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The territorial impacts of BlaBlaCar carpooling: between metropolitan polarization, intermediate cities' structuration, and rural services

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Abstract:

Often promoted by planning and transportation authorities as one of the principal ways to reduce the impact of mobility on transportation gas emissions, carpooling practices have increased over recent decades for daily commuting as well as long-distance travel. However, mainly due to the lack of data, little is known about the geography of these trips. On the one hand, the intensity of supply and demand may favor urban areas alongside common transportation systems. On the other hand, the scarcity of public transport in rural areas or small towns can support the growth of these shared mobilities.

This article presents a geographical investigation of carpooling patterns in France as revealed by massive data collected from the Blablacar platform, national leader for this type of online services. After a review of the literature, the paper presents the main elements of the methodology implemented to collect and analyze the web data of carpooling. The analysis presents new findings that reveal the geographical features of car-sharing in France. The impact varies depending on the size of the towns, the presence of regional and inter-regional urban systems, and the tourism specialization of rural areas. The study also emphasizes the unique position of Paris and the pivotal role of intermediate towns.

Keywords: carpooling, mobility, urban hierarchy, data-driven research, France

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1. Introduction

Transportation and planning issues are closely related, specifically when considering the economic and socioecological sustainability of cities (Sultana *et al.*, 2020). Congestion represents an economic cost to the whole community (Downs, 2005). The organization of land use and transportation infrastructure impacts social and spatial inequalities linked to the price of gasoline (El-Geneidy *et al.*, 2016; Lucas *et al.*, 2016; Manaugh and El-Geneidy, 2012; Van Wee and Handy, 2016), and can generate a feeling of injustice and protest movements like the Yellow Vests in France. Being dependent on non-renewable fossil fuels, transportation certainly generates emissions that significantly contribute to both climate change and urban air quality degradation. In 2019, in the European Union, road traffic is estimated to be responsible for approximately 60.6% of all carbon dioxide emissions, which is more than 20% of global emissions (European Environmental Agency, 2021), and the largest contributors to air pollution are private cars (Lau *et al.*, 2008). In France, the road transport sector is the largest source of carbon emissions per capita, accounting for 28.8% of the total (Hachaichi and Talandier, 2023). Thus, the promotion of less carbon-intensive modes of transport is one of the priorities of urban planning. Among the possible partial solutions, carpooling is increasingly encouraged. It reduces the negative impacts of transport at a lower cost to communities but has not yet been widely deployed in Europe, particularly in France. The expectations of local authorities and users are increasingly strong. Beginning in the 1970s in the United States, the North American academic literature on carpooling is more abundant and established than the European literature (ICARO, 1999). By comparison, in Europe, little information is available on carpooling users and practices (Aguiléra and Pigalle, 2021). European authors have mainly developed qualitative surveys on the profiles and motivations of carpoolers themselves (Shaheen, Stocker, and Mundler 2017), and studies mainly focused on short distance and daily carpooling commutes (Bento *et al.*, 2013; Buliung *et al.*, 2010, 2012). However, these studies have rarely studied other motivations such as long-distance carpooling, or personal and leisure travel (Delhomme and Gheorghiu, 2016; Gheorghiu and al., 2018). Furthermore, the geography of these mobilities and the spatial disparities they generate remain the subject of very little work. One of the few examples found in the European literature concerns the link between city size and carpooling. The authors hypothesized that a larger number of inhabitants could increase the choice and thus the diversity of carpooling partners (Delhomme and Gheorghiu, 2016). However, based on a qualitative survey, the authors were unable to obtain significant results to address this hypothesis. On the other hand, Pigalle and Aguiléra's study on car-sharing users' perceptions found that local carpooling decreases with high density (Pigalle and Aguilera, 2021), which contradicts most previous studies on the topic (Olsson, Maier & Friman, 2019). Their results indicate that low-density municipalities have more intense local carpooling. The absence of quantitative data explains the lack of spatial studies on this subject and the uncertainties surrounding the territorial impact of this mobility in France and Europe.

The question of territorial inequalities in the face of the growth of = is essential for planning. Indeed, recent technological trends suggest a rapid increase in carpooling practices. Social media and mobile technology apps are making it easier to connect ridesharing partners around the world (Neoh *et al.*, 2018), helping to develop a “sharing economy” culture (Hamari, 2015). Simultaneously, the success of these sharing platforms, such as =or Uber, is facilitating access to massive data from the web for research (Hamari, 2015; Masoud and Jayakrishnan, 2017; Liu *et al.*, 2021). These data offer the potential to better understand the spatial consequences of the development of these new practices and their challenges for planning in the future.

Based on extensive data from BlaBlaCar, this article presents a geographical analysis of carpooling mobility in France, examining three hypotheses: the positive impact of town size on carpooling supply, the influence of inter-town distance on regional and urban carpooling systems, and the potential for carpooling to facilitate town-country relations. Our hypotheses are partly validated. The results highlight the specific case of Paris, the relative importance of some intermediate cities and the impact of tourism specialization of rural areas. The article is structured into three sections: theoretical background, methodology, and results and discussion.

2. Theoretical background

Carpooling is defined as the practice of two or more people traveling together in a private vehicle (with one of the participants driving the vehicle, generally the owner), not necessarily coming from the same origin or going to the same destination.

During his journey, the driver can pick up or drop off passengers at different stops (Rietveld *et al.*, 1999). Moreover, internet-matching platforms permit flexibility and pre-arrangements (Agatz *et al.*, 2012). In theory, there is no financial gain, and the price simply covers the driver’s costs (gas and toll fees).

2.1 Carpooling issues and perspectives

The International Energy Agency estimates that carpooling = reduce the number of kilometers traveled by 12.5% and the fuel used by 7.7% if one person were to be added to each commute (Delhomme and Gheorghiu, 2016). It could also mitigate traffic congestion and CO₂ emissions (Minett and Pearce, 2011). People who carpool for distances of 48¹ km for example could save up to 33% of the monthly costs of commuting compared to those who choose to drive alone (TDM Encyclopedia, 2012). In France, recent studies calculated that carpooling increases the average car occupancy rate from 1.6 to 2.8 persons on long-distance journeys (Mazzella, 2018). This optimization would save 500,000 tons of oil one million tons of CO₂

¹ The average American commute is about 20.5 miles each way, or 41 miles roundtrip (65 km) - source U.S. Census Bureau. In France, it’s 27 km - source Insee.

emissions for two years (Maif, 2014). The social impacts are important, as it is a very affordable transport solution that increases access to mobility. Another positive externality is the beneficial impact of carpooling on road safety (*ibid.*). Therefore, it seems that carpooling represents an effective solution to some important environmental, social, and economic issues, even if it is still less developed in Europe compared to the US (Neoh and al., 2018).

Such expectations of a platform like BlablaCar should not overshadow the often less positive reality of these digital services. The uberization of services has been criticized for its exploitative nature and, in the worst cases, for simply introducing a rent-seeking intermediary who exploits workers and users alike. In the case of Blablacar, drivers offer a mobility service by filling up their car. The price offered covers part of the costs of gas and tolls. Based solely on C to C, the usual negative impacts are not observed here.

Regarding carpooling, Chan and Shaheen (2012) described the history of American car-sharing using five phases. During Phase 1 (1942–1945), the US government encouraged people to carpool to save energy resources for the war effort. In Phase 2 (late 1960s–1980), carpooling was adopted as a response to oil shortages. In Phase 3 (1980–1997) carpooling was thought to help reduce traffic congestion with high-occupancy vehicle (HOV) lanes, thereby improving urban air quality. In Phase 4 (1999–2004), the focus of carpool-matching programs was to gather large pools of registered users to increase the likelihood of successful partner matches. Finally, in Phase 5 (2004–present), carpooling became more technologically driven with platforms and mobile applications. We could perhaps imagine a sixth phase of expansion, in line with the growing culture of the sharing economy which is generating new uses, new demand, but also new objections, such as the ban on scooters in Paris, the outcry against Uber in many places, the legal challenges concerning Deliveroo's exploitation of workers, and so on. In Europe, carpooling is not new; in the case of France, it first emerged in 1958, but even if it is a long-standing practice, the country only inaugurated its first HOV lanes in 2020.

2.2 Carpooling practice: who and why?

The literature about carpooling focuses mainly on three points (Neoh and al., 2018):

- The motivations behind individuals' decisions to drive (e.g. Bergstad *et al.*, 2011; Steg and Tertoolen, 1999)
- The factors influencing commuter decisions to carpool (e.g. Arbour-Nicitopoulos *et al.*, 2012; DeLoach and Tiemann, 2011; Bulteau and al., 2020)
- Carpooling schemes case studies (Canning *et al.*, 2010).

These three elements provide a framework to help transportation planners in their decision-making. In the case of the US, scientific results mainly showed that, in the 2000s, carpoolers still tended to have a lower level of income. They also emphasize that Hispanic and African Americans carpool more than Caucasians and other ethnic groups (Blumenberg and

Smart, 2010, 2014; Chatman and Klein, 2009). Commuters are also mainly between 25 and 34 years old and are more likely to be single or married without children. In Europe, results show some important distinctions: a study in Germany (Carol and al., 2019) reveals that more than three out of five users with a German name received a confirmation to share a trip (66%), whereas only half of the users with a Turkish name (52%) were accepted as passengers. In France, some results are provided by an online survey of 618 members of the BlaBlaCar platform conducted in May 2013 (Sasheen *et al.*, 2017). The survey showed that long-distance carpooling users are, on average, better educated and form a younger cohort. Students are undoubtedly over-represented among BlablaCar users. Of the respondents, 87% had a baccalaureate level or more, in contrast to only 47% for the French population, and 45% of poolers were under 34 years of age in contrast to 27% for the French population. However, their level of income is relatively similar to that of the general population, and gender seems to be the most important predictor of carpooling use in France. These averages don't allow us to draw any conclusions about the spatial impact, as they don't reveal the heterogeneity of users, nor that of drivers, who see the cost of their mobility reduced in this way.

