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Research paper

Dark stores in the City of Light: Geographical and transportation impacts of 'quick commerce' in Paris☆

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ABSTRACT

Food e-commerce has long remained a limited phenomenon, which only changed noticeably during the COVID-19 pandemic. Not only did more consumers take advantage of the options offered online, it also prompted the launch of many food delivery start-ups around the world. Quick commerce in particular, offering grocery deliveries within twenty minutes or less, attracted significant sums of venture capital, alongside criticism from urban administrations and communities for the nuisances caused. Indeed, to offer instant grocery deliveries, quick commerce companies rely on a tightknit network of small, store-like warehouses, called 'dark stores', and a readily available vehicle fleet and staff. While plenty of ink has flowed about the urban implications of quick commerce in the press, a thorough scientific analysis lacks. To objectify and quantify the nuisances generated by quick commerce, we study geographical dimensions and transportation activities in Paris. By means of a press review, expert interviews, field observations and a cartography, we detail a supply chain consisting of various facility types; demonstrate the transportation-intensity of dark stores consisting mainly of electric two-wheelers; problematize the public space consumed by the vehicles in particular; and contrast the ultimately limited network of dark stores relative to traditional food retail.

1. Introduction: the rise of 'quick commerce'

A growing share of consumer spending has been moving from physical shopping to virtual practices over the last decade. While online shopping represented about 3% of global retail sales in 2010, it reached over 16% in 2020 (International Post Corporation, 2021). The situation is however very contrasted from one country to another. Large contrasts exist as well between product types. The sales of clothing and household appliances lends itself well to online channels, but this has generally been less the case for food. More recently, however, the trend has been turned around by the COVID-19 pandemic. The combination of lockdowns, business closures and physical distancing measures has pushed consumers to discover online channels for food. It is likely to have a lasting effect (UNCTAD, 2021), especially in markets with mature online offerings (Delberghe et al., 2022). Moreover, some of the indicators for long term transition to food e-commerce have in many places materialized, e.g., rapid introduction of new technologies and strategic logistics capacity building (Dannenberg et al., 2020). Online food grew dramatically in 2020 and rose another 9% the year after, says McKinsey research (Delberghe et al., 2022). Accordingly, the consultancy firm predicts that online will make up more than 20% of the European 'food at home' market by 2030 (Delberghe et al., 2022).

Most supermarket chains have found their way to the worldwide web. Following an omnichannel model, they offer consumers the possibility to select grocery items online as well as in store (Buldeo Rai et al., 2019). E-commerce has also given rise to a multitude of other business models (Gee et al., 2020). Some of them have modernized existing practices (e.g., delivery of prepared meals, local produce), while others emerged fairly recently (e.g., delivery of recipe boxes). How these business models are operationalized differs considerably as well. Some omnichannel supermarket chains have organized for consumer collection of online orders, by putting in place dedicated counters or sites (called 'drives') (Wollenburg et al., 2018). Others have prioritized home deliveries, as have online-only supermarkets and most other business models in food e-commerce (Seidel, 2021). Moreover, there is a clear tendency towards speed. This applies to e-commerce in general and certainly to food. The online food ordering and delivery market has inspired Dablanc et al. (2017) to introduce the concept of 'instant

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deliveries', i.e., delivery services within two hours ordered via online platforms.

During the COVID-19 pandemic, even faster delivery companies emerged. The business model, coined 'quick commerce', proposes home delivery of groceries within twenty minutes or less. Some of the pioneers, including the American Gopuff (2013) and the Turkish Getir (2015), kicked off almost a decade ago. Yet the pandemic years proved most fertile, launching dozens of companies around the globe (Buldeo Rai, 2023). To operationalize these activities, quick commerce companies rely on a readily available staff and a tightknit network of small, store-like warehouses in every city in which they are present. These warehouses are called 'dark stores', a term that has become fairly universal (Buldeo Rai, 2023). McKinsey research estimates that the top 15 companies in the quick commerce market had opened more than 800 dark stores in Europe by the end of 2021 (Delberghe et al., 2022). The consultancy firm estimates that quick commerce reached between €3 and €6 billion in 2021. As such, it accounts for less than 1% of the total grocery market but grows at a three-digit percent rate annually (Delberghe et al., 2022). An expensive business model seeking to monetize a sudden change in consumer behavior, quick commerce companies soon attracted significant sums of venture capital. Pitchbook data show that they raised $4 billion in 2021, or nine times more than the year before (Wolf, 2022).

By 2022, conditions for quick commerce had turned. Quick commerce was plagued by dried-up funds from venture capitalists and stiffened resistance from the cities in which they operate. It led to bankruptcies, closures and layoffs, as a Bloomberg article from April 2022 explains (Davalos and Levingston, 2022). Besides complex geopolitical and economic circumstances, the business model difficulties are a natural consequence of the 'blitzscaling' strategy that the companies and their investors had been pursuing. This strategy implies companies racing to serve a global customer base before any of their competitors (Kuratko et al., 2020). It essentially describes a cash-burning elimination race. In turn, declining acceptance and growing opposition of urban administrations and communities can be traced back to the nuisances inherent to instant deliveries (Schorung et al., 2022), i.e., noise disturbances, air pollution, consumption of public space (Allen et al., 2021). A New York Times article captured these concerns early (Hu, 2021), followed by many others in 2022 and 2023.

In response, the objective of this research is to objectify and quantify the nuisances generated by quick commerce in the city. In line with the aforementioned administration and community concerns, we focus on geographical dimensions and transportation activities and study how they have unfolded in the City of Paris. Despite plenty of ink being spilled about the urban implications of quick commerce in the press, a thorough scientific analysis lacks. This article responds to that gap. Although the quick commerce business model is under pressure, research on the topic remains important. Three reasons illustrate the relevance of this study. First, the likelihood that all quick commerce companies continue is low, but the survival of one or a few of these companies per city is likely. Second, instant deliveries organized from store locations represent a growing practice in retail in general. Third, interest and development in urban warehousing is strengthening. The geographical and transportation insights generated by this research can support the understanding and framing of not only quick commerce, but these other phenomena as well.

Applied to our case-study, we detect three remaining quick commerce companies in Paris anno 2023, i.e., Getir, Bam Courses and Flink. Getir is considered the dominant player in the long term. At the same time, omnichannel (e.g., Casino group) and online (e.g., Mon-marché.fr) supermarkets offer instant deliveries in the Paris market, both from urban stores and urban warehouses. Also warehousing space in the city is soaring, including in support of such online food services. Similar evolutions can be observed in cities around the world, including New York City and London. Given that they share comparable socio-economic characteristics, are prime areas for innovation in e-commerce and urban logistics and are among the main cities concerned by quick commerce, these two cities serve as points of comparison for the Paris case in our research findings.

