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# Half a decade in two years: household freight after COVID-19

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**Abstract:** E-commerce growth as experienced during the COVID-19 pandemic was only expected to occur by 2025-2030. Online shopping increased in intensity and diversity. At the same time, retailers diversified their operations and opened online channels, also in sectors that previously showed reluctance to make this shift. These evolutions resulted in an expansion of household freight in terms of volume, geography, and organisation. Hence, half a decade of innovation in the e-commerce sector was needed in the span of two years. This manuscript summarises the repercussions for household freight since the pandemic's start. Given that interactions between consumers, retailers, and logistics service providers drive the e-commerce system, this manuscript combines these different literatures into a holistic framework, going beyond traditional siloed research on last-mile logistics, retail strategies, or online shopping behaviour. We found that logistics has come to the forefront: logistics service providers now need to provide tailored services and come in direct contact with consumers. As a result, we need (i) to gain insights into the new geography and dynamics of household's freight origins and destinations; (ii) use this to re-examine existing relationships between consumer, retailer, and logistics service provider, and; (iii) assess the impact of more demanding consumers on the sustainability of the overall system.

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**Keywords:** COVID-19, e-commerce, last mile, consumers, retailers, household freight

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## 1. Introduction

The internet has transformed the world into a showroom without walls (Brynjolfsson et al., 2013). E-shoppers drive logistics activities, demanding ever faster and more convenient deliveries, traceable from warehouse to doorstep. Compared to traditional retail freight trips, this household-generated freight, that is *household freight*, is fragmented. In this context, a large number of small orders needs to be picked up from and delivered to a large number of addresses. This fragmentation substantially complicated the operational activities of logistics service providers (LSP), who take care of the distribution and warehousing activities (Cárdenas et al., 2017).

These issues have received increasing attention in urban freight research with the number of publications growing exponentially from 2012 onwards (Mangiaracina et al., 2019). Similarly, outside of academia interest is on the rise too. For example, the European Commission provided guidelines for efficient zero-emission urban logistics and last-mile deliveries in its New Urban Mobility Framework (European Commission, 2021). At the local level, London was one of the first cities to cover last mile solutions in their freight action plan (Transport for London, 2019), while elsewhere in Europe cities and regions are piloting various distribution strategies (e.g. Athens, Barcelona, Flanders, Ispra and Oxfordshire in the *GreenLog* project).

The academic literature and policy measures regarding household freight are, however, geared towards the optimisation of LSPs' last mile distribution operations - see e.g. Pahwa & Jaller (2022) for a cost-based analysis of last mile strategies, Janjevic & Winkenbach (2020) for an overview of last mile network designs, and Dablanc (2023) for an overview of best practices in urban logistics policies. In comparison, relatively little attention has been given to the main cause of last mile complexity, i.e. the interaction between consumers, retailers and LSPs. In this matter, Wang et al. (2022a) is a rare exception focusing on the consumer-side. They find that consumers' involvement in the retail delivery

process remains restricted to the purchase itself, though the authors identify opportunities in synergies between consumers and LSPs. For the retail-side, early work looked at the adoption of online channels by retailers and the shift towards omnichannel retailing (see e.g. Boschma & Weltevreden, 2008; Verhoef et al., 2015), but the number of studies remained remarkably small in comparison with the significant historical attention given to physical retail strategies. One exception is Beckers et al. (2022), who made a first attempt in providing a holistic perspective, studying the interactions between the three actors. They introduced a framework of three key axes determining the magnitude, efficiency and complexity of household freight traffic. First, households have been promoted to fully fledged freight actors directly determining delivery volumes and destinations. Second, the distribution process of online orders strongly depends on the supplier network and distribution system designed by the online retailer, often shifting logistics responsibilities from shippers to LSPs (e.g. through consolidation). Third, the efficiency of final freight trips is jeopardised by the lack of density of the delivery network. These three axes are fundamental to strategic decisions in the last mile from an operational, strategic, and policy perspective. In this regard, Rimmer & Kam (2018) coined the term *consumer logistics* for such a consumer-centric logistics organisation.

