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Accessibility to postal services: a potential spatial accessibility analysis

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Abstract

In a context where demand and supply characteristics of mail and package services are experiencing a major change, the paper focuses on accessibility to postal services. It proposes to measure potential spatial accessibility by introducing postal supply and potential demand using a Two-step floating catchment area (2SFCA) analysis. Based on an equilibrium between supply and demand through distance function, this method often used to health services accessibility experiences is transposed into postal activities. It aims to analyse postal supply location and identify areas with deficits or excess of postal supply given level of population and competition effects, considering standard mail and packages activities.

Introduction

Postal services ought to be "accessible" to users. This principle, part of postal universal service definition, is written in the Postal Directive for EU Member States. In practice, this accessibility principle has been translated into quantitative or qualitative terms related to the size (number of point and minimal distance) and localization of the postal outlets network (Borsenberger *et al.*, 2011).

The French Postal law (2010) imposed a minimal legal number of points of contact at 17,000 throughout the territory, either owned by La Poste or in partnerships, to guarantee in "the best economic and social efficiency" conditions, access to the postal universal services and to contribute to the development of territories. In this regard, (i) 95 percent of French households in each department and 99 percent of French households at the national level should live at less than 10 km from a postal point of contact, (ii) all municipalities of more than 10,000 inhabitants should have one point of contact for 20,000 inhabitants and (iii) no more than 10 percent of the population of a French "département" should be further than 5 kilometers or 20 minutes' car drive from the closest postal point of contact.

However, with the spread of Internet, the world has changed. Modern lifestyles have modified customers' needs. The most striking effect of this change is the decrease in the mail volumes and in the number of customers visiting post offices. In France, the average number of daily customers visiting a postal point of contact dropped from 2.7 to 1.6 million in over 10 years from 2006 to

2016. As a consequence, the unit cost (mainly fixed) of this physical retail network is growing both for the universal service provider but also for the society (Borsenberger, 2014).

In this context, thinking about accessibility to postal services taking into account both current demand and supply characteristics is crucial. This proposal has two objectives. From a methodological point of view, it aims to go beyond an accessibility analysis in terms of physical or time distance with potential spatial accessibility by introducing postal supply and potential demand using a Two-step floating catchment area (2SFCA) analysis. From an empirical analysis, it analyses postal supply location and identify areas with deficits or excess of postal supply given level of population and competition effects. We focus on standard mail and packages activity and restrict our analysis of accessibility to these services in the Greater Lyon Area (France). The paper aims at analysing basic postal services that can be provided either by 3 several types of postal point network: Postal Agencies, Post Offices, or Post Relay Points.

The paper proceeds with a literature review on the two-steps floating catchment area method to understand how this method has been developed and applied in health sector. Then, the method is transposed to postal activity in Lyon Metropolitan area. A third part analyses results and concludes with discussion.

1. The two-steps floating catchment area (2SFCA) method

Accessibility definition

A definition of accessibility, as it is generally understood, is given by Morris, Dumble, and Wigan (1979). Accessibility can be defined as "some measure of spatial separation of human activities. Essentially it denotes "the ease with which activities may be reached from a given location using a particular transportation system." Geurs and Wee (2004) add to this definition by emphasizing how accessibility must reflect the spatial organization and the quality of the transportation system that offers individuals (taken in isolation or in groups) the possibility of participating in activities located in different points of the territory. Accessibility thus reveals the presence of a supply of a set of opportunities in a given space (spatial dimension) while at the same time predicting the potential use that can be made of it (behavioral dimension), thanks to a system of transportation (technical dimension) over a given period of time (temporal dimension).

Theoretical background

The literature presents different measures of accessibility (Geurs and Ritsema Van Eck 2001). Among them, isochrone measures and the results of gravity-based models are the most frequently used. However, they have been subject to criticism. Isochrone measures, also called cumulative opportunity measures, determine the accessibility of an area by counting the number of opportunities reached, from the area, under time, distance, and cost constraints. These measures do not take into account the opportunity/distance (or time) ratio but only the number of opportunities reached. It leads to stipulating an increase in accessibility when the distance (or time) constraint is loosened (Pirie 1979). Moreover, as the threshold of the constraint is generally arbitrarily defined, the measure of accessibility does not distinguish opportunities present in proximity to the starting area from those that are found at the limit of the isochrony (Ben-Akiva and Lerman 1979). Vickerman (1974) also highlights the fact that isochrone measures attribute equal weight to all opportunities in an area.