Quick commerce is not the only manifestation of a food market in transformation. Other business models and their geographical and transportation impacts have been explored in literature. Excluding meals delivery, this segment is called 'e-grocery' in literature (Aziz et al., 2022; Martín et al., 2019). Since several types of services in the online food market are offered by the same companies, it is relevant to include them in this study. For example, supermarket chain Carrefour sells groceries and meal kits delivered within days as well as within hours and instant delivery platform Deliveroo carries groceries as well as meals (t-bureau de, 2022). We review this research on food e-commerce in the second section, in which we discuss its multitude of business models and range of urban impacts. Our multi-methodological approach consisting of press review, expert interviews, field observations and cartography is discussed in the third section. The fourth section describes our findings on quick commerce in Paris, regarding a supply chain of various facility types, transportation intensity of dark stores in urban environments as well as spatial patterns between competition and complementarity. The fifth section discusses the findings' relevance with regards to policy and planning and the final section concludes.

2. Literature review: business models and urban impacts of food e-commerce

In food e-commerce, a multitude of business models has emerged, with various impacts on the urban environments in which they operate. Some have organized for collection of online orders by consumers, but most have prioritized deliveries to consumers' homes (Gee et al., 2020). Omnichannel supermarkets prefer consumer collection because of profitability (Marouseau, 2013), even in geographies where home delivery is widespread (Wollenburg et al., 2018). Seidel et al. (2016) point out that grocery click-and-collect is a successful practice in France in particular. It has been coined 'drive' in French, following the American drive-through concept. Marouseau (2013) distinguishes between 'regular drives', apt for car-dependent consumers in suburban areas and 'pedestrian drives', fitted to consumers walking or biking in cities. Both types are either attached to existing supermarkets or detached on separate locations. In 2019, there were 76 pedestrian drives in France, most of them in Paris (Seidel, 2021). This number has increased since. According to the Paris urban planning agency, the Carrefour group has the largest number of pedestrian drives in Paris with more than 80 points, compared to 50 for the Casino group (Apur, 2022). Other supermarket chains are not very active in this segment.

Some innovations in grocery click-and-collect are noteworthy. Buldeo Rai et al. (2019) and Seidel (2021) refer to supermarkets having put lockers in place for collection, either in existing stores or on separate locations. The Paris urban planning agency mentions automated pedestrian drives. Here, consumers access their orders through scanning a code, instead of receiving their orders from the staff (Apur, 2022). Both innovations address profitability issues of online groceries, as the need for permanently available staff is reduced (Buldeo Rai et al., 2019). Nevertheless, throughout the different types of drives, it seems that they mimic the spatial patterns of regular supermarkets in cities. The same holds for their transportation activities, as they are also supplied by heavy goods vehicle from warehouses in the periphery (Seidel, 2021). For consumers' shopping trips, Seidel (2021) adds that drives' direct impacts are limited in terms of transportation mode and distance, at least in urban areas.

Home delivery is however the most widespread practice for online groceries in cities (Seidel, 2021). In line with the European study of Wollenburg et al. (2018) and the Belgian study of Buldeo Rai et al. (2019), Seidel (2021) found that German supermarkets organize their deliveries in-house. In France, however, supermarkets tend to create

partnerships with companies that have more delivery experience. Seidel (2021) also refers to the partnerships between supermarket chains and meal delivery platforms that emerged during the pandemic. In the Paris region, for example, self-employed (or 'gig') workers carried out home deliveries of online ordered groceries prepared in local supermarkets (Seidel, 2021). Wollenburg et al. (2018) note that shipments from stores require higher capacity investments for vehicles, a concern that supermarket chains possibly alleviate with gig work.

Mkansi and Nsakanda (2021) suggests that using existing stores for delivery can be more sustainable than using warehouses. Nonetheless, most grocery deliveries are organized from warehouses. These partially or fully automated facilities are located in the urban periphery and sometimes even within the center (Seidel, 2021). Seidel (2021) records an emergence of small warehouses or micro-hubs closer to consumers, either in mobile or in fixed locations, to optimize routes. Despite these efforts, increases in transportation by supermarket chains and suboptimal routing are noted, as units are small and order behavior is "uncontrolled" (Seidel, 2021). Unattended home delivery alternatives can partially address these inefficiencies. Punakivi and Tanskanen (2002) introduced reception boxes (i.e., installed in consumers' buildings, yards or garages) and delivery boxes (i.e., insulated boxes to be returned to the supermarket), allowing delivery of groceries when consumers are not home.

Online supermarkets are focused on selling the same basket of groceries to consumers as they would in store, i.e., recurring groceries that largely meet household needs. This is true for both delivery and collection. A range of companies has emerged that focus on only a part of these needs. Examples are emergency groceries, provided by quick commerce companies, and supplementary groceries, addressed by digitalized short chains for local produce. Regarding the former business model, studies discussing their urban impact are lacking, hence the objective of this research. Regarding the latter, literature focuses on the marketplace concept, the most advanced form of digitalized short chains (Chiffoleau et al., 2018). They exchange data and information to pool resources and reach consumers, but generally do not offer optimized transportation services (Nordmark et al., 2012). As a consequence, despite the limited geographical distance between producers and consumers, short chains do not necessarily decrease transportation distances and nuisances (Paciarotti & Torregiani, 2021). Raton and Raimbert (2019) argue that transportation patterns have thus become more relevant to study than geographical catchment areas. Yet the development of click-and-collect services for digitalized short chains is noteworthy, also in terms of urban geography. Chiffoleau et al. (2018) mention so-called 'farmer drives', partner stores and own stores.

Many other business models within food e-commerce do not target groceries. Two major segments include recipe boxes and prepared meals. Regarding the former business model, studies have assessed the impact of recipe boxes or 'meal kits' through food waste (Gee et al., 2019) and greenhouse gas emissions (Heard et al., 2019). Moreover, the freezer packs that keep the food fresh while being shipped are also found polluting (Butler, 2017). When it comes to recipe boxes' transportation impacts, they typically rely on subscriptions, a model that has spread from non-food to food e-commerce (Wagner et al., 2021). Subscriptions do not only encourage consumer loyalty and spending, but facilitate accuracy in inventory forecasting and efficiency in home deliveries (O'Shaughnessy, 2021). They are generally scheduled once a week from a regional or national warehouse (O'Shaughnessy, 2021). Following the lead of other thematic box companies, such as those for beauty, recipe box companies also launched click-and-collect as a second possibility to reach consumers. Collection points are created through partnerships with independent local retail or supermarket chains.