The increased attention of various stakeholders for household freight, however, still stands in stark contrast to the current limited academic understanding of household freight dynamics resulting from the interactions between the three main actors. Moreover, the rapid growth the sector went through since the start of the pandemic in early 2020 only further increased this disparity. The COVID-19 pandemic forcefully changed consumer behaviour and, as a result, parcel flows and retail strategies. Before March 2020, e-commerce experienced heterogenous though steady growth. In the last quarter of 2019 the internet accounted for around 20% of the UK and 11% of the US retail markets. These values quickly rose to 25% and 15% respectively by the 2<sup>nd</sup> quarter of 2022 (ONS, 2022; UNCTAD, 2021; US Census Bureau, 2022). In China, the share of online retail sales in total retail sales in goods rose from 20% in 2019 to 25% in 2021 (NBS, 2022). Similarly, in the European Union (EU), retail trade volume by mail or internet rose by 60 percentage points between 2019 and 2021 compared to 2015 base levels (European Commission, 2023). Also in terms of parcel volumes the EU saw a growth of 39% during the two heaviest COVID-19 years (2020-2021) in comparison to total volume increases of only 23% in the two years prior (European Commission, 2022).

To further our understanding of household freight dynamics following this e-commerce boom, this paper discusses the following research question: How did the COVID-19 pandemic impact household freight along its three axes of a) household demand and preferences, b) evolving logistics responsibilities, and c) delivery densities? We answer this research question by means of a structured literature review, considering 73 articles. In contrast to traditional siloed research focusing on either e-commerce logistics, retail strategies, or online shopping behaviour, this article takes a holistic approach. In doing so, the query results in a corpus consisting of four research strands: consumer behaviour, retail adaptation strategies, supply chain management (SCM) evolutions and technological innovations. We identify key evolutions and innovations at the intersection of these four research strands and the three household freight axes. Finally, the research concludes with paths for further research in the form of 22 open research questions. This manuscript should aid (i) researchers, such as transport modelers, transport geographers, or others, to study household freight more comprehensively, and (ii) retailers and logistics operators to develop better strategies through a better understanding of consumer logistics evolutions.

The paper unfolds as follows: First, in section 2, we describe the methodology used for the literature review. Subsequently, section 3 discusses household freight evolutions during the COVID-19 pandemic, structured along the four main research strands distilled from the literature review corpus.

Next, in section 4, we identify open research questions for household freight in post-pandemic society. Finally, we present our conclusions in the fifth and final section.

## 2. Methodology

### 2.1. Query

The manuscript uses a structured literature search on Web of Science, the reference database for the academic discipline. The following query was used to search for English, peer-reviewed journal research papers:

TITLE-ABS-KEY ( (1)

( covid OR corona ) AND (2)

( e-commerce OR ecommerce OR “electronic commerce” ) AND (3)

( ( delivery OR “last mile” ) OR ( “consumer behavior” OR “shopping behavior” OR “consumer behaviour” OR “shopping behaviour” ) OR “retailer” ) ) (4)

We limited the search to the SSCI and SCIE to make results more manageable. The search was updated last 13/01/2023 to include all papers published from the start of the pandemic (2020) until the very end of 2022. The final search led to a total of 113 results.

With this query we aimed to discover literature on three important dimensions of e-commerce growth and last mile logistics responses. First, consumer behaviour, or how the COVID-19 pandemic led to increased online demand. Second, how retailers reorganised operations in response. Third, how logistics and delivery innovations aided in the transition from physical to e-commerce shopping.

The search results were subsequently manually curated in accordance with the research objectives of this article. We first only retained papers that reflect on the influence of the COVID-19 pandemic. Second, we require that papers discuss changes in volume, i.e. changes in supply and demand, and/or innovations in logistics incorporating (post-)COVID-19 needs. In other words, we focus on papers considering the freight parameters of e-commerce. In the end we retained a corpus of 73 articles. The first paper was published in November 2020.