Based on the work of Hansen (1959), gravity-based measures can be seen as the potential opportunities that an individual can reach. Accessibility from area *i* to employment located in area *j* is therefore directly proportional to the number of jobs in area *j* and inversely proportional to the distance separating the two areas. Gravity-based accessibility uses the following formula:

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

With A_i, accessibility from area *i*, D_j, the opportunities present in area *j*, β a parameter expressing the awareness of the general cost of travel, C_{ij} the general cost of travel between areas *i* and *j*.

Gravity-based measures of accessibility have been subject to a certain amount of criticism in the literature (Geurs and Ritsema Van Eck 2001). A part of the debate is focused on the impedance parameter (Johansson *et al.*, 2002).

Division of areas in terms of administrative borders therefore creates a bias in terms of spatial analysis. The border is considered to be impermeable (Luo and Wang 2003) and the results are taken at the scale and with the zoning used (communal, infra-communal…) as explained in the different works dedicated to the Modifiable Areal Unit Problem (MAUP) (see, for example, the work of Openshaw and Taylor 1979; Wong 2004; Zhang and Kukadia 2005). This is the first criticism. In the same way, in terms of the hypothesis of equitable distribution of the population within the area, Dong et al. (2006) emphasize that accessibility is the same for the population of each area, regardless of the heterogeneity of the population. This is the second criticism. A third criticism underlines the absence of effects of competition between the opportunities offered and the demand for these opportunities. It is not rare to observe heterogeneous planning that leads to an imbalance between supply and demand. This limit can be lifted, however, by the use of a restricted gravity-based model (Wilson 1967; Weibull 1976).

Although subject to criticism, isochrone and gravity-based measures offer an aggregate accessibility that is relatively easy to calculate and to interpret, to some extent. In this sense, they are distinct from measures based on Random Utility Theory following the work of Ben-Akiva and Lerman (1979).

Starting from this point, Luo and Wang (2003) turned their interest in accessibility to doctors and developed a particular case of the gravity-based model (Hansen 1959) to remove the limits mentioned above. First (step one), they include the notion of a "floating area" by moving away from geographical areas and introducing circular buffer zones to define the threshold beyond which an individual would not seek consultation. They respond to the first criticism. For each area j a floating area is determined based on a distance d to the centroid. The set of individuals located in this floating area are likely to consume services in area j. When small zones are considered, population heterogeneity is lower and the second criticism can be solved.

Competition between individuals is introduced through demand for the supply of a given service and. The ratio relating the supply of services (health, postal, and other services) to the population likely to use these services is defined as follows:

$$R_j = \frac{m_j}{\sum_{d_{ij}<d_0} Pi^* w(d_{ij})}$$

With :

m_j the supply of services
Pi the number of local inhabitants at a distance less than or equal to d
d the distance to the center of area j
$w(d_{ij})$ weighting relative to distance

Step two allows to answer the third criticism. It defines for each area *i* of the localization of individuals the set of areas *j* of the localization of services accessible under distance *d*. Accessibility (PLA indicator) is then measured as the sum for each area i of the ratios calculated in step one for the services available under distance *d*, or:

$$APL_i = \sum_{d_{ij}<d_0} w(d_{ij}) R_j$$

Applications and limits

Use of the 2SFCA method began with work on accessibility to general practitioners and more health services generally (Radke and Mu, 2000; Guagliardo, 2004; McGrail and Humphreys, 2009; Luo and Wang, 2003; Wang and Luo, 2005; Luo and Qi, 2009; Barlet et *al.*, 2012) in a context of reduction of the offer of services. Competition between patients pushes individuals to cross borders to seek consultation outside their area of permanent residence.

Because this measure of accessibility presents several limits and in particular because of its dichotomic character (people outside the frontier don't benefit from accessibility), the hypothesis of identical accessibility within a single area or of a distance *d* of identical access no matter what the area (urban or rural). Thus several enrichments of the measure have been proposed like introduction of a distance decay function, variable catchment sizes, or a different weighting depending on the areas can add to the model (Wang 2012 and Neutens 2015 for a review of the literature). Distance decay function can be integrated via a time or a physical measure.