The latter business model is dedicated to home delivery of prepared meals. The model usually operates from existing restaurants, which is why research has so far focused on transportation. Based on data of a major platform provider in London, Allen et al. (2021) investigated transport characteristics and environmental impacts. They found that delivery workers undertake 9.6 deliveries per day on average, with each covering 2.2 km and taking 25 min from collection to delivery. The researchers conclude that the combined energy of transportation and cooking for meal delivery by moped or car is far greater, than if consumers purchase the ingredients themselves by car and cook them at home (Allen et al., 2021). In Paris, Dablanc et al. (2022) have been organizing surveys among meal delivery gig workers since 2016, to understand their activities better. Various aspects, from modal choice to employment status, are covered in yearly reports. Over the years, the survey has documented declining use of bicycles in favor of mopeds and cars, a persistent presence of undocumented migrants and a deterioration of working conditions (Dablanc et al., 2022).

With the rise of delivery-only restaurants, 'cloud kitchens', 'ghost kitchens' or 'dark kitchens', a geographical investigation of meals delivery becomes pressing. Allen et al. (2021) mention that Deliveroo has introduced approximately 100 dark kitchens in the United Kingdom, which they refer to as 'RooBoxes' and 'Deliveroo Editions Kitchens'. A Euromonitor International report from 2020 states that India has around 3,500 dark kitchens, far ahead of western economies such as the United States (1,500) and the United Kingdom (750) (Schaefer, 2020). John (2021) refers to an Oracle study, that has classified the concept into three main types: i.e., shared spaces, dedicated spaces and virtual brands. Food e-commerce, including meal deliveries, is hyperlocal by default and focuses on satisfying demand within very restricted geographies (John, 2021). As such, many dark kitchens have been built in proximity to residential areas, where they generate up to 200 vehicle trips per hour (Morris, 2018).

Different companies within food e-commerce thus impact cities differently. In an attempt to distinguish among business models, Mariquivoi (2022) proposes a framework in her master's thesis. Table 1 reproduces this proposal. We added some international examples to the primarily French companies in the overview, which is not comprehensive. The horizontal axis of the table demonstrates the urban locations of various business models: from none, if it concerns a platform that connects demand and supply, over warehouses, to drives and stores. The vertical axis signals the food product type, from prepared meals, over recipe boxes, to supplementary/emergency and recurring groceries. A growing presence of food e-commerce business models in cities is clear (Chiffoleau et al., 2018; John, 2021; Marouseau, 2013). Moreover, they also seem to trigger an increase in transportation activities (Dablanc et al., 2017; Seidel, 2021). Although these activities can replace motorized shopping trips by consumers, it seems less likely in cities (Bjørgen et al., 2021). Quick commerce companies are presented in the framework as well, although information on their geographical dimensions and transportation activities lacks. We will address this research gap in the upcoming sections.

3. Multi-methodological approach

The objective of this research is to objectify and quantify the nuisances generated by quick commerce in the City of Paris. We justify our case-study with five motivations. First, quick commerce companies tend to focus on cities, capitals in particular (Fischer, 2022). In fact, the City of Paris hosted over 80 dark stores from about eight quick commerce companies in February 2022 (Apur, 2022). Second, food e-commerce is now an established activity among the French. According to IRI market data outlined in Table 2, it accounted for nearly 20 billion euros in 2021, or 50% more compared to 2019 (Delvallée, 2021). Quick commerce generated only 122 million euros overall, but sales in Paris were seven times higher than in the rest of France (El Hassani, 2021). Third, administration and community concerns around quick commerce have been particularly strong in Paris (Schorung et al., 2022), intensifying the need for objective and quantitative information. Fourth, some research efforts have been done on quick commerce in Paris, including by the Paris urban planning agency (Apur, 2022), strengthening a basis for in-depth study. Fifth and final, the City of Paris is a particularly

Table 1
Food e-commerce framework (the authors, based on Mariquivoi (2022)).

	No location	Peripheral warehouse	Urban warehouse	Intra-urban warehouses	Collection points, by partners	Collection points, in drives	Physical stores
Recurring groceries	Kelbongoo	Greenweez Carrefour Monoprix Alibaba Amazon	Amazon Fresh	La Belle Vie Mon-marché.fr		Carrefour	Carrefour Monoprix Franprix
Emergency or supplementary groceries	Too Good To Go Phenix Everli	Potager City	Potager City Kelbongoo	Gorillas Flink Gopuff Getir Rappi Dingdong Maicai	Potager City Hors Normes Too Good To Go Phenix Rechtstreex	Kelbongoo	Kelbongoo
Recipe boxes		HelloFresh Quitoque Foodette Les Commis			Quitoque		
Prepared meals	Deliveroo Uber Eats			Frichti Rappi			
Business models: quick commerce, platforms, marketplaces, omnichannel retailers							

interesting case because of its historic insistence on local retail and its openness to integrating logistics facilities on the municipal territory (Dablanc, 2023).

To study quick commerce in the City of Paris, we applied a multi-methodological approach including press review, expert interviews, field observations and cartography. First, we conducted a press review from February to June 2022, focused on articles published in a weekly professional magazine on consumption in France, called LSA. We followed two of its newsletters, "connected commerce" and "food commerce", in an exploratory way, and searched for its articles on quick commerce using the Europresse database, in a targeted way. We stored all relevant information in files organized by topic (e.g., dark store locations, quick commerce contacts).

Second, from April to May 2022, we organized four semi-structured expert interviews. Our questions addressed supply chain structures of quick commerce companies and spatial patterns of dark stores. We interviewed the following experts:

- a journalist of professional magazine LSA (April 12, 2 h, in Paris);
- a launch and expansion associate from quick commerce company Gopuff (May 31, 40 min, telephone);
- a marketing intern of quick commerce company Flink (several times, about 3 h, in Paris); and
- a researcher from the Paris urban planning agency Apur who led a study on quick commerce in Paris (May 18, 2 h, in Paris).

