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European Transport \ Trasporti Europei (2013) Issue 54, Paper n° 7, ISSN 1825-3997

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Abstract

Urban goods movement modelling is a popular subject in urban logistics research. However, most models remain under-used because practitioners have difficulties to apply them to simulate urban policies and their impacts on transport flows, mainly when the assessed situations are different from the initial usage of the mode. This paper aims to answer to that issue by proposing a methodology of scenario construction and assessment using current models and tools. The methodological contribution of the paper arises on defining the main elements of a policy-based scenario and on developing a procedure to build the inputs a model needs to simulate the impacts of policy-oriented strategies on urban goods transport flows. First, the main elements policy makers can take into account when defining middle term strategies are identified. Then, a scenario construction procedure is proposed, able to build reference scenarios and trend scenarios. An example for the urban area of Lyon is proposed. According to the reference scenario, it becomes possible to compare and understand urban goods movement changes, by implementing the model introducing variations, such as activity relocation or urban distribution centre whose impacts concern not only the freight flows themselves but also the whole urban logistics organisation. In this way, the proposed methodology is adapted to policy-oriented strategic and tactical planning, mainly for public stakeholders.

Keywords: urban goods movement, transport modelling, scenario construction, urban policy, decision support.

1. Introduction

In the early 90's, the authorities of the different countries (mainly in Europe but also in North America and Eastern Asia) became confronted to the need of estimating urban goods movement (Woudsma, 2001) but a consequent lack of data on urban goods movement (UGM) made the exercise difficult. To deal with that lack of data, two main research directions have been developed in the last years: the first is that of urban goods specific surveys and the second that of urban goods estimation models. The main stakes of urban logistics can be considered at different topics and scales: reliability of the

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different logistic chains, local traffic growth, local traffic congestion, urban centres economic support, environmental nuisances (noise, pollutant emissions), urban logistic centres optimal location, greenhouse gas saving, but also urban spread effects and changes in the consumer behaviour, among others. In order to deal with public authorities planning issues, a lot of varied data collection and modelling approaches has been developed and, as we can observe from several works, a standard approach is not yet developed for none of both fields. This is mainly due to cultural and geographic reasons that make difficult to transfer approaches from an area to another (Ambrosini and Routhier, 2004).

Focusing on urban goods modelling, we observe many approaches and frameworks in the last 20 years (i.e. since Ogden, 1992), as shown by the numerous scientific works on that subject (for recent reviews on urban goods modelling, see Ambrosini et al., 2008; Anand et al., 2012; Comi et al., 2012; Gonzalez-Feliu and Routhier, 2012 and Taniguchi et al., 2012). But, as seen when comparing the most recent literature reviews, there is a big difficulty on proposing a unified vision (if we take the five last literature reviews, we do not find two that use the same definitions and terms to identify a model or make a classification). On another hand, most works remain theoretical or applied to specific calibration-based datasets, without a real application perspective. We find however a small number of approaches that derived into operational tools used by public authorities or private stakeholders, mainly for diagnosis related to strategic planning. Moreover, their practical usage is mainly restricted to urban areas within the country where the model was developed.

At the end of the 80's the Senate of Berlin aimed to propose West Germany's public authorities a tool to include commercial transport flows into traffic studies, resulting into the WIVER model (Meimbresse and Sonntag, 2001). This model, first presented in Sonntag (1985), is based on several in-depth surveys carried out at nearly 9000 premises (Munich, Berlin, Hamburg) and specific surveys of drivers on their traffic behaviour. The determination of traffic O/D is obtained in four stages, and based on the concept of round: first, the number of rounds is estimated at each origin zone; second the possible destinations are identified in comparison with the origins; third origins and destinations are matched and fourth the vehicle routes are constructed using a savings algorithm. This model has been applied to more than 15 cases of German transport planning studies, as well as to the cities of Rome and Lazio region (Italy), Madrid and hinterland (Spain) and Brussels metropolitan region (Belgium). Lohse et al. (2004) transferred the WIVER model to a general framework backed up by a system theory and included in the software program VISEVA, which can estimate both passenger and goods movements in urban areas. Recently, VISEVA has been integrated into the VISSUM modelling framework, a commercial tool of PTV traffic, and one of the most known transport demand models. However, it is unknown which are the current uses of the commercial transport module of VISSUM. Also in Germany, the company IVV Aachen developed a specific module to include goods transport in its urban transport planning software VENUS (Janssen and Vollmer, 2005). This model follows a classical four-step framework (Ogden, 1992) to estimate goods transport flows by vehicle types and trip purposes (Ambrosini et al., 2008). The VENUS software is currently available, but it is also unknown which is the acceptation and the main usage of the goods module (Gonzalez-Feliu et al., 2012a).

In France, a specific tool for urban goods diagnosis was developed under the French National Program of Urban Goods Movement (Dufour and Patier, 1997): the FRETURB model. This framework is the first to consider the movement (i.e. the pickup and/or delivery operation) as the statistical unit (Routhier and Aubert, 1999). Each movement is associated to a delivery or a pickup operation at a given establishment, a vehicle size, a mode of management and logistic behaviour. The model, built using three specific large establishment-driver surveys, estimates commodity flows between all the economic activities of a town. As input data, it requires a local establishment database but no large local surveys. Moreover, the data inputs can be obtained from standard files provided by the French National Institution of Statistics (INSEE). Several modules have been developed: inter-establishment flow generation (Routhier and Aubert, 1999; Bonnafous et al., 2013), inter-establishment flow distribution (Routhier and Toilier, 2007; Gonzalez-Feliu et al., 2013a), end-consumer generation (Gonzalez-Feliu et al., 2010, 2012b), e-commerce simulation (Gonzalez-Feliu et al., 2012a) and environmental impacts estimation (Ségalou et al., 2004; Gonzalez-Feliu et al., 2013a). Available as software since 2000, this FRETURB is nowadays used in more than 20 French urban communities (including most of the main French cities like Paris, Lyon or Lille, among others), as well as on the cities of Geneva and Zurich (Switzerland).