Despite their developments, this 2SFCA method is still used mainly in work related to the health sector. Only Borges Prosdocimi et al. (2017) have used this method to prioritize road investment in South Africa in relation to accessibility to a range of services. In the same way, Wu, Liu, and Peng (2018) have analysed and planned the location of green spaces using 2SFCA.

Pertinence of transposition to the Case of Postal Services

In this paper, we propose to apply the 2SFCA method in an analysis of accessibility to postal services. Transposing this method that has been used almost exclusively in the medical sector seems pertinent for a variety of reasons. Postal service in a town or a neighbourhood, like the presence of a doctor, is a "local" service that appears vital for life and local activity. According to the SNIIRAM (2010) and repeated by Lucas-Gabrielli, Nestrigue, and Coldefy (2016) "84 percent of consultations with a general practitioner took place in a municipality located less than 15 minutes away." In terms of postal activities, the framework directive for postal services (directive 97/67/CE) states the principle of universal postal service, under the conditions of principles of equality, of territorial continuity and adaptability and seeking the best economic and social efficiency (see Article L1 of the Postal and Electronic Communications Code).

Each individual, in relation to his or her administrative address, is assigned to a contact point for withdrawing items. Nevertheless, he or she remains free to visit the postal point of his or her choice (including for items by modifying the withdrawal point). In the same way that 16 percent of medical consultations (general practitioners) do not take place in an environment close to the residence, use of postal contact points seems to correlate less and less to residence location but is part of a more "dispersed" format of daily activity. Raynaud (2010), followed by Barlet *et al.* (2012), uses the term commodity in reference to the reception conditions that can incite a patient to travel farther from his or her residence to consult a general practitioner, with everything else being equal. Opening hours and waiting times can also apply in understanding the demand addressed to different postal points.

As for health services (Barlet et al. 2012), we consider that the inhabitants of an area (neighborhood or municipality) frequent the contact points located at a distance to their area that is less than the distance of reference (area of recourse). In the same way, each contact point potentially responds to the demand of all the inhabitants of the areas situated at a distance less than the distance of reference (catchment area). There may therefore be competition between individuals in accessing the contact point but also between contact points to "attract" individuals (Figure 1).

Accessibility to postal services is develop in the following part on the Lyon metropolitan area.

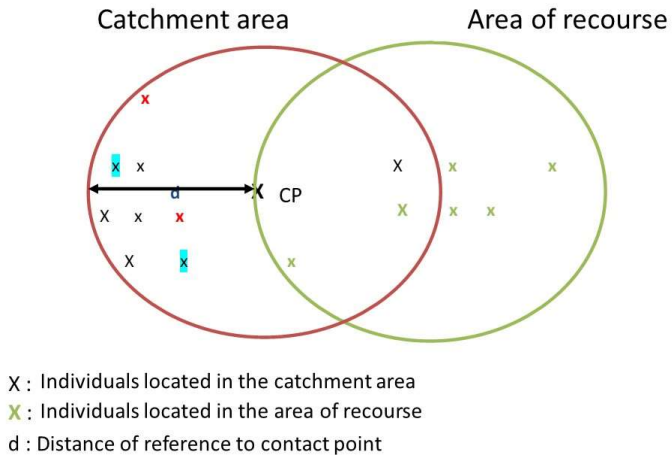
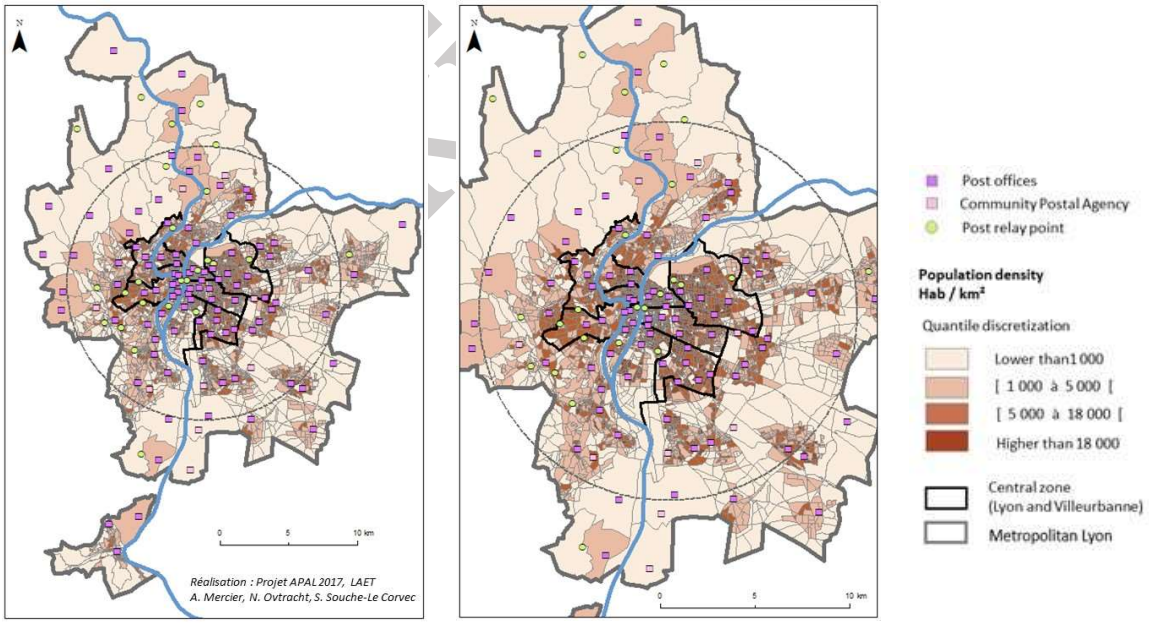