Third, in February and June 2022, we carried out field observations at three dark stores: Getir in the 11th arrondissement[1]; Gorillas in the 1st arrondissement[2]; and Flink in the 2nd arrondissement.[3] These field observations are largely based on the approach of Srinivas et al. (2019), who investigated the transportation-intensity of three Amazon facilities in Sacramento, California. At fourteen consecutive hours during the week and thirteen consecutive hours during the weekend, we recorded a number of activities for every location:

- departing delivery vehicles;
- arriving delivery vehicles;

[1] 34 Rue Popincourt, 75011 Paris.
[2] 68 Rue de Cléry, 75002 Paris.
[3] 18 Rue Réaumur, 75003 Paris.

Table 2
Food e-commerce in France in 2021 (Delvallée (2021), based on IRI data).

	In million Euro	In percentage
Omnichannel supermarkets: 'drive'	9,000	46%
Meal delivery platforms	8,700	44%
Recipe box delivery companies	1,100	6%
Online-only supermarkets	414	2%
Omnichannel supermarkets: delivery	404	2%
Quick commerce	122	1%
Total	19,740	100%

- number of units loaded per delivery vehicle;
- number of delivery vehicles parked;
- arriving supply vehicles;
- departing supply vehicles; and
- number of units unloaded per supply vehicle.

Fourth, a cartographic work was carried out to represent the spatial patterns of dark stores in Paris as well as the place of quick commerce in the food retail network. This research is also based on a comparison with New York City and London. The data collection on dark stores took place between February and May 2022. The database was built from the websites of quick commerce companies and Google Maps for the location of all dark stores. The data collection for New York City is also based on the collaborative website BetaNYC, which offers open access data on the location of dark stores. The data collection for food retail establishments is based on the same sources. For Paris we used the public database BDCOM of the Paris urban planning agency. The choice was made to include only the major supermarket chains to lighten the maps.

4. Findings on quick commerce and dark stores in Paris

The findings of our multi-methodological approach are outlined following three themes: supply chain structure, transportation intensity and spatial patterns.

4.1. A supply chain of various facility types

Quick commerce is often assumed to rely on a network of similar dark stores, supplied from a central warehouse. Following this

assumption, all dark stores within the quick commerce business model are equal. By focusing on the operations of one company, the American Gopuff, and one city, the City of Paris, this section presents evidence suggesting more diverse patterns. Specifically, we identified two types of dark stores, 'small' and 'large', different ways in which they relate to the central warehouse and the presence of administrative facilities. Although Gopuff has left the Paris market since the time of research, the findings are valid for most companies in the quick commerce market.

On the one hand, small dark stores are located in former stores on the ground floor of residential buildings in the dense urban center. They have the smallest floor area, with a maximum of 200 sq m, in which products are stored on shelves and in refrigerators. A large space is often allocated to the parking and storage of bicycles, probably due to the absence of other secure places outside. Mopeds and bicycles are parked at the curbside adjacent to the dark stores. On the other hand, large dark stores are located in industrial areas that are either still in activity or in redevelopment, in former manufacturing buildings or small warehouses in peripheral areas. They often benefit from adjacent courtyards or car parks, providing space for vehicles to park. Their location outside of the urban center gives them a larger storage area of up to 500 sq m. Therefore, the stock per product unit is larger, leading to lower frequencies of supply transportation.

The central warehouse is much larger than the local dark stores and is located in the Paris periphery. It is either owned or subcontracted by Gopuff, which testifies to their control of product stock and supply chain. Several hypotheses can be put forward concerning its function: cross-docking activities for supplying dark stores in the Paris region, storage activities as a national hub for dark stores in various French cities or storage activities as a base hub for expansion into neighboring countries. Finally, observations within Paris demonstrated that not all Gopuff locations are dedicated to logistics activities. Some locations have administrative support functions, such as a training center for their staff of delivery workers, located in the same street as one of their dark stores. Fig. 1 illustrates Gopuff locations in Paris in 2022.

The Gopuff supply chain is based on a vertically integrated model, economically, and on a network of dark stores, geographically. According to our research, Gopuff sources its assortment of maximum 4,000 stock keeping units directly from a traditional central purchasing unit, as well as from small local suppliers, for example for bread. The central warehouse is supplied by heavy goods vehicle, on a monthly basis for non-perishable products and on a bi-weekly basis for fresh products. The dark stores are supplied weekly by lights goods vehicle, electric in some cases. Dark store supply activities from the central warehouse are outsourced to a logistics service provider.

When an order is placed on the Gopuff application that consumers can download, a notification arrives on the smartphone of an order picker based in the dark store within their delivery area. The order picker has a maximum of 5 min to prepare the order, i.e., to pick the items and place them on the dispatching table. A delivery worker then takes over and delivers the order in one round on a moped or bicycle. Although Gopuff provides employment contracts to delivery workers, they also work with gig workers to address sudden peaks in demand. In the former case, vehicles are branded, in the latter case, gig workers use their own vehicles. The orders consist of small product volumes, packed in a paper bag and a refrigerated square backpack. Fig. 2 illustrates the Gopuff information and goods flows in Paris and neighboring municipalities. It launched a partnership with Too Good To Go, an application to reduce food waste, allowing consumers to collect baskets of products close to the use-by date at the dark stores. It is a limited practice and therefore not shown in the figure.

4.2. Transportation-intensive facilities

In line with concerns by administrations and local communities, our observations confirm that dark stores are transportation-intensive facilities. Fig. 3 shows the number of departing and arriving delivery vehicles during an average day in the week of three dark stores in Paris. On average, we observed one delivery vehicle departing or arriving every 3 min. However, when it comes to concerns about noise disturbances and air pollution generated by these vehicles, concerns are not always justified. All observed quick commerce companies provide electric bicycles for their delivery workers. Gorillas and Flink employ them uniquely, while they are used in addition to electric mopeds and the occasional pedestrian at Getir. Fig. 3 shows the breakdown of transportation modes used throughout the day. Bicycles and mopeds seem to share a maximal capacity of two orders stacked per trip. Mopeds allow slightly higher order stacking throughout the day, while bicycles stack more during busier hours. During the week, an average of 1.3 orders are stacked per trip, which increased to 1.5 orders per trip during the weekend. Only the Getir observations from February 2022 allowed us to get close enough to collect this detailed information. Possibly because quick commerce controversy increased in Paris (Schorung et al., 2022), delivery workers were less keen to be observed so the Gorillas and Flink observations in June 2022 became more difficult.