### 2.2 Topic analysis

Subsequently, topic analysis was used to identify the main research strands within the corpus. The literatures included are quite disparate and a topic analysis allows for a first classification of the various research themes discussed. Using this approach reduces bias that occurs when exploring a large corpus for latent topics (Asmussen & Møller, 2019). Concretely, we used structural topic modelling (STM) (Roberts et al., 2016). The analysis was done in R 4.1.3 (R Core Team, 2022). STM is an extension of Latent Dirichlet Allocation (LDA), the most widely used probabilistic topic model. LDA does not evaluate semantics but rather the co-occurrence of words. These arise from a mixture of topics, which are shared across the corpus, though the topic proportions differ per document. An important downside of LDAs is that they cannot model topic correlations, e.g. an *aviation* topic is likely to be strongly related to an *airports* topic, but not recognized as such. STM, on the other hand, does allow for topic correlation, leading to higher accuracies. STM has recently gained popularity in transport research. Like in this review, it has been successfully used to discover latent topics in the academic literature, e.g. for transport in general (Das et al., 2020). Otherwise, it has also been used extensively in opinion mining, e.g. to scope attitudes of the blind towards autonomous vehicles (Bennett et al., 2020).

Practically, the corpus of 73 articles was first prepared (removing capitalisation, numbers and symbols, stemming, etc.) using the *quanteda* package (Benoit et al., 2018). For the actual topic modelling implementation we used the *stm* package (Roberts et al., 2019) on the prepared corpus. To determine the optimal number of topics we used *semantic coherence* (how often words co-occur within a topic) and *exclusivity* (uniqueness of words to a certain topic), as suggested by Roberts et al. (2014).

The topic analysis revealed four main research strands (RS) on COVID-19 household freight impacts: (RS1) changing consumer behaviour, (RS2) retail adaptation strategies, (RS3) SCM evolutions, and (RS4) technological innovations. Table 1 shows the distribution of articles over research strands stratified across the three household freight axes defined in the framework of Beckers et al. (2022). It should be noted that papers do not necessarily fall within just one of the research strands (the sum of the row totals in **Table 1** is more than 73). There is a fairly equal distribution over the first three RS. RS4 is, however, highly specialised and therefore barely integrated in the other RS -only 1 in 10 papers in RS4 tackles another RS leading to lower coverage in the corpus. The sum of the column totals in **Table 1** similarly shows that some papers describe impacts on different household freight axes. Most papers have a European (24) or Asian (23) country as study area (see Appendix A). Fewer studies work with data from North (6) or Latin (3) America, while no African studies were found through the query.

We use the four observed RS to structure the remainder of this review. For each strand we will discuss the major findings and their impacts on household freight.

**Table 1: Overview of corpus**

|                  |                                    | Household freight axes     |   |                 | Total |
|------------------|------------------------------------|----------------------------|---|-----------------|-------|
|                  |                                    | Household as freight actor | Shifting logistics responsibilities from shipper to LSP | Lack of density |       |
| Research strands | RS1: Changes in consumer behaviour | 18                         | 9   | 6               | 33    |
|                  | RS2: Retail strategies             | 9                          | 12  | 5               | 26    |
|                  | RS3: SCM evolutions                | 10                         | 7   | 5               | 23    |
|                  | RS4: Technological innovations     | 4                          | 3   | 3               | 10    |
|                  | Total                              | 41                         | 31  | 20              |       |

Source: Own elaboration

### 3. Results: household freight during COVID-19

In the following four subsections we will discuss the evolution of the four household freight research strands identified through the clustering algorithm during the COVID-19 pandemic, using the conceptual framework of three household freight axes from Beckers et al. (2022). As such, this section

summarises COVID-19 household freight innovations and evolutions that (i) are the result of the more central role of the consumer, (ii) influence the relationships and distribution of tasks between retailers and LSPs, and (iii) impact the delivery density. Each subsection starts with a general overview of the literature in a research strand, followed by a table and discussion of the impacts on the three household freight axes.

### 3.1 RS1 Consumer behaviour

The rise in e-commerce activity during the pandemic was due to a larger share of the population shopping online and existing users shopping online more frequently for a wider variety of product categories. The tendency towards using e-commerce increased for all socio-demographics and this trend was confirmed worldwide (Cavallo et al., 2020; Figliozi & Unnikrishnan, 2021b; Guthrie et al., 2021; Nguyen et al., 2021b).