The diverse results show the differences between countries and between types of carpooling (short or long distance). Moreover, very little research has been done on the subject in Europe, even though these uses are increasing and evolving rapidly. Data from online platforms enable us to analyze the rhythms, temporality and geography of these mobilities, but not the social profiles of users and drivers, which are not provided in the database, not least because of the General Data Protection Regulation.

2.3 Massive data to study mobilities

Over the last decade, studies on individual mobility have benefited from new sources of massive amounts of passive data, defined as data not collected through active solicitation such as traditional origin-destination surveys. Whether it is ticketing, mobile phone or journey reservation data, all these (geo)digital traces renew the approaches to understanding individual and collective mobilities (Chen *et al.*, 2016).

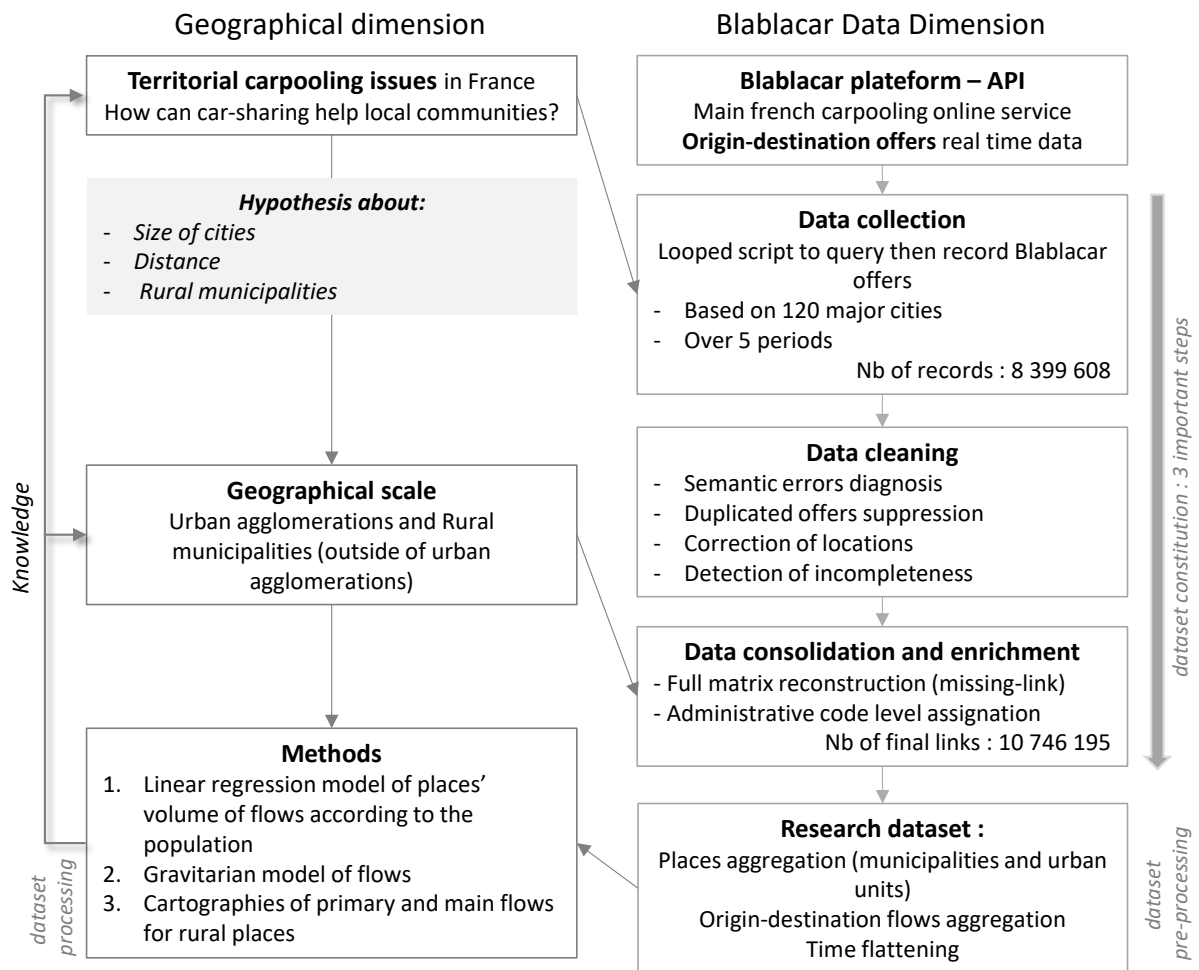
More generally, massive data are increasingly fueling reflections on the functioning of contemporary societies and particularly on how societal knowledge is produced (Bastin and Tubaro, 2018; Kitchin, 2014). The wealth of digital information produced by individuals and connected objects offers new research opportunities by capturing spatial practices with high granularity (Li and al., 2016; Ferreira and Vale, 2020) at spatiotemporal scales not easily accessible with usual methods (Beaude, 2015; Mericskay, 2018; Miller and Goodchild, 2015).

Beyond these promising perspectives, the mobilization of trace data mostly produced by private actors raises several questions (Kitchin, 2014) in terms of the nature of the data, the circulation, and the associated tools and processing methods. On the one hand, access to these new sources is characterized by a set of constraints limiting their use (technical, legal,

ethical and economic). On the other hand, the methods and tools of analysis are still in the consolidation phase and require both building dedicated and reproducible protocols and transposing the usual quantitative methods onto the new data. Then, studying carpooling flows has to face three main methodological issues: collecting data from the web, improving the data quality, and transforming the database into geographical datasets (Miller and Goodshild, 2015).

3. Data and methodology

In France, the number of carpooling websites was estimated at 78 by the end of 2010 (CERTU, 2007), and BlaBlaCar is the main service for connecting drivers and passengers. The BlaBlaCar company was founded in 2006 and is very popular in France, with approximately 95% of the French carpooling market (Mericskay, 2018). The number of users has increased exponentially every year to reach 10 million users across 13 different countries in 2014 (Dillet, 2015) and more than 40 million members in 2017, for a total of more than 10 million journeys offered per year throughout Europe, mainly in France (Mericskay, 2018). In contrast to the new BlaBlaLines platform dedicated to short distances and daily commutes, BlaBlaCar is mainly used for medium and long-distance trips. Passengers and drivers are connected through a website designed to combine social media with a reservation platform. Given its notable success, BlaBlaCar provides an interesting case study for ridesharing (Sasheen *et al.*, 2016). Blablacar has opened up transaction data recorded on their site to gain a better understanding of usage. However, this data is neither designed nor organized to produce geographic knowledge about car-sharing behaviors and mobility patterns on a national scale. To construct a spatial dataset suitable for analysis (see fig. 1), a processing chain must be built starting from the collection of massive unstructured data.



Processing workflow : from data collection to research dataset preprocessing and first spatial explorations and analyses directed by geographical and territorial questions at national scale.

Figure 1: Processing workflow from data collection to places and flows analysis

3.1 Data collection of carpooling footprints

The literature recognizes three main methods of accessing web information: the use of scraping, the establishment of partnerships with the data producers and the mobilization of APIs (Bastin and Tubaro, 2018). In this research, two ways of collecting data were combined due to BlaBlaCar's data dissemination policy.

First, the approach followed is based on collecting data from the API² developed in 2016 by BlaBlaCar, which is mainly meant for use by Otrip comparators. This API provides free access to online trip offers at the time of the request. Completed trips as well as filled trips are not available. The data collected from the API includes several fields related to the location of the

² Application Programming Interface of BlaBlaCar: <https://support.BlaBlaCar.com/hc/en-us>, consulted on 08/24/2020. This API aims to provide access to online comparators of itineraries across different modes of transportation (car, bus, and train).

origin and destination points (geographical coordinates, pick-up address, pick-up city, country, etc.), to time (date and time of departure and duration of the journey), price and booking methods.

Second, BlaBlaCar imposes restrictions on both data storage and the amount of data collected : no more than 200 records per day. To overcome this limitation, BlaBlaCar offers a special agreement that enables the extension of the query protocol to 10,000 records per hour for a maximum of 100,000 records per day, with the proviso that data should not be disseminated. Faced with these constraints, our approach consisted in optimizing the collection by requesting the flows emitted (and received) in a set of 120 cities (Fig.2) out of all French municipalities. This selection aims to optimize the spatial coverage of the French territory to address the geographical patterns of carpooling. These 120 cities were initially chosen by selecting the 100 largest urban units in terms of population. In a second step, we adjusted this panel to include the “chief towns” (or capitals) of rural departments. Although they are sparsely populated, they are nevertheless important poles of attraction for their hinterland. Additionally, a few large tourist centers were included, such as Arcachon or Briançon, again because of their ability to generate mobility and also to cover the whole of France.