Transportation activities at dark stores tend to increase throughout the day, with peaks around noon, towards the end of the workday and later in the evening. The pattern is similar to the observed weekend day, although the late evening peak seems more pronounced and longer. A dark store generates between 150 and 300 vehicle movements per day in the week and a bit more in the weekend (Table 3). We compared our findings with the observations of an Amazon Prime Now Hub dedicated to 2-h delivery in Sacramento, California, the most urban location studied by Srinivas et al. (2019). With a size of 20,000 sq f, his facility is about five to ten times larger than an average dark store, but generates a

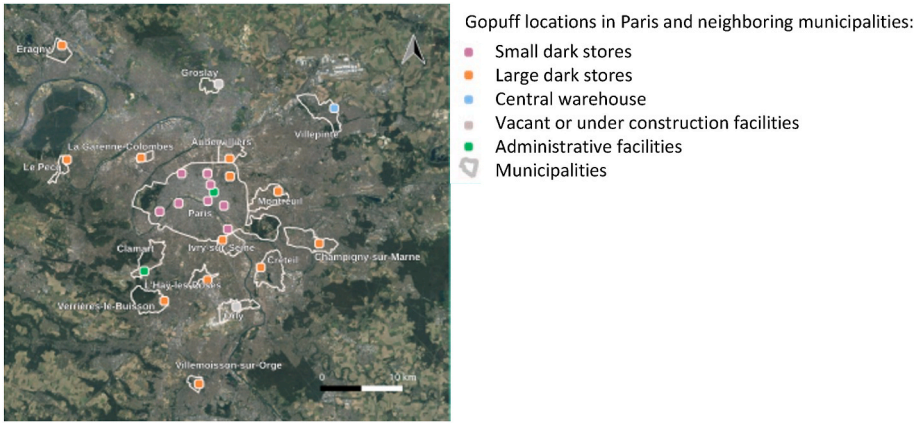

Fig. 1. Gopuff locations in Paris and neighboring municipalities, on April 2022 (the authors, based on Mariquivoi (2022)).

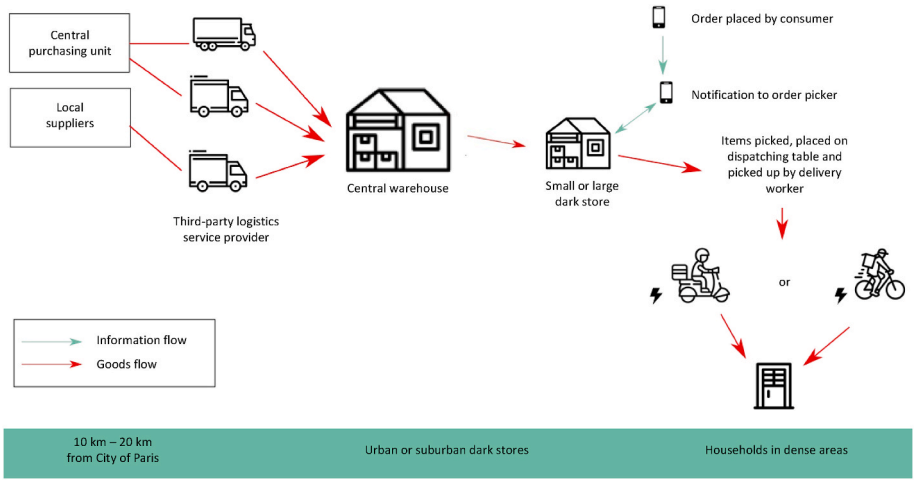

Fig. 2. Gopuff information and goods flows in Paris and neighboring municipalities (the authors, based on Mariquivoi (2022)).

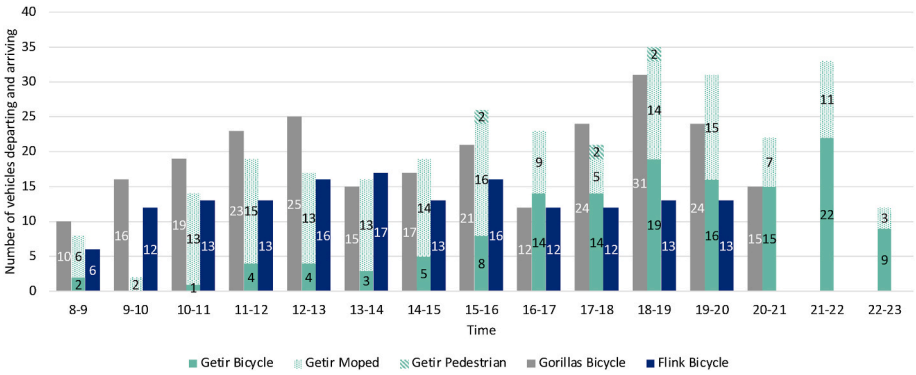

Fig. 3. Departing and arriving delivery vehicles during an average day in the week of three dark stores in Paris, on February/June 2022 (the authors, based on observations by Nathan Partouche, Maxime Priet, Beatriz Oliveira and Juliette Weber). Note: omitted bar graphs mean absent data but not necessarily absent vehicles.

Table 3
Departing and arriving delivery vehicles during an average day in the week and the weekend of three dark stores in Paris, on February/June 2022 (the authors, based on observations by Nathan Partouche, Maxime Priet, Beatriz Oliveira and Juliette Weber).

		Week day		Weekend day	
		Total	Average per hour	Total	Average per hour
Getir	Electric bicycle	136	9.1	174	12.4
	Electric moped	156	10.4	137	9.8
	Pedestrian	6	0.4	0	0
	Total	*298*	*19.9*	*311*	*22.2*
Gorillas	Electric bicycle	252	19.4	247	20.6
Flink	Electric bicycle	156	13.0	183	15.3

lower number of delivery vehicle departures per day: 97 passenger cars from users of the Amazon Flex app, compared with 126 mopeds or bicycles. Although the nuisance levels generated by cars and electric two-wheelers differ, the comparison does confirm dark stores' transportation-intensity in terms of the number of delivery vehicles in and out of each facility.

Moreover, despite the low-emission and low-noise nature of the vehicles used, they do consume a significant amount of public space. We observed an average of 11–13 vehicles occupying the nearby on-street parking spaces during our observations. It can also be noted that quick commerce relies on electric vehicles, contrary to mopeds used in the prepared meal delivery business in Paris (Dablanc et al., 2022). Also, the consumption of curb space would obviously be greater if quick commerce companies used passenger cars or vans. It remains however significant since the business model is primarily focused on emergency shopping, that would otherwise be made by Paris-based consumers on foot or by bicycle. Getir stores its bicycles and mopeds inside the warehouses towards the evening, a practice that they plan to expand towards the day, to address concerns of local administrations and communities.