Pre-COVID-19 online shoppers tended to be overwhelmingly young, affluent and well-educated urbanites (Beckers et al., 2018; Kirby-Hawkins et al., 2019). Most studies found that experienced online shoppers showed the highest increases in e-commerce use during the pandemic (see Appendix B for a detailed overview). Indeed, previous e-commerce use was an important determinant of further use and growth (Chen et al., 2021; Guthrie et al., 2021). Yet, health and safety concerns also became an important reason to start shopping online, leading to increased usage by older age groups (Itani & Hollebeek, 2020; Nguyen et al., 2021b; Safara, 2022; Svatosova, 2022; Warganegara & Hendijani, 2022). This was observed in both developed and emerging economies. In addition to age, income (X. Wang et al., 2021; Zannat et al., 2021), household size/children (AbdulHussein et al., 2022) and education (Lo et al., 2021) were linked to more cautious behaviour and therefore to more online consumption. Gender, moreover, also had a significant effect, with men being less risk averse and thus showing less growth in e-commerce activity (Figliozi et al., 2021b). Safara (2022), furthermore, found that in the Middle East characteristics of health had a higher impact on online shopping frequency compared to job or gender. Figliozi & Unnikrishnan (2021b), similarly, found some evidence that households with disabilities had a higher increase in the use of e-commerce. Truong & Truong (2022) offer a dissenting voice, finding that prevention behaviour leads to decreased online spending. An important observation is that the socio-demographic profiles of online customers may be different between product categories. Figliozi & Unnikrishnan (2021b), for example, found that income and household size are important determinants for buying consumer goods online, while they are not for e-groceries.

Not only did online consumption rise during the pandemic, the nature of e-commerce demand also evolved. With travel bans in place – and after an initial hoarding phase - e-commerce became a leisure activity. Koch et al. (2020) and Nguyen et al. (2021a) found increases in *hedonic motivations* for online shopping among German and Vietnamese respondents respectively. Similarly, *enjoyment* was found to be a strongly significant determinant of the intention to use online food delivery services in the US (Jun et al., 2022). Also in Italy a transition from *prevention* to *hedonic* shopping motives for e-groceries was observed (Cavallo et al., 2020).

**Table 2: Impacts of changing consumer behaviour on household freight**

| Household freight axes     | Impacts of changing consumer behaviour   |
|----------------------------|--|
| Household as freight actor | <i>11.1: Demand diversity (products and consumers) leads to increased complexity</i> |

|   |  |
|---|--|
| Shifting logistics responsibilities from shipper to LSP | <i>11.2: Delivery characteristics influence the purchase probability of hedonic shoppers</i>   |
| Lack of density   | <i>11.3: Increase in online shopping use increases delivery density</i><br><i>11.4: Individual delivery preferences negatively impact consolidation opportunities</i><br><i>11.5: Understanding the consumer reduces failed deliveries</i> |

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Source: Own elaboration

The surge in e-commerce traffic during the COVID-19 pandemic was of course beneficial to LSPs. Not only did demand for their services grow substantially, but higher volumes also resulted in higher delivery densities, which improved operational efficiency (*11.3*). That is, less fragmentation means shorter distances between stops, resulting in lower delivery costs (Cárdenas et al., 2017). The relationship between delivery densities and costs is asymptotic though: the marginal gain is limited as already only limited time is spent driving from one stop to another. Moreover, last-mile logistics reached its carrying capacity limits during the first wave of the pandemic (Beckers, Weekx, et al., 2021; Rossolov et al., 2022). Companies did, however, immediately start investing in additional infrastructure (Milewska, 2022a).

On the other hand, the pandemic also introduced complications for LSPs. As Hood et al. (2020) already identified pre-COVID, sociodemographic characteristics influence delivery preferences. While customers' characteristics increasingly diversified, so did the demand for more varied tailored services (Gruntkowski & Martinez, 2022; Maltese et al., 2021). Similarly, product type, shopping experience, shopping incentive, and different attitudes such as risk perception now define the location (e.g. home or drop-off), the speed, and the moment of delivery (Cavallo et al., 2020; Dias et al., 2022; Inoue & Hashimoto, 2022; X. Wang et al., 2021). Figliozzi & Unnikrishnan (2021b), for example, found that home delivery preferences are highly dependent on income, and Inoue & Hashimoto (2022) found age and gender differences in the use of unattended deliveries. In addition, Wang et al. (2021) showed that more cautious shoppers prefer unmanned pick-up deliveries. Hence, growing consumer diversity significantly added to logistics' complexity (*11.1a*).