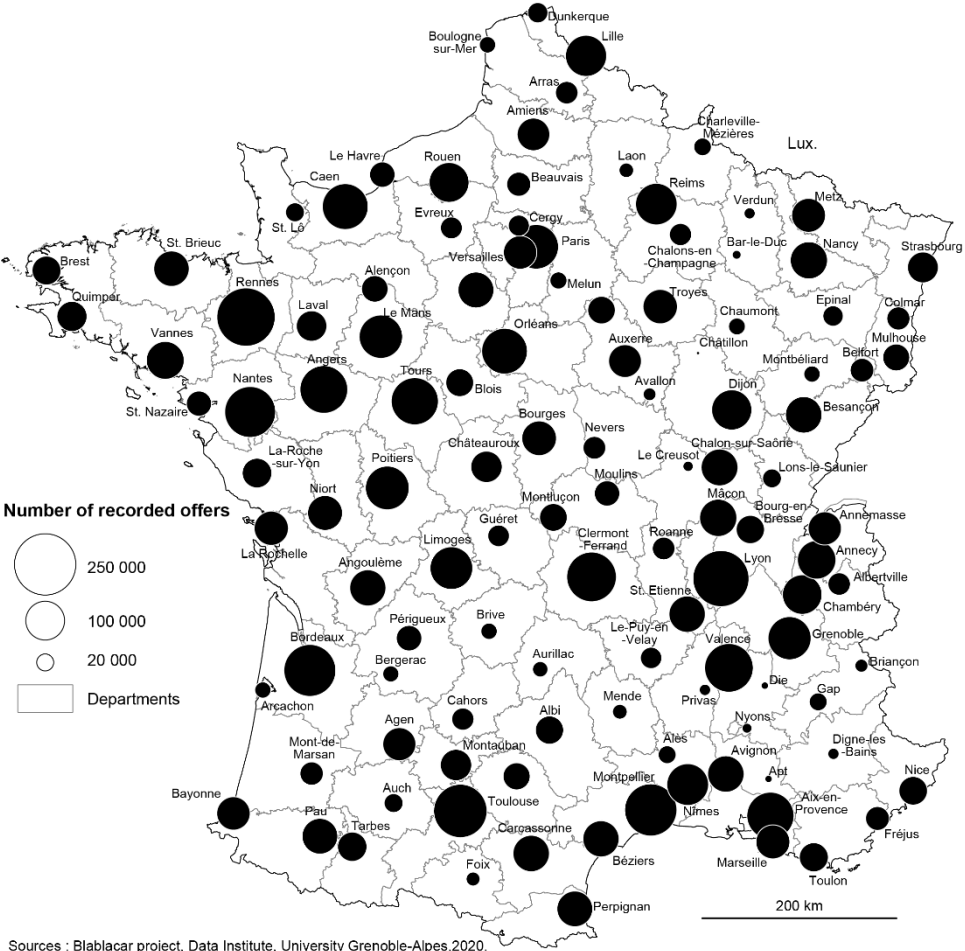


Figure 2. Number of BlaBlaCar offers recorded for 120 query cities in France.

The data collection protocol is a python script that queries the API based on several criteria and runs continuously over a period. This protocol includes two simple parameters. First, it queries the names of cities as a semantic argument and loops them for departures and then for arrivals. The second parameter corresponds to the geographical radius of the centroids of the queried cities within which the pick-up and drop-off data are recorded. This research uses the API's default radius, set to 15 km for departures and 5 km for arrivals. These 120 areas including radius concentrate more than 42 million inhabitants in France (66.5% of the French population).

To record substantial data representative of BlaBlaCar journeys, this protocol was implemented over five periods of time (Table 1). These stages are listed chronologically and characterized by duration and period within the year: two of them cover regular work weeks (collections 3 and 4), one is during summer vacations (collection 2), and the others (collections 1 and 5) correspond to periods when railway strikes took place on a national scale. Overall, the collected dataset reached 8,399,608 records formatted as a long-format matrix.

0	Start	End	Duration (days, %)	Records (number, %)
1 (strike)	5/4/18 10:20 AM	5/20/18 8:20 AM	15,9 (12,0%)	1,303,019 (15,5%)
2 (holiday)	7/14/18 12:15 AM	8/29/18 5:46 AM	46,2 (35,0%)	3,293,516 (39,2%)
3 (regular)	3/6/19 8:48 AM	3/28/19 9:11 AM	22,0 (16,6%)	1,200,676 (14,3%)
4 (regular)	4/29/19 9:50 AM	5/23/19 1:49 PM	24,1 (18,3%)	1,533,750 (18,3%)
5 (strike)	11/25/19 3:46 PM	12/19/19 12:50 PM	23,9 (18,1%)	1,068,647 (12,7%)
Total	-	-	132,2 (100%)	8,399,608 (100%)

Table 1. Periods and results of query stages.

Table 1 shows that regular days make up 34.9% of the total and produce 32.6% of the links; vacation days represent 35.0% of the total and generate 39.2% of the links; while strike days account for 30.1% of the total and 28.2% of the links.

For the latter two collections, there is a difference between strike days at the end of the year (November and December) and in the spring (April and May). Furthermore, in the case of

collection 5, we observe a lower proportion of links relative to the share of days. The strike did not increase resort to the BlaBlaCar offer. During the spring period, the weight of the links is, on the contrary, much heavier than that of the days. The numerous public holidays and long vacation weekends may explain the contrasting result. Although temporal data (time and date) provide valuable information, this paper focuses on a first geographical approach, but future explorations integrating periods and time are underway.

3.2 From collected to consolidated data: an enhanced corpus on carpooling

The collected data consist of online carpooling offers that are proposed by the drivers and made available to the passengers. Each record is a link between two places (defined by their pick-up and drop-off geographical coordinates) that fits into a full journey as defined by the initial start and the final destination of the driver; thus, the link does not necessarily have the same starting and ending points as the journey.

Like many other web data (Arribas-Bel, 2014), the BlaBlaCar dataset contains many errors or biases.

- First, the recording of data at the offer level implies potential missing links when stopping places are not included in the query list of cities (Fig.3). For example, a journey from an origin to a destination transiting by Stop 1 and Stop 2, with the origin and destination as queried places, generates a missing link between Stop 1 and Stop 2 in the dataset. Based on the number of unique places within trips recorded by collects, there are 2,809,510 missing links.
- Second, as the route is either informed by drivers (vehicle, place of departure or arrival) or computed by automatic algorithms (addresses, distances), the data imply in both cases inaccuracies and incompleteness.
- Third, there are duplicated data in specific cases. For example, when the driver modifies his route between two query loops or proposes a round-trip or long-term journey.

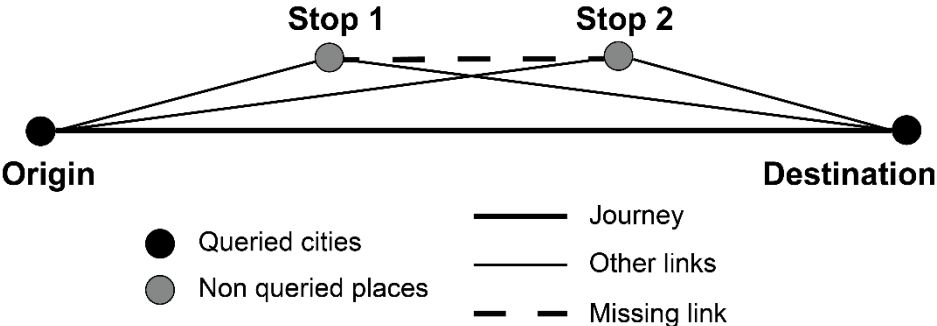


Figure 3. Expected data and missing links.

Based on a diagnosis that aims to identify errors and estimate the gap between collected and expected data (Duroudier et al., 2020; Guptill and Morrison, 1995), the quality of the dataset was improved by a cleaning protocol that is reproducible over the various collections. It followed three main guidelines. First, if information was missing from the links but existed for the journey, then we indicated it for the links as well. Second, data was filtered and some journeys deleted because of outliers. Third, the missing links were reconstructed based on the full matrix of places within trips, bringing the total to 10,746,195 links. The reconstructed links are informed with their places of departure and arrival and by other semantics attributes inferred from the journey level.

3.3 From carpooling offers to spatial data

Designed as a collection of carpooling offers, the dataset has been reframed to allow the geographical analysis of flows between places. The data have two geographical components: the coordinates of the departure and arrival points and the addresses. These are used both to match the Insee³ municipality code to all locations, allowing aggregations in administrative and statistical meshes from the municipalities to urban agglomerations.

To better grasp the geography of carpooling patterns and to answer our question about territorial inequalities between large-sized cities and other places, the analysis is conducted at a hybrid spatial scale that mixes urban agglomerations and rural municipalities. An urban agglomeration is defined as one or more municipalities with contiguous urbanized areas (i.e., less than 200 meters between buildings) and at least 2,000 inhabitants⁴. There are 2,310 urban agglomerations in France grouping 7,083 municipalities and then 27,756 rural municipalities.

This scale choice aims to account for Blablacar's practices and reveal the spatial impacts of car-sharing. Regarding agglomerations, Blablacar's carpooling service is primarily aimed at urban core residents rather than those of the municipality. Pick-up addresses are often conveniently located at places such as train stations, park-and-ride facilities, or motorway exits. Thus, in urban areas, the service is not only for the population of the municipality where the pick-up place is located, but also for the population of the agglomeration. Additionally, this division allows for consideration of rural areas on a municipal scale, in cases where no urban unit exists.

³ *Institut national de la statistique et des études économiques*, as the French Census service.

⁴ Definition of urban areas: <https://www.insee.fr/fr/metadonnees/definition/c1501>, consulted on 08/24/2020.