4.3. *A model between competition and complementarity*

We have represented the six most strongly established quick commerce companies in Paris and its neighboring municipalities at the time of research (April 2022). They represent 91 dark stores overall, 67 inside the city limits of Paris (25 dark stores from Getir, 14 from Frichti, 13 from Flink, 13 from Gopuff/Dija, 10 from Gorillas, 8 from Cajoo, 6 from Zapp). The most developed quick commerce companies (Getir, Frichti, Flink, Gopuff) have deployed a network of dark stores to cover the entire Paris territory. Quick commerce has established a radius of 1.5 km as reference for defining the catchment area around their dark stores. Fig. 4 represents these catchment areas, showing both a strong coverage and overlapping and competition between companies. This can be explained by the fact that the Paris market was still in a consolidation phase at the

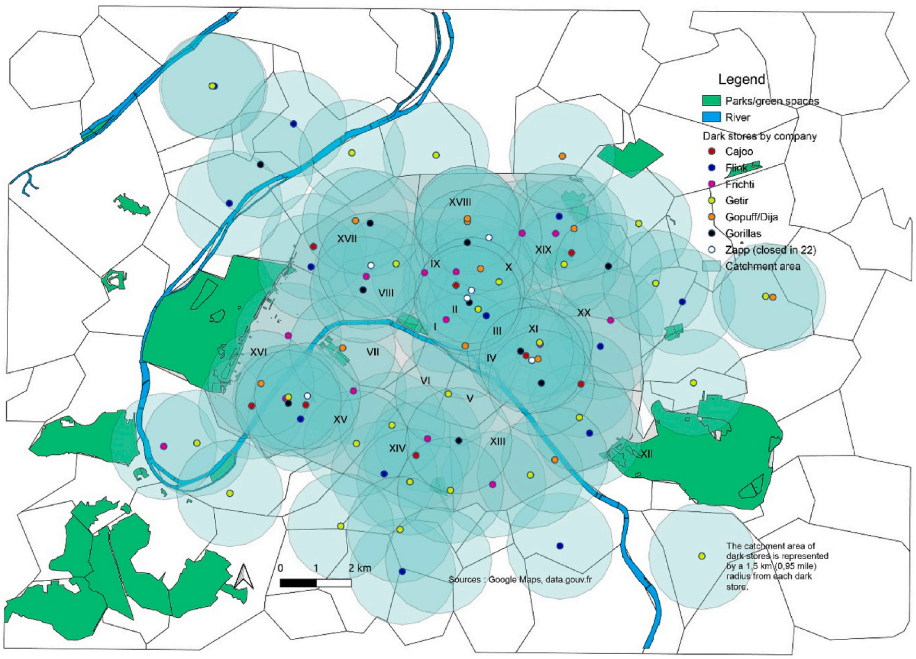

Fig. 4. Locations and catchment areas of dark stores in Paris and neighboring municipalities on April 2022 (the authors, based on websites of quick commerce companies, GoogleMaps). Note: catchment areas are represented by a 1.5 km radius from each dark store.

time of research.

When we compare the spatial patterns of dark stores in Paris with those of dark stores in New York City and London, we can formulate three findings. First, a different market development with the largest number of dark stores in New York City (115 dark stores) versus 55 for Greater London on April 2022; second, a different market maturity depending on the context with a smaller number of companies in London (three dominant, three secondary companies) and New York (four main companies after the withdrawal of Russian start-ups, Buyk and Fridge No More, following the sanctions against Russia since March 2022) than in Paris; third, a more uniform spatial pattern in Paris than in London and New York City. Indeed, Fig. 5 shows the location of dark stores in Greater London as well as their catchment areas. There is a very strong concentration in the north and southwest of the city, which results in an uneven spatial coverage. In New York City, the vast majority of dark stores are located in Manhattan and western Brooklyn. Fig. 6 shows the location of dark stores in New York with their catchment area. The map of New York City also shows a spatial imbalance within the urban area. The majority of dark stores are located in Manhattan and in western and northern Brooklyn. The spatial coverage of quick commerce is therefore very uneven, with some areas particularly well-served and others left out (i.e., Bronx, eastern Brooklyn, Staten Island).

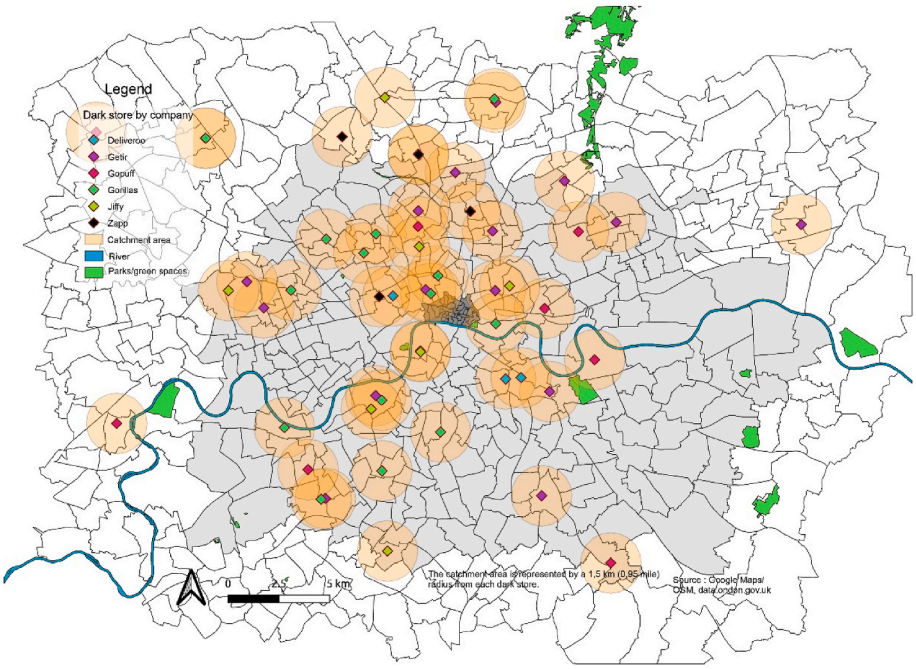

Fig. 5. Locations and catchment areas of dark stores in Greater London on April 2022 (the authors, based on websites of quick commerce companies, GoogleMaps). Note: catchment areas are represented by a 1.5 km radius from each dark store.

