

ORIGINAL PAPER

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Heterogeneity of logistics facilities: an issue for a better understanding and planning of the location of logistics facilities

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Abstract

In the last few years, the issue of the location of logistics activities emerged in the literature, in Europe and in the United States, especially from the perspective of logistics spatial dynamics as logistics sprawl. These issues of spatial dynamics question urban policies, because they underline the lack of interest in freight in the planning process. Indeed, one of the major issues in planning logistics facilities is the lack of a good understanding of the logistics sector: it is difficult to guide public action in the absence of detailed and precise data. The great heterogeneity of logistics facilities is often underestimated by public policies. The visibility of some sectors in public policies or academic literature, as parcel industry or e-commerce, hides other sides of logistics as an industry sector. With this paper we underline differences in the location of facilities, which translates into a difficult implementation of public policies to regulate logistics sprawl in the case of the Paris region. This paper studies precisely the location of the warehouses and terminals, and their place in the spatial organization of logistics facilities in the Paris Region. In particular, we compare the location of mass retail and wholesale trade facilities, logistics provider's facilities and parcel's industry facilities.

Keywords: Logistics facilities, Typology, Paris region, Database, Logistics sectors

1 Introduction

Developing “smart cities” by using new technologies and services in the areas of transport, energy and ICT to reach high level of urban sustainable development relies on a great amount of data and information (e.g. in the Europe 2020 strategy). In the field of urban freight, logistics and transportation of goods, basic data such as freight flows or the location of the logistics facilities are not always identified. The lack of data implies using general data as proxy distorting reality or the produce new data from fieldwork. In the last few years, the issue of the location of logistics activities has emerged in the literature, in Europe and in the United States, especially from the perspective of logistics spatial dynamics, as in logistics sprawl for example [1]. In the last few years, academic research works have emphasized the relationship between freight flows and urban regions, highlighting new geographies of freight

distribution at various scales [2]. Indeed, macro-regions are increasingly favored to host logistics activities [3]; meanwhile, at the metropolitan scale, we observe a deconcentration of logistics functions away from their urban core toward the suburbs and exurbs. The growth of logistics facilities in most metropolitan areas illustrates both centrifugal processes, from the urban core to the suburban and ex urban areas of the urban region, and centripetal processes, from the margins of the macro-region to the edges of the urban core [4]. The deconcentration of logistics facilities is described in detail in the recent literature ([5–13]; [1]). Recently, public authorities have been increasingly aware of the logistics sprawl issues and its consequences, such as land consumption, growing distances travelled for trucks and deliveries, and growing CO₂ emission. As a result, they promote the development of logistics facilities in the city center by supporting and / or subsidizing city logistics experiences and urban project dedicated to freight. This trend is discussed in specialist publications on logistics and freight ([14–16]).

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These two opposites, but concomitant, spatial dynamics have led us to take an interest in the factors that determine the location of logistics activities. These spatial issues question urban policies and underline a partial knowledge of the logistics sectors. Indeed, one of the major issues for the planning of logistics facilities is a good understanding of logistics as an industry sector. The great heterogeneity of logistics services and their corresponding facilities is rarely taken into account in the academic literature, or by public policymakers. The visibility of specific sectors, such as parcel industry or e-commerce, hides other sides of the logistics sector and could lead to a misrepresentation of what services are provided and how to plan for the location of their services.

In this paper, we make the hypothesis that with detailed data on logistics activities, we could identify different spatial patterns for different logistics activities and show that the location of logistics facilities also depends on their sector. The heterogeneity of logistics sectors impacts the spatial distribution of logistics facilities. This analysis is based on previous studies. For example, Raimbault et al. [17] have differentiated logistics facilities in the Paris Region (between what they call the parcel industry, distribution centers and inland ports). Heitz and Beziat [18] have also attempted to illustrate this heterogeneity through a comparison of the location of the parcel industry facilities and that of other logistics activities. In this paper, we propose a new methodology to identify and classify logistics facilities in the Paris region, depending on the kind of logistics service they provide. These services are diverse, depending on the market segments of the transport and logistics industry on one hand, and on the different role that can be played by logistics facilities in industrial, distribution, and transport networks on the other. The aim of this paper is to show that taking account the heterogeneity of logistics services helps to understand the general location pattern of logistics facilities.

The rest of the paper is structured as follows. Section 2 presents a literature review on the location of logistics facilities. Section 3 describes the methodology used for building an original database which gives us the location of logistics facilities and the services they provide in the Paris Region. In Section 4, we use our database to analyze the dispersion of facilities and their insertion into the urban fabric with a series of indicators, to draw the general logistics geography of the Paris Region. Section 5 puts this spatial analysis in perspective, describing the location of logistics facilities belonging to three specific market segments of the transport and logistics industry. We show the different location patterns of the logistics facilities of three market segments depending on the services they provide. In Section 6, we propose a statistical analysis based on the location indicators of the different kinds of

logistics facilities to show the non-homogeneous location patterns of logistics facilities, with facilities offering different services sharing the same location patterns. Section 7, in conclusion, provides a summary of our main results.

1.1 Location of logistics facilities' issues in metropolitan areas and the limit of a dominant holistic perspective

Analyses focuses on the location of logistics facilities usually rely on a broad definition of "logistics". Logistics facilities are identified as specific buildings, warehouses, which host all activities linked to logistics and freight transportation. The literature covers the factors of location well enough for logistics facilities in general (e.g. [5, 6, 1, 10, 19]) and rarely distinguishes specific segments of the industry. Amongst them, there is the importance of proximity to transport infrastructure, and more specifically to road infrastructure [19]. Accessibility is a key factor in the location of logistics facilities. Bowen [5] found a high correlation between these accessibility measures and the growth in the number of warehouse establishments in the period 1998–2005. Nuzzolo and al. [20] showed that accessibility tend to be a very important criterion for delivery mostly regarding congestion. One other obvious and essential factor is the availability of land and its cost. In recent years, logistics activities have tended to require bigger and bigger buildings [21, 22]. This means they are more likely to be located in peripheral areas than in the dense center of the agglomeration, where the competition with other activities is fiercer. Metropolitan areas contain most of the customers, so logistics facilities have to find a balanced location between the proximity to consumers, the available lands and the difficulties they might have to deliver the dense part of the metro area (e.g. congestion). Finally, a key factor is the part played by public stakeholders, both as regulators and facilitators, due to the contribution of freight to urban externalities such as road congestion and air pollution [23]. This list of location factors is not exhaustive. The great heterogeneity of logistics facilities also creates variations in general spatial trends. Most of the existing literature considers the logistics facilities as a whole, holistically, and does not distinguish between different types of logistics activities (e.g. wholesale, distribution logistics, groupage transport hubs, industrial logistics, etc.).

In the existing literature, investigations on the subject of the location of logistics facilities use various databases according to the scope of the analysis. Two kinds of data give us information on logistics facilities. On the one hand, some researchers only consider specific logistics services: groupage networks [24], specific wholesale activities [25], or Logistics Service Providers [26]. They usually rely on datasets that are built specifically for the research at hand (e.g. Dabanc,

Andriankaja, (2011) for parcel's delivery facilities in the Paris Region [7], or Verhetsel and al. (2015), for the most important 200 companies in logistics in Flanders, Belgium [27]). On the other hand, the dominant trend consists in the study of indistinct "logistics services" which rely on generic establishment databases. In France, an establishment is an administrative term: it describes a localized unit of production of service and / or goods.

In these datasets, establishments are usually characterized by activity codes, which can be used to define the logistic sector. Most papers dealing with the location of logistics facilities rely on data from establishment files classified by NAICS (US) or NACE (Europe)¹: e.g. Bowen (2008) [5]; Cidell (2010) [6]; Dablanc (2014) [1]; Van Den Heuvel and al. (2015) [9]; Woudsma et al. (2015) [11], Heitz and Dablanc (2015) [10]. De Lara [28], have used, for example, "wholesale trade" and "transportation and warehousing" categories from the NAICS classification. Dablanc and Ross [8], Dablanc [1] or Heitz and Dablanc [10] have used more precise categories "warehousing and storage" and "support activities for transportation" but with an underestimated number of facilities from NACE classification. Basically, by using these classifications, researchers must choose between detailed but underestimated the number of facilities or aggregated number at a geographical level that overestimates the number of facilities. While this method does not provide the most accurate estimate of the number of logistics facilities, it allows comparisons to be made between different regions on the same basis. Such data is valid at the regional or megaregional scale but their lack of precision at the local scale does not offer the possibility to make distinction between logistics sectors. For now, researchers rely on the classifications provided (NACE and NAICS), which fails to identify the exact nature of the logistics service.

There are limitations to both approaches. First, studies on specific logistics services have the advantage of using very definite and often precise datasets. But, by nature, their perspective on logistics activities is narrowed by the scope of their analysis. Second, the use of generic establishment databases creates several challenges that are difficult to overcome [29]. Depending on the purpose of the file (administrative, fiscal, commercial) and the methodology of investigation (self-administered, surveyed, observed), the precision of NACE code can be very inconsistent [29], because "the complexity of modern supply chain and logistics presents difficulties in defining facilities and sites that house logistics activities" [8]. Then, a significant portion of logistics and transport services are performed on own account by the shippers themselves. These shippers, who belong to various sectors (industry, wholesaling, retail, agriculture...), can have their own warehouses which are not coded as logistics activities, but rather are registered with the company's activity code.

Some research works have already attempted to introduce shades of difference between the logistics sectors. To explain different logistics functions, [30] make the distinction between materials management and physical distribution to explain demand in logistics. Physical distribution corresponds to the freight flows between places of production and places of consumption, like wholesale and freight handling. These activities are concentrated in urban areas to take advantage of transport infrastructure and proximity to consumers [31]. Material management corresponds to industrial production, all stages of the supply chain. These activities are located at all scales of urban hierarchy. The increasing logistics integration and the recent evolution of the logistics sector have blurred the line between the sectors as we used to observe them. Differences in the location of different logistics services mean that it is difficult to implement public policies to regulate logistics sprawl. Attempts are limited by holistic data that are not detailed enough.

