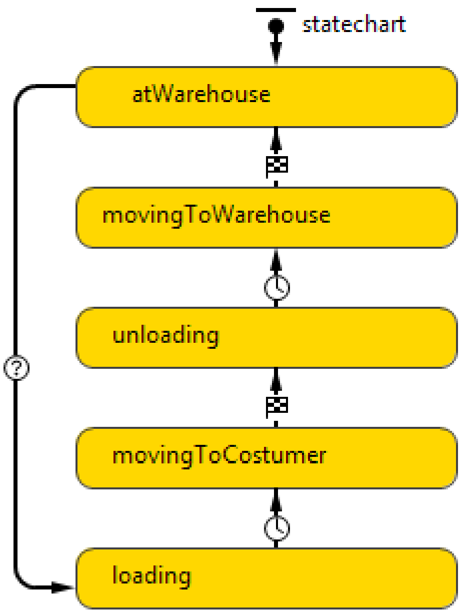

Figure 1: Vehicles motion

3.1. Assumptions
The agent-based simulation model is based on various assumptions in order to allow modeling the problem setting. Therefore, wholesalers have identical cost structures and they provide their logistics service at a given and competitive price that cannot be changed in the short run. As a result, service quality (measured by lead-times) is the only determinant for a store to choose its wholesaler. A 3-month time-horizon is selected to simulate the coalition behavior in the medium time frame. This time period is simulated in which the small wholesalers engage in forming a coalition based on types I and II cooperations. Moreover, in the long run some stores may open or disappear and the coalition may evolve to more formal agreements. Likewise, new wholesalers may enter in the market or existing agents may exit from it or change their cost structures. While this factor can be easily added to the simulation, based on the medium-term focus of the simulation, such factors are not considered in the computational experiments.

3.2. Cooperative Behavior
Each time an order arrives, the store served evaluates the shipment concerning the achieved service quality, measured by the lead time. Therefore, a threshold value is implemented to consider the expected lead time of the store. This threshold is calculated by the best potential lead time considering the closest wholesaler and no shipping delay multiplied with a tolerance parameter. If products are delivered before this threshold, a positive performance point is given to that wholesaler, otherwise, a negative performance point. Additionally, an extra point is given if the current shipment was shorter than the average lead time, otherwise, a negative performance point. At the end of the working day, the wholesaler with the least performance points (the wholesaler with the weakest performance, namely wholesaler A) starts a coalition with another wholesaler in order to stay competitive. Nevertheless, wholesaler A will take some time to choose a partner to make the coalition. The partner eventually chosen (namely wholesaler B) will be someone that also has a motivation to make the coalition due to negative customer evaluations (least performance points). After this contact, A and B start a type I cooperation to improve the respective service levels. In this context, type I cooperation implies limited information sharing about their customers in such a way that A and B maintain the same shipping volume respectively, but potentially swap customers in order to improve service levels. After another evaluation period, the coalition is assessed with two potential outcomes:

1. Service quality improved as a result of the coalition.
2. Service quality did not improve as a result of the coalition.

If (1), trust in the coalition will increase, and, therefore, the likelihood of raising the degree of cooperation and/or enlarging the coalition with new members will increase as well. If (2), trust in the coalition will decrease, and therefore, the likelihood of raising the degree of cooperation and/or enlarging the coalition with new members will decrease as well. Based on the coalition trust achieved over time, a coalition potentially upgrades to a type II cooperation. In the type II cooperation, wholesalers share not only information about their customers but also orders. This implies that a coalition acts as a whole firm pooling all the customers and assigning them to the most appropriate wholesaler. Thus, the total profit will increase; however, the distribution among the members of the coalition may differ. Therefore, as the trust in the coalition is high, it is assumed that this factor will be offset by profit-sharing agreements. Additionally, if the coalition service quality improves, other wholesalers may be interested in joining the coalition. In such a case, a type I cooperation with the coalition is started and again evaluated based on the performance.