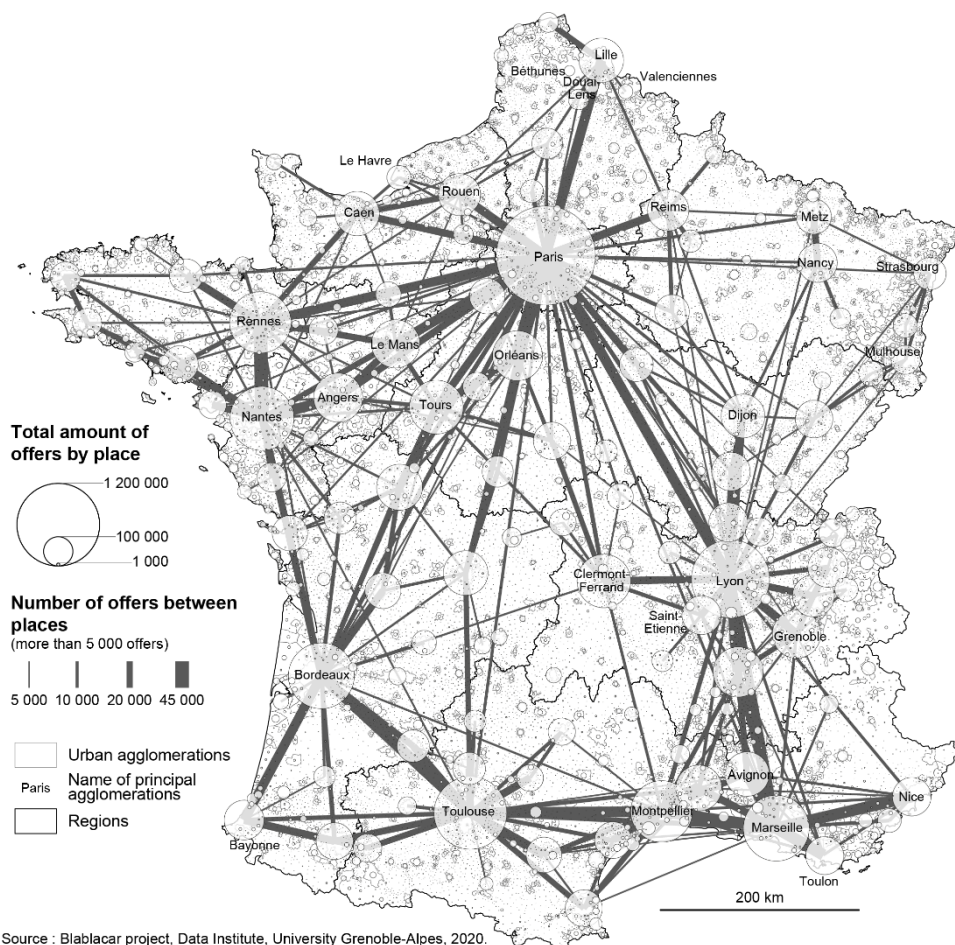


Figure 4. Centralities and main flows according to Blablacar offers

Figure 4 shows the spatial structure of our data. A majority of French municipalities (about 75% of 34,841 continental units) counted at least one departure and one arrival of a BlaBlaCar offer over the whole collecting period. Only 4,893 municipalities (14%) did not count any offer during this time, while 11% of others were only concerned by one departure or one arrival.

The northeastern regions from Normandy to the northwest border of Switzerland count many rural municipalities that do not have any offer of carpooling, except in some major metropolitan areas (around Lille, Strasbourg, Metz and Nancy). This under-representation may be related to the low population density of these territories, which are mostly rural. Other factors such as the proximity of borders or the pattern of some other modes of transportation could explain this geography. On the other hand, territories with a better level of accessibility are mainly located to the south and west of the Normandy–Switzerland line. Plenty of areas in the south only have a few municipalities that are not connected to the BlaBlaCar carpooling network; for example, in the Alps, along the Mediterranean Sea, on the Atlantic coast, and in the Bretagne and Pays-de-la-Loire regions. The case of Corsica is not considered because almost none of the municipalities are connected. The BlaBlaCar platform has not yet

penetrated the mobility practices of the inhabitants, nor does it compete with other transportation systems.

The national framework reveals significant regional disparities. To explore the spatial distribution of Blablacar's offers and flows, three questions should be investigated using different methodology:

- What is the relationship between city size and car-sharing services? The distribution of services is highly concentrated, with ten cities generating around a third of the total recorded journeys. In contrast, almost 10,000 towns have fewer than 10 pick-up or drop-off points across all collection periods.
- Are regional urban systems taking shape? If so, the role of distance between towns needs to be questioned.
- Finally, there may be rural effects resulting from specific territorial characteristics. What are the specific features of the relationship between urban and rural areas?

3.4 Analysis Models

Massive Origin-Destination movement data analyses are always a challenge due to the complexity of the phenomenon to study and the high dimensionality of the data reflecting it (Andrienko, N. and Andrienko G., 2011, Andrienko *et al.* 2017). Here, three different methodological approaches are implemented to analyze the geographical patterns of the Blablacar carpooling offers.

The first approach paints a geographical picture of carpooling in France by focusing on the attractivity of cities and municipalities. According to the literature on systems of cities (Pumain *et al.*, 2006), the total amount of carpooling offers should be mainly related to the size of places: the more inhabitants there are, the higher the number of offers. This relation is measured by using a log-linear regression of the volume of offers by the population of cities and municipalities:

$$\log(M_i) = a \log(P_i) + b$$

Where M_i is the sum of departures and arrivals for each city and municipality, and P_i the number of inhabitants. The total amount is considered due to the symmetric pattern of in and out flows (the linear correlation coefficient of both logarithmic variables is 0.994). The aim of this initial model is to verify our hypothesis regarding the relationship between city size and the feasibility of carpooling. Additionally, analysing the residuals of the model can help identify overrepresented and underrepresented areas in relation to their population.

The second approach follows the hypothesis that a regional system with well-connected cities in proximity is more conducive to car-sharing. This approach introduces the distance of flows

between cities and municipalities designed by Blablacar offers. The study of carpooling flows is implemented by using a gravity model where the number of offers between two places is proportional to the number of offers in departure and arrival places, and inversely proportional to the distance which separates them. A better adjustment of the distance role is obtained with a Pareto form of the gravity model (Baccaïni and Pumain, 1998):

$$F_{ij} = M_i \cdot M_j \cdot D_{ij}^{-\alpha}$$

Where F_{ij} is the predicted non-oriented flow between city i and city j (with $i \neq j$), M_i and M_j the respective numbers of offers of both cities, D_{ij} the euclidean distance between i and j , and α a parameter expressing the dissuasive effect of the distance. The model is computed with a Poisson generalised linear regression (Flowerdew and Aitkin, 1982):

$$\log(F_{ij}) = \beta_0 + \alpha \log(D_{ij}) + \beta_1 \log(M_i) + \beta_2 \log(M_j) + \varepsilon$$

All variables in the model are significant. The model acts as a filter to highlight repellent and desire lines where Blablacar offers are less or more numerous than expected based on the distance and the amounts at both origin and destination.

The third hypothesis is that car-sharing can connect urban and rural areas where public transport is lacking. However, the low demand to and from these areas presents challenges. To answer, we chose a third methodological approach. It derives from the limitations of the previous ones that capture patterns of major flows but that are unable to catch rural practices which involve smaller flows. To do so, this article leads on two cartographic methods: the map of primary flows from rural municipalities, and the map of main non-oriented flows in relation with rural spaces. A primary flow is defined as the more important flow from a rural municipality with all other locations.

4. Spatial structures of Blablacar flows revealing spatial interactions within French territories

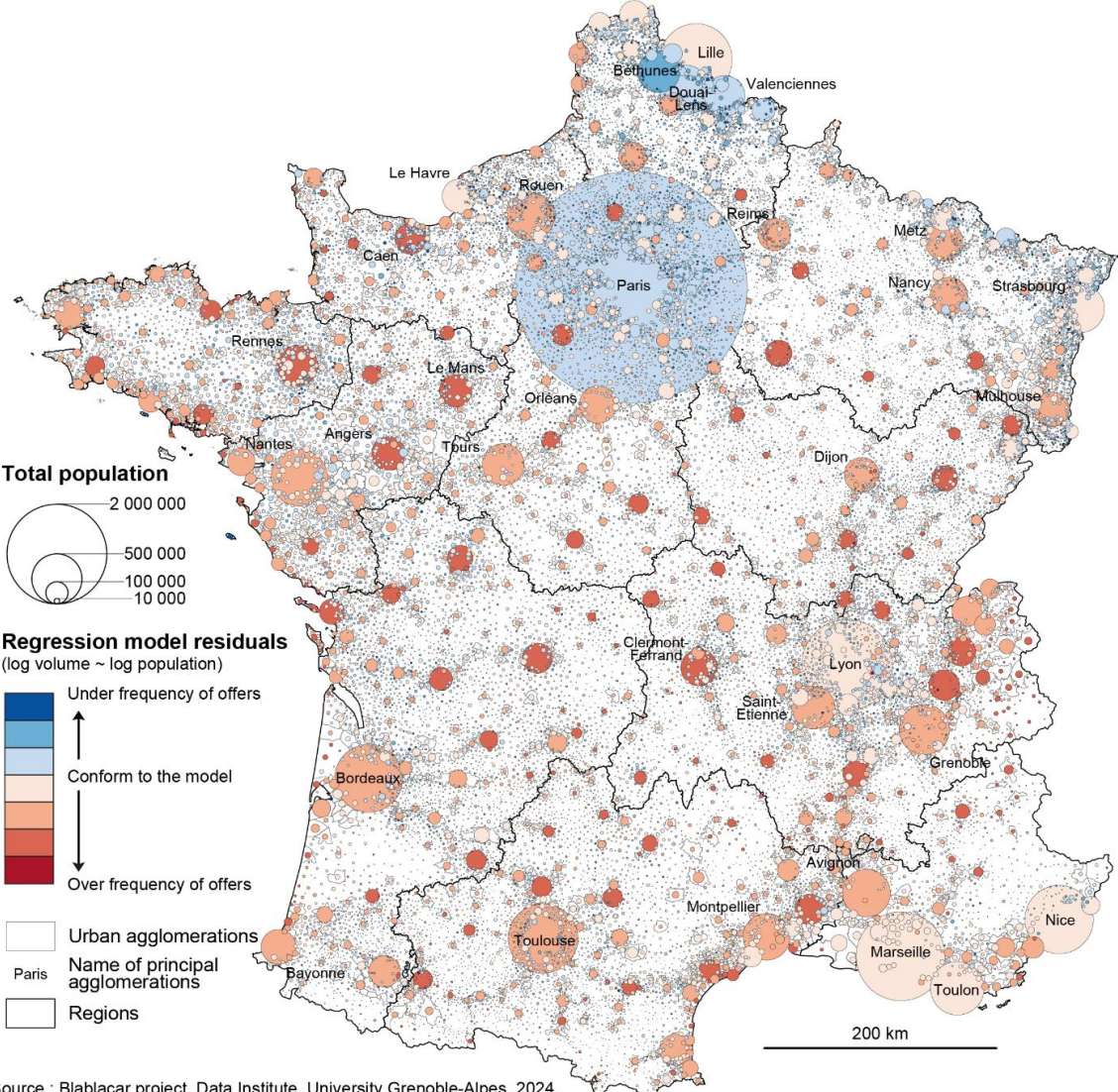
Our results are presented by following our hypothesis and methodological steps.