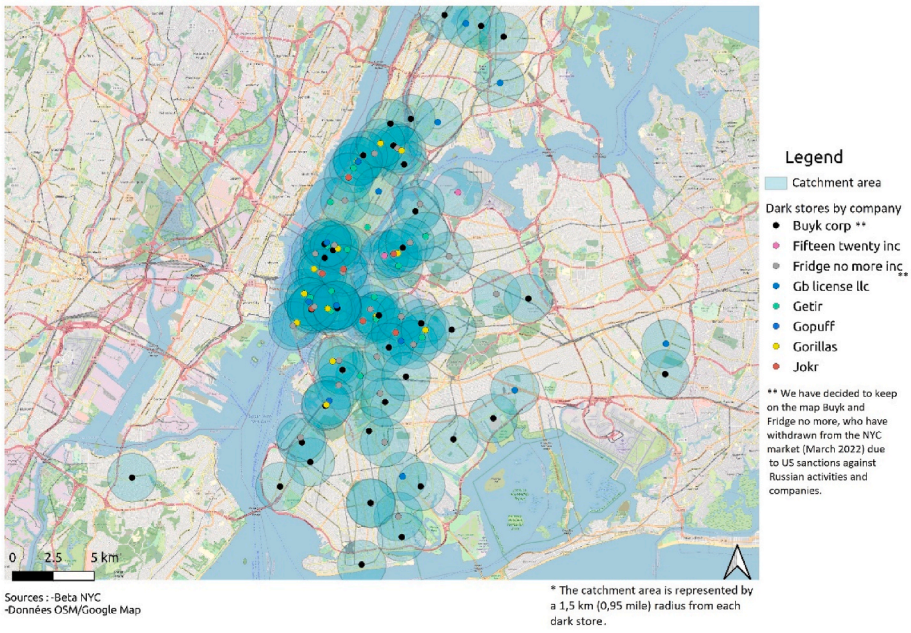

Fig. 6. Locations and catchment areas of dark stores in New York City on April 2022 (the authors, based on websites of quick commerce companies, GoogleMaps, BetaNYC). Note: catchment areas are represented by a 1.5 km radius from each dark store.

The international press has widely reported on the development of quick commerce and dark stores in major cities to these 'shadow warehouses'. Three main criticisms are made. First, the non-compliance of land use and zoning rules by installing warehouses in commercial or residential areas (Schorung et al., 2022); second, the risk of unfair competition with small businesses and traditional food retail; third, the development of a dystopian city made up of closed stores and covered windows. The cartographic work adds nuance to the second observation. Indeed, the development of dark stores must be compared to the food retail network, which has considerably more locations. The following maps of Paris (Fig. 7) and New York City (Fig. 8) illustrate this. In both cities, we see a clear imbalance between the two sectors and the installation of dark stores near traditional stores.

5. Discussion: findings' relevance with regards to policy and planning

Quick commerce promises instant delivery of otherwise common grocery items to urban homes. Its network of 'dark stores' introduces new types of urban facilities, changing the relationship between commercial and logistics spaces in dense areas of major cities. It also creates new types of transportation flows. These flows can be intense, especially at certain times of the day and in certain locations.

In this research, we have demonstrated that dark stores represent

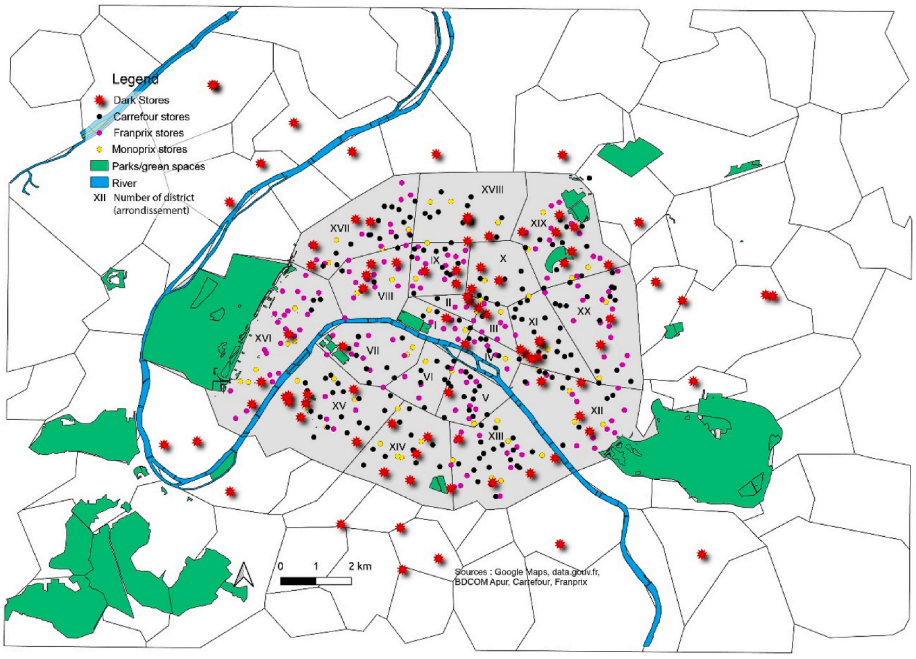

Fig. 7. Dark stores versus traditional food retail networks in Paris on April 2022 (the authors, based on websites of quick commerce and food retail companies, GoogleMaps, BDCOM).