Customer diversity also led to the emergence of relatively new e-commerce niches, which introduced even more complications (*11.1b*). These new niches often require highly specialised logistics services, fast deliveries, and cold chains, e.g. to ensure safety or freshness. Moreover, consumers became much more hygiene conscious, demanding sanitary adjustments throughout the logistics chain (Guan et al., 2022; Movarrei et al., 2021). Good examples of such niches requiring special care and where hygiene is particularly important include health products, of which demand grew significantly due to the e-commerce participation of older age groups (Guthrie et al., 2021), and home grocery delivery services (Gomes & Lopes, 2022; Lo et al., 2021).

The transition from *prevention* to *hedonic* shopping further increased volumes. Delivery characteristics also influence the perception of online retail services and thus consumer enjoyment, and an *enjoyable* delivery service could increase the probability of online purchases (*11.2*). This requires conscious decision making by the retailer when selecting a logistics operator, and therefore also partly explains the rollout of in-house delivery services by major retailers.

Increased complexity due to personalisation and product diversity also decreases consolidation opportunities, thus undoing some of the delivery density benefits of increased demand (*11.4*). Manerba

et al. (2018), for example, showed an increased environmental impact of 400% when consumers can select a 2-hour time window for deliveries. Personalisation, however, also allows for a better understanding of consumer behaviour, which in turn enables a reduction in logistics costs. Combining delivery characteristics with available data (e.g. through census data or from retailers) can be a powerful tool in forecasting demand, allowing for leaner delivery personnel commitments and decreasing failed deliveries rates (11.5) (Boyer et al., 2009; Vakulenko et al., 2017).

### 3.2 RS2 Retail adaptation strategies

Historically brick-and-mortar retailers have struggled with incorporating online channels in their business activities and pre-COVID-19 the e-commerce sector was dominated by online-only companies. While e-commerce was often regarded as a threat to traditional retail formats, it did make brick-and-mortar retailers more resilient during the pandemic. COVID-19 therefore served as a catalyst for online retail strategies (Beckers, Weekx, et al., 2021; Hardaker et al., 2022). Unsurprisingly, the existing large online players reaped most of the pandemic benefits as they already had access to the necessary infrastructure (Milewska, 2022b). On the other hand, the corpus identifies various strategies among other retailers, with *offliners* using the internet as a temporary mitigation strategy but others also embracing the long-term opportunities that e-commerce brings (Hardaker et al., 2022). Against expectations, the pandemic initially provided business opportunities to small entrepreneurs due to a combination of flexibility and embeddedness (Little & Sylvester, 2022). Retailers with short supply chains suffered less from international supply issues, while embeddedness in the local community ensured support and trust from loyal customers. The opportunities for brick-and-mortar retailers were even larger in developing countries that lacked big online players, as consumers tended to prefer known retail brands (Bhatti et al., 2022).

Retailers moving online had to decide between building their own online channel or using an existing e-commerce platform. A quick solution for local entrepreneurs was to sell through social media platforms, but this seemed insufficient to reach a wider customer base (Cavallo et al., 2020). A growing body of econometric modelling literature is concerned with optimal online channel selection (e.g. Cao et al., 2022). A self-build model seems to yield a greater profit than a platform model for brick-and-mortar retailers when the delivery fee decreases, because the marginal profit of the online channel is less than that of the offline channel (He et al., 2021). Organising logistics oneself is also positive for brand awareness and quality control (Movarrei et al., 2021). Hence, the largest online retailers such as Amazon, Alibaba, and JD invest heavily in logistics (He et al., 2021). On the other hand, platforms were already accepted by consumers pre-COVID-19 and were easy to connect to for retailers (Beckers, Weekx, et al., 2021). Online delivery platforms such as Deliveroo or UberEats therefore provided a lifeline for restaurants during the pandemic (Elhan-Kayalar et al., 2022).