In Italy, the Emilia-Romagna Region developed the specific urban goods estimation model CITY GOODS (Gentile and Vigo, 2013). The model deals with two main questions: to find the generation determinants (related to the movements and not to the quantity of freight) of the different supply chains, and constructing vehicle routes for urban deliveries and pickups (passing them from the movement to the commodity). Although hybrid models combining commodity and movement have been proposed (Ogden, 1978; Slavin, 1998), CITY GOODS is the first model of this category that became an operational tool. The main scientific contribution of this model is the typology of economic activities to estimate the generation determinants and their importance at the urban level. Several Italian cities have used CITY GOODS for their urban plans, mainly in Emilia Romagna, where the tool has been adopted in the main cities' transport planning departments.

To those works we can add the Nätra software in Sweden (Eriksson, 1997) and the CROW framework in Norway (Routhier, 2001). Such frameworks have been applied in the late 90's in their respective countries. Moreover, some research works that are not still operable tools have been applied to real contexts and used for real planning issues (Wisetjindawaat and Sano, 2003; Hunt and Stefan, 2007; Wang and Holguín-Veras, 2008; Muñuzuri et al., 2009, 2010, 2011). In any case, those works are in general criticised since they fail to meet stakeholders' needs (Nuzzolo et al., 2012). According to Comi et al. (2012), four-steps models (VENUS, Nätra, CROW) fail on constructing routes, tour models (WIVER, Hunt and Stefan, 2007) and delivery models (FRETURB; CITY GOODS; Muñuzuri et al., 2011) in forecasting analysis in which the effects of city logistics measures/policies should be assessed. However, models that attempt to include forecasting and problem solving into their frameworks remain theoretical and difficult to implement (Crainic et al., 2009; Russo and Comi, 2010; Nuzzolo et al., 2012; Gonzalez-Feliu, 2013).

As a conclusion of that quick overview, we can question the use of the modelling tools by public authorities. Even if a small portion of cities are willing to use this type of tools, they restrict them to diagnosis in the context of 5-years urban plans and therefore the scientific communities have no means to verify properly usage. We can then assume that it is possible that they are not used at their full potential or out of the range of their primal aim. This leads us to extract two important notions of this reflection: the pertinence and the practices of goods movement estimation tools. These two points are fundamental if local authorities want to assess the integration of the urban goods movements in their development policies using a simulation tool. Indeed, the methodological and relevant choice of an approach/tool is a key to achieve an efficient assessment. Therefore, we can see a high potential in the construction of a methodology which can help public authorities in having the data inputs to run a modelling or simulation tool for a giver purpose, but also to guide its users through good practices.

This paper aims to show the importance of generated data in urban goods simulation by proposing a methodology for scenario construction and applying it to a middle-term forecasting before-after analysis. First, the background, context and motivation of such methodology are introduced. Second, the forecasting, reference situation and trend scenarios generation methodology is proposed. Third, a reference scenario for middle term forecasting in the urban area of Lyon is presented. Fourth, various applications are proposed and discussed. Finally, the generalization of such approach and the importance of rich generated data in urban goods before-after scenario simulation analysis is analysed, as well as recommendations for public decision makers are proposed.

2. Background and context, and overview of the Freturb model

In France, the main questions of urban goods movement planning and management started to be made at the beginning of the 90's (Dufour and Patier, 1997). To deal with the main issues of public and private stakeholders, the French National Program on Urban Goods Movement was created in 1993. Several actions were carried out around three main axes: urban goods understanding and modelling, urban logistics platforms and urban logistics projects and experiments. This paper relates to the first axis, which initial goal was to develop a standard survey methodology (Gonzalez-Feliu et al., 2013a) and to build a comprehensive database in order to help decision-makers in the field of urban goods movement. Three quantitative surveys have been implemented in Bordeaux, Marseilles and Dijon and the FRETURB model has been developed in parallel (Gonzalez-Feliu et al., 2013a). One of the main stakes of this approach consists in creating a relevant tool for local authorities to assess and eventually carry out urban land-use actions by knowing the impacts of such measures in the form of vehicles flow using macro-simulation models. Such concern is nowadays reinforced by energy issues and environmental impacts of vehicles flows (mainly related to energy consumption, greenhouse gas emissions, air, water and soil pollution and noise).

Note that urban goods movement is not limited to retailing distribution (Woudsma, 2001) but includes a larger set of flows (Ségalou et al., 2004; Gonzalez-Feliu et al., 2010): inter-establishment movements (about 40% of road occupancy issues of urban goods movement), end-consumer's movements (50%) and urban management flows (10%). For a detailed definition of such flows, see Gonzalez-Feliu (2010).

As seen in precedent section and in several scientific works, urban goods models are numerous and some of them are operational. However, they are not used at their best by public and private stakeholders, mainly because users do not have a tool to provide the inputs to simulate the situations they aim to. Indeed, although most models are strong to simulate different situations, they are in general presented and justified based on their calibration results, and the potential usages are not accompanied by a scenario construction methodology. Moreover, a user will not profit of the best aspects of a model if it does not have the key to provide a well-defined input dataset that represents the reality (or the hypothetical situation) he or she aims to simulate. For that reason, this paper presents a framework to define such scenarios for any model and apply it to simulate some relevant and contrasted scenarios of urban land use development using FRETURB. The proposed scenarios are based on appropriate assumptions on possible evolutions over a twenty years period in the field of urban logistics.

