10th bi-annual Postal Economics Conference on E-commerce, Digital economy and Delivery services

Toulouse, Manufacture des Tabacs, March 29th-30th, 2018.

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 parcel delivery services are experiencing a major change, the paper focuses on accessibility to postal services through physical retail network. 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 measure the accessibility taking into account population and competition effects between consumers' demand, considering standard postal activities provided in points of contact.

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 and localization (number of point and minimal distance) 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, the services of general economic interest (SGEI) the French State has given to La Poste.

One SGEI is related to the accessibility to the postal universal service and is the translation into the French law of European requirement according to which "*Member States should take steps to ensure that the density of the points of contact and of the access points takes account of the needs of users*". This was precisely translated in French law in the following terms: 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, and all municipalities of more than 10,000 inhabitants should have one point of contact for 20,000 inhabitants.

In addition to the USO, La Poste is in charge of another SGEI of country-wide presence, in order to contribute to the development of the territory. This SGEI requires that no more than 10 percent of the population of a French "département" is 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 taking into account the fact that the SGEI consisting in maintaining a presence through a brick-and-mortar network is partially financed by public subsidies (Borsenberger, 2014).

In this context, thinking about accessibility to postal services taking into account both current demand and supply characteristics is crucial. This paper 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 point of view, it gives an empirical measure of accessibility to basic postal services taking into account population and competition effects between consumers. We focus on standard postal activity over the counter (sales of stamps, letters or parcels postage, remittance of postal items, and so on) 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 both in Post Offices managed by La Poste and in partner points of contact managed by public authorities (Agence Postale Communale) or private retailers (Relais Poste Commerçant).

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 (behavioural 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 criticisms. 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).

The first criticism concerns the bias introduced in spatial analysis by the administrative division of the territory. The administrative borders are considered to be impermeable (Luo and Wang 2003) and the results of spatial analysis depend on 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). In the same way, a second criticism is related to the hypothesis of uniform distribution of the population within the area. As emphasized by Dong et al. (2006), the assumption implies that accessibility is the same for the population of each area, regardless of the heterogeneity of the population. A third criticism underlines the absence of effects of competition between the opportunities offered and the demand for these opportunities. Yet, 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 criticisms, isochrone and gravity-based measures offer an aggregate accessibility indicator that is, to some extent, relatively easy to calculate and to interpret.

Starting from this state-of-art, Luo and Wang (2003) developed a particular gravity-based model in order to remove the limits mentioned above and applied it to the issue of the accessibility to doctors. The first step of their approach responds to the first criticism: they develop the concept of a "floating area", moving away from geographical areas by introducing circular buffer zones to define the threshold beyond which an individual would give up to go to the doctor's office. 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 a given service. 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

The second step of their approach allows to answer the third criticism. They define for each area i where individuals are localized, the set of areas j characterized by the fact that services are accessible for individuals localized in areas i under distance d. Accessibility from area i (Potential Localized Accessibility 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 generally health services in a context of reduction of the offer of services (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). 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 of each point within a single area or of a distance d of identical access does not matter what the area (urban or rural). Thus several improvements of the measure have been proposed like the introduction of a distance decay function (through a time or a physical measure), variable catchment sizes, or a different weighting depending on the areas (Wang 2012 and Neutens 2015 for a review of the literature).

Despite these 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 points of contact. 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 essential for social link and economic activities.

Both in health and postal sector, accessibility to the services is crucial. This includes two different notions: proximity in terms of distance but also convenience (in the conditions to access to the service). Raynaud (2010), followed by Barlet *et al.* (2012), uses the term "convenience" 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 be factors explaining the demand addressed to different postal points.