4.1 BlaBlaCar as a large cities practice

Blablacar's car-sharing model exhibits a clear hierarchy of cities in terms of both emissions and receipts of flows. The size of the city explains almost 65% of the total variance of the Blablacar offer, as shown in Appendix 1.

The Paris metropolitan area has the highest concentration of flows, with 1.1 million offers, followed by Lyon, Marseille, Toulouse, Bordeaux, Nantes and Rennes, each with over 400,000 departures and arrivals during the periods studied. Cities with populations of up to 200,000 account for almost 45% of flows, and they exchange more with other large cities. Intermediate

cities with populations ranging from 20,000 to 200,000 are also significant as they account for approximately 40% of flows, particularly to other large and intermediate cities. It is more feasible to address supply and demand in densely populated areas due to the greater number of opportunities available. Furthermore, qualitative studies conducted in France among BlaBlaCar users (Sasheen et al., 2016) have highlighted the profile of carpoolers, which shows an overrepresentation of young people and those from higher socioprofessional categories. These profiles are also overrepresented among city residents.



Source : Blablacar project, Data Institute, University Grenoble-Alpes, 2024.

Figure 5. Regression model residuals from linear model between carpoolers offers (Mass-Mi) and size of cities (Poulation-Pi)

Model residuals are presented in Figure 5. The data suggests that Paris is under-resourced in relation to its population, which may be attributed to the abundance of transportation services to and from the French capital. Additionally, the data confirms the under-

representation of flows in the north-northeast. This region includes large urban areas such as Lille, as well as towns and rural municipalities, which are not significant carpooling locations. The difference in the density of the intercity rail network between Lille and its surrounding areas, as well as the lower density in rural areas, could account for this result. By contrast, other major cities in France have a positive residual, although =.

Many urban areas with populations between 100,000 and 500,000 inhabitants are important carpooling hubs, particularly in central and western regions (Rennes, Tours, Angers, Le Mans, Poitiers, La Rochelle, and Limoges, Clermont-Ferrand), along the Mediterranean (Perpignan, Montpellier, Nîmes, and Avignon), in the Rhône corridor (Valence and Dijon), and the Alps (Chambéry and Annecy).

Smaller urban units with populations ranging from 20,000 to 100,000 inhabitants are also important locations for car-sharing. This is evident in the central-eastern region of France, including Mâcon, Châlons-sur-Saône, Bourges, Auxerre and Nevers. Other highly accessible medium-sized cities are situated between larger cities, such as Valence and Carcassonne. These cities, among which Guéret and Montluçon, are located along major roads. These results illustrate the significant role that intermediate cities play in the mobility system. While they may not always be the primary destinations for BlaBlaCar services, their central location within rural areas often makes them popular stops for carpooling journeys.

These findings confirm the correlation between city size and carpooling availability. However, further analysis of deviations from the model has highlighted the crucial position of many intermediate cities within the French urban system as shown by BlaBlaCar's carpooling practices. These areas attract more traffic than expected given their size. Intermediate towns can also serve as important hubs connecting towns of different sizes, both large and small, as well as rural municipalities.

4.2 Desire and repulsive lines of carpooling

Our second approach aims to verify the type of interaction drawn by Blablacar flows between cities considering their sizes and the distances between them.

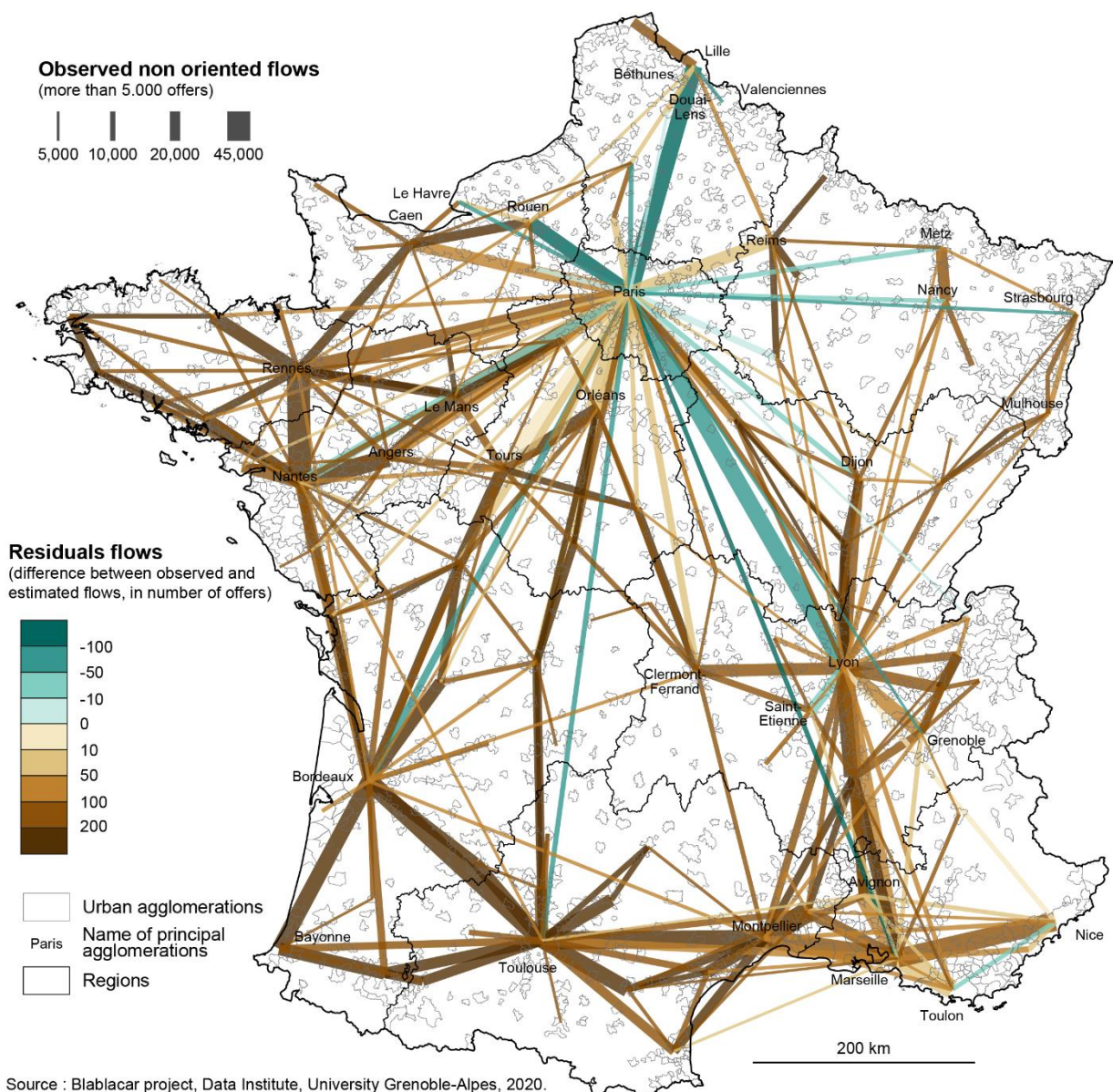


Figure 6. Desire and repulsive lines of carpooling from the gravity model.

The relationship measured by the gravity model is verified, indicating a relationship between the size of the urban units, the distance between them and the number of flows observed. The model explains almost 70% of the variance (annex 2).

By analysing the desire and repulsive lines of carpooling from the gravity model (Figure 6), we can identify the specific uses of Blablacar in terms of linking French cities and regions. Two geographical models are emerging. The first model is national, connecting Paris to other cities in France. The second model is regional, showing the closer relationships between two regional capitals or between major cities and intermediate towns in the same region.

So, the first striking result concerns relations between Paris and the major French cities. Overall, links between Paris and Lille, Marseille but also Lyon, Strasbourg, Toulouse, Nantes

and Bordeaux are under-represented in Blablacar's traffic, in view of the size and distance. Conversely, links between Paris and some intermediate cities are over-represented, for example Reims, Clermont-Ferrand or Dijon.

Several explanatory hypotheses can be put forward: high-speed train services (TGV) are very well developed between Paris and the major cities, and the regular flows between these cities are partly made up of large numbers of skilled commuters who prefer the quality, speed and comfort of a high-speed line.

One exception to the first result is the over-representation of the link between Paris and Rennes in the model. This is despite the fact that Rennes is one of the largest French cities with excellent TGV services. The over-representation could be due to the high proportion of students in the city's population. Rennes is France's third-largest student city, after Poitiers and Montpellier. It is worth noting that these last two cities are also positively linked to Paris, indicating the influential role of student activity. Further research could be conducted to identify the variables that account for these particular geographical characteristics.

The model displays over-represented flows that create inter-regional city networks, with the exception of the Paris region. For instance, this is evident in the routes of Rennes-Nantes, Nantes-Bordeaux, Bordeaux-Toulouse, Marseille-Lyon and Lyon-Dijon. If we consider intra-regional flows, we can also observe strong links between major cities and intermediate towns. Some over-represented flows between small tourist towns can be identified, showing the interest of the Blablacar offer for local journeys within tourist regions, which undoubtedly complements the local public transport offer (which does not always absorb the increased needs during tourist periods). It should be noted, however, that some of the over-represented flows linked to tourist towns have direct links with the Paris region (in particular with certain municipalities in Brittany).