4. RESULTS AND DISCUSSIONS

The model was tested with 26 wholesalers and 273 stores, which interact in a geographic space based on spatial data originating from Vienna, Austria. An overview of the problem setting is shown in Figure 2, with stores indicated in green and wholesalers indicated in red (if currently not in a coalition) and gold (if currently in a coalition). The graphical user interface further shows customer orders, plots routes of vehicles performing the last-mile distribution and further gives various statistics and results to the model user.

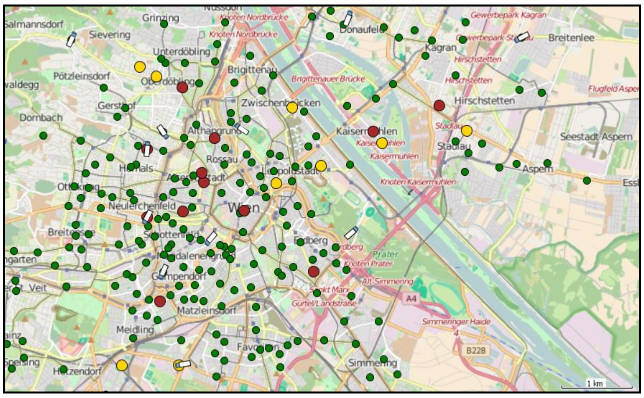

Figure 2: Simulation user interface

Table 1 shows the savings in lead times compared to a non-cooperative scenario based on 100 replications of the simulation experiments for each setting. On average, cooperation improves lead times by 24 %, indicated by the 'System' row, ranging from a minimum of 14 % to a maximum value of 39 %. 'Customers' and 'Wholesalers' saving rows are computed only for the setting where cooperation is enabled. In those cases, savings are calculated comparing lead times before cooperation started and after the wholesaler joined the coalition. When cooperation is enabled, degree of cooperation, i.e. type I and II, may evolve within the members of the coalition. Depending on the individual store, average savings range from 18 % to 45 %. From the wholesaler's point of view, its lead times decrease on average between 15 % and 48 %.

Figure 3 shows the distribution of average lead times (vertical axis) allowing cooperation (cooperation= 1) and without allowing it (cooperation= 0). Fluctuations in the individual replications are larger when cooperation does not take place. As a result, cooperation reduces not only lead times but also uncertainty in delivery lead times.

Table 1: Savings in Lead-Times vs No Cooperation

	Min	Max	Average
System	-14%	-39%	-24%
Customers	-18%	-45%	-30%
Wholesalers	-15%	-48%	-30%

The system's behavior (i.e. taking into account all wholesalers) is illustrated in Figure 4, where the vertical axis corresponds to performance points and the horizontal axis corresponds to time. The negative performance at the beginning of the simulation horizon indicates that, on average, wholesalers are not fulfilling store requirements in terms of lead time. After some time, coalitions start to form as wholesalers start cooperating. As a result, the wholesalers' performance improves considerably.