Figure 1 : Representation of potential accessibility localized to contact point (CP)

2. Application to the Case of Postal Services

Case study presentation

The measures of localized potential accessibility were carried out on the Lyon metropolitan area. This perimeter encompasses 59 municipalities containing 1.3 million inhabitants over an area of 534 km2. We examined all the contact points offering "essential" services, such as basic postage services and pick-up of packages or items. These points could therefore be Community Postal Agencies, Post Offices[1], or Post Relay Points (see Map 1).

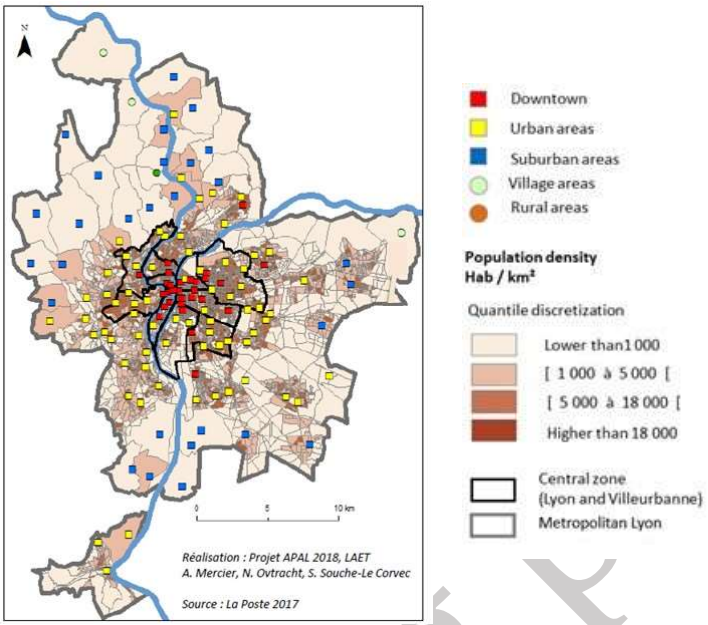


Map 1: Location of the contact points of the Lyon metropolitan area (year 2017-date: La Poste))

Classification of municipalities, and of their IRIS category (IRIS: aggregated units for statistical information), was implemented according to the internal categorization of La Poste into three

[1] A Community postal Agency is a Post Office managed by the city council. A Post Relay Points are located in independent retailers.

classes (see Map 2): Downtown (7% of areas and 7% of the population), Urban (12% of areas and 78% of the population), and Suburban (7% of areas and 15% of the population). This classification has been built by La Poste considering number of convenience stores, the share of vertical and horizontal housing and the size of the metropolitan area.