4.3 Rural services

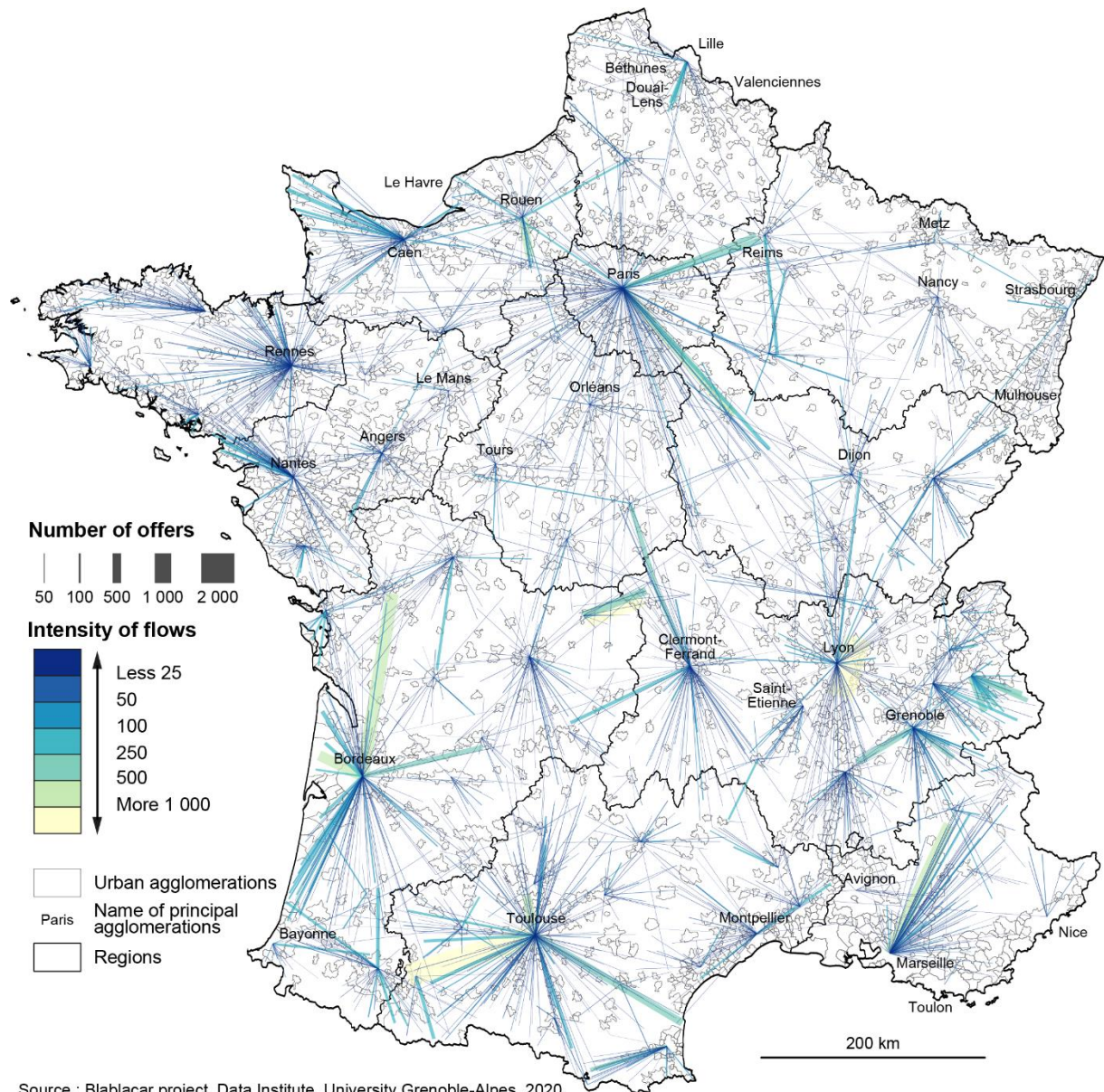
The final results describe rural and peripheral municipalities that count carpooling offers. Even if they are under-represented in terms of absolute numbers of flows and weighted values by resident population, BlaBlaCar could constitute a private and flexible mobility option for this type of area (ADEME, 2015). The map (Fig.8) represents the primary flows and shows where rural municipalities are connected by their most important flow.

On a large regional scale, major metropolitan areas form some important star-shaped networks: Paris, Bordeaux, Toulouse, Lyon, Rennes, Marseille and Clermont-Ferrand. Bordeaux, for example, determines the primary flow of many rural places at a short distance along the tourist coastline as well as at longer distances (150 km) with communes closer to some other cities such as Bayonne in the southwest, Angouleme in the east, and Niort or La Rochelle in the north. Intermediate cities also stand out as regional centers by structuring their

local and departmental rural environment: for example, Perpignan, Nîmes, Limoges, Poitiers, Troyes and Nancy. Thus, rural places are often served by their nearest metropolitan areas.

Another view of rural spaces according to BlaBlaCar carpooling is provided by Figure 8 which represents only the more important non-oriented flows (over 50 links) that take their origin or destination in peripheral or rural municipalities. This item of data represents approximately 957,000 links (9% of the total). This map shows how carpooling connects some major cities with famous rural tourist areas located on the Atlantic and Mediterranean coasts or in mountain towns, especially in the Alps and the Pyrenees. Some other important rural flows also link large or intermediate cities to specific tourist attractions, such as Futuroscope near Poitiers, Le-Puy-du-Fou in the Vendée (both large theme parks), or Lourdes in the Pyrenees, known for religious tourism. These flows illustrate the importance of tourist patterns in the BlaBlaCar travel system.

It is interesting to highlight the type of cities that generate this type of flow, namely Rennes, Nantes, La Rochelle, Bordeaux, Toulouse, Montpellier, Marseille, Lyon, Grenoble and Chambéry. These French cities are renowned for their attractiveness to residents and businesses and for their economic and demographic dynamism, and they are among the cities that have seen the greatest growth in jobs and population over the last few decades. Moreover, one of the results highlighted by this study is the proximity and connectedness of these cities to rural hinterlands with strong amenities. This finding confirms what other studies have shown about the positive impact of environmental and tourist amenities in the hinterland on the attractiveness and economic development processes of cities in France (Davezies, Talandier, 2014).



Source : Blablacar project, Data Institute, University Grenoble-Alpes, 2020.

Figure 7. Primary flows from rural municipalities.

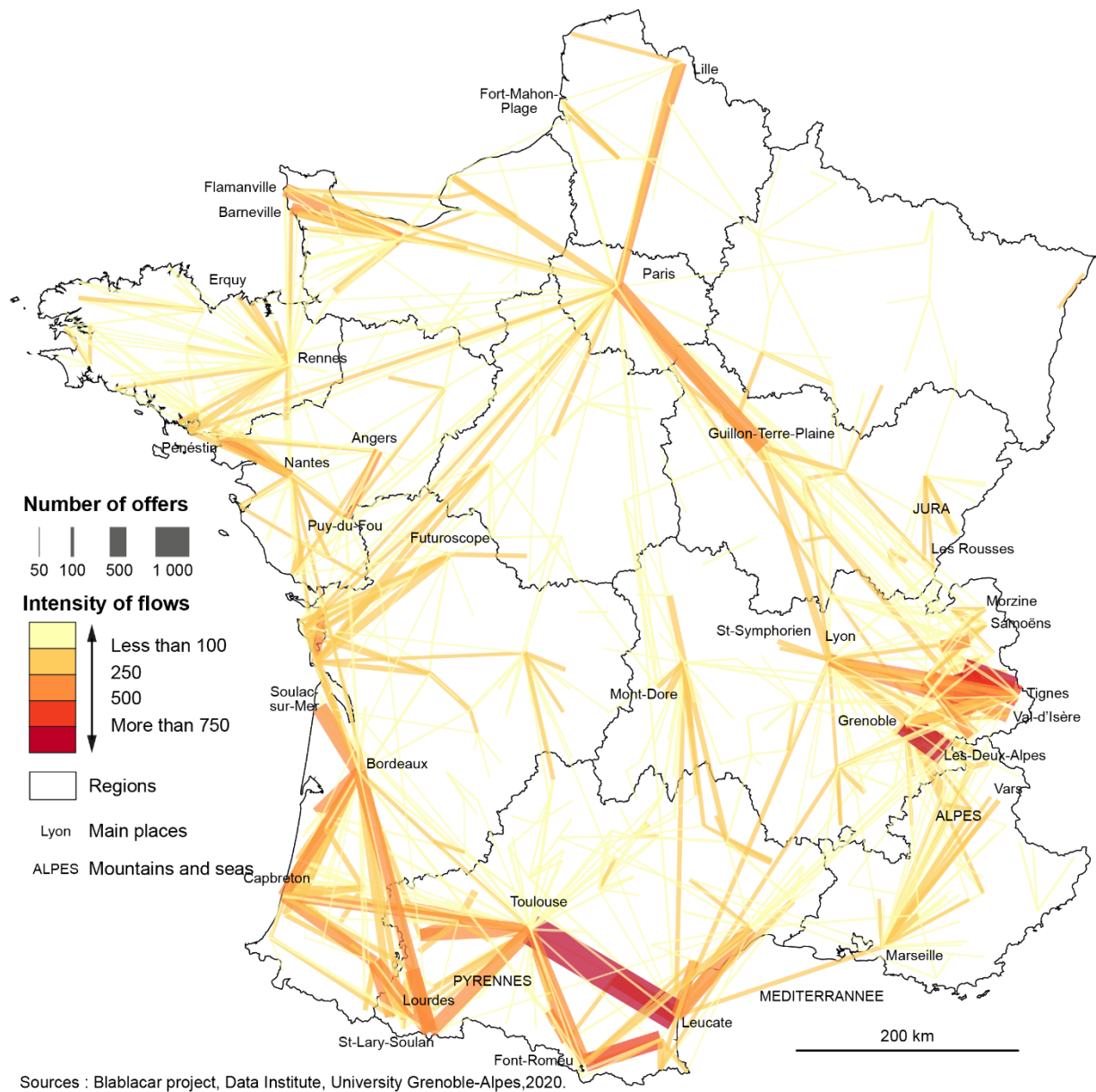


Figure 8. Main flows with rural municipalities (over 50 offers from and to rural municipalities).

5. In conclusion, some issues for regional planning

This paper presents a comprehensive analysis of BlaBlaCar carpooling data, offering new perspectives for regional planning. The possible outcomes are many, including reducing the environmental and economic costs of motorized mobility, as well as addressing social and spatial disparities.

