A combined people-freight accessibility approach for urban retailing and leisure planning at strategic level

Jesus Gonzalez-Feliu, Aurélie Mercier

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Jesus Gonzalez-Feliu[1], Aurélie Mercier[2]

[1] Laboratoire d'Economie des Transports, Centre National de la Recherche Scientifique, 14 Avenue Berthelot, 69363 Lyon Cedex 07, phone : +33 4 72 72 64 44, e-mail : jesus.gonzales-feliu@let.ish-lyon.cnrs.fr

[2] Laboratoire d'Economie des Transports, Université Lumière Lyon 2, 14 Avenue Berthelot, 69363 Lyon Cedex 07, phone : +33 4 72 72 64 44, e-mail : aurelie.mercier@let.ish-lyon.cnrs.fr

Abstract

Although accessibility is usually known by urban planners, it is often applied to only people transport. However, retailing deployment needs to relate accessibility and attractiveness to both people transport (for shopping purpose) and goods transport (for delivery purpose to retailers). This paper proposes an exploratory gravity accessibility analysis applied to urban goods transport in Lyon, France, to support public decision choices in terms of retailing land use. First, an overview of accessibility used in urban goods transport is made to motivate the proposed framework. Second, the indicator is presented and justified. Third, the analysis is applied to the current situation for the urban area of Lyon, presenting and discussing the main results. Finally, recommendations to public authorities for their land-use policy assessment in terms of impacts on freight transport are proposed.

Keywords: retailing land-use; urban goods transport; accessibility; attractiveness

1. Introduction

Urban goods movement demand estimation is a popular subject in research and practice, and different models have been proposed and implemented in the last decades. However, most of them focus on retail deliveries, the part of urban goods which is one of easiest to optimize. Indeed, since most retailing deliveries can be shared into LTL routes and optimized using vehicle routing approaches, other flows, mainly those of people traveling for shopping purposes and bringing goods to households, are less studied. Moreover, public planners dispose of few tools to integrate urban goods trips into their studies and analyses (Comi and Rosati, 2013; Gonzalez-Feliu et al., 2013a). In people transport, two main methods are used to support city planners: Transport and Land Use Interaction (LUTI) models (Wegener, 2004) and accessibility-based tools (Buettner et al. 2013). To the best of our knowledge, both approaches are not widely deployed in urban logistics. We focus here on the concept of accessibility, often used in urban planning, seldom takes into account the goods transport and supply structures. This approach seems promising but has been little studied in urban goods transport.

This paper aims to propose a modeling approach for urban retail planning and development based on a double accessibility concept. First, a synthetic literature review on combined interestablishment and end-consumer movement generation models is made. Second, the methodology of the proposed framework is described. This framework first defines, for a whole urban area, the accessibility of the various zones. Such accessibility is doubly defined: first for delivery purposes, i.e. in terms of truck accessibility; second for shopping purposes, i.e. in terms of shopping attractiveness. Both indicators are defined on the basis of exponential gravity accessibility, and then combined to propose a unique indicator. Then, a model estimating the road occupancy issues in each zone is proposed. This model estimates road occupancy rates concerning both deliveries and shopping trips. First, an overview on accessibility and their applications to goods transport is made. Second, the methodology for defining the gravity accessibility related to retailing deployment in urban areas; this indicator defines, for a whole urban area, the accessibility of the various zones. Third, the accessibility analysis is applied to the current situation in the urban area of Lyon (France). Finally, recommendations to public planners are proposed.

2. Literature review

The notion of accessibility has been used and analyzed since long time in urban transport planning but also in urban development analysis (Geurs and van Wee, 2004). We observe in literature several definitions of accessibility, some of them derived into quantitative indicators, others related to qualitative studies. Accessibility can be defined "*the extent to which land-use and transport systems enable individuals to reach destinations by means of a transport mode*" (Geurs and van Wee, 2004). Following this definitions, four categories of accessibility indicators can be defined.