Map 2 : Location of contact points according to area classification

Step 1: Calculating the Catchment Area (CA) around a CP

The catchment area, for distance d, around a contact point (CP), corresponds to the supply of postal services in relation to the population likely to use these services. Each CP is a potential response to the demand of local individuals at a distance less than or equal to *d*.

Determining Buffer Zones

The calculation of potential accessibility is made in consideration of buffer zones of a radius of 400 meters and 1000 meters around the contact points (CP). All the IRIS areas situated in this buffer zone as well as the number of inhabitants located at a distance less than or equal to d were considered based on the distribution and data of the INSEE (General Census of the Population).

The distance of 400 meters corresponds to a demand "of proximity" more in urban and downtown areas, assuming that the individual reaches the contact point on foot. The hypothesis was made that an individual would accept walking five minutes at an average speed of 4.8 km/h (Montufar et *al.,* 2002). The distance of 1000 meters allows the inclusion of travel by automobile or public transportation to reach the contact point, in particular in suburban areas. Keeping the hypothesis of a budgeted time of five minutes, the speed of travel is 12 km/h, close to that of public transportation (Allaire, 2006).

Determining postal supply

We estimated the postal supply for all contact points offering "essential" services, in other words, the Community Postal Agencies, Post Offices, or Post Relay Points (RPC). The supply by contact point is written as follows:

$$O_{PDC} = \sum_{i=1}^{n} GA_i * Amp\_PDC + \sum_{i=1}^{n} G_i * Amp_i$$

With:

O_{PDC} the weekly supply by contact point

GA_i the number of automatic tellers available in the contact point. These automatic tellers are available and operational throughout the opening hours of the contact point

Amp_PDC the amplitude of weekly opening hours of the contact point

G_i the number of "physical" counters open for activities outside the "Postal Bank" and "Postal Mobile Phone" activities

Amp_i the amplitude of weekly opening hours of each counter for activities outside the "Postal Bank" and "Postal Mobile Phone" activities. The start time corresponds to the time at the end of the first operation and the closing time corresponds to the time of recording the last operation. For "physical" counters open morning and afternoon, the midday closing time is included. It should be noted that offices that perform less than five operations during lunch time and/or "special" operations and/or operations just after closing time or just before opening are considered to be closed during the midday period.

The supply of postal services by area in relation to the population is therefore written as follows:

$$R_j = \frac{m_j}{\sum_{d_{ij}<d_0} Pi^* w(d_{ij})}$$

With:

m_j the supply of services for area *j* and $m_j = \sum O_{PDC_j}$

Pi the number of inhabitants located at a distance less than or equal to *d*

d the distance from the center of area *j*

$w(d_{ij})$ a relative weighting of the distance (see below)

Step 2: Calculating the Area of Recourse to CPs for the Population

For each area *i* of localization of individuals, the set of areas j of localization of services accessible is defined under a distance d_0. It is therefore considered that inhabitants can access all the CPs located at a distance less than or equal to *d*.

For each area *i,* the ratios calculated in step one are summed for the services available under a distance d_0 or:

$$APL_i = \sum_{d_{ij}<d_0} w(d_{ij})R_j$$

Potential localized accessibility (PLA indicator) is read as a number of weekly hours of postal service available by inhabitant or by thousand inhabitants.

Taking distance into account

Several works propose applying a declining function of accessibility based on the distance from the center (Kwan 1998, Osth *et al.* 2016 for a recent survey). Several functional forms are suggested in the literature (gravity-based measures, cumulative opportunity measures, and space-time measures). Like Lucas-Gabrielli, Nestrigue, and Coldefy (2016), we propose to test several types of gravity-based functions depending on the type of area and on distance in meter to be coherent with our buffer zones where distance is given in meter.

Results are presented in Table 1 :

Downtown	log(y)= 2.143 - 1.232 log *dij*	R^2= 0.51 p-value=0.046 cte=2.85
Urban areas	log(y)= 1.851 - 0.69$dij^{0.2}$	R^2=0.84 p-value=0.0014 cte=2.68
Suburban areas	log(y)=1.73-0.17$dij^{0.3}$	R^2=0.699 p-value=0.0097 cte=2.12

Table 1 : Functions of distances based on EPL data

For urban areas results are coherent with literature (Kwan, 98; de Vries et *al.* 09) as negative exponential function gets the best results.