First, the study indicates that regional culture and equipment play a significant role in explaining the importance of carpooling practices. For instance, there is a notable contrast in the use of carpooling between the north-east and other regions of France. Local populations can be encouraged to change their behaviour through communication and awareness-raising activities. However, the availability of other modes of transport may also contribute to these differences. To gain a better understanding of these regional specificities, further studies could be conducted to elucidate the explanatory factors.

Second, the analysis provides results that confirm the structure of the French urban hierarchy, with large cities organizing flows at the national scale, as Paris, while rural places are less connected. In metropolises, traffic congestion is a serious problem because it increases travel time and energy consumption and impacts air quality. To reduce congestion and air pollution, policymakers have used several strategies. One of the tools that could be developed in large French cities is the creation of dedicated lanes for carpooling. It was first implemented in the Grenoble area in 2020, but only three other French cities have proposed this service to date (Lyon, Strasbourg, and Bordeaux). It should be noted that the development of this type of dedicated lanes is one of the proposals of the Citizens' Climate Convention, set up by President Emmanuel Macron to respond to the Yellow Vests crisis. Included in the "Climate and Resilience" law, their deployment should be monitored in the coming years. Thus, studies based on data from digital platforms can help national and local decision-makers improve their knowledge of the needs and practices of car-poolers.

Third, our study shows that sharing platforms generate spatial inequalities. It highlights the polarization of flows by large metropolitan areas within the urban hierarchy. As BlaBlaCar carpooling is primarily a private market, the largest cities offer better opportunities to sell a carpooling service, in terms of both supply and demand. Thus, as drivers may try to optimize the probability of having passengers, they may be more likely to propose well-known places rather than rural places that are only at the start and end of the journey. However, a less expected result appears. In this market pattern, intermediate cities seem to take on a nodal role, connecting cities of different sizes (large and small) and achieving the highest values from and to peripheral and rural municipalities. It reveals the key role these cities play as hubs in the mobility system: if they are not necessarily principal origins and destinations of BlaBlaCar offers, they may often be proposed as stops in the journey because of their centrality within their regional environments or along major travel axes.

This result is interesting for two reasons. In these medium-sized cities, public transport is less developed than in the larger cities. All journeys to and from these cities are made by car but we also know that the average income of the inhabitants is lower than in other cities in France. Therefore, there are environmental and social issues to be addressed in promoting and developing carpooling in intermediate cities.

Four, when distance was taken into account, we noticed a lack of representation of links between Paris and other cities. This is likely due to the fast and comfortable train connections and the profile of the users who make this journey. Regional patterns also emerge, connecting regional capitals based on proximity. Within the region, the provision of carpooling is structured by connection between large and medium-sized cities.

Another interesting result concerns rural communes, which are not excluded from carpooling. Most communes have at least one link on all the collections. In addition, links with small, medium-sized and large towns are not negligible, and they even are important for certain areas identified by their tourist specialisation, such as the Alps and Pyrenees, Mediterranean coast and Atlantic coast. Analysis of the flows between urban and rural areas in France has revealed the strong connections between major cities and their surrounding touristic rural regions. The low population density in these areas presents challenges for the development of public transportation. To reduce greenhouse gas emissions, promoting long-distance car-sharing for leisure and holiday purposes could be a crucial aspect of mobility planning.

Finally, the spatial analysis of carpooling practices, which is still not extensively studied in Europe, is a real challenge for regional planning. However, the use of platform data that is massive but passive means that processing methods need to be adapted to reconstruct formal spatial flows with origins and destinations⁶. We also need to be aware that the data describes the practices of users of a specific service, which does not represent all carpooling practices. The aggregation of data from different platforms could be considered, but this would involve new methodological challenges (data heterogeneity, differences in APIs and collection methods, etc.). However, access to platform data and the development of methods for processing and visualizing massive data offer exciting prospects for the study of transport geography and regional studies.

Bibliography

- ADEME-6t-bureau de recherche. (2015). *Enquête auprès des utilisateurs du covoiturage longue distance*. ADEME. <https://librairie.ademe.fr/mobilite-et-transport/2713-enquete-aupres-des-utilisateurs-du-covoiturage-longue-distance.html>.
- Agatz, N., Erera, A., Savelsbergh, M., & Wang, X. (2012). Optimization for dynamic ride-sharing: A review. *European Journal of Operational Research*, 223(2), 295-303.
- Aguiléra, A., & Pigalle, E. (2021). The future and sustainability of carpooling practices. an identification of research challenges. *Sustainability*, 13(21), 11824.
- Andrienko, G., Andrienko, N., Fuchs, G., Wood, J. (2017). Revealing Patterns and Trends of Mass Mobility Through Spatial and Temporal Abstraction of Origin-Destination Movement Data. *IEEE Trans. Visual. Comput. Graphics*, 23 (9), 2120–2136. <https://doi.org/10.1109/TVCG.2016.2616404>.
- Andrienko, N., Andrienko, G. (2011). Spatial Generalization and Aggregation of Massive Movement Data. *IEEE Transactions on Visualization and Computer Graphics*, 17 (2), 205–219. <https://doi.org/10.1109/TVCG.2010.44>.
- Arbour-Nicitopoulos, K., Faulkner, G. E., Buliung, R. N., Lay, J., & Stone, M. (2012). The school run: Exploring carpooling as an intervention option in the Greater Toronto and Hamilton Area (GTHA), Canada. *Transport Policy*, 21, 134-140.
- Arribas-Bel, D. (2014). Accidental, open and everywhere: Emerging data sources for the understanding of cities. *Applied Geography*, 49, 45–53.
- Baccaïni, B., Pumain, D. (1998) Les migrations dans le système des villes françaises de 1982 à 1990. *Population*, 53(5), 947-977. DOI : 10.2307/1534831
- Bastin, G., Tubaro, P. (2018). Le moment big data des sciences sociales. *Revue française de sociologie*, 59(3), 375–394.
- Beaude, B. (2015). *Big Data in Social Sciences*. <http://infoscience.epfl.ch/record/207921>.
- Bento, A. M., Hughes, J. E., & Kaffine, D. (2013). Carpooling and driver responses to fuel price changes: Evidence from traffic flows in Los Angeles. *Journal of Urban Economics*, 77, 41-56.
- Bergstad, C. J., Gamble, A., Hagman, O., Polk, M., Gärling, T., & Olsson, L. E. (2011). Affective–symbolic and instrumental–independence psychological motives mediating effects of socio-demographic variables on daily car use. *Journal of Transport Geography*, 19(1), 33-38.

Blumenberg, E., & Smart, M. (2010). Getting by with a little help from my friends... and family: immigrants and carpooling. *Transportation*, 37(3), 429-446.

Blumenberg, E., & Smart, M. (2014). Brother can you spare a ride? Carpooling in immigrant neighbourhoods. *Urban Studies*, 51(9), 1871-1890.

Buliung, R. N., Bui, R., & Lanyon, R. (2012). When the internet is not enough: toward an understanding of carpool services for service workers. *Transportation*, 39(5), 877-893.

Buliung, R. N., Soltys, K., Bui, R., Habel, C., & Lanyon, R. (2010). Catching a ride on the information super-highway: toward an understanding of internet-based carpool formation and use. *Transportation*, 37(6), 849-873.

Bulteau, Julie, Feuillet, Thierry, & Dantan, Sophie (2019). Carpooling and carsharing for commuting in the Paris region: A comprehensive exploration of the individual and contextual correlates of their uses. *Travel Behaviour and Society*, 16, 77–87

Canning, P. E., Hughes, S. J., Hellawell, E. E., Gatersleben, B. C. M., & Fairhead, C. J. (2010). Reasons for participating in formal employer-led carpool schemes as perceived by their users. *Transportation planning and technology*, 33(8), 733-745.

Carol, S., Eich, D., Keller, M., Steiner, F., & Storz, K. (2019). Who can ride along? Discrimination in a German carpooling market. *Population, space and place*, 25(8), e2249.

Chan, N. D., & Shaheen, S. A. (2012). Ridesharing in North America: Past, present, and future. *Transport reviews*, 32(1), 93-112.

Chatman, D. G., & Klein, N. (2009). Immigrants and travel demand in the United States: Implications for transportation policy and future research. *Public Works Management & Policy*, 13(4), 312-327.

Chen, C., Ma, J., Susilo, Y., Liu, Y., Wang, M. (2016). The promises of big data and small data for travel behavior (aka human mobility) analysis. *Transportation Research Part C: Emerging Technologies*, 68, 285–299.

Davezies, L., & Talandier, M. (2014). *L'émergence des systèmes productivo-résidentiels. Territoires productifs-territoires résidentiels: quelles interactions?* (No. 19, pp. 136-p). La documentation française.

Delhomme, P., & Gheorghiu, A. (2016). Comparing French carpoolers and non-carpoolers: Which factors contribute the most to carpooling?. *Transportation Research Part D: Transport and Environment*, 42, 1-15.

DeLoach, S. B., & Tiemann, T. K. (2012). Not driving alone? American commuting in the twenty-first century. *Transportation*, 39(3), 521-537.

Dillet, R. (2015). BlaBlaCar acquires its biggest competitor Carpooling. com to dominate European market. *TechCrunch*, 15 April 2015. <https://techcrunch.com/2015/04/15/blabla-car-acquires-its-biggest-competitor-carpooling-com-to-dominate-european-market/>

Downs, A. (2005). *Still stuck in traffic: coping with peak-hour traffic congestion*. Brookings Institution Press.