According to the SNIIRAM (2010) and Lucas-Gabrielli, Nestrigue, and Coldefy (2016), in France, "84 percent of consultations with a general practitioner took place in a municipality located less than 15 minutes away." In the postal sector, the 'aménagement du territoire' public mission devoted to La Poste requires that no more than 10% of the population of a French 'département' is further than 5 km or 20 minutes' car drive from the closest postal point of contact. Implicitly, the starting point of reference is the residence. However, in the same way that 16 percent of medical consultations (general practitioners) do not take place in an environment close to the residence, the postal contact points visited are not necessarily the closest to the residence. Visits to post offices could be included in a larger trip and part of a more "dispersed" format of daily activity.

Due to the difficulty to catch this aspect of mobility in the analysis of accessibility to postal points of contact, as for health services (Barlet et al. 2012), we consider that the inhabitants of an area (neighborhood or municipality) visit the contact points located at a distance to their area that is less than a 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 estimated in the following section on the Lyon metropolitan area.

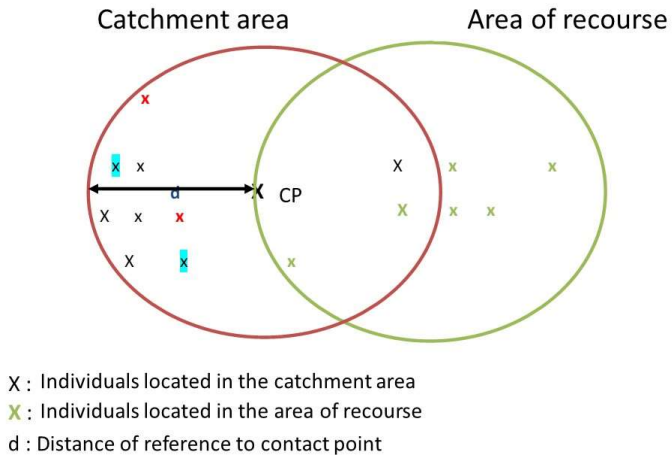
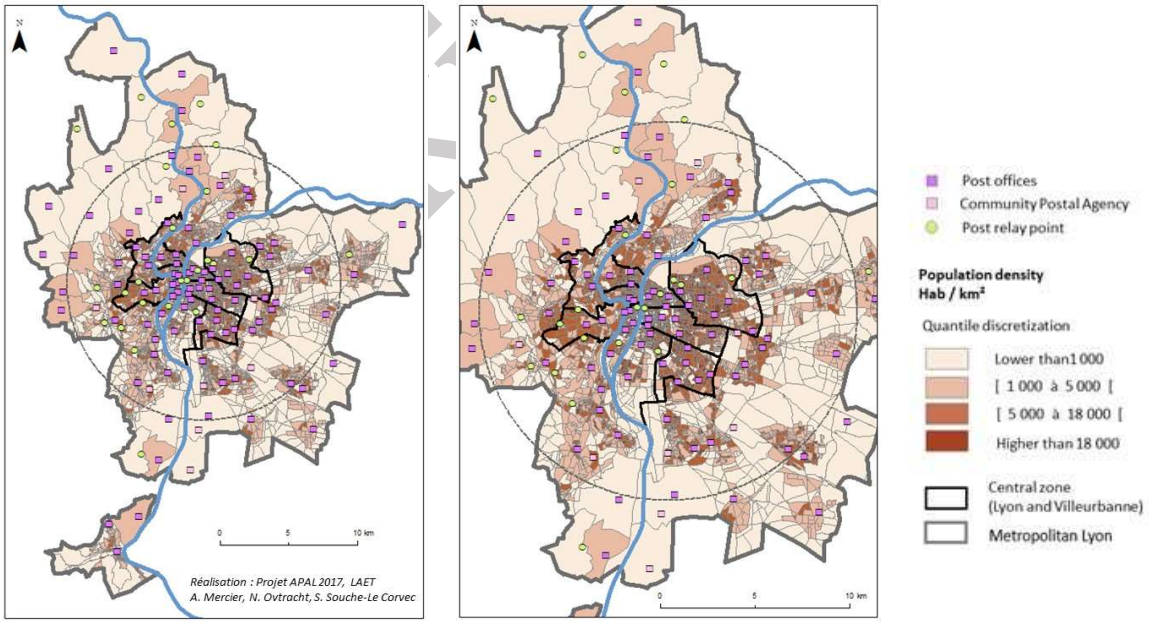


Figure 1 : Representation of potential localized accessibility (PLA) to contact point

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 "basic" postal services, such as postage services and pick-up of parcels or other mail items. These points could be Post Offices, Community Postal Agencies or Post Relay Points[1] (see Map 1).