1.2 Methodology for a comprehensive logistics facilities database and construction of a typology

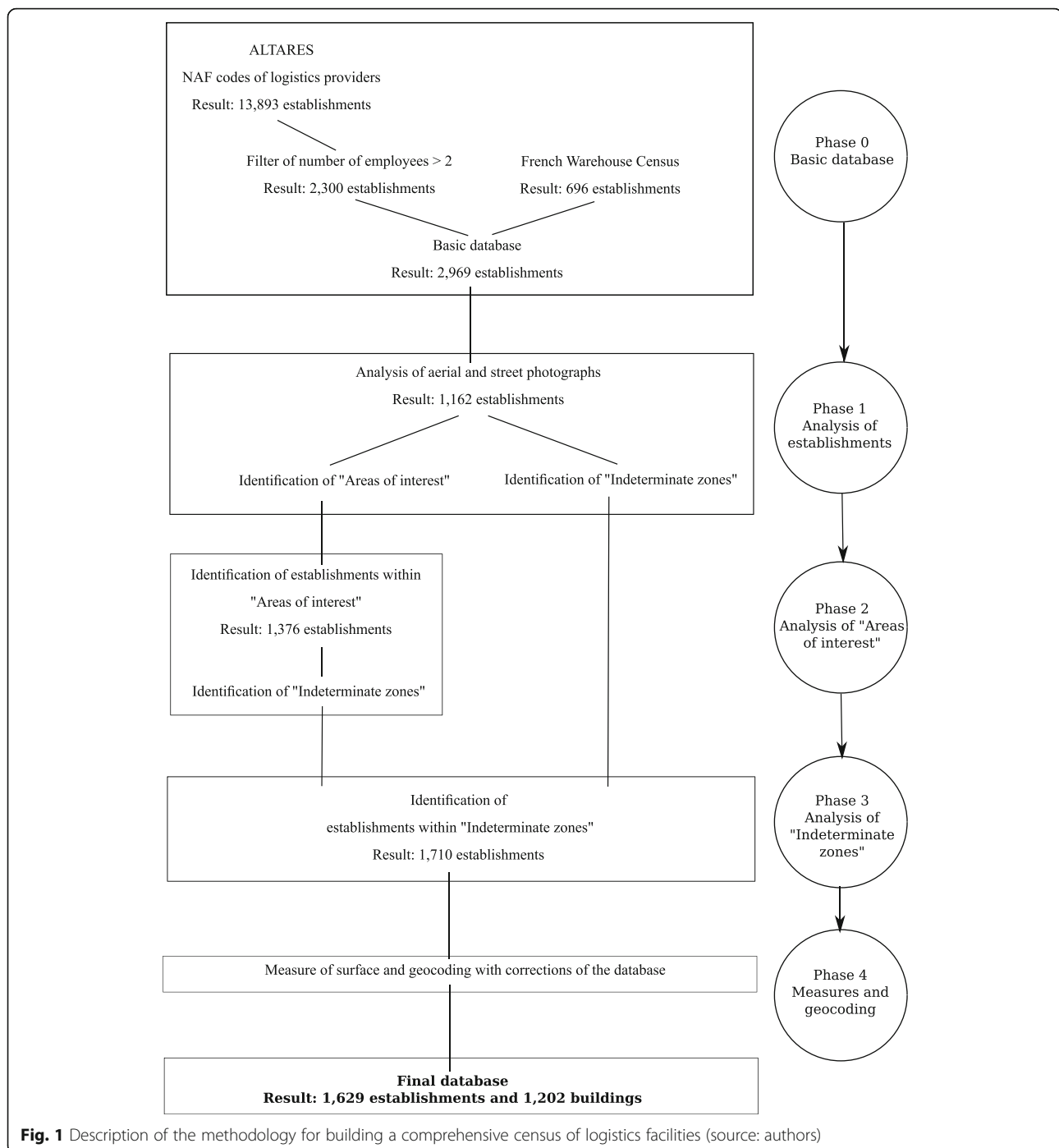
1.2.1 Methodology for a comprehensive logistics facilities database

The methodology for building this comprehensive census involves several steps. The detailed methodology can be found in [28]. We rely on the SIRENE file, which accounts for all economic establishments in France. From this database, we select logistics activities using activity codes in Table 1.

We combine this extraction with the French Warehouse List (*Répertoire des Entrepôts*), which identifies warehouses bigger than 5000m², and accounts for warehouses that are used directly by shippers (see Phase 0 in Fig. 1). From this database, the first step is to identify establishments that can correspond to logistics facilities, using

Table 1 NAF Code used for the primary extraction of logistics establishments (INSEE, 2016)

NAF code	Description
49.41A	Interurban freight transport by road
49.41B	Proximity freight transport by road
52.10A	Refrigerating warehousing and storage
52.10B	Non-refrigerating warehousing and storage
52.21Z	Service activities incidental to land transportation
52.22Z	Service activities incidental to water transportation
52.23Z	Service activities incidental to air transportation
52.24A	Harbor cargo handling
52.24B	Non-harbor cargo handling
52.29A	Freight services organization
52.29B	Chartering and transportation organization
53.20Z	Other postal and mailing activities
82.92Z	Packaging activities



aerial and street photographs (Phase 1). We also identify "areas of interest": industrial zones which may contain logistics facilities; and "indeterminate areas", where we know there are logistics facilities, but we can't identify the establishments that match the buildings (usually because there are no available photographs). Then, using aerial and street photographs, as well as field studies and local planning documents, we complement this database by locating and identifying other warehouses and freight terminals

within areas of interest and indeterminate zones (Phases 2 and 3). Finally, each facility is geocoded in the database (Phase 4). For the needs of this paper, Fig. 1 shows the general framework.

1.2.2 Typology of the logistics facilities according to the services they offer

The objective of the typology is to distinguish logistics facilities according to their activities. In most studies, the

location of logistics activities is analyzed in relation with freight mobility needs [32, 33]. These needs depend on the type of goods as well as the quantity and frequency of distributed goods. Since data on the quantity and frequency of distributed goods is unavailable and would require a specific survey, we propose a different approach based on open data to classify logistics activities. In our study, activities are determined by the market segment of the operator of the facility on one hand, on the role of the facility in the distribution, industrial or transport networks of the operator on the other hand.

NACE codes give us good information about the activity of the facilities operated by shippers on their own-account, because all these facilities are logistics facilities that serve the core activity of the shipper. However, NACE codes are often inappropriate tools to distinguish between logistics facilities operated by logistics providers depending on their activities, for two reasons. First, some NACE codes are too broad compared to the segmentation of the logistics market. Four NACE codes (49.41A, 49.41B, 52.10B, 52.29B, see Table 1) describe 44% of logistics facilities of the database, but give little information about the market segment of their operators, and no information about the role of the facility in the transport networks of their operator when the facility is part of such a network. Second, NACE codes are self-referenced by the companies, and two facilities operated by the same kind of company (and sometimes the same company) for the same activity can be described by two different NACE codes. Even if some NACE codes describe a specific activity (as 59.29A, see Table 1), some facilities that are used for this activity may not be described by these codes but by generic ones (as 49.41B, 49.41A or 52.29B, see Table 1).

To tackle this issue, we use available commercial information to identify the market segment of the companies operating the facilities, and operational information to identify the role of the facilities that are part of transport networks (hubs or terminals). This information can be found in the specialized press and the companies' websites. This methodology was used successfully by Strale [34]. The issue, when using these kinds of sources, is that the information given by the websites or the press varies widely. Therefore, we identify specific criteria that have been used in the scientific literature to distinguish logistics segment markets or operations ([35–38]): the function of the logistics facility, the operator of the facility, the kind of goods processed in the facility, and the destination of these goods. For each of these criteria, categories are selected to allow each logistics facility to match with one of these categories - when possible. Each criterion was transformed in one or several closed-ended questions, of which the categories are the answers. We searched some information online about the activities of each

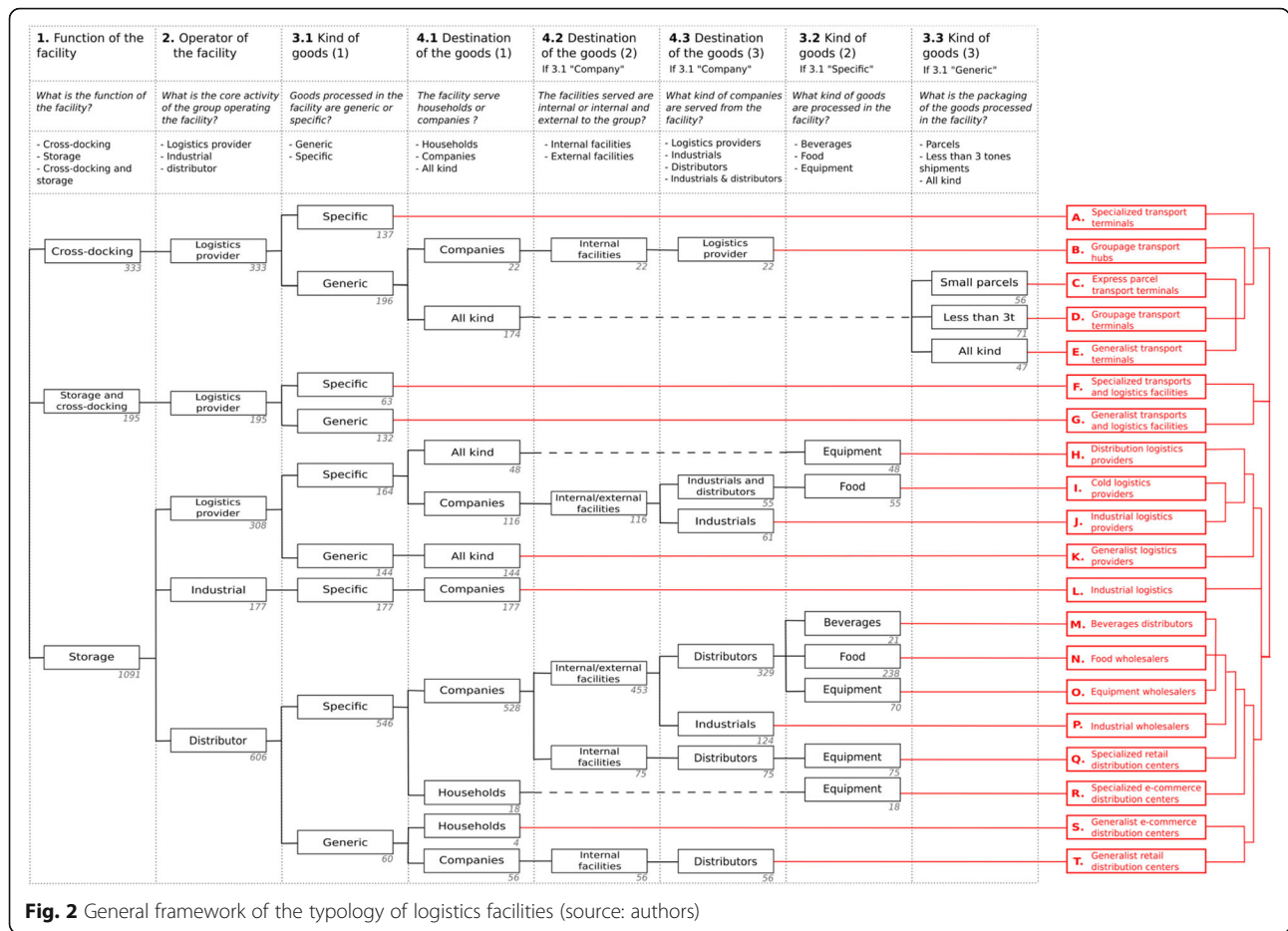
economic establishment occupying the logistics facilities of our database online, to find in which category (e.g. the “answers”) each logistic facility falls for each criterion (e.g. the “questions”). We could not create categories in specific instances: if the information was not available, if activities were too specific to justify a single category, or if the criterion was not adapted to the activity. Figure 2 shows the general framework of the typology.