**Table 3: Logistics impacts of retail adaptation strategies on household freight**

| Household freight axes                                  | Impacts of new e-commerce entrants   |
|---|--|
| Household as freight actor                              | <i>12.1: Redesign of physical touchpoints in omnichannel experience store</i><br><i>12.2: Shorter communication line for consumers</i>                 |
| Shifting logistics responsibilities from shipper to LSP | <i>12.3: Outsourcing logistics activities for more efficient distribution</i><br><i>12.4: More online retailers and increased logistics complexity</i> |



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Source: Own elaboration

Concerning retailer logistics impacts, an important issue is the redesign of shops into physical omnichannel touchpoints (12.1). Besides facilitating delivery fleet access, the growing demand for curbside pickup should be accommodated (Figliozzi et al., 2021b; X. Wang et al., 2021). The often central location of shops makes them very attractive for these activities. Another practical way to achieve better service levels is through shortening the communication lines to consumers (12.2). Direct communication was a reason why shopping locally initially grew during the pandemic (Pollák et al., 2022). Logistics companies too should take this in stride, by providing accurate and reliable information, such as delivery areas and time windows (Jun et al., 2022). At the moment many online stores still lack professionalism though (Beckers, Weekx, et al., 2021), which is alarming when customers increasingly demand an enjoyable online shopping experience (Koch et al., 2020; Warganegara et al., 2022). In the same vein, overall communication between retailers and LSPs on the one hand, and consumers on the other remains underdeveloped (Pollák et al., 2021).

For retailers, however, the pandemic was not only about reorganising retail operations, but also their logistics services. There was a significant decline in consumer satisfaction after the initial COVID-19 outbreak as a diverse clientele migrated online (Yang et al., 2022). Part of this could be attributed to logistics issues during the initial surge in online orders (Milewska, 2022b). In this regard, retailers could improve the perceived usefulness to consumers by increasing service levels, for example, with convenient delivery options or after-sales service (Bhatti et al., 2022; Guan et al., 2022; C. N. Wang, et al, 2021a; Yang et al., 2022). Logistics was therefore heavily externalised in order to respond quickly to rapidly changing consumer requirements (12.3). Third-party logistics (3PL) providers, i.e. LSPs that offer outsourced logistics services going beyond mere distribution, can help unblock the last mile by faster, multimodal, and more sustainable deliveries through inventory staged in an urban layer of e-commerce facilities (Beckers & Verhetsel, 2021; Purcărea et al., 2022; Yang et al., 2022). As a result, the 3PL market has seen an enormous growth since the pandemic (C. N. Wang et al., 2021b). While increased volumes are generally positive for the last mile efficiency of these companies, the growth in the number and diversity of retailers with an online presence somewhat reduced efficiency because of retailer fragmentation (12.4). Hence, not only the number of destinations increased, so did the number of origins, adding to logistics complexity.

E-commerce platforms are similarly a more efficient option for the retailer, e.g. allowing them to minimise their carbon footprint through the bundling of flows (Cao et al., 2022). Moreover, given their broad assortments, e-commerce platforms allow for setting up delivery subscription plans, a valid strategy for attracting and retaining customers, but also one that leads to increased deliveries (Figliozzi & Unnikrishnan, 2021a). As a result, e-commerce platforms also grew significantly during the pandemic (12.5). The market power of platforms reduces competition though, leading to dependency. In Indonesia, for example, the platform GoJek reduced service areas. While this shortened trips, it also lowered the potential income for businesses (Elhan-Kayalar et al., 2022).

### 3.3 RS3 Supply chain management evolutions

Changing demand, lockdowns, and transport bottlenecks challenged supply chain managers during the pandemic. Large inventories began to build up in distribution centres and retailers such as JD.com organised specific promotions for this idle stock (Milewska, 2022a; Shen & Sun, 2021). Although some cross-border e-commerce businesses might have been incentivised to explore shorter supply chains through local producers, the impacts of COVID-19 on the effectiveness of e-commerce distribution networks were mostly limited to some delays of hoarded products at the start of the first lockdown,

and initial capacity constraints were quickly turned into economies of scale (Burgos & Ivanov, 2021; Din et al., 2022; Rossolov et al., 2022).