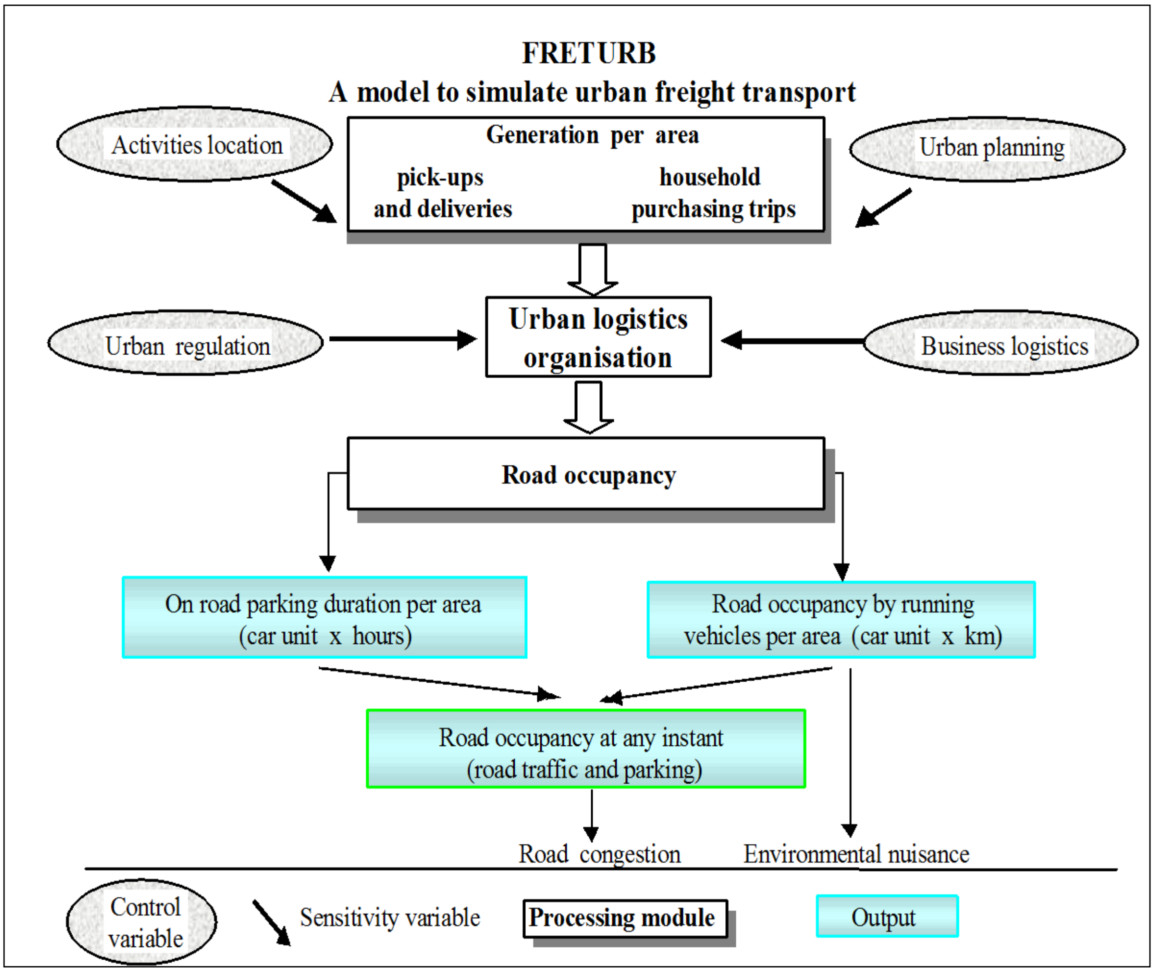


Figure 1 : Structure of the FRETURB model (adapted from Routhier, 2001)

The Freturb Model was built simultaneously with three specific thorough surveys concerning 4,300 premises, describing 11,600 delivery and collection operations, as well as interview-surveys of 2,200 drivers (Ambrosini and Routhier, 2004). The Freturb model shows specific features. Essentially, it is not based on a freight origin-destination matrix, because it is inappropriate to provide good vehicles flows estimations regarding the rounds (75 % of the pick-up and delivery flows). The premises where pick-ups or deliveries are carried out have been considered as a relevant basic unit, because information can be simultaneously collected about the logistic chains, the goods, the vehicles and the activities, among others.

The model structure is presented in Figure 1. The model is modular and is detailed in Gonzalez-Feliu et al. (2013a). We distinguish the following modules. First is that of generation of the pick-up and delivery operations in each urban area. Structural variables consist of the activity types, the number of jobs of the premises, the type of premises, the number of subsidiaries. Second is that of end-consumers movement generation. In addition to pick-ups and deliveries the model includes household purchasing trips as a function of the demographic and socioeconomic characteristics of the area (for both the population and the retailing tissue). Third is that of urban management flows, so that it is possible to compare all three UGM components. The main results take the form of road occupancy rates related to running vehicles, estimated on the basis of the distance travelled between two stops. It is estimated in each area, according to the number of stops of the rounds, the vehicle type, the operating mode and the density of activities. The length of the direct trips and the length of the approach trips (in case of rounds) are based on the distance to the town centre. To those results are added road occupancy rates by stationary vehicles (only estimated for inter-establishment movements), in terms of duration of space occupancy (illicit on road parking, no parking allowed, private parking spaces) according to demographic and activity density on one hand and to the number of stops of the rounds trips and the vehicle type on the other hand. Last but not least, a module of road occupancy at any instant, based on the opening hours of each economic activity. In this case, it is useful to display UGM peak and off-peak hours. Various simulations can be undertaken by modifying some of the control variables, which have a strong impact on the freight flows generation. As Figure 1 shows it, they concern the activities' location, the measures of urban planning and land use, those related to urban regulation and the organisational and technical actions related to logistics management. Let us stress here that the Freturb model shows the significant impacts of the activity type and the activity location on the freight flows, but it cannot explain the logistics changes in any activity.

In the following table we report the main input and output data related to the FRETURB model, as well as the form and sources of such data. For a more detailed description of the model, see Routhier and Aubert (1999), Routhier and Toilier (2007); Gonzalez-Feliu et al. (2012b), Bonnafous et al. (2013) and Gonzalez-Feliu et al. (2013a).