The first category is that of infrastructure-based indicators, largely used in transport planning studies made by public authorities. These measures deal with service level related to a transport infrastructure, as for example the congestion level or the average travel speeds on a road network (Linneker and Spence, 1992; Ewing, 1993). The second is that of location-based measures, analyzing accessibility at physical locations, usually on a macroscopic perspective. The measures usually describe the level of accessibility to spatially distributed activities, and are largely used in urban planning and geographical studies. Two main groups of indicators can be distinguished in this category: distance based indicators and potential accessibility measures. The distance-based indicators (Ingram, 1971; Pirie, 1979), also called connectivity measures, represent the degree of which two locations are connected. Several distance measures can be defined, as for example the line distance between two points, other non-linear distance measures, the travel time or the transportation cost required to access a number of opportunities (Geurs and van Wee, 2004). The potential accessibility, also called gravity-based measures, estimate the accessibility of opportunities in zone i to all other zones. These measures take into account both the number of opportunities and the transportation costs to reach them (Stewrart, 1947; Hansen, 1959; Ingram, 1971; Vickerman, 1974).

The third category contains person-based measures, which define accessibility at the individual level and measures limitations on an individual's freedom of action in the environment (Burns, 1979; Miller, 1999; Recker et al., 2001). The fourth one is related to utility-based measures, which derive from the main benefits that people derive from access to the spatially distributed activities. This type of measure has its origin in economic studies, and interprets accessibility as the outcome of a set of transportation choices. Two main types of measures are used: logsum indicators, which study the desirability of the full choice set (Ben-Akiva and Lerman, 1979), and doubly constraint entropy models (Martinez, 1995).

Although most works deal with personal travel accessibility (either by car or public transport), we observe also works dealing with freight accessibility , mainly related to the location of terminals (Taniguchi et al., 1999; Hesse and Rodrigue, 2004), or to congestion charging of inter-urban highways (Litman, 2003; Sohn, 2006).

Regarding urban goods distribution, the gravity accessibility has been used to analyze the suitability of optimizing urban goods transport systems with cross-docking, relating them to vehicle routing optimization methods (Gonzalez-Feliu, 2008; 2012; Crainic et al., 2010). In those works the opportunities are defined by the quantity of freight to deliver, following carrier organizational aspects; furthermore, costs are associated directly to Euclidean travel distances (i.e. distances “as the crow flies” and not real distances or travel times). Since the works are carrier-based and aim to study the suitability of route optimization approaches based on the only distance and cost factor, those indicators offer a good vision of the problem. However, to the best of our knowledge, we did not find accessibility analyses focusing on retailing activities, dealing with both personal and freight transport, for public planning purposes. Although some works focus on relating shopping trips to deliveries (Crocco et al., 2010; Gonzalez-Feliu et al., 2010a, 2012a; Russo and Comi, 2010; Nuzzolo and Comi, 2014), they relate planning scenarios to impacts in transport using a modelling framework without examining accessibility. Since accessibility is very popular in personal transport (Crozet et al., 2012), it seems important to us to analyze the potential of such indicators for goods transport related to retailing activities, so including elements to represent both deliveries and shopping trips.

3. Methodology

The aim of this work is to study the retailing accessibility. To do this, we propose a gravity accessibility indicator (Hansen, 1959). This indicator takes the following form:

$$A_i = \sum_j D_j e^{-\beta C_{ij}}$$

where A_j refers to the accessibility to retailing activities at zone j, D_j represents the opportunities at zone j, C_{ij} the generalized travel cost from zone i to zone j, and $\beta > 0$ a given parameter representing the travelling impedance.

In this work we assume $\beta = 0.18$ corresponding to the sensitivity to generalized travel costs for personal household-work trips at morning peak hour (Mercier and Stoiber, 2010).

The opportunities D_j are defined as the number of jobs of retailing activities at zone *j*, (Crozet et al., 2012b). Retailing activities can be of different sizes and natures (Gonzalez-Feliu et al., 2012b). Regarding the nature, a standard classification of retailing activities can be obtained from the NACE code of each premise (Gentile and Vigo, 2013). Such classification, although useful for freight transport demand estimation, is not adapted to shopping trip generation since household trip surveys (the only available data sources including shopping trips) do not include a detailed category of retailing activities. Indeed, only four categories of shopping trips are identified, related respectively to open marketplaces, small retailers, medium stores and big stores. The size of those retailing activities is defined related to its commercial surface in a standard way, as follows: a small retailing activity has a surface up to 450 m², a medium store a surface between 450 and 1500 m² and a big store more than 1500 m² (Beauvais, 2005). According to Gonzalez-Feliu et al. (2012b), it is important to distinguish small retailers and medium-big stores when relating them to both deliveries and shopping trips, since their trip generation variables and intensity are different. Although medium and big stores could be considered separately, the quantity and quality of data available, and the similar functions of medium and big stores (for both grocery and non-food products) led us to group them into the same category.

