

A modelling approach for city locating logistic platforms based on combined forward and reverse flows

Nadia Ndhiaief*, Olivier Bistorin** and Nidhal Rezg*

*LGIPM, Université de Lorraine, Ile de Saulcy, 57000 Metz, France

**LGIPM, ICN Business School, 13 Rue Michel Ney, 54000 Nancy

Abstract: Logistics platforms and reverse logistics are the most used solutions addressing daily problems in urban areas such as noise, pollution and cost. Their main goal is to ensure sustainable development in modern cities. The paper proposes an approach based on forward and reverse flows in urban logistic. To that end, we present a location-allocation of logistics platforms in a reverse logistics system. We, then, locate allocation and evaluate their effect on logistic platforms. In doing so, we present a mathematical model of the city logistics platform to specify location-allocation problem. Our model considers both flows: urban freight and reverse logistics. Subsequently, we improve city logistics platform's financial situation by reducing operating costs. Finally, we use a numerical algorithm for optimization and illustration purposes.

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Keywords: urban logistics, logistics platform, reverse logistics, optimization and sustainable development.

1. INTRODUCTION

In the last decade, more than 100 million people have moved to the cities and about 70% of the population will live in by 2050 (Lee, 2014). This growth is causing many problems such as traffic congestion, environment pollution, safety risks, etc. Dealing with this, many studies from different communities have been investigating transport issues and urban logistics (Guyon et al., 2012). Urban logistics “*is the process of totally optimizing the logistics and transport activities by private companies with the support of advanced information systems in urban areas*” (e.g. cities) (Taniguchi et al., 2001). It is an integral part of the market economy framework while considering traffic environment, congestion, safety and energy savings (Taniguchi et al., 2001).

Urban logistics have an important role on economic vitality of cities dealing with express deliveries, frequent deliveries, e-commerce, fast growing and home delivery market (Behrends, 2016). Consequently, cities always try to offer new strategies in order to increase citizens' quality of life and to improve economic competitiveness (Schliwa et al., 2015). Moreover, urban logistics frequently called the last mile, are one of the most expensive and polluting part in the supply chain (Gevaers et al., 2009). New logistics schemes have been developed in order to improve urban logistics and minimize negative impacts. It focuses on the consolidation of goods flows by using a distribution centre. It appears to be a good solution to meet the new objectives of the policy makers: redesigning the flow of goods inside the city while not increasing the cost, reducing pollution and making the city more attractive (Moutaoukil et al., 2015).

We can cite as logistic platforms: urban distribution centre (UDC) or urban consolidation centre (UCC) defined as city

logistics centre (CLC) in order to cope with these negative impacts. The CLC has a crucial position in the modern urban logistics system (Rao et al., 2015). It is defined as a logistics hub where consolidation and coordination activities are executed and which can be close proximity or within the city center area (Crainic et al., 2009). However, the location of CLC problem affects the functioning, efficiency and costs for urban logistics. Thus, an efficient selection of CLC location will reduce the logistics costs, make more valuable the logistics flows, reduce negative externalities, and make cities more sustainable (Rao et al., 2015).

In this paper, we present an enrichment of city logistics centre using additional functionalities based on reverse flow. Besides, we analyze allocation's location and evaluate their effects on logistic platforms at a given position. In doing so, we present a mathematical model of the CLC location-allocation problem supporting two kinds of flows: urban freight and reverse logistics. This model aims to improve financial situation of CLC by addressing current expenses due to their high operating cost (Ndhiaief et al., 2015). We propose a mixed integer programming with quadratic terms in which both forward and reverse flows are integrated. Then, we use Branch & Bound with default parameters of the solver to optimize our model.

The paper is structured as follows. Section 2 introduces our approach where we define a mathematical model for searching the best location among multiple logistics platforms (including delivery and pick up) to maximize the profit. We illustrate our approach using a numerical example in section 3. Section 4 presents the related work of logistics platforms and reverse logistics. Finally, we conclude and discuss future directions in section 5.