Under the “Function” criterion, logistics facilities fall under two categories, depending on whether they are terminals (used for cross-dock operations) or warehouses (used for storage). Some facilities are used both for storage and for cross-docking, at the same time or at different times, because they process very specific kinds of goods (for example, fine art or sensitive products – **CLASS F**) or are operated by small transport and logistics companies that can easily switch from one market to the other to respond to opportunities – **CLASS G**.

For the “Kind of operator” criterion, logistics facilities are distinguished according to whether they are operated by a third-party logistics provider or by a shipper. The shippers' facilities have been themselves broken down according to the core-activity of the group: manufacturing (**CLASS L**) or distribution.

Under the “Kind of goods” criterion, logistics facilities are first broken down into two categories depending on whether the nature of the goods processed in the facility is specific (for example, fresh food or industrial goods) or generic (as pallets, or parcels). Some generic-goods facilities are distinguished according to the kind of packaging of the goods: parcels (**CLASS C**), other less-than-truckload (LTL) shipments (**CLASS D**) or all kinds of packaging (**CLASS E**). Other specific-goods facilities are distinguished according to the nature of the goods: equipment, food, or beverages. Some facilities cannot be described by the nature of the goods processed, or by the packaging of the goods processed, either because this information is not available, or because the goods processed are too specific and do not justify a single category (for example, transport terminals specialized in high value goods, or goods that require a special handling – **CLASS A**), or because the facility can process different kind of goods at the same time or at different times. For example, when observing a warehouse operated by the logistic branch of an industrial company, or by a logistics provider serving industrial companies, or by an industrial wholesaler, it is difficult to say whether the goods stored in the facility are intermediate goods (stored before being transformed), capital goods (stored before being used as a production factor), or even finished goods (stored before being commercialized – except for the industrial wholesaler).

The “destination of the goods” criterion has to be considered differently depending on the function of the facility (transshipment or storage), due to the different



nature of these two logistics functions. For a warehouse (used for storage), the “destination” of the goods stored will be the next facility where the goods will be transported to be stored, transformed, sold or consumed, without considering the possible transshipment during the transport operation between the two facilities. For a terminal (used for transshipment), the “destination” of the goods transhipped will be the next terminal where they will be transhipped again, or the final destination of the goods (where they will be stored, transformed, sold or consumed) if the terminal hosts the last transshipment of their transport operation.

Therefore, the “Destination of the goods” criterion is distinguished according to whether logistics facilities are used to deliver only households (e-commerce distribution centers – CLASS R and CLASS S), only companies (for example, industrial and cold logistics providers’ facilities) or both households and companies (for example, facilities of generalist logistics providers that can serve all kind of activities – CLASS K – and facilities of logistics providers specialized in distribution, that can serve both retail companies and e-commerce companies – CLASS H).

Logistics facilities that only deliver facilities belonging to their own groups: this is for example the case of groupage

networks’ hubs (CLASS B), used as transshipment centers that link the different terminals of a same groupage network (though other groupage terminals can deliver both the network’s facilities and other economic activities and households), and of the retail distribution centers (CLASS Q and CLASS T), that only deliver the retail facilities of their groups (which is not the case of wholesalers’ logistics facilities and the distribution).

Lastly, facilities that only deliver companies are distinguished according to the kind of companies served: logistic providers (for groupage networks’ hubs), industrials (for example, facilities of the logistics providers specialized in industrial logistics – CLASS J - and of the industrial wholesalers – CLASS P), distributors (for example, beverages, food and equipment wholesalers – CLASS M, CLASS N and CLASS O) and both industrials and distributors (for cold logistics providers’ facilities – CLASS I - that can store both intermediate fresh goods (industrials) and finished fresh goods (distributors), at the same time or at different times).

The typology results in 20 classes, which correspond to twenty types of logistics facilities. A given facility remains in its class as long as the facility’s operator of the facility

does not change, or as long as the role of the facility in the transport network of the operator does not change. Thanks to the iterative design of the typology, the classes can either be aggregated by deleting a criterion (for example “facilities operated by logistics providers” vs. “facilities operated by distributors” vs. “facilities operated by industrials”), or disaggregated by adding some categories (for example, to distinguish specialized transport terminals based on their specialization). If the categories, used to build the typology (and the 20 classes that arise from them), are adapted to the logistics characteristics of the Paris region, the same criterion may be used to build a typology of logistics facilities in other regions with the same method.

1.3 Location of logistics facilities in the Paris region:

General facts

The Paris Metropolitan Area corresponds, more or less, to the Ile-de-France region, which is France’s largest consumer catchment area with 12 million inhabitants and 5.6 million jobs. The Ile-de-France region spans 12,000 km² and includes 1300 municipalities. It has a strong monocentric structure inherited from centuries of urban growth. Monocentric urban regions are characterized by a large and growing population and by the fact that economic and leadership activities are concentrated in one area. The dense, uninterrupted, parts of a large city are easily identifiable. However, the urbanized areas of its outer suburbs, which are scattered and located several tens of kilometers from the center, are difficult to distinguish from rural areas. The City of Paris, which corresponds to 20 municipalities called “arrondissements”, counts 2.2 million people and 1.6 million jobs. The capital is the geographic center of the Paris Region, surrounded by the “Petite Couronne” which is the close suburbs made up of 3 departments (Seine-Saint-Denis, Hauts-de-Seine and Val-de-Marne) with 6.7 million people. The first suburb ring of Paris is also the former industrial belt, characterized by a high population density (9000 inhabitants/km²) and the location of important functions like a major business district (“La Défense”) or the large transport infrastructure like the river ports of Gennevilliers and Bonneuil, Orly and Roissy-CDG airports, or the Rungis wholesale market. The “Petite Couronne” is itself

surrounded by the “Grande Couronne”, the outskirts of the Paris agglomeration, which also represents 70% of the Ile-de-France Region’s area. The Grande Couronne is more rural and has been structured by successive waves of deconcentration of population and activities since the second half of the twentieth century. Secondary centers have emerged in this peripheral area where property prices and traffic congestion are lower. Easily accessible by high speed transport infrastructures; these centers are encouraged by regional planning policies in order to balance the regional distribution of jobs and population.²

The table below (Table 2) shows that logistics facilities are not homogeneously distributed in the Paris Region. The city of Paris which corresponds to 0.9% of the Paris Region’s area represents 1.2% of the logistics facilities. The return in the city center of some logistics activities, and some supportive public policies, Paris is a showcase for experimental logistics facilities and green experiences in urban freight transportation highlighted in literature [16], sometimes at the expense of the “Petite Couronne” the closest suburbs of Paris, that are adjacent to Paris itself and share some of Paris’s characteristics, like urban density. The Petite Couronne represents 5.5% of the Paris region’s area and accounts for 44.7% of the logistics facilities. This makes it the densest logistics areas in the Paris Region. In comparison, the “Grande Couronne”, although it accounts for the majority of logistics facilities represents 93.6% of the Paris Region’s area and is therefore much less dense. Some studies have found that the suburban and ex-urban areas have seen the number of logistics facilities increase, as a result of logistics sprawl ([10, 7]). Public policies should ensure that logistics facilities remain in dense urban areas, despite the trend toward deconcentration.

Paris is an isotropic metropolitan area in which land market forces theoretically lead to an exponential decrease in population density the farther one gets from the employment center. More generally, the Paris region is structured according to a center-periphery gradient, with a population and jobs density decreasing from the center to the peripheral areas. This also applies to the location of logistics facilities which are bigger in size and in number of employees as the distance from the center of Paris increases. The average size of a logistics facility in the “Grande Couronne” is about 12,986.7 m² compared to

Table 2 Indicators on the general location of logistics facilities in Paris Region

	Population density (inhabitants per km ²)	Average size (m ²)	Average number of employees	Average distance from the center of Paris (km)	Share of total of facilities (%)
Paris	21,347.0	5164.5	49.5	4.3	1.2
Petite couronne	6767.6	5610.6	49.2	12.1	44.7
Grande couronne	458.5	12,986.7	77.3	26.7	54.1
Total	986.7	9599.1	64.4	19.9	100

5610.6m² in the “Petite Couronne”. These general indicators provide a general overview on the spatial distribution of logistics facilities in the Paris Region. We now propose to view this logistics and freight landscape through the prism of the different logistics services offered by these facilities which should improve our comprehension of the location of logistics facilities.

1.4 Differentiated location of logistics facilities according type: Cases studies

The twenty types of logistics facilities identified in the typology offer different services, depending on their function, their operator, and the kind of goods they process and the destination of these goods. We make the hypothesis that these differences in terms of services lead to differences in terms of location patterns. Depending on the type of logistics facilities, the reason of these differences in location patterns may be one of the characteristics used to build the typology. The location factor of a logistics facility can be driven by its function, its operator, the kind of goods it processes and the destination of these goods, or a combination of several or all of these characteristics. As we cannot explain the location patterns of each of the twenty types identified, because of the number of types and the internal heterogeneity of some types (e.g. *Specialized transport terminals*), we have chosen to concentrate on four case studies that correspond to three specific and archetypal market segments of the transport and logistics sector. The aim of these case studies is to show that there are huge differences in the location patterns between the three market segments, and that even facilities belonging to the same market segment (or to the same company) can have very different location patterns depending on their role in their distribution, industrial or transport networks on the other side.

