Estimating traffic flows and environmental effects of urban commercial supply in global city logistics decision support

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Abstract

We present an integrated transport and land-use model for prediction of traffic flows for the entire urban logistics system. The model shows the relation between several aspects of commercial strategies (store location, commercial area's supply, and urban planning policies) and both the upstream distribution of goods and the downstream usage of private vehicles for shopping. Several case studies based on representative scenarios are proposed.

Introduction

City logistics studies the urban part of the logistic chain and more precisely freight movements in order to reduce costs and externalities related to urban freight distribution, mainly congestion and pollution. Two main movements can be identified for freight in urban areas: *logistic movements* are related to freight distribution between the different activities, i.e. the exchange of goods between establishments; *end-consumer movements* can be defined as the trips where the purchased goods are moved by the consumer [3]. The first group of urban freight movements has been one of the most studied subjects in city logistics research. The second group, commonly studied in other fields [5] but often not modelled as a part of the global urban freight distribution chain, is however an important component in terms of traffic volumes. In France, shopping trips represent from 10% to 25% of the total person trips, depending on the day of the week [1]. Moreover, end-consumer movements represent among 50% of the total km.PCUs (Passenger Car Units) of urban freight transportation. In terms of pollution, the urban transport of goods, including end-consumer movements, produces about 25% of the total CO_2 emissions for transport, 35% of the NO_x emissions and 40 to 50% of the solid particles [4].

The aim of this paper is to propose an integrated road traffic flow prediction model for urban logistics systems, then to apply it, using a set of scenarios to represent several future states, to the metropolitan area of Lyon in France.

Freight movements estimation: a global approach

The model is built considering the interactions between urban planning for commercial areas, land-use strategies, distribution solutions and shopping trip flows, in order to evaluate the impact of the different city logistics approaches on the overall system, defined by the different types of goods movements. The model is composed of two modules: logistic movements simulation (FRETURB) and end-consumer movements generation (Shopping Trip Generation, STG).

FRETURB is a prevision and diagnosis model for decision support in urban freight distribution that integrates several modules [1]. In our integrated approach, we will use the following two:

- Pick-ups and deliveries demand generation in each urban area. This module's variables are related to the establishments: type of activity, number of jobs and number of subsidiaries.
- Road occupancy by running vehicles module. This module estimates the traffic flow of freight distribution vehicles in each area, according to the number of stops in the rounds, the vehicle type, the operating mode and the density of activities. The distance to the town centre is considered in case of direct trips and the first leg in case of rounds.

The model has been calibrated from logistic behaviours observation, for several surveys in the late 1990's . Organisation and management of the logistic chains have been analysed according to a large typology of establishments (116 types according to the nature of their activity and their size).

We introduce a new *Shopping Trip Generation* model built from the following definition of private car shopping trips: for each purchasing activity, two related trips are defined, one ending at the shopping activity and the other starting at it. First of all, the demand is estimated considering that the shopping destination is chosen according to the commercial zone attractiveness, which depends on the commercial supply, the type of purchase and the available modal choices. Finally, the O/D matrix is defined, analogously to FRETURB's "Road occupancy by running vehicles": the traffic flow of shopping trips by private car is estimated in each area from the trip generation data, according to the distance, to the type of urban area and to socio-economic variables.

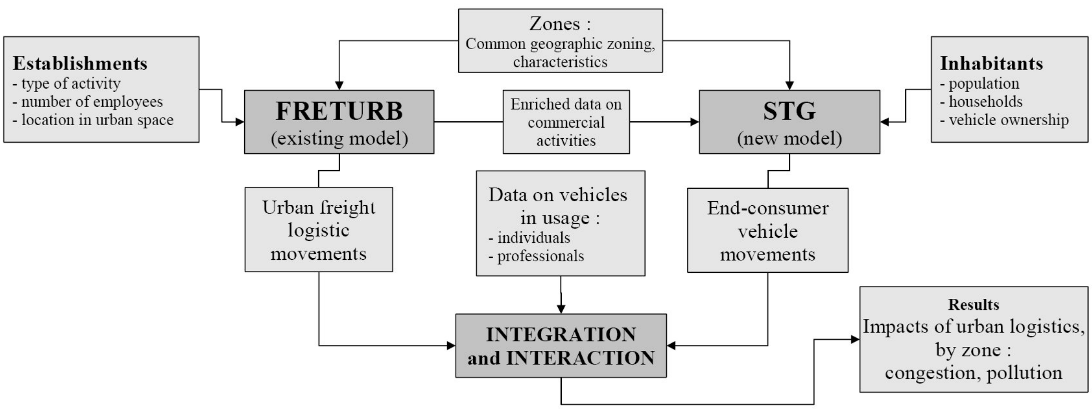

Figure 1 A Flowchart of the integrated simulation model

The method works as follows. Consider a city, divided into representative zones. Each zone is defined by two data sets: one defines the economical activities of the zone (establishments data) and the other characterises its population (inhabitants data). From the first data set, the FRETURB module calculates the vehicle flow exchanges between zones for freight distribution and collection, and gives to the STG module the composition of each commercial area (in number of stores and employees, by type of commercial activity). The STG module calculates analogously private cars shopping trips. After that, these flows are integrated in order to calculate the total number of km.PCU for freight-related vehicle trips, to calculate the congestion level. Finally, CO_2 emissions and local pollution rates can be also obtained by considering the characteristics of the different vehicles (professionals and individuals) in the considered city.