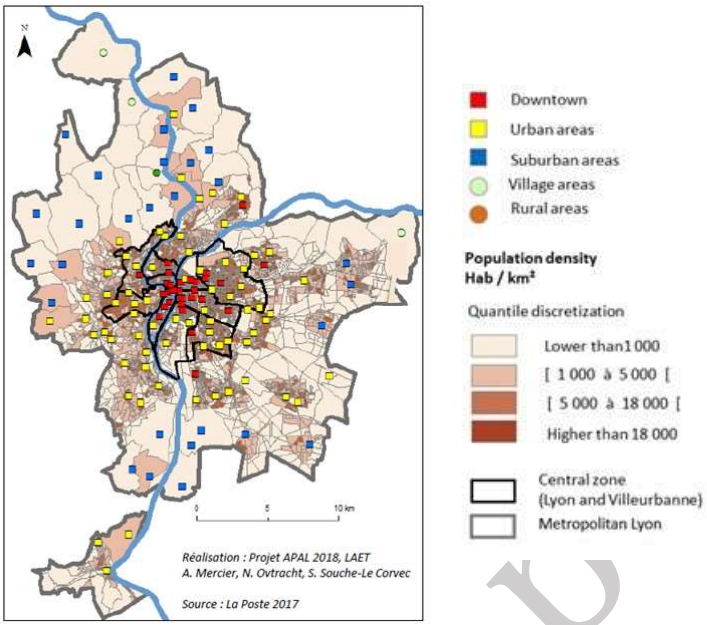


Map 1: Location of the contact points of the Lyon metropolitan area (year 2017-date: La Poste))

Municipalities and their IRIS category (IRIS: aggregated units for statistical information) were classified into three classes (see Map 2): Downtown (7% of areas and 7% of the population),

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

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 the 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 around a postal point of contact

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

To measure the potential accessibility, we consider 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" in urban and downtown areas, assuming that individuals reach 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

The weekly supply of postal services in a point of contact point O_{PDC} is assumed to be equal to:

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

With:

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 basic postal activities

Amp_i the amplitude of weekly opening hours of each counter for basic postal 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, we take into account the midday closing time. It should be noted that offices that perform less than five operations during lunch time are considered to be closed during the midday period.

The ratio of the supply of postal services to the population in area *j* 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* ; so $m_j = \sum O_{PDC_j}$

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 accessible CP 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:

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

Potential localized accessibility (PLA indicator) is read as the number of weekly hours during which postal services are 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

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

For suburban and downtown areas, results are more unexpected. According to Kwan (1998), for suburban areas the power function should be the best function. However, in our case, the negative exponential function is better. As we explain, we use the internal postal categorization to qualify the postal point. Our results suggest areas identified as suburban by La Poste are closest to urban areas than suburban ones if we consider the definition given by Kwan. Concerning downtown areas, the R^2 level is moderate indicating our results are significantly weaker than for urban areas 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 a survey performed in December 2015 in six post offices 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 dividing accessibility by the inverse of the surface area.