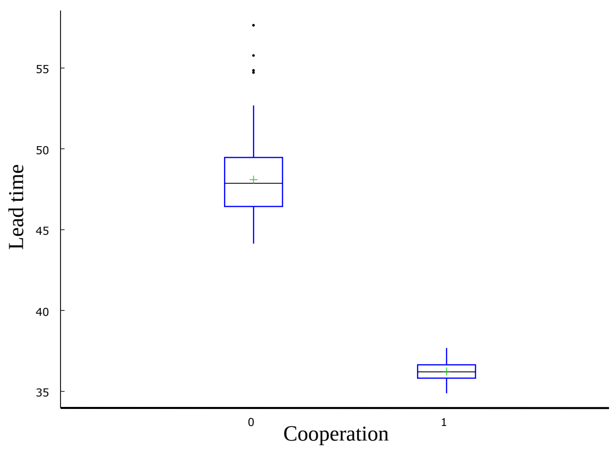

Figure 3: Distribution of times by cooperation

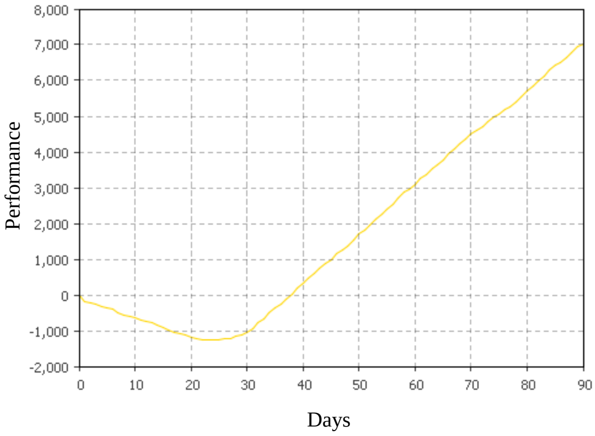

Figure 4: Wholesalers' performance in a single run

Nevertheless, considering the particular performance of individual wholesalers, four different outcomes can be identified. These are shown in Figure 5. The most common behavior is the one on the top in which cooperation helps the wholesaler to improve the performance. In Figure 5.1, the wholesaler is performing poorly and forced to start the coalition in order to stay competitive. In Figure 5.2, in contrast, is the case in which a running coalition enabled a wholesaler to improve the performance by joining at a later time. Less common cases are depicted at the bottom of Figure 5 in which cooperation does not result in a real improvement, eventually bringing candidates to leave the coalition. For instance, Figure 5.3 describes the case of a wholesaler that started cooperating in order to improve its performance. However, as the coalition size increases, performance is unstable. The main reason is that new members have a more advantageous situation with respect to its location. Finally, the Figure 5.4 is a case in which a wholesaler does not improve its performance because of cooperation. The simulation enables one to analyze different setting and to investigate the impact of horizontal cooperation and of joining or leaving a coalition based on simulated demand behavior as well as the location of stores and wholesalers.

5. CONCLUSIONS

Horizontal cooperation is an important strategy that SMEs can adopt in order to take advantage of greater economies of scale. Regarding last-mile distribution, cooperation is a way to reduce transportation costs (Lehoux et al. 2014). This paper has addressed the topic of horizontal cooperation from a service quality point of view in the context of urban deliveries. Therefore, lead times were used as a critical indicator of service quality in last-mile distribution. An agent-based simulation model was developed to investigate the impact of horizontal cooperation on lead times under consideration of various horizontal cooperation agreements and trust-related factors.

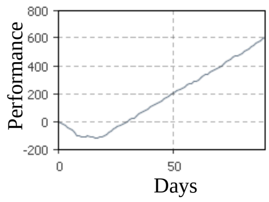

Figure 5.1

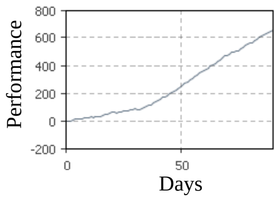

Figure 5.2

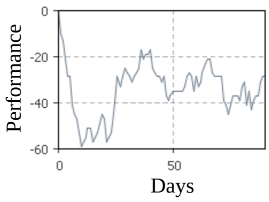

Figure 5.3

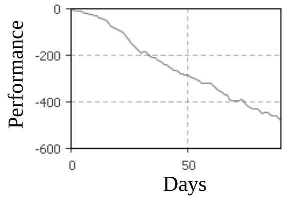

Figure 5.4

Figure 5: Performance of 4 different wholesalers in a single run

As a result, average lead time reduction reaches on average 24 % in the test setting; however, lead times can be reduced by up to 39 %. Improvements in service quality are not a trivial issue. Customer satisfaction and customer loyalty, among others, are key determinants that allow firms to improve market position and business competitiveness (Lindgreen et al. 2012).

In future work, the simulation will be extended to consider a wide range of different horizontal coordination agreements and further will be tested in different experimental settings. Therefore, employed procedures will be extended to calculate savings in travel costs and emissions. Additionally, the impact of the geographic distribution of wholesalers and customers is of high interest. Hence, investigating different geographic settings with the developed agent-based simulation enables one to analyze different influencing factors to derive implications and beneficial settings for horizontal cooperation requirements under consideration of service quality and trust-related issues.

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