Table 1 : Inputs and outputs of the FRETURB model

<table>
<tr><td>Input data:
Three main files (SIRENE, zone, distance)</td><td>Output data:
Related to each category of flows</td></tr>
<tr><td>SIRENE file: extracted and enriched from the French National Establishment Census Database

• ID
• Type of activity: code NACE – European Union
• Number of employees of the establishment (it can be 0)
• Status of the establishment: headquarter or subsidiaries
• Number of establishments of the same firm
• Location: geo-localisation or zone code</td><td rowspan="3">Inter Establishment Movements (IEM)
• Disaggregated outputs: Number of movements (pickup or delivery operations) by establishment, by management mode, by vehicle type, by type of trip.
• Aggregated data: Number of movements, number of kilometres, parking time, O/D matrix (undirected). All these data per week
- By zone
- By sector
- By activity type (8 and 45 types)

End-consumer’s movements (ECM)
• Aggregated data: Number of movements, number of kilometres, catchment area. All these data per week (Monday to Saturday):
- By zone
- By sector
- By activity type (2 types: proximity retailers and supermarkets-hypermarkets)

Urban management movements (UMM)
• Aggregated data: Number of kilometres per year or per week.</td></tr>
<tr><td>Zone file: Extracted and enriched from local or regional databases.

• ID zone
• Sector
• Centroid X position
• Centroid Y position
• Population
• Surface
• Number of households
• Average number of cars per household</td></tr>
<tr><td>Distance file: Extracted and enriched from local or regional databases.

• Zone i
• Zone j
• Vehicle type (vans, rigid trucks, articulated trucks)
• Average distance (we prefer the real distance considering the network)
• Average time

If Number of zones > 100, it is needed to aggregate them on macro-zones.</td></tr>
</table>

The proposed scenarios and the general methodology aim to reveal urban goods movement changes on a given initial situation, both in terms of number and types of vehicles and in amount and types of flows. Moreover, scenario assessment will also show what urban planning policies are the most appropriate for a sustainable urban management about regulatory decisions, technological innovations, changes in the logistic systems, considerations about new types of vehicles or new ways of locating the urban economic activities. The proposed approach is policy oriented and mainly addressed to public authorities.

3. Methodology

In order to include the particularities of urban goods movement in a land-use and transport interaction scenario analysis, it is important to propose coherent scenarios for a before-after analysis[1]. To support the scenario construction and analysis phases of such assessment, we propose a general framework to represent the situations to assess in order to feed in a coherent way the urban goods simulation model that will be used. For practical reasons we will use the FRETURB model for the simulations but the framework will be defined to be applied to any model. To this, it is important to know before building the scenarios the generation determinants, the needed inputs and the possibilities of outputs the model can provide. Please note that in this paper we do not consider the role of the different actors involved, i.e. the question of knowing if measures are more or less easily accepted by the economic agents is not presently studied, but focus on the construction of scenarios and its assessment.

The framework is related to before-after analysis, i.e. to the assessment of a set of scenarios and the comparison with respect to an initial situation. Note that the initial situation is also a scenario to be built and simulated, not only a transcription of given data. Indeed, according to Bonnafous (1989), a model is a representation of the observed reality. The reference situation can then be seen as the observed reality at stage 0, but it is an observed reality. Moreover, in urban goods movement, observed data or calibration data come from surveys, or from standard data files that need to be completed and enriched. The inputs of urban goods scenarios are not directly obtained by measurements or standard files but need to be constructed. For that reason it is important to provide a framework to build a solid reference situation, as well as a set of scenarios to assess that are coherent and comparable between them and also to the reference one.

[1] By before-after assessment we intend the comparison of a given future scenario (after) with respect to an initial situation, i.e. reference scenario (before) in the sense of Leonardi et al. (2012).

Taking into account this fact, it is important to consider how to represent an initial situation and which variables will be taken into account to simulate the impact of different public authorities' actions on urban goods flows, as well as to understand how both politics and policies can represented into scenarios. Figure 1 sums up into a chart the main decision process in urban logistics long-term planning.