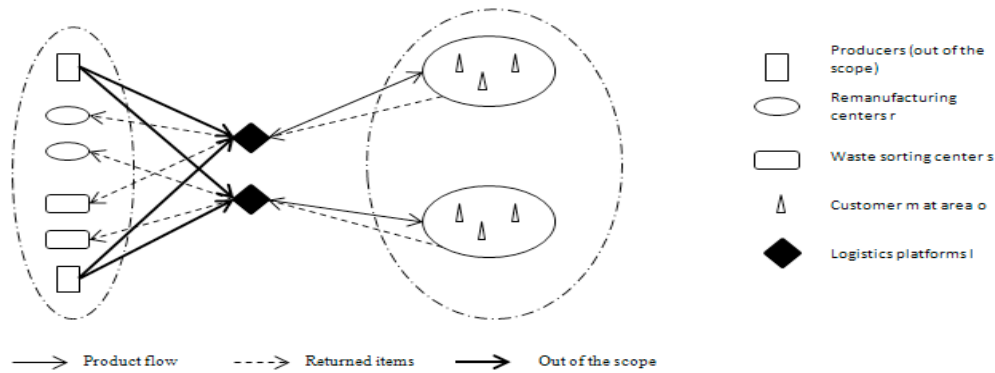


Fig. 1: global supply chain proposed in this work

2. PROBLEM DESCRIPTION AND MODELLING APPROACH

2.1 Problem description

The proposed approach focuses on delivery and collecting system (products returned and recyclable waste) in urban areas (see fig.1). The proposed model involves four kind of participants i.e., a set of available spaces L of logistics platforms, a set NT of customers, a set R of remanufacturing centers and a set S of waste sorting centers. At the customer level, there are product demands D_{mot} , returned products ready to be recovered YN_{mot} and recyclable waste QS_{mot} . These logistics platforms are in charge to ensure deliveries new products and collecting returned products and recyclable waste.

Moreover, we aim to improve the financial situation of city logistics platform. In doing so, the returned products collected YR_{rt} will be sold to remanufacturing center. Regarding recyclable waste QS_{st} , it will be sold to waste sorting center. We have also as revenue the collection cost fs_{ol} paid by customers, where logistics platforms are not charged to transport collected product to remanufacturing centers and waste sorting centers.

We assume that the product demands are known but generated randomly and satisfied by retailers. Once the demands received from retailers, the logistics platforms are charged to ensure flows consolidation and to redirect them to the customers in order to satisfy them. During the delivery process, product retailers and recyclable waste are shipped back to logistics platforms. We suppose that the urban area has Z zones, where each zone has N customers.

Our modeling effort is to optimize platforms localization in a sustainable way and maximize profit. In doing so, platforms are considered incapacitated, where vehicle used for vehicle routing has three kinds of capacities: (1) capacity in products, (2) capacity in returned products, and (3) capacity in recyclable waste. Regarding the solution domain of candidate logistics platforms, it is discrete and the number of hubs to locate is exogenous (the number is primarily specified).

2.2 Problem formulation

Here we define our mathematical reformulation by identifying three parts: parameters, variables, objective function and constraints (cf. page 4).

• Model parameters

Here, we list the model's parameters (cf. table 1).

Table 1. Parameters of the model

$m \in N$	Index of customers
$l \in L$	Index of potential location sites for logistics platforms
$r \in R$	Index of remanufacturing center
$s \in S$	Index of waste sorting center
$o \in Z$	Index of area
$t \in T$	Index of period
D_{mot}	Demand of customer m in area o during the period t
DZ_{ot}	= 1, if a customer belongs to an area o with a demand at a period t , otherwise = 0
pvr_l	Sale price of returned product related to logistic platform l
pvs_l	Sale price of recycle waste related to logistic platform l
fs_{ol}	Collection cost paid by customer from area p to site l
YN_{mot}	Amount of products collected from customer m belonging to area o and transported to logistic platform at potential location l
QN_{mot}	Amount of recyclable waste collected from customer m belonging to area o and transported to logistic platform at potential location l
fl_l	Excess of operating cost of each logistics platforms
$Cpol_l$	Cost of pollution associated to the site l
$Caccl$	Accessibility cost of resident associated to the site l
CL	Renting cost of each vehicle
Cap	Cost of pollution associated to renting vehicles
Ct	Transportation cost of products per kilometers

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