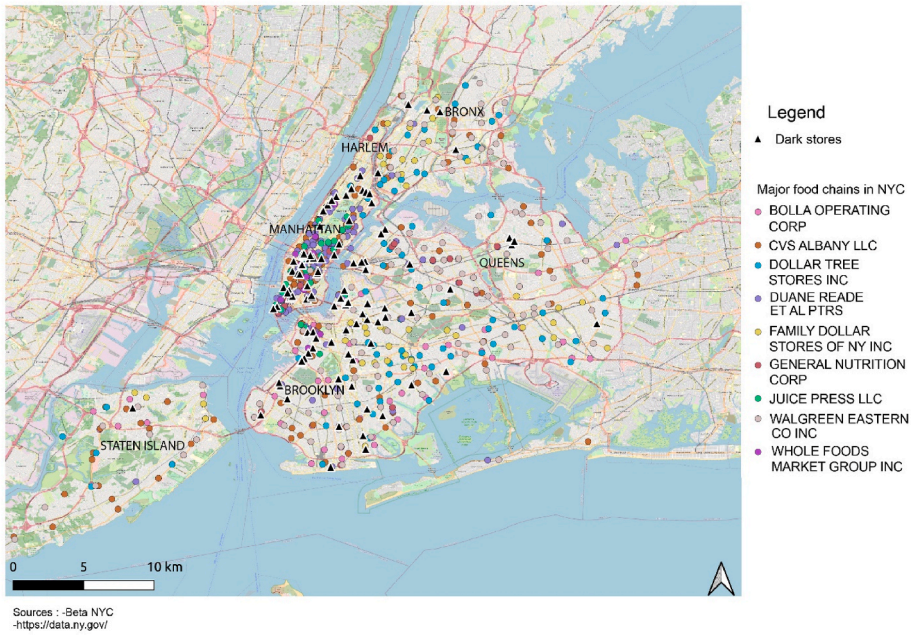

Fig. 8. Dark stores versus traditional food retail networks in New York City on April 2022 (the authors, based on websites of quick commerce and food retail companies, GoogleMaps, BetaNYC).

only a very small share of food consumption and of the number of food selling facilities in Paris. After all, there are less than 100 facilities within Paris. Yet, each dark store is a high generator of vehicle movements, i.e., 150 to 300 per facility per day. Quick commerce is indeed transportation-intensive. Although these vehicles are zero-emission (e.g., bicycles, electric bicycles, electric mopeds), they occupy space, generate congestion on the curbside and their drivers occasionally make noise while waiting for deliveries. These impacts have generated a backlash from urban administrations and communities in the City of Paris. Such reactions have been echoed in other cities around the world as well. For example, the City of Barcelona has totally banned dark stores in January 2023, while the City of Amsterdam has restricted dark stores to certain business and industrial zones since 2022. In New York, City Councilwoman Gale Brewer is leading a campaign to restrict dark stores to protect bodegas or small neighborhood stores.

Corresponding to a specific segment of online food consumption, dark stores are and should remain few in number. Taking the example of large Chinese cities, that have a longer history of quick commerce, the market share of quick commerce seems to stabilize around 5% of all online food consumption of residents in these cities (Zaugg, 2021). Their total impact in traffic in general, and goods transportation in particular, thus remains marginal. If we take the example of Paris, with about 400,000 total delivery and collection movements every day (Toilier et al., 2018), dark stores at their most only represent 30,000 movements (7.5%). As these movements are made with small size zero emission vehicles, the environmental problems of dark stores are limited to their surrounding areas (e.g., curb congestion, noise).

These findings suggest a first conclusion in terms of policy and planning: there is an overreaction from urban administrations relating to dark stores. This overreaction is especially coming from the political side, as opposed to the technical and practice side. In Paris, elected officials won a court case after heated political discussions during the summer of 2022 and a legal battle which has closed on March 2023. As per the French urban planning code, they can now legally ban dark stores, officially defined as warehouses, that would violate urban planning rules on logistics facilities. This applies even in if they offer click-and-collect services or a coffeeshop. Local elected officials' position in France on e-commerce warehouses actually represents a paradox: politicians classify dark stores as warehouses, so as to be able to prohibit them more easily in urban areas while at the same time, they wish that large e-commerce warehouses in suburban areas be considered as retail stores, so that they can be subject to the operating permits that exist in France for large supermarkets.

We propose a second conclusion: our research suggests that there are more relevant local policies regarding dark stores. Beyond the legal wrangling over the status of dark stores or the relevancy of consumer behaviors, it would seem more appropriate for urban administrations to focus on the specific impacts of transportation such as noise and congestion from delivery vehicles serving dark stores. This is a matter for traffic regulations and curbside management. Adding to the issue of road safety are delivery driver accidents, which seem to be an important problem as demonstrated by previous studies on instant food delivery in the City of Paris. More than a quarter of all moped and bicycle drivers when making instant deliveries have had a serious accidents in the last year (Dablanc et al., 2022).

A third conclusion on policy and planning from our research is the following: in order to take these new transportation and traffic challenges into account in urban policies, better data on quick commerce activities are necessary. Reliable metrics enable diagnoses to be made, which in turn enable appropriate policies to be adopted. Acquiring regularly updated data on new urban logistics services, especially very fast changing ones such as quick commerce, provides urban administrations with instruments to improve traffic management and infrastructure planning. It also allows to evaluate the effects of policies. Data make it possible to carry out cost-benefit analyses of public policies and to provide information to quick commerce companies so that they can situate themselves in relation to average indicators for the sector. Today, as our research has demonstrated, data on quick commerce and its impacts on traffic are incomplete and collecting better data is a policy priority.

6. Conclusion

Food e-commerce has long remained a limited phenomenon, which only changed noticeably during the COVID-19 pandemic. Consumers took advantage of the options offered online and many food delivery start-ups launched around the world, quick commerce companies in particular. Offering grocery deliveries within 20 min or less, quick

commerce soon attracted significant criticism from urban administrations and communities for the nuisances caused. Despite plenty of ink being spilled about the phenomenon in the press, a thorough scientific analysis lacked. To objectify and quantify the nuisances generated by quick commerce, we studied the geographical dimensions and the transportation activities associated with quick commerce in the City of Paris. This city in particular has been a playing field for the rise and subsequent fall of the quick commerce business model. Today some companies are still very active and the model has its ramifications in both legislation on the place of logistics in the city and the services and priorities of food retail in general.

By means of a press review, expert interviews, field observations and a cartography, we identified a supply chain consisting of various facility types, we demonstrated the transportation-intensity of dark stores although consisting mainly of electric two-wheelers, we problematized the public space consumed by these vehicles and we contrasted the ultimately limited network of dark stores relative to traditional food retail. These findings led to the posing of three conclusions, namely an observation that responses to quick commerce from urban administrations can be seen as an overreaction, a suggestion for planning and policy to focus on traffic regulations, curb management and road safety, and the recommendation that continuous urban logistics data collection be made a policy priority. Other concerns related to quick commerce have been raised, such as working conditions of instant delivery workers, consumers' health in the on-demand economy and the net transportation impact of online shopping, providing promising avenues for future research.

CRediT authorship contribution statement

Heleen Buldeo Rai: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration. **Joséphine Mariquivoi:** Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Visualization. **Matthieu Schorung:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing – original draft, Visualization, Supervision, Project administration. **Laetitia Dablanc:** Conceptualization, Investigation, Writing – original draft, Writing – review & editing, Supervision, Project administration, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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