1.4.1 Groupage network hubs and terminals: Delivering Paris and its region; linking Paris with France, Europe and the world

Groupage transportation is defined by the French National Institute of Statistics and Economic Studies (INSEE)³ as the segment of the transport industry that deals with less-than-truckload shipments (less than 3 tons) in which transport services are divided in at least three transport operations, separated by at least two cross-docking operations. Shipments are collected at the sender’s facility and dropped in transport terminals by pick-up tours. In the transport terminals, they are consolidated into full-truckload shipments for line-haul transport to another transport terminal, in which they are unconsolidated to be delivered to the receiver by delivery tours.

This activity requires transport networks composed of several transport terminals, used to link line-hauls

with pick-up tours (consolidation) and with delivery tours (unconsolidation), and of transport hubs, used to link line-hauls with each-other. Each transport terminal has a specific area of delivery and pick-up (in France, these areas often correspond to the borders of the *Département* administrative area) and are the starting points of the delivery and pick-up tours serving these areas for their operators. Each hub is linked with other hubs and terminals of their networks, on different geographic scales (from the global air hub linked with the other global air hubs of its network and with the main European road hubs to the regional hub, linked with other regional hubs and the different terminals of its region). All the links between the different facilities of a groupage transport operator are more or less hybrid hub-and-spoke transport networks, that guarantee the full loading of the line-hauls between terminals and hubs, and between terminals themselves, when the volume of exchange between two terminals is enough to constitute a full-loading vehicle and additional cross-docking in a hub is not necessary [39].

The structure of the French’s groupage service market has never stopped evolving since the late 80s, following the changes in production and distribution patterns in Western Europe ([40–42]). In this paper, we divide the French groupage service market into two segments, according to size of shipment ([43, 44]): the small parcels segment, and the larger shipments segment. This segmentation is commercial (transport services are billed by parcel in the first segment and by shipment in the second) and operational (standardized parcels allow the automation of transshipment operations; furthermore, standardized parcels and pallets means easier handling of goods during transport and storage operations). Groupage transport companies are therefore specialized in either parcels transportation or larger LTL shipment transportation, and the facilities used for small parcel transshipments (here called “Parcels’ terminals”) are not the same as the ones used for larger parcel or pallet transshipments (here called “Groupage transport terminals”). At the same time, we chose to differentiate terminals from facilities used as hubs (here called “Groupage transport hubs”). Hubs are not linked with an area of delivery and pick-up but with a range of other transport facilities in their network.

Dablanc and Andriankaja [7] have analyzed the effects of the relocation of groupage transport facilities (used either for the transshipment of standardized parcels and larger shipments, or as hubs) in Paris, from the urban core in the 1970s to the outer suburban area today. Our survey does not permit a diachronic analysis, but it does allow us to distinguish between facilities according to the activities they receive. Yet, the segmentation criteria for the two segments of the groupage service industry results in major

differences between the kind of activity served by the facilities of one or the other segment. Parcels' terminals mainly serve small independent retailers, services, and more and more private individuals with the emergence of e-commerce. Groupage transport terminals mainly serve manufacturing industries, logistics facilities and small independent retailers. This has two consequences on the dispersion of parcel and groupage transport terminals in the Paris region (Fig. 3). On the one hand, parcels' terminals are more concentrated around Paris than groupage transport terminals, because the activities they serve are more central. With a few exceptions only, all the transport facilities located in the City of Paris are dedicated to parcel transshipment. On the other hand, groupage transport terminals tend rather to be located in the northern and eastern sides of the Paris region, because the manufacturing industries and logistics facilities they serve are often located in these parts of the Paris region. None of the groupage transport terminals located in the close suburbs of Paris are in the western parts of the Petite Couronne. Whereas there are big differences in the location of the facilities of the two market segments within the dense area of Paris region, that is less the case in the far suburbs.

In any case, facilities located in the far suburbs of Paris region are not designed to serve the urban core. They serve the rural departments in which they are located [43]. In these departments, population distribution largely matches industrial distribution and groupage transport terminals and parcels' terminals are concentrated close to the main agglomerations of the *Départements* they serve (especially in the west: Versailles-Saint-Quentin in Yvelines and Cergy-Pontoise in Val d'Oise). In these departments, where transshipment facilities are concentrated, and delivery points dispersed, some delivery tours are pooled between different groupage transport service providers, which are not the case in the urban core of Paris region, where transshipment facilities are dispersed, and delivery points concentrated [43].

The location of hubs follows a totally different logic. The location of hubs is linked not to areas of delivery and pick-up but to the hubs' position in the transport network. When observing the dispersion of the groupage transport hubs compared to the dispersion of the other logistics activities, we can see that hubs are the type of logistics facility that is the most concentrated but also furthest from the center of gravity of the City of Paris (Fig.

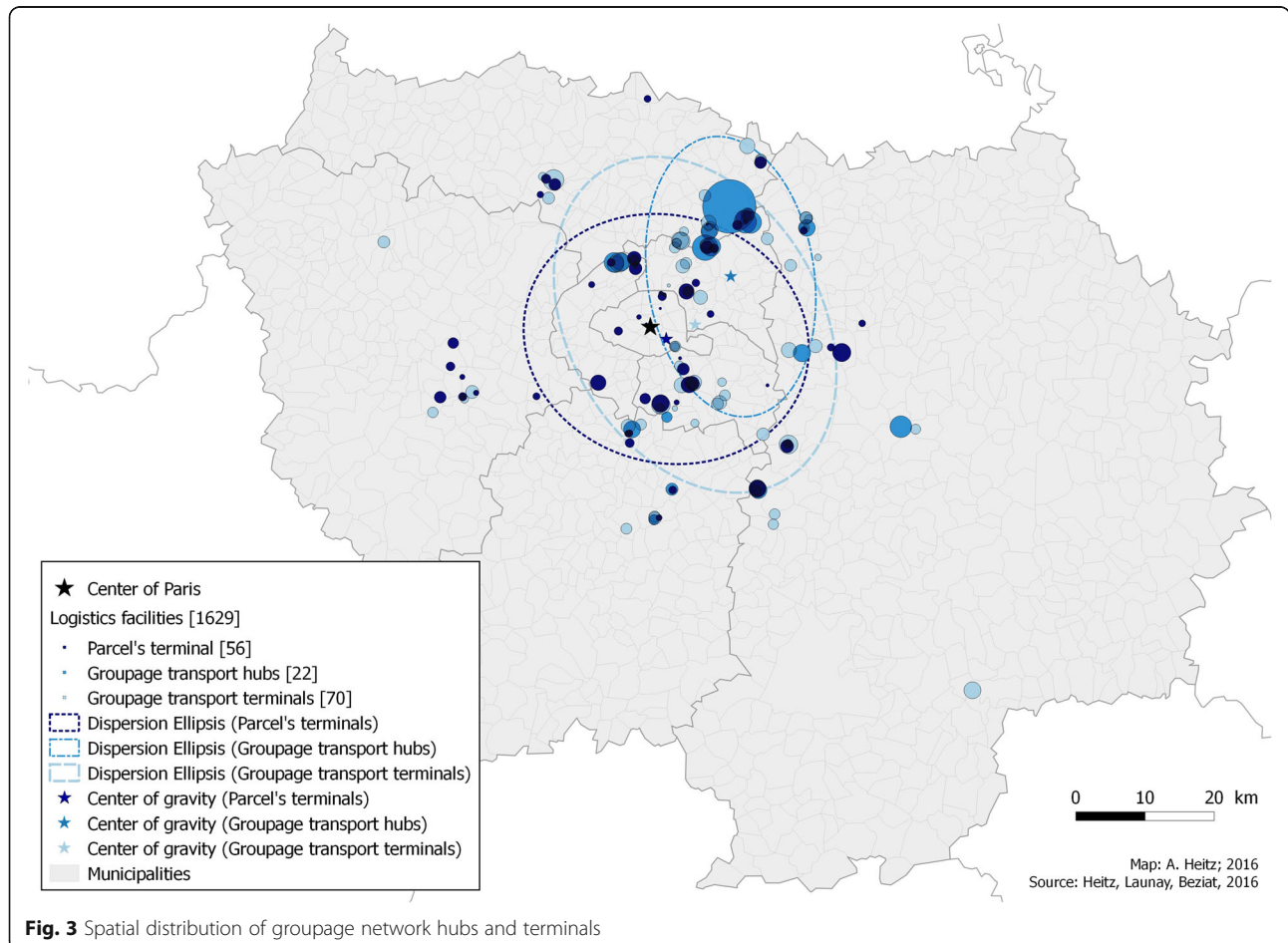


Fig. 3 Spatial distribution of groupage network hubs and terminals

3). Half the groupage transport hubs of the Paris region are concentrated around the Roissy-Charles-de-Gaulle airport (in the north-east of Paris agglomeration), which is Europe's busiest airport in terms of cargo traffic.⁴ These hubs are used to link French (or European) road groupage terminals to all the other European (or Global) hubs of their networks, but also European (and Global) hubs with each other (this is the case for the FedEx facility, located within Roissy-Charles-de-Gaulle airport, and the biggest transshipment hub in Europe). With the notable exception of two hubs in the Gennevilliers river port (where large logistics facilities can be located close to Paris), all the other groupage transport hubs of the Paris region are located in the east and south limits of Paris agglomeration, next to the major highway interchanges, because of the location of the Paris region within the West-European highway network. These hubs are used to link Paris road groupage terminals (and international hubs) to all the French (and West-European) groupage terminals in their networks.

The location of a groupage transport facility depends on the kind of shipments it processes, and on its place in its network. While a small transport terminal delivering the outer suburbs of the Paris region and an international hub in Roissy-Charles-de-Gaulle airport may be operated by the same company, share the same NACE code and have essentially the same activity (transshipment), their roles in their respective transport networks are completely different, as are their potential for relocation, and the flows of goods they are generating. Considering the prominent place of this activity in urban logistics, public policy seeking to ensure the sustainability of parcels and isolated pallet deliveries at the local scale should consider the structures of the groupage networks that enable the sustainability of parcels and isolated pallets transportation at a regional, continental, or global scale. Given the concentration of activities in Paris (the localization of facilities delivering Paris and up to 20 km in its suburbs), the size of Paris region (several transport terminals for each groupage network), Paris's place in the French highway network (presence of regional hubs) and the European airport network (presence of global hubs), understanding the deployment of groupage transport networks in the Paris region requires taking account of all geographic scales, from the global to the local.