For suburban and downtown areas results are less unexpected. Following Kwan (1998), for suburban areas the power function should be the best function. However, the negative exponential function is better. As we explain, we use the internal postal categorization to organize the postal point. Our result suggest suburban areas are more urban point than suburban. Concerning downtown areas, the R^2 level is moderate indicating results are significantly weaker than for urban area for example. Choukroun (1975) cited by de Vries et al. (2009), explain the power function significance pointing out the impact of the users' preferences heterogeneity and in particular the use of various travel modes. In our survey, it seems that in downtown areas around 50% of the postal point are walker and the rest public transport or car users.

The calibration of these functions was based on the EPL survey performed in December 2015 at six PO in the Lyon metropolitan area with a final sample of 970 respondents

The impact of the size of the area is also integrated into the results. First, an "intrazone" distance corresponding to $\pi(r^2)/2$ was considered. Moreover, to avoid overvaluing the accessibility of larger areas mainly located in the periphery, we adjusted the results by surface area by dividing accessibility by the inverse of the surface area.

3. Results and Discussion

The results show major disparities in accessibility of postal services with ratios between 0 and 196,000 weekly hours per 1 000 inhabitants, for an average in the Lyon metropolitan area of 1 450 hours / 1 000 inhabitants. Statistical analysis highlights a very dispersed distribution around the average (see Table 2).

Average	Variance	Standard deviation	Quantile 1	Quantile 2	Quantile 3	Quantile 4	Maximum	Coefficient of variation
1448,4	162 442 513	2 752	0.5382	2.7102	8.0750	58.8969	196 191	190