Taking into account such considerations, we aim to pursuit three types of analyses. The first will include all retailing jobs, without making the difference between small retailers and medium-big stores. This first analysis will give a general vision on the retailing attractiveness without regards of the type of retailer. The second and the third concern respectively small retailers and medium-big stores, taken into account separately

All three accessibility analysis approaches are made on the urban area of Lyon (France), which has been divided into 743 zones (Iris Zoning of year 2000).

To take into account the freight deliveries, the generalized cost is not related to private car travel but to goods distribution. To do this, we calculate the total cost, in euros, of an urban delivery trip between two zones. Such cost is related to both the travelled distance (mainly fuel and tire usage, among others) and the travel time (employee's costs, insurance, etc.), and can be estimated using standard ratios (CNR, 2012; Gonzalez-Feliu et al., 2013b). The generalized cost C_{ij} between zone *i* and *j* can then be formulated as follows:

$$C_{ij} = 0.35 d_{ij} + 34.52 t_{ij}$$

Where d_{ij} is the average travel distance and t_{ij} the average travel time between *i* and *j*. To estimate travel distances and times, we used the MOSART platform (Crozet et al., 2012a,b) on the basis of Lyon's urban road network of year 2012 and the evening peak hours for travel times. The model is calibrated using the Household Trip Survey of Lyon 2006 (Sytral, 2006).

4. Simulation results

Taking the current situation (that of year 2006) in Lyon's conurbation, we have estimated the corresponding retailing-based gravity accessibility indicator for each zone. 746 zones have been identified. We report below two maps: the first represents the accessibility for small retailers, the second that of big stores. In both cases, to orient the reader, we chose a color code related to descriptive statistical characteristics of the obtained results. In other words, we ordered accessibility in decreasing order and divided the obtained results in four groups (one per quartile) and gave a color to each quartile: dark brow represents first quartile, red second quartile, orange third quartile and pink fourth quartile.

We observe that for small retailers, the quartile spatial distribution of zones in terms of accessibility shows well that Lyon has a very attractive city center: most accessible retailing activities are located in the inner center and the main city, and zones are less accessible as well as distance to city barycenter increases.

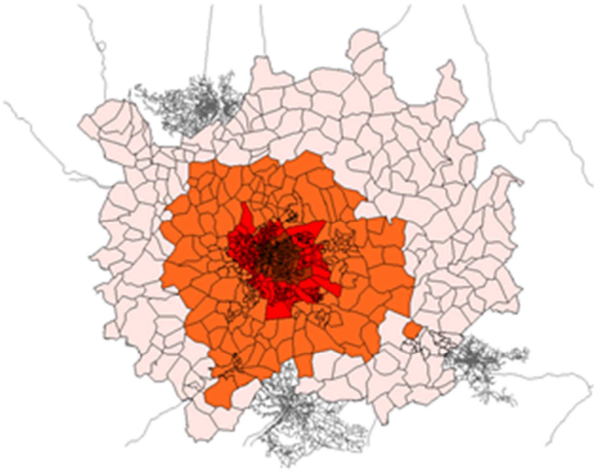

Figure 1. Small retailers' accessibility in Lyon's conurbation

If we observe the accessibility of medium and big stores, we find also the monocentric influence, but with different catchment areas than for small retailers. Indeed, we observe that the East and South west peripheral zones (where big stores are deployed since several decades) close to the main city belong to the first quartile of accessibility. Moreover, near-periphery zones at north and west of Lyon have also retailing areas, but less deployed and influent, and the accessibility is on the second quartile. Then, we observe a similar distribution of accessibilities, with some small differences due to the concentration of medium and big stores in the urban area: also such stores become less accessible when moving to the far periphery.