1.4.2 Feeding Paris: The location of wholesale facilities and distribution centers in the Paris region, two food distribution systems

In the 1960s and 70s, the supermarket, a new model of marketing from North America, appeared in Europe. The supermarket model was particularly successful in trading manufactured goods and supermarkets were

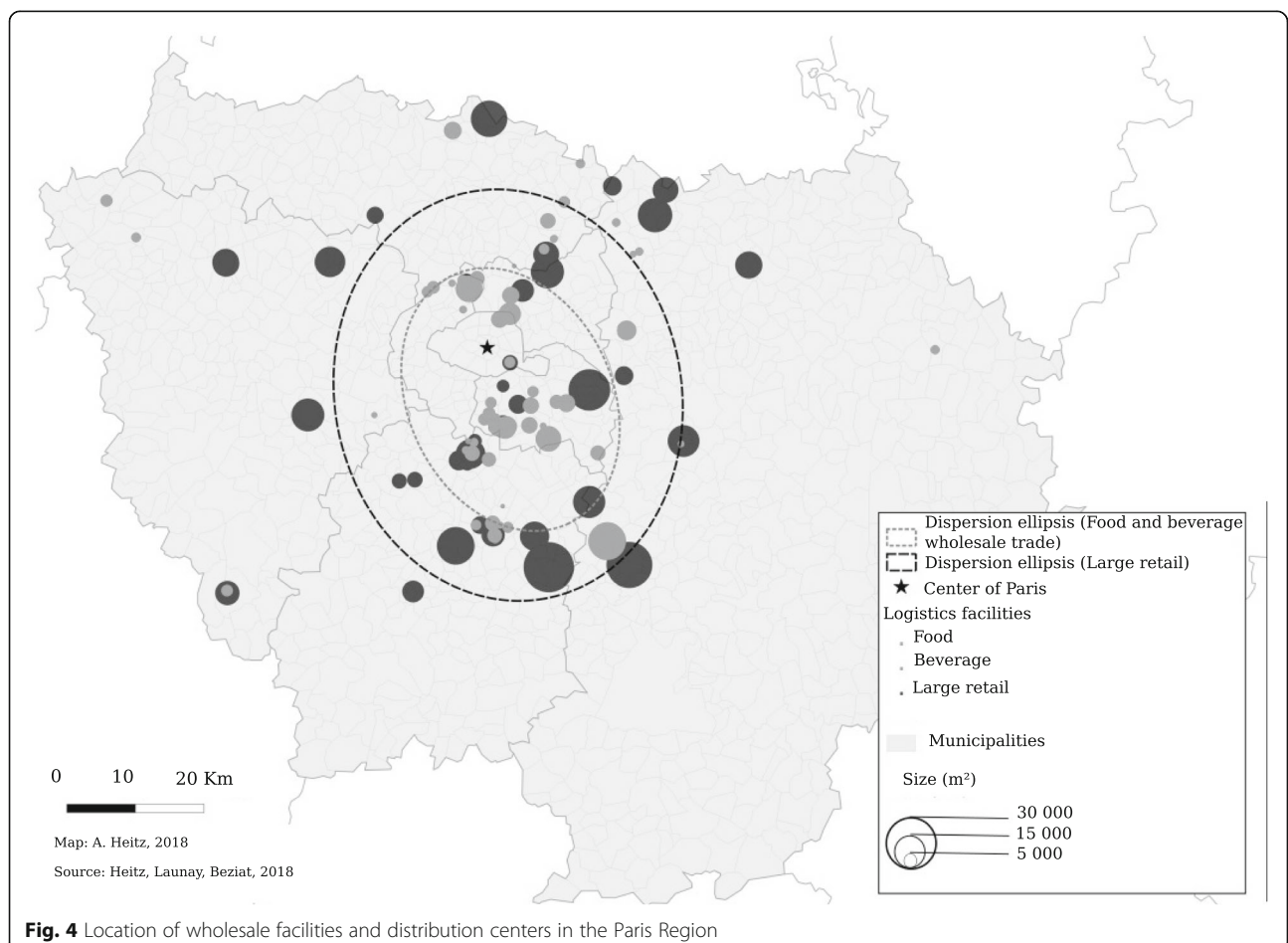
recognized for their convenience as a one-stop shopping center for consumers. Food sales by supermarkets have grown at the expense of traditional independent retailers in Western Europe. In the 70s and 80s, the increasing number of supermarkets and hypermarkets in France, along with the generalization of food consumption, may have given the illusion of a decrease in the wholesale food market. In fact, what happened was the development of two concomitant food distribution systems in the Paris Region. According to a study realized in 2008 [44], the number of hypermarket and supermarket has increased by +367% between 1970 and 2006 in France. Wholesalers have had to adapt to the new distribution power of supermarket chains.

Wholesale markets are defined as "physical places where professional agents congregate to buy and sell products to other professionals" [45]. The literature distinguishes two main types of wholesale markets. In rural areas, assembly wholesale markets collect food products from producers and gather them in bulk. In urban areas, terminal wholesale markets de-bulk large shipments of products to sell to other stakeholders [45]. In the 2000s, supermarkets in France accounted for 40% of the revenue of fresh produce wholesalers [48]. So, in some cases, food wholesalers occasionally supply supermarkets or hypermarkets. Both sectors are not hermetically sealed to one another. Within the wholesale sector, food represents a quarter of product sales and one sixth of employment. The food wholesale market is bigger than the consumer products wholesale market. The specificity of the French case is that food wholesalers are mostly supplied by food producers (80% in 2013) and mainly supply the retail sector. Food wholesale trade is relatively open up to the foreign market, since 2013, the opening rate is only about 12.1%. Wholesale trade is very dependent on the land's characteristics. Wholesale trade puts down roots in a given territory. Looking at the figure below, we see that the wholesales food sector is more concentrated around the center of the Paris region. With an average distance to the center of 15.4 km, this sector seems to be located close to the center, close to the demand. Indeed, Paris concentrates a large number of small retailers, restaurants, hotels, etc. which are mainly supplied by the wholesale trade sector. Furthermore, wholesale food facilities are located within the dense part of the Paris agglomeration (5160 inhabitants/km²), which may explain the average size of facilities, which is around 5500m². In Paris, 65% of fresh produce is sold by small independent retailers. This is because historically public policies have supported fresh food from independent retailers. Since the 60s, public authorities have also protected small and medium businesses in city centers to secure independent trade in the cities. Successive laws from the 70s to the 90s (Royer (1973), Galland (1986) and Raffarin (1996)) have limited the expansion of

supermarket chains in France (Bardou 1997) by requiring a special permit from the local council (in charge of defending the interests of small and medium enterprises) to build new supermarkets. As a result, there are few large supermarkets in the city center of Paris and attempts by supermarkets to buy smaller grocery shops have also been undermined [45]. In order to protect the wholesale market in the 1970s, the public authorities created the market of Rungis, which is a “market of national interest” governed by a dedicated rule. As such, Rungis is protected by an exclusion zone of 20 km. Within that zone, wholesalers must be located in the Rungis market. Proactive regulations seem to have favored small independent wholesale and retail businesses in and around city centers. These regulations are generally motivated by the will to preserve middle-scale businesses and employment.

Alongside the development of food wholesale trade, the rest of the Paris Region is covered by a large network of supermarkets and hypermarkets, usually organized at the national level or even European level, unlike the food wholesale trade which is more local. Each firm relies on its own distribution network of supermarkets and hypermarkets covering a wide range of products from food to consumers’ goods (e.g. furniture, clothes...). The mass

retail market represents 60% of the food market in France versus 40% for wholesale food market [46]. To supply its supermarkets, the mass retailers rely on specific facilities called distribution centers. Theoretically, the optimal location for a distribution center is the center of gravity of the entire supermarket network. This location is adjusted according to the importance given to land prices and road accessibility. Many supermarkets and hypermarkets need to be distributed throughout the Paris Region, except in Paris itself. Land prices and road accessibility are the true adjustment factors of location in the Paris Region. Consequently, we have observed that distribution centers tend to be located in the fringes of the Paris agglomeration, in the suburbs [47]. The move to the outskirts has accompanied logistics sprawl in general in the Paris Region [10]. Furthermore, because the Paris Region is centrally situated at the national level, a location in Ile-de-France also means a location at the center of the transportation network and at the barycenter of the supermarket networks for many of these companies. According to our analysis, distribution centers are mainly located in suburban areas. The average distance to the center of Paris is 22.2 km, and the average population density in the municipality where they are located is about



2211 inhabitants/km², low population density suburban areas.

As the figure below shows (Fig. 4), the food wholesale trade is located in dense, urban areas, close to the center of the Paris Region (light grey), and distribution centers are mainly located in the suburbs, in low dense areas (dark grey). The two dispersion ellipses show a high concentration of wholesale trade facilities in the dense part of the Paris Region, around Paris, and a more dispersed mass retail sector. Both sectors seem to be centered on Paris or the south east.

Differences in location between these two sectors, processing the same food and fresh products, are significant. Public policies have influenced the duality of this system and promoted an urban wholesale trade and a suburban distribution system to supply supermarkets. Peripheral zones become the main theatre for the development of logistics real estate [48], while the centers become areas of very selective logistics [49]. The existence of a twofold dynamic involving both logistics deconcentration within a metropolitan region and the re-concentration of some activities in densely-settled areas, encouraged by public policies to fight against urban sprawl, is leading to a complex logistics landscape. It seems that wholesale trade and mass retail are a very good example of these two opposite trends, which pose a new challenge for public policies. To regulate the food market in the Paris region, public authorities have to coordinate two different locations of facilities, networks at different scale (local and national) and different stakeholders involved in the two sectors. A public policy that seeks to regulate the food supply (by favoring local production or by restricting trucks or last mile deliveries) should take into account not only the operating differences internal to the sectors as well as the differences in location. A location in a dense urban area where the pressure is high tends to weigh heavily on the food wholesale trade and can favor supermarkets.