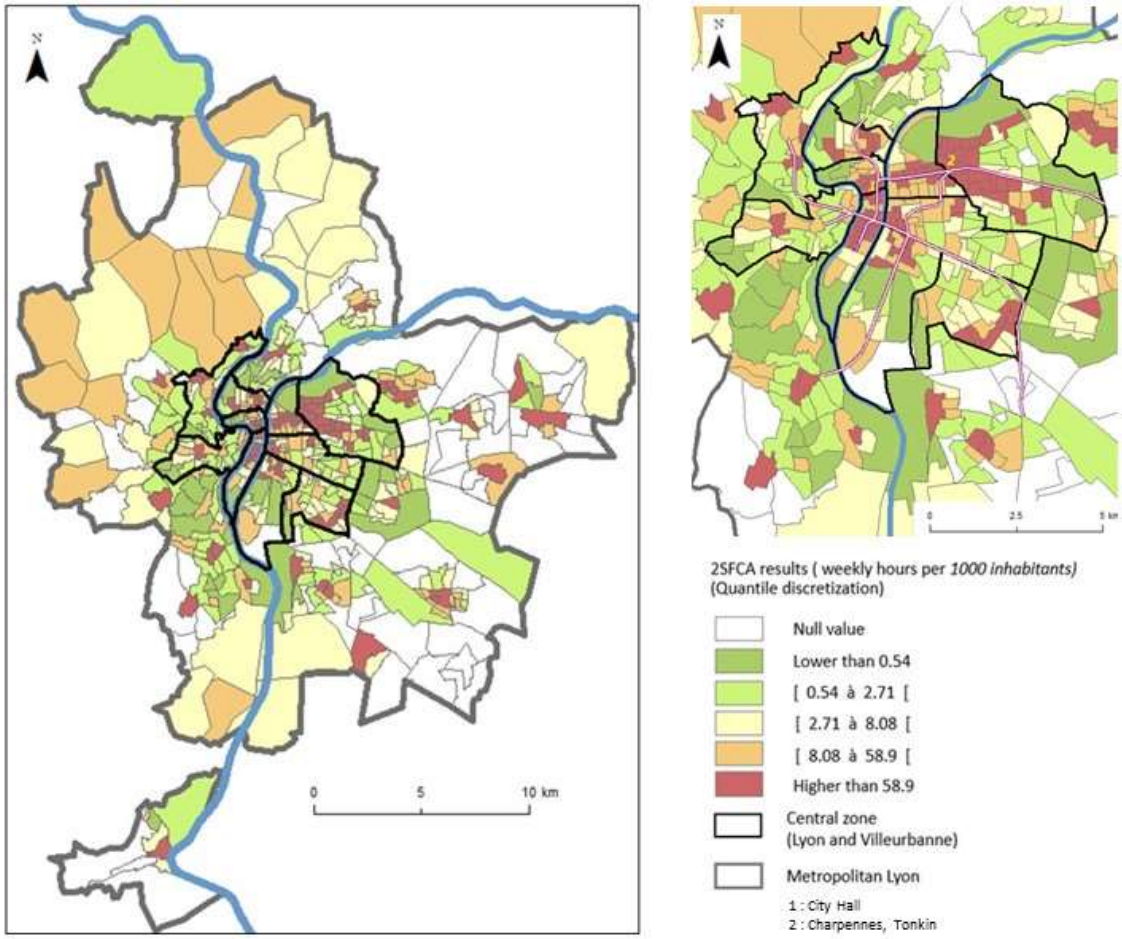
Table 2 : Basic statistics

While 13% of the areas have zero postal accessibility, as they are located more than 1 000 meters from a contact point, only 2% of the areas have an accessibility that is double the average of the metropolitan area (i-e 1 448,4). 73% of the areas therefore benefit from postal accessibility of between one hour and 2,800 hours per 100,000 inhabitants per week (or 0.028h of opening time per inhabitant per week that is to say less than 2 minutes).

Overview of Potential Accessibility in the Lyon Metropolitan Area

Map 3 shows that Lyon central areas benefit from very good postal accessibility, in particular Presqu'île and the Part-Dieu sector, respectively historical and business centers where cultural and economic activities are locate). Good accessibility is also noted for the centers of activity of peri-urban municipalities, in particular eastern Lyon. This good level of accessibility is connected to the presence of "traditional" contact points of La Poste but also, especially in downtown areas, to the supply of post relay points.

Municipalities to the west of the Lyon metropolitan area also benefit from good accessibility to postal services. It should be noted, however, that since the distinctions are less sharp in this sector of the metropolitan area, given the lower number of residents than in the east, visual representation tends to over-estimate the accessibility of the municipalities in the west on the whole. In both east and west, the areas outside centers of activity and agricultural lands in eastern part have less accessibility to postal services.