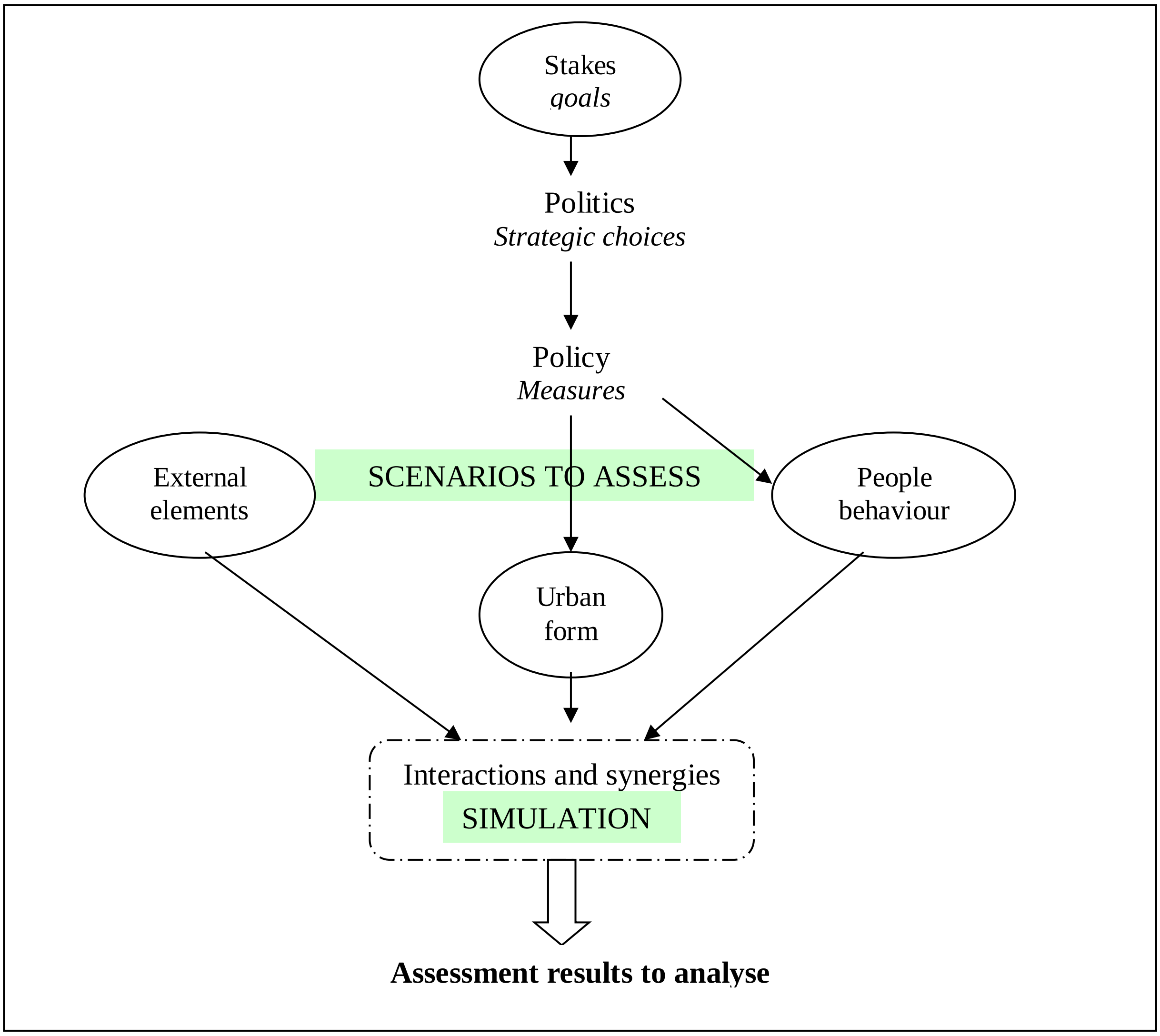


Figure 2 : Chart for urban goods assessment (adapted from Gonzalez-Feliu et al., 2013b)

The stakes will define the main goals of the long-term analysis. Public authorities take actions to meet a target, that is established a priori for different reasons (economic, environmental, political, social and urbanistic, among others) To meet the established target, several strategic choices are possible (*Politics*). These choices become the main expected objectives that can be implemented through the appropriate *policies*. The most usual policies are related to:

- the action on the land use (location of the warehouses, platforms, hyper and supermarkets and generally all type of industry), the effects of the high density;

- the optimisation of the goods management (co-operation and consolidation, bin packing, full trucks, routing etc.) including the new logistics places and with the help of the new technologies;
- the regulation by the public authorities (congestion charging and road pricing, incitements towards green behaviour);
- the development of the e-commerce, home deliveries and relay points deliveries;
- the development of clean vehicles with zero emission.

External elements are those that will interact with the policies and measures, of which the impact cannot be directly controlled by public authorities. The most important external elements are the economic and the social contexts, at all scales (world-range, continental, national, regional, local, urban, suburban, etc.) and their trends can be hypothesised but not always correctly estimated. In the economic context, the petrol price fluctuations, the economic crisis and the new economies impacts have changed the established trends and have to be taken into account carefully because of this prediction difficulty (Gonzalez-Feliu et al., 2012c). The social context, and more precisely the inhabitants' and professionals' reactions to the changes proposed by the new policies, has also to be analysed. In any case, these elements become more important in the analysis phases than in the scenario construction phase, where they are taken as evidence. Moreover, the changes in the people behaviour have to be also taken into account.

The urban form is the configuration of the urban area as a result of the politics and policy phases, and consists of the following elements:

- energy sources and motorization technologies;
- demographic and socio-economic characteristics of the population;
- demographic and socio-economic characteristics of the economic activities;
- organisation and management of the city operations.

From the elements listed above, different scenarios can be implemented and have to be simulated. Obviously, interactions and synergies among the main elements of the urban form are expected. The simulation tools in long term issues for urban goods movement are in general mesoscopic models, that are more detailed than macroeconomic models and can be adapted to a urban area in order to estimate the main trends in a long-term horizon without long and difficult calculation processes. The simulation results can be progressively improved through an iterative feedback procedure.

The methodology is axed on two main stages. First, an initial situation has to be generated. Then, and only once the initial situation is well defined, a set of scenarios representing the main choices and actions of public authorities is defined, taking into account the input needs and the output availabilities of the simulation tool to be used, the type of analysis and the decision makers to support.

4. Initial situation definition

To define the initial situation, it is important to know well which are the involved decision makers (mainly public authorities, at different levels), the data availabilities and the possibilities and functionalities of the available simulation tools. To facilitate the understanding, we will continue by directly illustrating the steps of the methodology by the implementation of scenarios using the FRETURB model

4.1. Urban context and available data (1999)

The Lyons conurbation in France, composed of 106 communes of the urban district, forms our study area. It counted in 1999, 1,300,000 inhabitants, 1,046 km², 83,557 premises and 652,000 jobs. It has been divided into three parts: the town centre, the closest suburbs (ring 1) and the more distant communes (ring 2, see Figure 3).

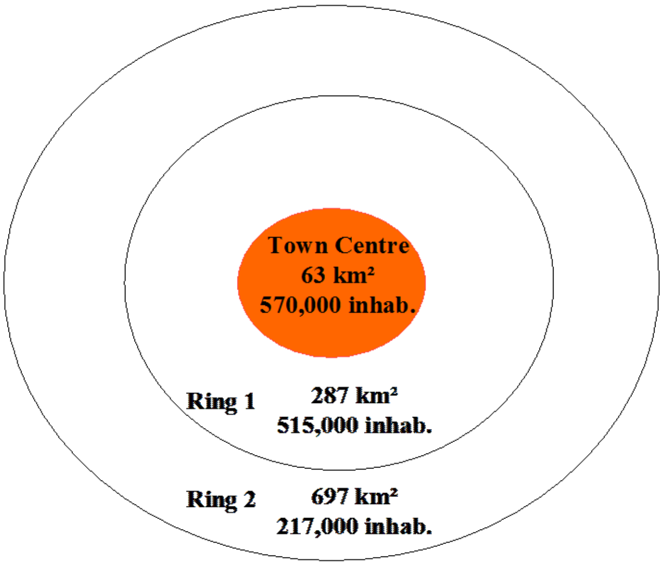


Figure 3: the Lyons conurbation

Our analysis weighs up the residence and activity densities on the one hand and their impact on the freight vehicles flows and the travelled distances on the other hand. Consequently the role of city size and the question of urban sprawl are put forward. Several indicators are produced (in particular trip length, trip duration, on road parking duration) in order to bring information to more relevant analyses, according to the types of vehicle, the covered zones (according to the rings), the activity types, the operating modes (hire or reward or own account) and the organisational modes (direct trips or rounds).