1.5 The location of logistics facilities occupied by logistics service providers

The management of logistics functions is viewed as a way to maximize the value and minimize the costs of a business. Many companies have chosen to focus on strategic core businesses and re-engineering, while logistics activities (such as transportation, warehousing, inventory, order processing, and material handling) have traditionally been given low priority and as a result, have been outsourced to third-party logistics providers, or 3PL ([50–52]). Razzaque and Sheng [53] have enumerated the drivers for the outsourcing of the logistics functions, which has accelerated since at least the 1980's. We list a few of these here: the increasing

complexity of the supply-chain (just-in-time principles, development of global markets and foreign sourcing), the need for a more flexible production and distribution system, as well as improved productivity resulting from the specialized production of logistics services.

The outsourcing of logistics functions has been a staple of large production and distribution networks for some time now. ASLOG, the French Supply-Chain and Logistics Association (*Association Française de la Supply-Chain et de la Logistique*), estimates that 84% of transport operations, and 40% of warehousing operations are outsourced [54]. This process is also increasing for smaller businesses in urban areas. The French Urban Goods Movements Surveys have shown that the share of third-party “movements” (operations of deliveries and take-offs) has increased from about 45% in the 1990's [5] to 51% in the 2010's [55]. Some of this progression is due to the development of already established third-party services. Traditional companies, proposing full truck load or groupage or less-than-truckload network services, have been operating in urban areas for a long time. However, since the 1990's, the evolution of logistics' markets has brought about a wave of consolidation within the 3PL industry. This has caused the rise of a specific segment of third-party logistics operators: Logistics Service Providers (LSP), large companies capable of offering sophisticated solutions on a continental or global scale [56].

Harry et al. [57] and Razzaque and Sheng [53] list the advantages of relying on LSP. While traditional transport services are multi-clients, LSP offer specific, tailor-made services to their clients. They offer Supply-Chain Management and multi-dimensional services, as opposed to traditional services that are usually one-dimensional (either transport or warehousing operations, for example). These services are also offered in the frame of multi-year contracts, which solidify the business relationship between the shipper and the logistics provider, as opposed to simpler (and less pricey) arrangements with traditional companies.

The literature on the subject of the growth of LSPs is abundant. Selviaridis and Spring [58] have listed over 110 papers on the subject. Most aim to understand the phenomenon from a technical and economic point of view, at several levels: the company (shipper or LSP), the relationship between the shipper and its LSP, or the network of 3PL allowing the creation of these sophisticated logistics solutions. In France, the progress of LSP usage for large retailers [59] and manufacturing companies [60] has been analyzed in detail. One significant gap in the literature revolves around the spatial manifestation of the ascent of this market. For the Paris Region, Raimbault [48] has described the growth of a real estate market dedicated to logistics (led by global household names such as Prologis or Goodman), producing standardized facilities (the rule of thumb is

6000m² for a standard warehouse cell), usually for large international LSPs. These facilities are often located in the periphery of the Paris Region, thus contributing heavily to the observed logistics sprawl. Logistics real estate companies' services also go beyond isolated warehouses, offering prime locations in privately planned "freight villages" to their customers, with all the related services that these locations entail.

In our database, we analyze four categories of LSP-occupied logistics facilities: generalist logistics providers (CLASS K), retail logistics providers (CLASS H), cold food logistics providers (CLASS I) and industrial logistics providers (CLASS J). Figure 5 shows that their location is very typical. LSP facilities are located further from the city-center than other combined logistics facilities (as shown by the two ellipses). They are also bigger, especially in the suburbs: 16,650 m² on average for LSPs vs. 7950 m² for other logistics facilities. Finally, Fig. 5 shows the importance of LSP facilities in specific peripheral locations around Paris (Essonne and Seine-et-Marne in the South-East).

The development of these large, standardized facilities (see Fig. 6) located in the distant suburbs of a large

metropolitan area such as Paris present important economic advantages. Real estate market players hold "catalogues" of standardized, interchangeable warehouses, generally located away from dense city centers but close to highways and still close enough to large urban areas that they have access to potential clients for LSP companies. LSP companies enjoy the flexibility of having at their disposal a large number of potential facilities. They can rent these facilities according to the needs and the duration of the contracts they have with their client (the shipper), then stop their activity when necessary. On the other hands, these large standardized facilities present important challenges for the regional and metropolitan planning of logistics facilities, as presented in Raimbault [48]. They contribute heavily to logistics sprawl, as they are brand new, large facilities. More importantly, they tend to locate in small, rural, peripheral municipalities, where they meet very little local resistance, and the development of these facilities is completely unchecked by policy-makers. As such, they represent a kind of "invisible" logistics development, outside the scope of policy-makers.

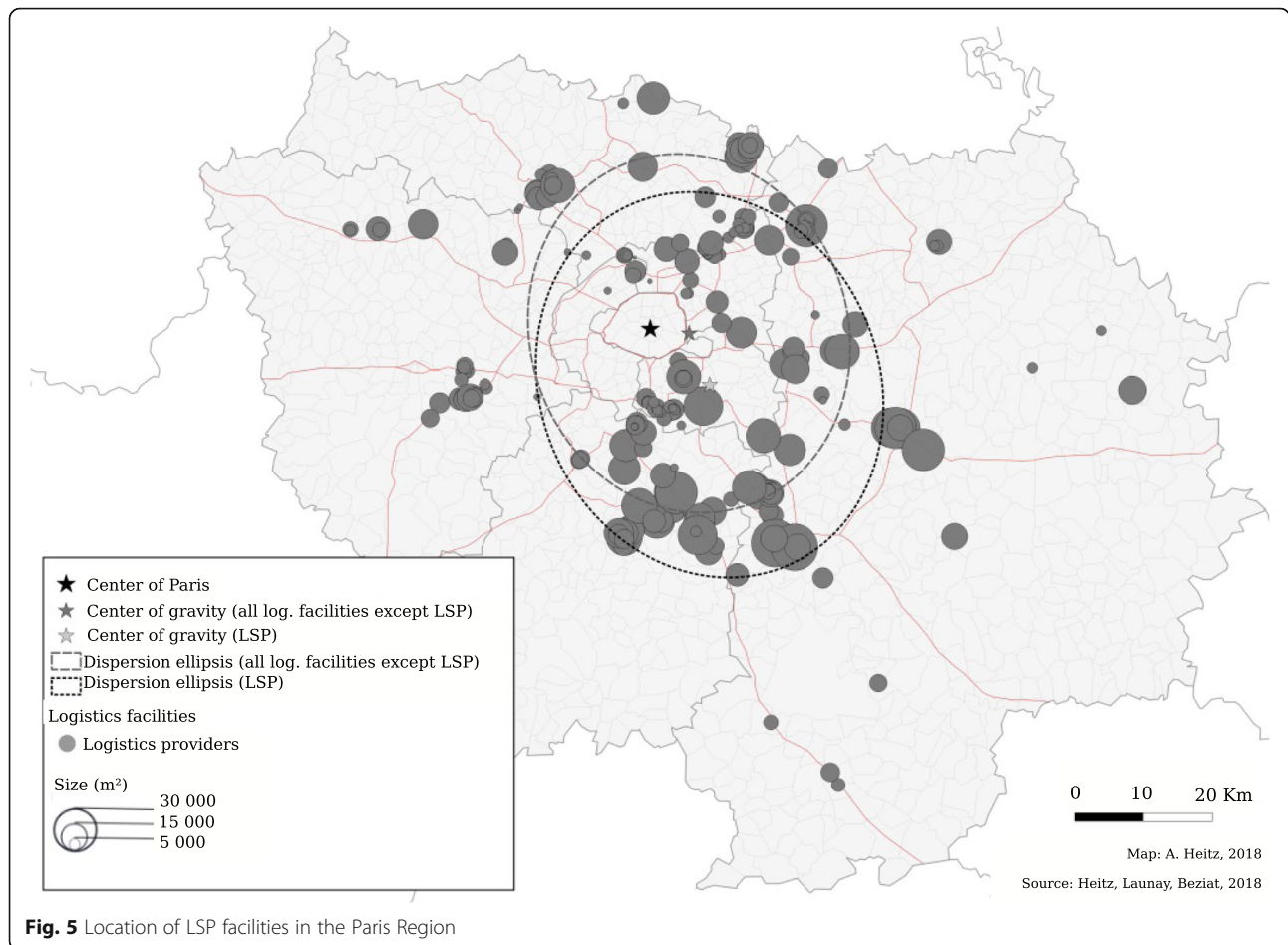


Fig. 5 Location of LSP facilities in the Paris Region

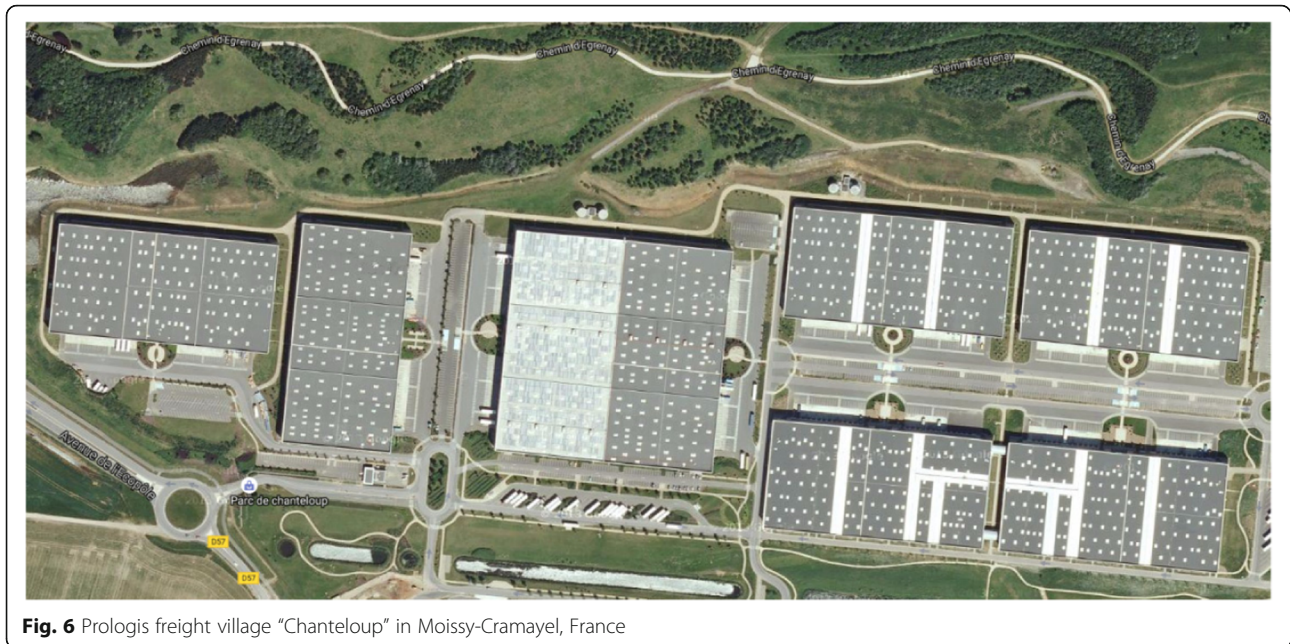


Fig. 6 Prologis freight village “Chanteloup” in Moissy-Cramayel, France

2 Location of logistics facilities in the Paris region according to their sector

The three case studies help to understand the location patterns of the different facilities belonging to three specific market segments of the transport and logistics industry, thus justifying the method of the typology. However, the case studies are of little help in interpreting all the logistics facilities in Paris Region. To tackle this issue, in this section, we crossed our typology of logistics services according to their sectors and to some spatial indicators in order to look for spatial similarities between the logistics sectors and propose an interpretation of the location pattern of all the logistics facilities, according to their sector and their territory.

