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Stakeholder's profitability of carrier-led consolidation strategies in urban goods distribution

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ABSTRACT

This paper presents the necessary conditions to ensure a minimal profitability of carrier-led consolidation strategies in urban distribution. These conditions are shown by compact formulas obtained by continuous approximations representing the cost of the stakeholders involved: society, regular carriers, consolidation facility operator and environment. The domain of the retailer density variable that always produces negative effects on each stakeholder has been identified. The envelope of this domain does not depend on vehicle costs and other site-related parameters. On the other hand, there is a critical density of receivers that makes the carrier cost savings higher than the *CF* operator costs.

1. Introduction

The predominance of population concentration in urban areas was achieved for first time in the human history in 2008 (UNFPA, 2007). From this time on, world population is expected to continue concentrating in cities or metropolitan areas due to incremental access to economic opportunities and services (UNFPA, 2012). Cities must provide efficient networks of these basic services to meet the near future citizens' needs at a reasonable cost. This is the case of the urban goods distribution. In order to improve its efficiency and to reduce externalities, local governments have been implementing heterogeneous innovative measures, through urban mobility plans or using national or supranational funds. City managers have done a great effort in developing detailed *ex-post* evaluation methodologies to comprehend the results, derive lessons to other implementations and benchmark the best practices in city logistics. Unfortunately, *ex-ante* estimations of these urban goods measures are seldom provided. The cause-effect relationships are not studied and there is no estimation of the required conditions to guarantee the achievement of the objectives.

Consolidation strategies are one set of measures that can improve the efficiency and reduce the externalities caused by freight vehicles in urban areas (Browne et al., 2005). The basic idea is to consolidate goods in new or existing facilities before the distribution to the final customers is done. This way, the number of freight vehicles and their mileage within an urban area are reduced by grouping the shipments of different delivering routes into a single vehicle covering the destination area. However, there is a major challenge for the success of consolidation strategies: which stakeholder leads the consolidation and how the new distribution costs of the consolidation facility are compensated by the stakeholders that experience a cost reduction.

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In Holguín-Veras and Sánchez-Díaz (2016), two different kinds of organizational implementation of consolidation strategies are identified. On one hand, receiver-led consolidation strategies, where the major decision role relies on receivers. A common example is when the manager of a great pole freight attractor (commercial malls, hospitals, huge office buildings) reorganizes the upstream supply chains, reducing the number of deliveries in this facility. This measure may reduce the number of in-bound routes but it does not need any collaboration among carriers.

On the other hand, carrier-led consolidation strategies, where receivers are physically scattered in the urban area and they are not organized under a common framework or legal body. In that case, multiple carriers use a consolidation facility to deliver goods in the distribution area. Each carrier is responsible for performing multiple deliveries to a subset of these receivers (Nathanail et al., 2012). Indeed, these strategies cause significant changes in the inbound supply chains at the facility, as well as in the outbound local distribution routes, from the facility to the final customers. Interurban vehicles just need to stop once at this facility to deliver all goods to receivers located in this area. In this facility, the shipments are consolidated and a common fleet distributes them to the final destinations. Consolidation strategies imply some level of collaboration among carriers since their parcels are combined in the common fleet for last-mile delivery or, at least, are handled in a shared space in the consolidation facility. However, the natural competition of carriers makes this kind of consolidation strategies more complex than the receiver-led. The main objective of carrier-led consolidation measure is to increase the load factor in the last mile distribution, to reduce the number of gross vehicles in the area and to reduce the environmental impacts of the freight distribution while maintaining the level of service.

A well-known example of these carrier-led consolidation strategies is the controversial *Urban Consolidation Center* (*UCC*) concept or also named Urban Logistic Spaces (*ULS*). They are medium logistic facilities located in the neighborhood of the distribution area in which deliveries are consolidated. In Browne et al. (2005) a deep analysis of the potentialities and major weaknesses of *UCC* is presented. In spite of the promising expected results, one of the major challenges is the necessary funding to afford the set-up facility cost. Moreover, this measure implies new handling costs as well as time penalty for all shipments to be distributed through *UCCs*. The economic impacts on multiple stakeholders involved in several *UCC* trials have not been deeply estimated. It has resulted in unfeasible business models. In fact, more than 100 implementation of this kind all over the world were reported, but just 12 are still in service (Allen et al., 2012). Several contributions present a quantified assessment of the impacts of *UCC* in specific implementation in Europe, North American and Japan cities (Paddeu et al., 2014; Köhler, 2001; Kawamura and Lu, 2008; Chen et al., 2012; Browne et al., 2007; Gonzalez-Feliu and Morana, 2011). These results apply to each case study and it is difficult to extrapolate the achievements to other physical contexts.

Alternatively, the concept of *Urban Stage Areas*, *uSA,* (referred as *Espace Logistique de Proximité* in France) has succeeded in the recent years as a consolidation strategy (Holguín-Veras et al., 2008). It overcomes the funding problem of building a new unaffordable consolidation facility. A container or other small non-expensive storage structure is installed in an existing facility inside a city center (for example, a parking garage). Vehicles drop the products to be delivered in the adjacent area of this facility and, in a second stage, other environmentally-friendly vehicles from the same company deliver them to the final retailers. Even, this last mile distribution can be made by foot. In Janjevic et al. (2013), the special features of *ULS* are analyzed.

The estimation of the logistic cost savings from carrier-led consolidation strategies is addressed in several contributions based on continuous approximations of the network distribution variables (Daganzo, 1988a, 1988b; Campbell, 1990). Saberi and Verbas (2012) presented a similar approach aimed at minimizing the emissions of the freight transportation vehicles due to carrier-led consolidation policies. Roca-Riu and Estrada (2012) and Roca-Riu et al. (2016) analyzed the effect of equal and non-equal market share carriers demand in the whole transportation network. The total transportation cost variation at local and line-haul network are estimated. These contributions provide a useful tool to approximate the total cost of both systems and therefore the operational savings. More recently, Janjevic and Ndiaye (in press) define the generalized cost of regular carriers when they route their parcels through *UCC*. This generalized cost is obtained as an analytical estimation of the time and distance- related cost as well as the service fare. Unfortunately, there is not any analysis of the consolidation effect on the profitability of each stakeholder involved and the necessary cash flows among them. In this paper, we would like to study how the cost incurred by each agent (mainly carriers and consolidation facility operator) changes due to the consolidation strategy and what novel cash flows among stakeholders ensure the profitability for each participating agent. Zhou et al. (2011) analyzed the cost savings and the optimal price setting of companies. Although the study is developed for the long-haul network, they define an economic model where the product substitutability among carriers is addressed, considering price setting and discount offer. In the urban context, Krajewska and Kopfer (2006) and Krajewska et al. (2008) addressed the cost allocation problem among companies. This problem studies the distribution of new costs and its benefits due to the collaborative process among participants. The methodological framework of this approach considers both combinatorial auctions and operational research game theory. Unfortunately, these latter contributions do not provide insights about how the distribution network should be designed to exploit the economies of scale of consolidation facilities at a specific site.

The aim of this paper is to define the necessary conditions to ensure a minimum profitability of the carrier-led consolidation strategies for carriers, the consolidation facility operator, environment and society. These conditions are determined using a set of compact formulas involving the logistic cost estimation and the cash flow among stakeholders. Cost estimations are compared between the regular service and the service with consolidation facilities. Formulas depend on the key characteristics of the urban site and distribution network: demand and size of parcels, size and type of fleet, local and