Concerning the available databases, we dispose in the given area of data of two different temporal stages (1982 and 1999). Such data include demographic, employment, activities and freight flow information, gathered from French National Statistics databases in order to feed the model. Due the lack of knowledge about the logistics practice in the early eighties we have been obliged to base the modelling assumptions on the logistics practice in the late nineties. Location and activity structure impacts on pick-up and delivery flows and urban goods movement are specially considered.

The Freturb model gives an account of the development of the Lyons conurbation between 1982 and 1999, trying to estimate the impacts of changes in the spatial configuration of economic activities (number of premises and number of jobs according to the activity in each commune). We focus on the following indicators:

- the number of pick-ups and deliveries;

- the travelled kilometres, according to three types of vehicle (light commercial vehicles (< 3.5 t), rigid lorries and articulated vehicles);
- the on street parking duration, which impacts the traffic congestion.

Note that the model is calibrated from a logistic behaviour given by several 1995-99 surveys. Organisation and management of the logistic chains have been analysed according to a large typology of activity premises (116 types according to the nature of the activity and the size of the premises) and the results correspond to a "theoretical" logistic organisation similar to the results of those surveys (Gonzalez-Feliu et al., 2013). That is the reason why this model is relevant for industrialised countries only. The following table shows the structure of the activity in the three rings. It will be a base for comparisons with our scenarios.

Table 2: the main parameters per ring in 1999, Lyons

1999	Number of premises	Number of pick-ups/deliveries	Number of jobs	Average km/trip*
Town centre	45,400 (54%)	248,800 (39%)	328,800 (50%)	5.7
Ring 1	25,000 (30%)	253,500 (40%)	223,900 (34%)	8.0
Ring 2	13,200 (16%)	134,700 (21%)	99,200 (15%)	9.7
Total	**83,600 (100%)**	**637,000 (100%)**	**651,900 (100%)**	**7.5**

*We mean by trip, the movement of a vehicle between two pick-ups or deliveries stops in the course of a round.

4.2. The reference scenario

Since many years in most of urban centres, a strong tendency of urban sprawl can be observed. An important drop in the number of small retail trades of the town centres is effective. Activities are growing in peripheral commercial zones along the highways and main roads. So our reference scenario, considered over a twenty years period from 1999 up to 2020, is supposed to keep the main trends noted between 1982 and 2006. Our assumption is to consider, over this period, a linear growth of the activities (number of premises). The model adds the difference between the 1999 number of premises and the one from 1982 to the one from 1999. We have assumed that the trends (concerning the number of premises, jobs and pick-ups and deliveries) of the 1982-99 period are kept according to an accurate breakdown of the activities (in 116 types).

In the town centre, note that some activities show downward trends: in this case the number of premises comes to zero. So we have had to pass these lacks of premises on to the rings 1 and 2 and to the closer activities; otherwise it would have led to an unrealistic increase in the number of jobs in 2020, compared with national economic and demographic forecasting.

Table 3: a simulation of the main parameters per ring in 2020, Lyons

2020	Number of premises	Number of deliveries	Number of jobs	Average km/trip
Town centre	46,117 (49%)	216,664 (31%)	326,497 (43%)	6.1
Ring 1	30,345 (32%)	299,838 (42%)	284,460 (38%)	8.2
Ring 2	18,206 (19%)	192,565 (27%)	145,805 (19%)	10.1
Total	**94,669 (100%)**	**709,067 (100%)**	**756,762**	**8.1**

Urban sprawl tends to go on (see table 1) and the number of pick-ups and deliveries increase in the distant outskirts of the conurbation. Between 1999 and 2020, the average distances per trip show a smaller increase (+0.6 km) than between 1982 and 1999 (+1.2 km). The trend to this lengthening is due to urban sprawling but it is slowed down by an increase in the activity density.

Table 4: 1999-2020 evolution of pick-ups and deliveries and travelled distances, according to the types of vehicle

1999-2020 evolution	Light commercial vehicles (< 3.5 t)	Rigid lorries	Articulated vehicles	Average
% of pick-ups and deliveries	+13%	+12%	+1%	+11%
% of travelled distances	+25%	+22%	+18%	+21%

The total number of pick-ups and deliveries increases, essentially light commercial vehicles and rigid lorries. The lengthening of travelled distances is twice more important than the number of pick-ups and deliveries. In the case of articulated vehicles, the trend is more noticeable because they work in the less dense and distant zones of the conurbation.

Our assumptions lead to the following results: the positive trends between 1999 and 2020 have levelled off and the negative gaps (especially industry and warehouses) have widened comparing to the 82-99 period. During this period, heavy industry and logistics platforms were set up beyond the reference area.

5. Scenario simulation results and discussion

From this reference scenario, we built a few simulations - somewhat typical -, in order to estimate their impact on the change of the expected trends, notably the average travelled distances of the commercial vehicles. Such simulations use three types of variables:

- Land-use choices, related to warehouse, wholesalers, retailers and households locations and their respective concentration/sprawl.
- Organizational choices, related to the usage of consolidation platforms (urban distribution centres, UDC), the organization or routes and the proximity deliveries strategies, among others.
- Technological choices, related to engine power sources and ICT/ITS assistance.

In the present paper, we will focus on land-use choices and their combination to organizational choices, focusing on inter-establishment movements (for e-commerce interactions, see Gonzalez-Feliu et al., 2012a). The effects of technological choices have been made the object of a recent paper (Gonzalez-Feliu et al., 2012c)

Using the Freturb model, two parameters involve substantial changes: the activity type and the activity location. Remember that the model can't give an account of the logistic changes that occurred in each activity between 1982 and 1999. For that reason we propose a first group of scenarios expanding the findings in Gonzalez-Feliu et al. (2012b) not only to retailers but to other activities of the city. Analysing the consequences of a significant return of commercial trades in the town centres may be considered according to two scenarios, as follows.