Proposed scenarios and computational experiments

The model is applied to the urban area of Lyon (near 2 000 000 inhabitants), using the information provided by the 2006 household survey (covering 454 towns and near 830 000 households), and the 2005 SIRENE directory, the national exhaustive firm register, providing establishments NACE among other information.

Different scenarios are proposed to simulate four contrasted extreme commercial land-use policies. Starting from the current situation (year 2006), the simulation is conducted to know the effects, at the horizon 2025, of an exclusive development of:

- big commercial areas on the periphery, with specialised retailers and hypermarkets;
- medium supermarkets and specialised stores, in every district of the city;
- e-commerce with home delivery services, that should help to limit the shopping trips, but needs specialised distribution services on the upstream side of the chain;
- e-commerce with reception points, where the consumer can go by car or by other modes, depending on the quality of the network and its sufficiency in every part of the city.

A fifth simulation should be a more realistic scenario with a mixture of the commercial policies presented above, in order to find a sustainable mix of policy choices for the coming decades.

The main results show that the decisions in urban planning and the choices of the stakeholders have significant effects on the overall traffic flows of the urban goods movements. Peri-urban location of commercial areas decreases the upstream supply-chain costs (concentration of commercial activities, no need to travel into the dense city area), but increases the downstream transportation costs (raise of the usage of private car for shopping), because of both unavailability of public transport and low density of the built urban space. The third and fourth scenarios appear to be better configurations in terms of congestion and environmental impacts of combined logistic and end-consumer movements.

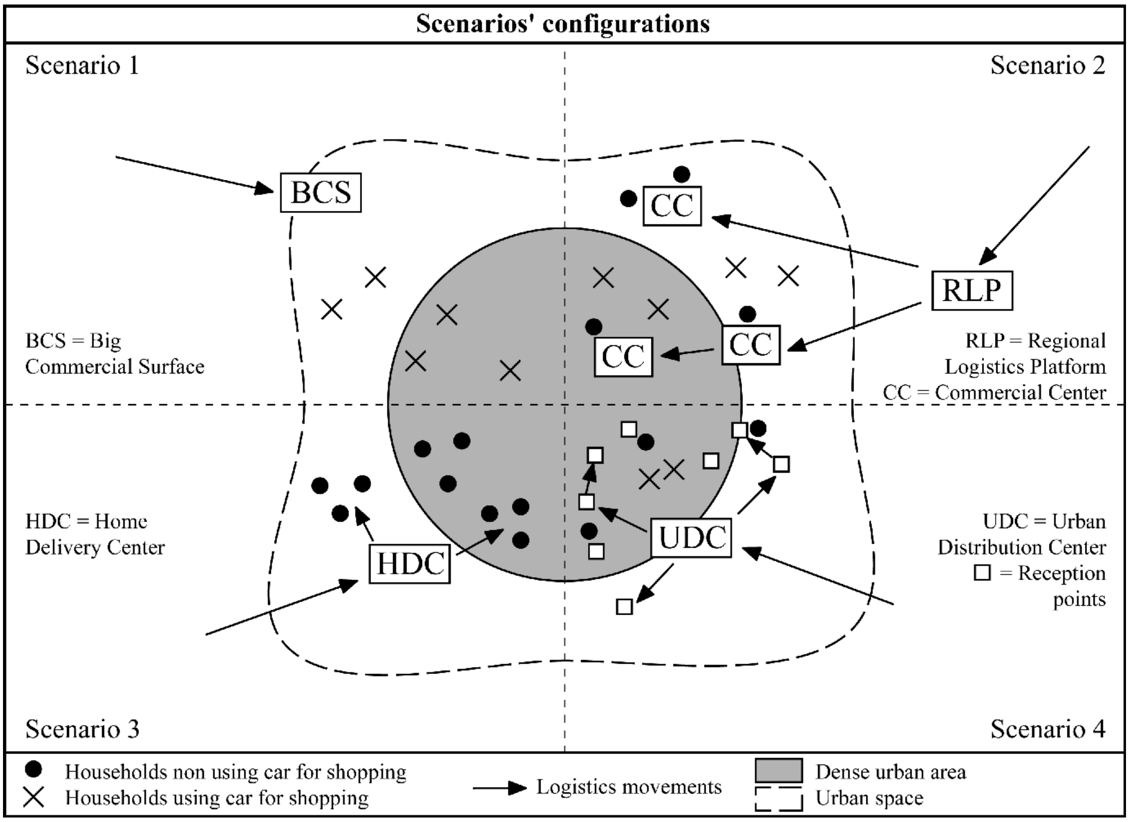

Figure 2 A schema of the four extreme scenarios

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