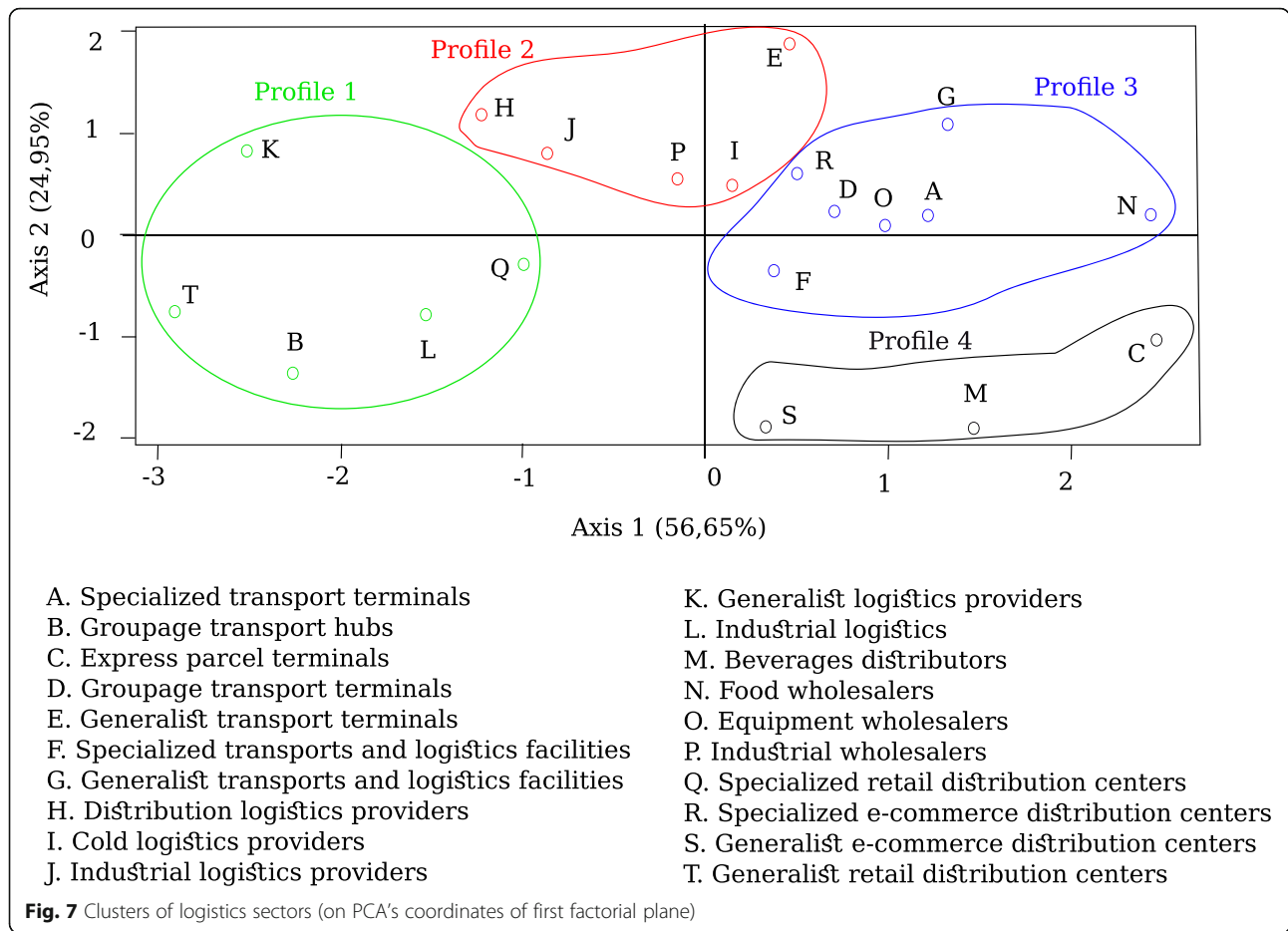
2.1 PCA and clustering analysis: Data and method

By applying our new methodology for identifying logistics facilities, this research aims to provide new insight into the location of logistics facilities according to the sector (type) to which they belong. We have classified each facility according their type and calculated for each type their average distance to the center of Paris, the average population density of the municipalities where they are mainly located, the average size of the facility and the average number of employees. Using average indicators, despite the fact that the statistical distributions are not homogenous, allow us to use a Proponent Component Analysis (PCA) in order to summarize the structure of the logistics sectors. With the PCA method we are able to measure proximities between facilities from different logistics sectors and between our four variables. The PCA is used on quantitative variables, so we have to complete this

method with a clustering method (k-means) to manage qualitative variables like the sector type.

As we can see on the plot below (Fig. 7), some proximities and oppositions between facilities from different sectors are highlighted in the factorial design that explains almost 80% of the inertia of the scatter graph. According to our PCA, six types contribute the most to the x axis' formation: “generalist logistics providers”, “industrial logistics providers”, “generalist retail distribution centers”, which are characterized by a large distance to the center of Paris and a low population density, and “Express parcel transport terminals”, “Beverages distributors” and “Generalist e-commerce distribution centers”, which are characterized by close proximity to the center of Paris and location in high population density areas. The y axis determines both proximity to the center of the Paris Region and provides information on the population density of the area where the warehouses are located. Five types contribute the most to the ordinate axis' formation in the PCA: “Generalist e-commerce distribution centers” and “Groupage transport hubs”, the warehouses with the most employees, contribute the most to the axis' formation, followed by “Generalist transport terminals”, “Industrial logistics providers” and “Distribution logistics providers”, with few employees, are also contributors to the axis' formation. The second axis characterizes the number of employees. In conclusion, we are able to say that distance to the center of Paris and population density are two major factors of location in the Paris Region, and two factors of differentiation between the different logistics sectors.

To go further, we studied the similarities and dissimilarities of logistics sectors by creating clusters based on



the PCA result. We created a typology, using an ascending hierarchical classification (ACH) (which does not require knowledge of the number of classes) based on coordinates of the principal axis of the factor analysis, to describe in detail the different logistics sectors according to geographical and urban criteria. Using ascending hierarchical classification allows us to create a tree that groups all the types in several clusters. Based on the resulting tree, we conclude that four clusters are clearly identifiable. Based on that conclusion, we propose a typology that groups, in four clusters, all the logistics sectors that take into account the density of population, the distance to the center of Paris, the number of employees and the size of the facilities.

We then used an unsupervised learning algorithm that clusters all the facilities, classified by type, based on their similarity (K-means) to create groups of logistics sectors that share the same specificities regarding their location. The algorithm randomly assigns each observation to a cluster and finds the centroid of each cluster. Then, the algorithm iterates through two steps: it reassigns data points to the cluster whose centroid is closest and calculates the new centroid of each cluster. The within cluster variation

is calculated as the sum of the Euclidean distance between the data points and their respective cluster centroids. The graph below (Fig. 7) shows the typology clustered in four groups of proximities according the PCA results. The first two axes of dispersion of variables revealed by the PCA, form the first factorial plane on which all logistics sectors are projected. Each group is determined by a specific profile that we describe in the next section and which contains logistics facilities classified by type.

3 Results

The four profiles group between 3 and 7 logistics sectors. We have calculated the average of the four

Table 3 Profile description

	Profile A	Profile B	Profile C	Profile D
Average population density (inhabitants/km ²)	2227.1	2552.1	3263	5864.5
Average distance to the center of Paris (km)	23.3	23	17.5	17.2
Average number of employees	116	48.3	48.3	90.8
Average Size (m ²)	18,776.5	8083.4	5842	7349.3

variables (population density, distance to the center of Paris, number of employees, size) for each profile represented in the table below (Table 3).

Profile 1 groups five logistics sectors: “Groupage transport hubs”, “Generalist logistics providers”, “Industrial logistics”, “Specialized retail distribution centers” and “Generalist retail distribution centers”. Those five logistics sectors share some characteristics, such as large sized facilities. The average size is 18,776.5 m², which is the biggest average of all the profiles. This group is also characterized by the largest distance to the center of Paris, and a significant dispersion into the Paris Region. According to this result we can make the hypothesis that these activities have particularly participated in logistics sprawl over the last decades. The evolution toward bigger warehouses can be attributed to several factors: higher integration of operations, better pooling of logistical flows, or real estate optimization. Given these changes, in land availability and cost, and given the fact that logistics activities have low profitability per square meter, logistics sectors that rely on big warehouses tend to be located in places where the land is available and cheap. It means they are more likely to be located in peripheral areas than in the dense center of the agglomeration, where the competition with other activities is much fiercer. Indeed, they are located in the less dense part of the Paris Region. The average population density in the municipalities where they are located is around 2227,1 inhabitants/km², which is quite low compared to the other profiles. Logistics sectors in profile 1 also have a large number of employees. These sectors not only deliver the Paris Region but also the rest of the country. Their specificity is to rely on a national or supra regional network, so their center of gravity is beyond the Paris region area. This profile is quite homogenous and the different logistics sectors share the same territorial functioning.