5.1. Impacts of urban density and activity relocation

5.1.1. Return of retail trade to town centre

This 2020 scenario simulates two main trends: the first is that the drain stopping of small retail shops in the town centre: the number of premises of 1999 is kept; the second, that the building stopping of hypermarkets (> 2,500 m²) in the rings 1 and 2: hypermarkets are converted into supermarkets and the latter into small retail shops. According to this assumption, the premises which are not built in the ring 2 are allocated to the ring 1. The same is done between the ring 1 and the town centre. To that purpose, changes in the assignment of some premises are carried out in the different areas of the city (from the outskirts towards the central zones; from less dense zones towards more dense zones). Small retail shops or supermarkets are generated by the model in place of the hypermarkets to come all over the scenario's period, according to the total weight delivered by the different types of shop as follows in the table 10:

Table 5: substitution assumptions between the different types of shops

	Average weight of delivered goods per premises	**Equivalence**
Hypermarket (> 2,500 m²)	464 tonnes per week	9 supermarkets
Supermarket (< 400 m² and > 2,500 m²)	53 tonnes per week	37 retail shops
Department store	39 tonnes per week	27 retail shops

This scenario assumes that the behaviours of the inhabitants are similar to those of 1999 regarding private car using. It is relevant only if the settlement tends to a sprawling stabilisation.

Table 6: breakdown of the private cars in household purchasing trips

	Supermarkets	**Hypermarkets**	**Small retail shops**
Reference scenario	11%	26%	63%
Scenario 1.1	13%	15%	71%
1999	9%	18%	73%

5.1.2. Return of wholesale trade and light industry to town centre

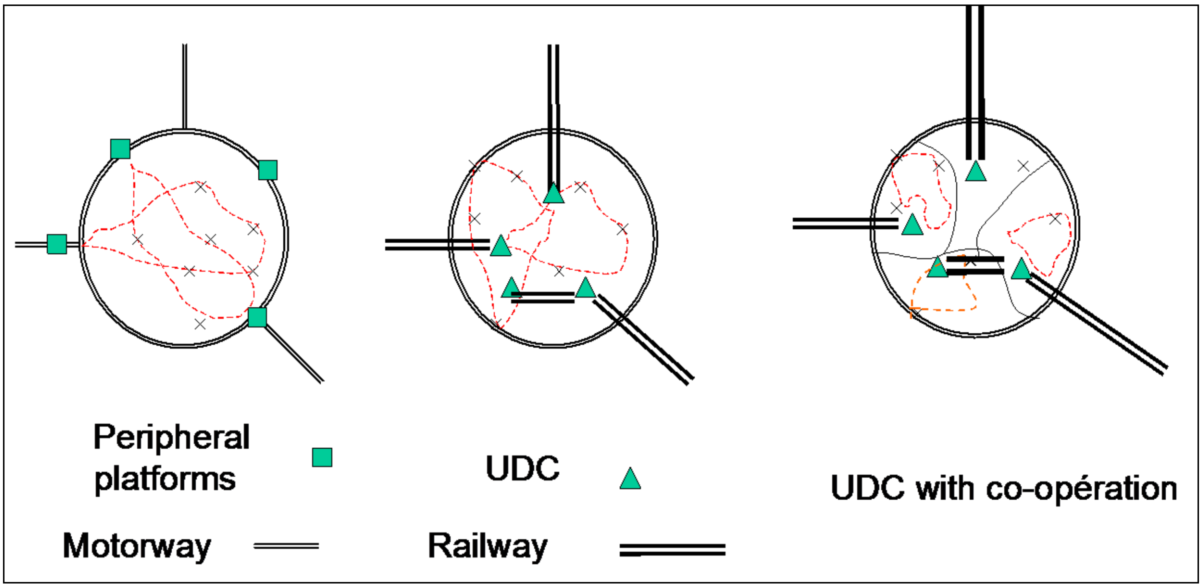
The above assumption is now enlarged from retailers to wholesale trade and not polluting industries (producer and intermediate goods industry (small items) and consumer goods industry). In the town centre and according to the reference scenario, the growth rate of these industries is negative while it is positive in the two rings. For that reason, in the town centre, the number of light industry premises of 1999 is kept. The remaining growth between 1999 and 2020 is allotted to the rings 1 and 2 (by relocation from a zone to one another), according to the significance of these industries in each of them. In the town centre, the number of wholesale premises of 1999 is kept. An average growth rate (2 %, got from the growth rate of each zone between 1999 and 2020) is used to calculate the number of premises in rings 1 and 2 in 2020.

5.2. Changes in the urban logistics structure

5.2.1. Urban distribution centres (UDC) without co-operation

This 2020 scenario is built in the following way: a few platforms, consisting in wholesale premises, warehouses or depots, initially distributed around the main interchanges (see figure 7: first drawing) are relocated in more central zones (see second picture of figure 4), to serve these urban central areas. Note that the provisioning mode of the UDC may be implemented by means of railway installations. Various recent French studies seem to suggest that, in the best case, only around 20 % of the delivered weights in the central zones are capable of passing through an UDC. This is confronted by a case study in Italy where essentially the small retail shops and the services activity in the city centre are concerned by UDC (Gonzalez-Feliu and Morana, 2010). In the contrary frozen food, perishable goods and voluminous goods don't usually pass through UDC. In our case, those 20 % of weights amount to the capacity of 70 warehouses. So the implementation of the simulation consists in relocating 70 peripheral platforms in the town centre and not far from it. Note that the total flows are not changed and these flows concern the only central zones of the conurbation. Besides, the urban logistic chains of delivery are not modified.