3. Results and Discussion

The results show major disparities in accessibility to 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

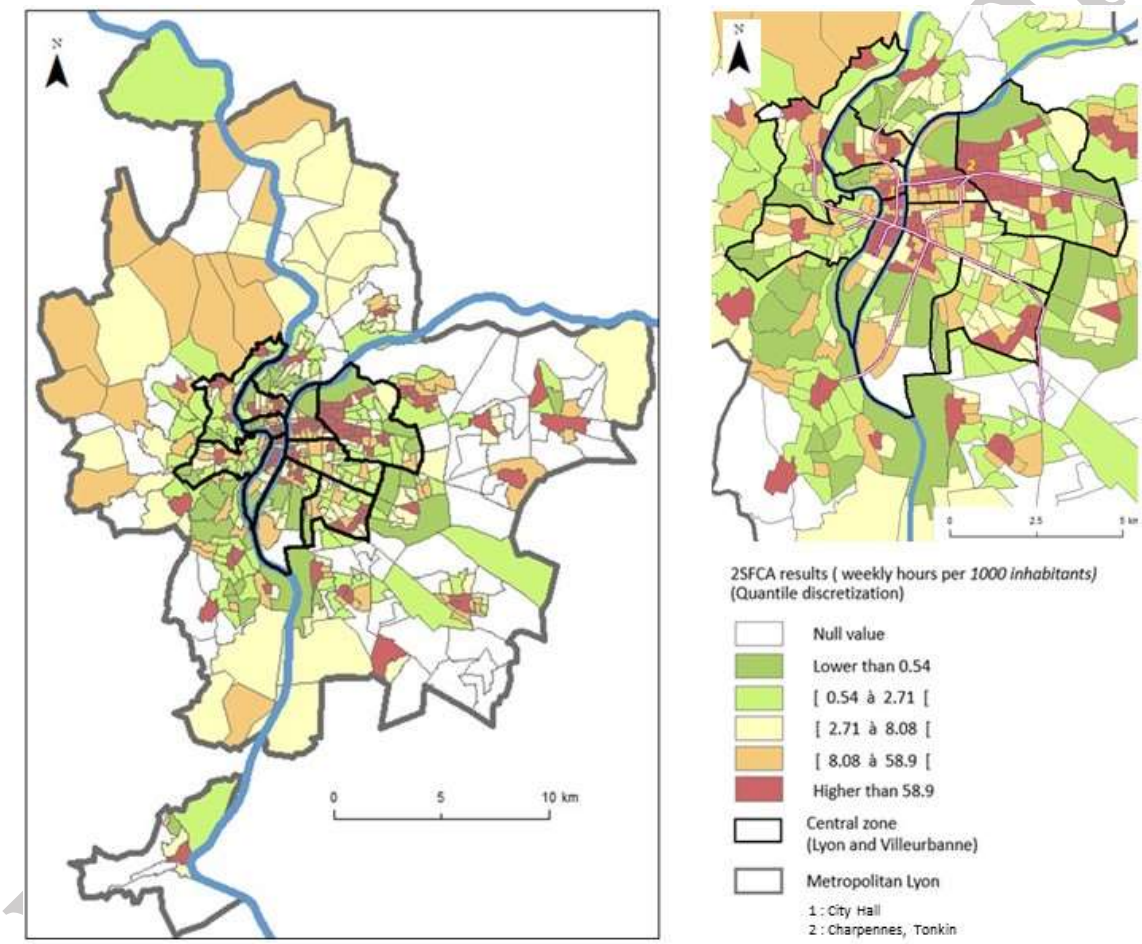
Table 2 : Basic statistics

Note that 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 sectors, respectively the historical and business centers of Lyon. Good accessibility is also observed for the centers of activity of peri-urban municipalities, in particular in the eastern Lyon. This good level of accessibility is linked to the presence of post offices but also, especially in downtown areas, of postal relay points.

Municipalities in the west of the Lyon metropolitan area also benefit from good accessibility to postal services. It should be noted, however, that 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" – a limit of our method

In our work, an accessibility indicator equal to zero does not mean that people have no access to postal services; it simply means that the closest postal point of contact is located at a distance higher than 1,000 meters. Indeed, La Poste meets her legal requirements in the metropolitan area of Grand Lyon, as throughout the whole national territory.

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).

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 primarily by the industrial classification of these areas and/or the low density of inhabitants due to the presence of agricultural land.

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 almost entirely applied to health services 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 the provision of services 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. We will also distinguish in future work the type of point of contact (post offices vs. partners). 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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