Profile 2 consists in five logistics sectors which are “cold logistics providers”, “distribution logistics providers”, “industrial providers”, “generalist transport terminals” and “industrial wholesalers”. As in profile 1, these sectors are characterized by a considerable distance from the center of Paris (23 km) and a location in less dense areas. They are also dispersed in the Paris Region, but their facilities are much smaller (8083.5m²) and in number of employees (48.3 employees per facility). This profile is not homogeneous and not easy to interpret at first sight. These sectors can be described as specialized providers, like providers of cold goods, industrial goods or industrial wholesale trade. The fact that they supply specific and different demands and goods, from food to industrial materials, makes it difficult to see what they have in common from a logistics or management perspective. They seem to have the same location pattern, they are also characterized by a low

number of employees contrary to profile 1, but they are too different from each other from a logistics perspective to be considered as a homogeneous cluster. They are more dispersed in the Paris Region than facilities from profile 1. So, located in the outskirts of the Paris agglomeration, they include different types of logistics facilities, which share a common spatial pattern. These activities are co-localized.

Profile 3 groups seven logistics sectors, namely « specialized transport terminals », « “Groupage transport terminals”, “Specialized transport and logistics facilities”, “generalist transport and logistics facilities”, “food wholesalers”, “Equipment wholesalers”, “Specialized e-commerce distribution centers”. They are located in denser areas (3263 inhabitants/km²) than facilities from profiles 1 and 2. They are located 17.5 km on average from the center of Paris, they are therefore closer to the center of Paris. Like profile 2, profile 3 is very heterogeneous. Different logistics sectors share the same spatial pattern. These sectors are related to food or equipment wholesale and e-commerce. They are generalist and, to be able to supply urban demand, they are located in dense areas. This profile also includes facilities that propose transport and cross-dock services. These are often older, which may explain their location in dense areas and small warehouse sizes. As with profile 2, profile 3 companies have few employees. The average size is around 5000m², which is very small because they are located in dense urban areas. Profile 3 is characterized by small facilities located in dense urban areas close to the center of the agglomeration. Dense areas have diverse logistics facilities.

Profile 4 includes three logistics sectors: “Express parcel transport terminals”, “Beverage distributors” and “generalist e-commerce distribution centers”. According to their average distance to the center of Paris (17.2 km) and the population density of the areas (5865 inhabitants/km²), they handle urban distribution and therefore need to be as close to the center as possible in dense urban areas. Warehouses are bigger than facilities in profile 3.

All four profiles are quite heterogeneous. While there are some similarities in their location according to spatial, urban or architectural characteristics, they are not necessarily similar. This is mostly because, in each profile, we have found several functions (cross-docking and transportation). The great heterogeneity of the profiles tends to prove that, despite spatial similarities, and urban proximities, for some logistics sectors, the location of logistics facilities cannot be explained only by spatial indicators. Each logistics sector can have its own spatial pattern that can be explained by different factors. The sum of all these different spatial patterns gives us a smooth freight landscape, but even if some logistics sectors share a same location pattern, they remain different from an economic or functional

perspective. Public policy stakeholders are linked to specific territories, from local to regional. Their political scope does not overlap with the scope of logistics activities. From a territorial perspective, public policies plan logistics facilities according to their location pattern, and usually miss the specificity of each logistics sector. To plan urban distribution or suburban distribution, public stakeholders consider all logistics facilities according their location pattern but planning logistics facilities should also take into account co-location effects.

Logistics suburbanization may appear to be the result of some specific logistics sectors, like logistics providers and retail distribution. Many logistics stakeholders, from retail to industry, may co-exist in the same location, but the factors that explain their location can be different. Dense urban areas also have to deal with a wide panel of logistics facilities, logistics sectors that must accommodate each other and their urban environment. This is a great challenge for public policymakers because they have to plan for specific logistics activities, which are collocated and therefore apparently identical, when they are in fact very different from each other, as well as segmented, with specific interests, and sometimes interests that can vary according to scale.

4 Conclusion

This analysis is a first step in an atomized description of logistics facilities. In this article we have documented the significant increase in the number of research works on the location of logistics facilities. We have highlighted the fact that these pioneering works are limited by the lack of detailed data on logistics sectors and mostly describe the location of logistics facilities from a holistic perspective, except for several works that focus only on a description of specific logistics sectors. Moreover, while the topic of logistics sprawl has been raised in the academic literature, the discussion on changes in the location of logistics facilities depending logistics sectors has been only recently brought to light. In this paper, we propose a new methodology to census and classify logistics facilities in order to observe the spatial pattern of the different logistics facilities, according to logistics sectors. Using this new database, we present a new freight landscape for the Paris Region.

First, we observe that 50% of logistics facilities are located in less than 10% of the Paris Region, so there is significant concentration of small warehouses and logistics facilities in dense urban areas, located not in the city of Paris, but in its closest suburbs (“Petite Couronne”). In contrast, large facilities with many employees have spread to the fringes of the agglomeration, in the “Grande Couronne”. We have analyzed three specific segments of the

transport and logistics industry, to identify the different location patterns of their facilities. The parcel delivery industry, which relies on groupage transport hubs and parcel terminals, and the food sector, which relies on retail distribution and wholesale trade, are very heterogeneous and do not share the same spatial pattern. Retail distribution shares the same spatial pattern as many logistics services providers. With these case studies we are able to reveal a complex freight landscape and a specific spatial pattern for each logistics sector thereby complicating public policymakers’ understanding of the logistics facilities on their territory. Logistics sectors are not homogenous and do have different spatial patterns.

Some of these spatial patterns, however, present similarities. In section 6, we attempted to look for proximities between all the logistics sectors that we had identified, in order to cluster them according their spatial specificities. We found that two clusters (Profile 1 and 4) were quite homogeneous, the cluster 1 groups logistics providers and hubs, the largest facilities, which rely on transport networks and transportation infrastructures. Cluster 4 groups logistics facilities that are strongly connected with urban demand and urban distribution and are therefore located in dense urban areas. The two other clusters (Profile 2 and 3) are less easy to interpret. They are very heterogeneous. Logistics sectors that are not similar may share the same location pattern. Understanding the general geography of the logistics facilities in urban regions requires looking at the different logistics services in each logistics facilities and considering the heterogeneity of their activity.

This paper focused on the case of the Paris Region, but the method developed to census logistics facilities could be reproduced in different region or in different countries. Our main source is an establishments file (which most countries possess), satellite images and field work. As the logistics real estate market tends to be more and more harmonized around the world, by the influence of international stakeholders such as Prologis, JLL or CBRE, the recognition of warehouses and distribution center implied less and less endemic characteristics. Nevertheless, field work is important to adjust the method to the case by considering some local specificities. Regarding the typology we developed here, it appears to be very suitable for the French case but should be improved to be used in different contexts. Further research will allow us to create a typology which could be used apart from the local specificities.

One of the purposes of these new method and production of data on the location of logistics facilities is to guide public stakeholders to better plan freight and logistics facilities, specifically in the dense part of the metro area from where they are pushed away (contributing to logistics sprawl). In this case, the dataset created have been used by the City of Paris, to produce the new “Atlas des grandes

fonctions métropolitaines” [61] that allow public stakeholders newly integrated to the Greater Paris Metropolis to have a better knowledge of their territory and build a new coherent project based on the same detailed data and background. Moreover, the City of Paris is a leader for urban logistics and needed a comprehensive study of this sector to rely on, to go further in this development.

The method developed in this paper can also be duplicated and applied in other cases. Indeed, the basic data (establishments files) and field works required to produce the dataset are available in every metro area. The complexity of freight transport system has been emphasized by several research work, especially regarding modelling of freight transport demand (e.g; [62]). Most country lack freight flows surveys but with detailed data on logistics facilities (such as type of activity, size, number of employees and precise location) it become possible to improve estimation of freight flows. The typology provided in this paper could supply the models and produce better estimation of freight flows, freight movements, contributing to a comprehensive transportation planning of the metro areas. Logistics facilities are new in the urban landscape, from an urban planning perspective, the unawareness of their value and the essential part they play in the consumption system, make difficult their appropriation for public policies and people who perceive them as negative externalities generators. It could be possible to estimate a degree of negative externality depending on the type of logistics facilities to influence the location of logistics parks. It could be possible to evaluate the possibility of modal shift (e.g. trains, cargo-cycles, electric vehicles) regarding the type of logistics. For example, developing urban logistics solutions and the use of cargo-cycle is possible for parcel's industry and less possible for the industrial logistics. Thus, the typology allows calibrated public policies on freight.

Developing “Smart cities” relies on a collection of information and data intended for better planning and organizing cities [63]. Based on technologies, data, ICT, this concept allow public authorities and private stakeholders “to optimize efficiency and effectiveness in the pursuit of competitiveness and sustainability” [64]. The procedure proposed in this paper to census logistics facilities contributes to the development of standardized data collection methods using easily accessible open data. These types of frameworks are necessary to better understand the location of economic activities, logistics facilities, which are responsible for a considerable share of urban freight flows and CO2 emissions (source). Locating and understanding the nature of logistics facilities is a necessary step towards more integrated freight transport planning. Public stakeholders use transportation policies (passenger and freight) as a way to provide more sustainable and

environmentally friendly city logistics systems. For this, they rely on available data to experiment and improve in the transportation field.

5 Endnotes

¹NACE codes refer to the French term “Nomenclature statistique des Activités économiques dans la Communauté Européenne”, which translates as statistical classification of economic activities in the European community). NAICS codes refer to the “North American Industry Classification System”.

²Statistics on the Paris Region (population, density, employment, areas, are provided by INSEE: <https://www.insee.fr/fr/statistiques/2011101?geo=REG-11>, accessed 09/25/2017; 08/10/2018

³<https://www.insee.fr/fr/metadonnees/nafr2/sousClasse/52.29A>, accessed on 09/25/2017

⁴http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Top_20_airports_in_the_EU28_in_terms_of_total_freight_and_mail_carried_in_2015.png, accessed on 09/25/2017

Acknowledgements

This article presents some results of a research carried out for the Metrofreight Center of Excellence on urban freight. Metrofreight is financed by the Volvo Research and Educational Foundations (VREF).

Authors' contributions

All three authors participated in the data collection effort, fieldwork, and databases analysis. AH conceived the general framework for the paper, coordinated the data collection, and carried out the statistical analysis, as well as the case study on food distribution systems. AB designed the data collection methodology and provided the case study on LSPs. PL designed the typology, and provided the case study on groupage networks. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

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Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Received: 24 May 2017 Accepted: 17 December 2018

Published online: 18 January 2019

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