Map 3 : Accessibility to postal services in the Lyon metropolitan area

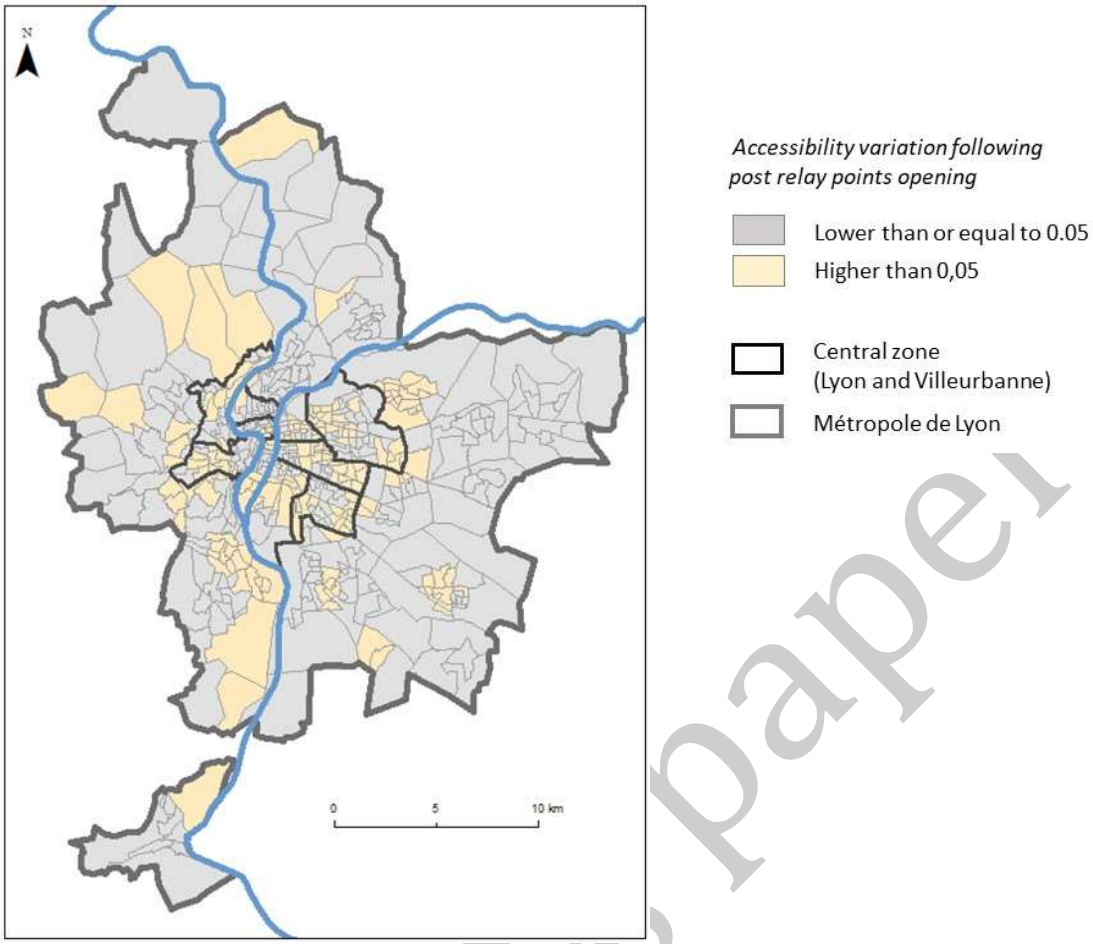
The Issue of White Areas

On the scale of the metropolitan area, 13% of the areas (representing 9% of the population) have null postal accessibility and 28% of the areas (representing 28% of the population) have accessibility that is non-null but less than 3h/1000 inhabitants (or a half-day of opening hours for a contact point per week). The "white areas" (with null accessibility) can access postal services beyond a radius of 1000 meters and therefore correspond to the criteria established by law.

These areas are located in the second ring, mainly in the eastern part of the metropolitan area. The absence of accessibility "in proximity" is explained by the primarily industrial classification of these areas and/or the low density of inhabitants due to the presence of agricultural land.

The Impact of Post Relay Points (RPC) on Results

The diversification of commercial contact points by the La Poste group leads us to pose the question of accessibility to the different types of points. In other words, to determine whether accessibility depends mainly on "traditional" points (Community Postal Agencies and Post Offices) or on Post Relay Points (RPC). The comparison of postal accessibility with and without RPC is presented in Map 4:



Map 4 : Accessibility variation following the opening of Post Relay Points

Map 3 and Map 4 emphasize how the presence of RPC is not restricted to the peripheral areas and that it also allows an improvement in postal accessibility for central areas. All the arrondissements of Lyon, as well as the municipality of Villeurbanne, benefit from this new postal supply, which can come at the detriment of traditional points. Improving accessibility for the yellow areas does not rely as much on the presence of an RPC-type point as on the amplitude of its opening hours. On the scale of the metropolitan area, an RPC is open on average 65h/week as opposed to 35 hours for a "traditional" contact point. These results should be nuanced to the extent that a traditional office often offers several open counters as well as automatic tellers. By including the entire supply, the average weekly amplitude of traditional points is raised to 213 hours. While the amplitude of availability of service is smaller, the level of the overall supply is greater in these points than in the RPC.

Conclusion

This paper holds a two-fold interest, both methodological and empirical. Methodologically, it shows that it is possible to apply the 2SFCA method to measure accessibility to postal services. This method was until now exclusively applied to health services (in terms of works published in academic journals) and the methodology had to be adapted to account for the diversity of postal services and the contacts points offering them.

On the empirical level, the results highlight that postal accessibility depends highly on areal size assumptions and the way internal travel is integrated. Without repeating ourselves, accessibility is better for (western and southern) suburban areas than for central ones. In spite of a lower provision of postal services in terms of opening hours or number of counters, competition between individuals is lower in less populated areas than it is in urban centers, where accessibility is better. By taking into account the impact of areal size, the disparity in access results is reduced and city centers (in central or suburban areas) offer the highest levels of accessibility.

Forthcoming work seeks to remove limits on accessibility sensitivity. Weekly supply by contact point should be more precise integrating a differentiation between standard mail or packages activity and postal services where specific skills would be required. Floating zone size raises questions on distance to centroid, on zone form (circular or not) and on people location into areas.

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