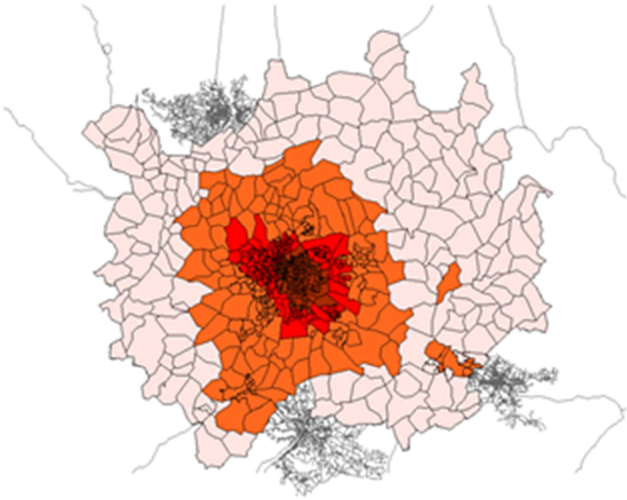

Figure 2. Stores and malls' accessibility in Lyon's conurbation

5. Discussion

The results presented above show the interest of applying an accessibility analysis to show the attractiveness of the different retailing areas of a conurbation. This analysis takes into account a gravity indicator that includes both the attractiveness in terms of opportunities to reach the zone for shopping (in this case, the number of employees) and the difficulty or easiness to reach them (in this case, a generalized monetary cost function). With this type of indicator, it is possible to render the difficulty that households located at defined zones have to reach retailers for their daily or weekly grocery supply, and also for their weekly leisure-shopping activities (not related to grocery).

The analysis has been made separating small retailers from big stores for the reason that they do not have the same impact on shopping trip behavior (Gonzalez-Feliu et al., 2010b). Moreover, taking the number of jobs as one of the variables to estimate accessibility, the comparison is difficult, since the ratio of weekly quantity freight received per employee is strongly different (Gonzalez-Feliu et al., 2012b). Furthermore, and as seen above, the impacts of each type of retailers is not the same. While taking a look as both maps we can have an initial vision of such impacts, but further analyses need to be made.

For such reasons, public authorities that aim to apply those types of analyses need to take into account this fact, and try to integrate both analysis before making conclusions and choices. To do this, we propose the following developments or uses of this approach:

1. If data concerning shopping behavior is available (for example, with Household Trip Surveys or Commercial Association Surveys, as stated in Gonzalez-Feliu et al., 2010a), it is important to cross accessibility results to shopping trip behavior and traveled distances by those trips, to connect accessibility (potential to access) to real behavior of people (real use of land and infrastructures). This can be useful to explore

the potential and limits of current retailing areas of the city (for example, to see if parking offer is enough, to make a diagnosis of congestion in shopping peak hours in precise points of the city, to analyze the potential of switching deliveries to off-peak hours in some areas or to state on the needs of retailing zones in a conurbation).

2. When such data is not available, it is still possible to relate such results to catchment area models (Kubis and Hartmann, 2007; Gonzalez-Feliu et al., 2010) to state on similar results, although the errors will be higher. However, such methods remain robust to state about the potential of zones to grow, to increase parking facilities or to switch deliveries to off-peak hours.
3. A third usage is that of forecasting and scenario assessment (Ambrosini et al., 2013). Accessibility can be a good tool to assess the potential of creating a new retailing area, a new infrastructure or completely different public policies concerning urban goods transport). To do this, it is important to construct a good reference scenario and be sure that the proposed assessment method is consistent and coherent with the reference in order to pursuit a before-after analysis (Leonardi et al., 2012).

6. Conclusion

This paper presented an exploratory analysis of accessibility to support city planners in terms of retailing development and the consequences in both people and goods transport. A gravity accessibility indicator has been proposed and applied to a real conurbation (Lyon, France). The analysis shows interesting results and a potential, for both small retailers and medium-big stores. However, it remains exploratory and needs to be further developed. To do this, new variables can be introduces, such as the quantity of goods to deliver or the total number of references a retailer can offer. Another further development can be that of using relative accessibility (Mercier, 2008) to relate small retailers to medium-big stores and make integrated analyses. In any case, accessibility can be a good tool to support city planners and it is important to deploy it and show to potential users the interests of using it.

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