Figure 4: urban distribution centres without and with co-operation



5.2.2. Urban distribution centres with co-operation

Compared with the previous scenario, this one is built as follows: the platforms are relocated in more central zones, in such way that each of these platforms have a commercial influence without overlap (see third picture of figure 7). In this case, beyond the relocation of the platforms, the transport operators have to co-operate, what requires a strong will from them and the local authorities. Central zones are partitioned, in such way that the direct trips and the rounds generated from each platform are restricted to their own geographical commercial influence area. In this case, the simulation consists in estimating the delivered flows (all in all, these flows are similar to those of the previous scenario) according to 7 commercial areas defined on the central zone of Lyons conurbation. This division into sectors results in a mechanical decrease in the travelled distances. For this scenario, the model is implemented on each commercial area. Note that the remaining 80 % flows (not passing through the UDC) are managed independently (without co-operation) by the concerned operators.

5.3. Assessment results and analysis

All scenarios are simulated and reported on Table 7. Note that some scenarios (1.1 and 2.1) do not present a big difference in terms of total travelled km but the impacts are better seen in average number of km per trip. Concerning number of pickups and deliveries, the scenarios do not have a significant impact.

Table 7: a comparison between the different scenarios (35)

Scenario	Total travelled kilometres per week	Gap	Number of pick-ups and deliveries per week	Gap
Scenario 0	5,729,000	-	709,000	-
Scenario 1.1	5,726,000	-0.1%	714,000	0.7%
Scenario 1.2	5,332,000	-6.9%	709,000	0.0%
Scenario 2.1	5,694,000	-0.6%	709,000	0.0%
Scenario 2.2	5,345,000	-6.7%	709,000	0.0%

Scenario	Average km/trip (vehicles < 3.5 t)	Average km/trip (rigid lorries)	Average km/trip (articulated)	Average km/trip (all vehicles)	Gap
Scenario 0	6.6	7.9	16.3	8.1	-1.2%
Scenario 1.1	6.5	7.8	16.3	8.0	-7.4%
Scenario 1.2	6.1	7.3	15.1	7.5	-1.2%
Scenario 2.1	6.5	7.8	16.2	8.0	-7.4%
Scenario 2.2	5.9	7.4	15.8	7.5	-1.2%

If we observe scenario 1.1 and compare it to the reference we can state an increase in the number of household purchasing trips (+3.6%), that is 18,000 trips per day. Moreover, there is a slight decrease in the number of private car purchasing trips (-0.8%), that is 3,500 trips per day, and a significant decrease in the private car distances (-6.3%), that is 115,000 km per day. This results on an overall impact which is negligible because it is compensated by the savings related inter-establishment flows. Scenario 2.2, without modifying shopping trip behaviour, has an important impact on inter-establishment flows. Indeed, the main limits of the return to the centre of wholesalers and logistics activities is the land cost, which does not facilitate those changes, but the results in terms of road occupancy are evident (near 7% of km savings per week).

Scenario 2.1 (the relocation of UDC) allows a very small decrease in the travelled distances (less than 1%), confirming the qualitative findings of several authors on such field (Allen et al., 2012). Scenario 2.2 (relocation of UDC with co-operation) is more attractive: the saving reaches 384,000 km (about 7% with respect to scenario 0).

6. Conclusion

In this paper we proposed a methodology to estimate scenarios for before-after assessment in terms of urban goods movement and land-use policies. In order to estimate impacts of relocation measures, it is important to take into account private car household purchasing trips which represent the most part of the kilometres dedicated to the urban supplying. Beyond the relocation of the platforms, the transport operators have to co-operate, what requires a strong will from them and the local authorities.

The first of the above scenarios, aiming at keeping the small retail trade activity at the 1999 level in the town centre, have no impact on either the total travelled kilometres per week or the average travelled distances per vehicle types. A significant increase in the number of pick-ups and deliveries towards more small retail shops can be observed. On the contrary, this scenario involves a rather significant decrease in the private car travelled distances carried out by the consumers on the occasion of their purchase. It is noticeable that the second scenario leads to use more light and small commercial vehicles and to keep an average travelled distance per delivery around 7.5 kilometres, which is similar to the 1999 one. The impact of the first of the two last scenarios (2.1: UDC without co-operation) has not a significant impact on the total travelled kilometres and on the average travelled distances per vehicle types. In the contrary, the last scenario (2.2: UDC with co-operation) leads to similar average travelled distances per vehicle types, compared with 1999. Obviously, to be appropriately implemented, this scenario requires a strong political will from local and national authorities to incite loaders, receivers and carriers to use UDCs; but in the end the results show well the positive impacts for a sustainable development of the city. However, the applicability issues, mainly in terms of acceptance by the difference stakeholders, have to be taken into account complementarily to this analysis to avoid legal conflicts (Ville et al., 2012)

Several other scenarios can be considered, such as that of collaborative transport systems, new forms of B2C distribution and commerce (already studied in Gonzalez-Feliu et al., 2012a) and generalisation of new engine technologies and ITS, among others. At the moment, directly related to our investigations, we focus on the following ones. First, a more thorough examination of urban logistics structure changes by considering logistic sites lighter than urban distribution centres, located in the town centre. Instead of relocating the peripheral platforms, each of them are reassigned to one zone of the town centre. The commercial influence of each place is rather small, so as to optimise the length of trips, with positive environmental impacts. Second, we are also studying the impacts of share changes in operating modes (hire or reward and own account operators). It is important to leave aside not flexible activities in relation to own account transport (perishable goods or cold chain, among others). Third, the ongoing technological developments concerning the use of specific urban vehicles (carrying capacity of 5 t) and the use of clean urban vehicle. The implementation of the environmental module of the Freturb model enables to produce interesting results (Ségalou et al., 2004).

Finally, we aim to stress that the methodology is not exclusive to FRETURB but can be applied to any model, taking into account that input data need to be identified then the different scenarios to assess have to be translated into those inputs. A further development of the method would be the construction of a computer-based procedure that helps to produce such input data for the main categories of models.

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Acknowledgements

The authors wish to thank Jean-Louis Routhier, from Laboratoire d'Economie des Transports, for his participation to the discussion of the scenarios as well as anonymous reviewers for their valuable suggestions that helped to improve this paper.