Duroudier, S., Chardonnel, S., Mericskay, B., André-Poyaud, I., Bedel, O., Depeau, S., Devogele, T., Etienne, L., Lepetit, A., Moreau, C., Pelletier, N., Ployon, E., Tabaka, K. (2020). Diagnostic qualité et apurement des données de mobilité quotidienne issues de l'enquête mixte et longitudinale Mobi'Kids. *RIG* 30, 127–148. <https://doi.org/10.3166/rig.2020.00105>

El-Geneidy, A., Levinson, D., Diab, E., Boisjoly, G., Verbich, D., & Loong, C. (2016). The cost of equity: Assessing transit accessibility and social disparity using total travel cost. *Transportation Research Part A: Policy and Practice*, 91, 302-316.

Ferreira, D., Vale, M. (2020). Geography in the big data age: an overview of the historical resonance of current debates. *Geographical Review* vol. 112, 2022 - Issue 2, 250–266. <https://doi.org/10.1080/00167428.2020.1832424>

Flowerdew, R., Aitkin, M. (1982). A methode of fitting the gravity model based on the Poisson distribution. *Journal of Regional Science*, 22, 191-202. <https://doi.org/10.1111/j.1467-9787.1982.tb00744.x>

Friman, M., Fujii, S., Ettema, D., Gärling, T., & Olsson, L. E. (2013). Psychometric analysis of the satisfaction with travel scale. *Transportation Research Part A: Policy and Practice*, 48, 132-145.

Gheorghiu, Alexandra, & Delhomme, Patricia (2018). For which types of trips do French drivers carpool? Motivations underlying carpooling for different types of trips. *Transportation Research Part A: Policy and Practice*, 113, 460–475.

Guptill, S. C., Morrison, J. L. (1995). *Elements of Spatial Data Quality*. Elsevier, Oxford.

Hachaichi, M., & Talandier, M. (2023). Assessing the ecological performance of French territories using a spatially-nested approach. *Ecological Indicators*, 155, 110947.

Hamari, J. (2015). Why do people buy virtual goods? Attitude toward virtual good purchases versus game enjoyment. *International Journal of Information Management*, 35(3), 299-308.

ICARO - Increase Of CAR Occupancy through Innovative Measures and Technical Instruments. Effectiveness of car-pooling. (1999). Final report Contract No PL 96-1056. .Project funded by the european commission under the transport rtd programme of the 4th framework programme.
<https://trimis.ec.europa.eu/system/files/project/documents/icaro.pdf>.

Kitchin, R. (2014b). Big Data, new epistemologies and paradigm shifts. *Big Data & Society*, 1(1), 1–12.

Lau, J., Hung, W. T., Cheung, C. S., & Yuen, D. (2008). Contributions of roadside vehicle emissions to general air quality in Hong Kong. *Transportation Research Part D: Transport and Environment*, 13(1), 19-26.

Li, S., Dragicevic, S., Castro, F. A., Sester, M., Winter, S., Coltekin, A., Pettit, C., Jiang, B., Haworth, J., Stein, A., Cheng, T. (2016). Geospatial big data handling theory and methods: A review and research challenges. *ISPRS Journal of Photogrammetry and Remote Sensing*, 115, 119–133.

Liu, X., Yan, X., Wang, W., Titheridge, H., Wang, R., & Liu, Y. (2021). Characterizing the polycentric spatial structure of Beijing Metropolitan Region using carpooling big data. *Cities*, 109, 103040.

Lucas, K., Van Wee, B., & Maat, K. (2016). A method to evaluate equitable accessibility: combining ethical theories and accessibility-based approaches. *Transportation*, 43(3), 473-490.

Maif, 2014, Sécurité routière : l'influence positive du covoiturage, rapport réalisé par la Maif.
https://www.espacedatapresse.com/fil_datapresse/consultation_cp.jsp?idcp=2800254

Manaugh, K., & El-Geneidy, A. (2012). Who benefits from new transportation infrastructure? Using accessibility measures to evaluate social equity in public transport provision. In *Accessibility analysis and transport planning*. Edward Elgar Publishing.

Masoud, N., & Jayakrishnan, R. (2017). A real-time algorithm to solve the peer-to-peer ride-matching problem in a flexible ridesharing system. *Transportation Research Part B: Methodological*, 106, 218-236.

Mazzella, F. (2018). Préface. In L. Reillier & B. Reillier (Dir), *Platform Strategy: Libérez le potentiel des communautés et des réseaux pour accélérer votre croissance* Paris, Dunod, « Stratégie d'entreprise » p. 11-14. URL : <https://www.cairn.info/platform-strategy--9782100784639-page-11.htm>

- Mericskay, B. (2018). "Potentials and limits of (geo)digital footprints in mobility analysis: the example of the data from the BlaBlaCar carpooling platform", *Cybergeog: European Journal of Geography*, SIG, document 889, URL : <http://journals.openedition.org/cybergeog/33225> ; DOI : <https://doi.org/10.4000/cybergeog.33225>
- Miller, H. J., Goodchild, M. F. (2015). Data-driven geography. *GeoJournal*, 80(4), 449–461.
- Minett, P., & Pearce, J. (2011). Estimating the energy consumption impact of casual carpooling. *Energies*, 4(1), 126-139.
- Neoh, J. G., Chipulu, M., Marshall, A., & Tewkesbury, A. (2018). How commuters' motivations to drive relate to propensity to carpool: Evidence from the United Kingdom and the United States. *Transportation Research Part A: Policy and Practice*, 110, 128-148.
- Olsson, L. E., Maier, R., & Friman, M. (2019). Why do they ride with others? Meta-analysis of factors influencing travelers to carpool. *Sustainability*, 11(8), 2414.
- Pfeiffer, D., & Cloutier, S. (2016). Planning for happy neighborhoods. *Journal of the American planning association*, 82(3), 267-279.
- Pigalle, E., & Aguiléra, A. (2021). Covoitureurs des villes, covoitureurs des champs: une analyse spatialisée du covoiturage en France. *Peut-on se passer de la voiture hors des centres urbains?*, (7), 173-187.
- Pumain, D., Paulus, F., Vacchiani-Marcuzzo, C., & Lobo, J. (2006). An evolutionary theory for interpreting urban scaling laws. *Cybergeog: European Journal of Geography*.
- Rabino, G., Occelli, S. (1997). "Understanding spatial structure from network data: theoretical considerations and applications", *Cybergeog: European Journal of Geography*, document 29. DOI: <https://doi.org/10.4000/cybergeog.2199>.
- Rietveld, P., Zwart, B., Van Wee, B., & van den Hoorn, T. (1999). On the relationship between travel time and travel distance of commuters. *The Annals of Regional Science*, 33(3), 269-287.
- Shaheen, Susan, Adam Stocker, and Marie Mundler. 2017. 'Online and App-Based Carpooling in France: Analyzing Users and Practices—A Study of BlaBlaCar'. In *Disrupting Mobility: Impacts of Sharing Economy and Innovative Transportation on Cities*, edited by Gereon Meyer and Susan Shaheen, 181–96. Lecture Notes in Mobility. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-51602-8_12.
- Steg, L., & Tertoolen, G. (1999). Affective motives for car use. *PTRC-PUBLICATIONS-P*, 13-28.

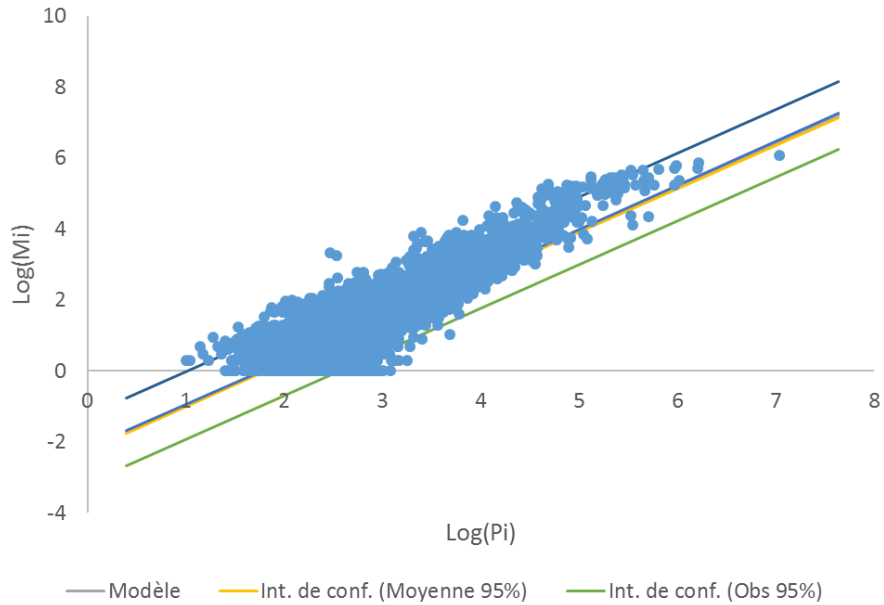
Sultana, R., Birtchnell, T., & Gill, N. (2020). Urban greening and mobility justice in Dhaka's informal settlements. *Mobilities*, 15(2), 273-289.

TDM Encyclopedia, 2012, [Online TDM Encyclopedia - About This Encyclopedia \(vtpi.org\)](http://vtpi.org)

Tertoolen, G. (1999). Affective motives for car use. In PTRC (Ed.), PTRC: Transport Policy, Planning and Practice (pp. 13 - 27). PTRC.

Van Wee, B., & Handy, S. (2016). Key research themes on urban space, scale, and sustainable urban mobility. *International journal of sustainable transportation*, 10(1), 18-24.

Annex 1: Results of linear model between carpoolers offers (Mass-Mi) and size of cities (Poulation-Pi)



Parameters of the linear model

	Model
Mi - Carpoolers offers	
Pi - Population	1,231*** (0,0001)
Intercept	-2,204*** (0.0001)
Observations	23381
R2	0,640
Adjusted R2	0,640

Annex 2: Parameters of the gravity model

	Model
<hr/>	
Mi - Carpoolers offers	
Dij	-1,099*** (0.0001)
Mi	0,986*** (0.0001)
Mj	0,807*** (0.0001)
Constante	-9,822*** (0.0001)
<hr/>	
Observations	23381
R2	0,690
Adjusted R2	0,690
<hr/>	