**Table 4: Impacts of SCM evolutions on household freight**

| Household freight axes                                  | Impacts of SCM evolutions                 |
|---|---|
| Household as freight actor                              | <i>I3.1: The consumer as KPI</i>          |
| Shifting logistics responsibilities from shipper to LSP | <i>I3.2: Branding and trustworthiness</i> |
| Lack of density   | <i>I3.3: Dynamic pricing</i>              |

Source: Own elaboration

Hence, last mile strategists could concentrate on smoothing the delivery process, which during the COVID-19 pandemic increasingly influenced the online shopping experience and behaviour (Dias et al., 2022; Guan et al., 2022; Movarrei et al., 2021). As such, customer experience became one of the most important variables in last mile service provisions (C. N. Wang et al., 2021a), and consumer-centric key performance indicators (KPIs) became crucial when designing logistics services on the strategic, tactical, or operational level (*I3.1*) (Sandoval et al., 2022).

As the delivery experience became more important, so did LSP branding. LSP branding encourages trust, a factor that gained in significance during the pandemic (Sakas et al., 2022). While LSP choice previously tended to be a cost minimising exercise, retailers and consumers started to increasingly opt for established brands. These were perceived to be safer, and to offer greater flexibility and personalisation (Figliozzi et al., 2021a; Gomes et al., 2022; Movarrei et al., 2021). LSPs should thus cherish this new responsibility, and work on their branding and trustworthiness (*I3.2*). As such, JD.com invested over 1.2 billion yuan in financial and logistics support to retailers during COVID-19 (Shen et al., 2021).

According to the literature, *timing* and *hygiene* were the two most urgent service level parameters LSPs should improve upon. Consumers are still price sensitive yet seem willing to pay for additional delivery services (Gomes et al., 2022). As a result, however, negative delivery experiences also adversely impact future shopping decisions (Grunkowski et al., 2022; Mehlawat et al., 2021). Regarding timing, the *on-demand* mentality and renewed competition from (local) stores after lockdowns stresses the importance of meeting timelines (Suguna et al., 2022; C. N. Wang et al., 2021a). However, LSPs can also use consumers' willingness to pay to manage delivery densities. As is already customary in online grocery retailing (e.g. Sainsbury's' "green delivery slot"), delivery demand can be steered through dynamic pricing (*I3.3*). This does require an information exchange between receivers and LSPs, or integrated data systems between shippers and LSPs. Regarding hygiene, companies had to set up contactless deliveries through parcel lockers and other technological innovations (see section 3.4).

### 3.4 RS4 Technological innovations

This topic already garnered substantial academic interest pre-COVID-19. Since last mile deliveries are financially and environmentally costly due to fragmentation and failed deliveries, research emphasised consolidation (e.g. delivery hubs) and efficiency (e.g. parcel lockers). Mangiaracina et al. (2019) provide an excellent overview of these evolutions within a last mile costs framework. During the COVID-19 pandemic the demand for contactless delivery systems rose (X. Wang et al., 2021; Yang et al., 2022), likely due to hygiene concerns.

**Table 5: Impacts of technological innovations on household freight**

| Household freight axes                                  | Impact of technological evolutions  |
|---|---|
| Household as freight actor                              | <i>14.1: Tailored automated services</i>  |
| Shifting logistics responsibilities from shipper to LSP | <i>14.2: Logistics automation to increase resilience along the supply chain</i> |
| Lack of density   | <i>14.3: New delivery infrastructure</i>  |

Source: Own elaboration

Also for LSPs tailor-made automated services are of great interest, as they allow for more personalised (Sułkowski et al., 2022) and efficient (Torres et al., 2022) last miles (*14.1*). LSPs could, for example, exploit consumer data to accurately predict delivery success, match an autonomous vehicle with a receiver, or optimise parcel locker capacity. Consumers indicated they were even willing to give up privacy for such tailored and efficient services (Gong et al., 2022). In addition to automation in the planning process, the experimental deployment of autonomous vehicles in the last mile accelerated during COVID-19. In New York, Unilever used autonomous vehicles in ice cream last mile delivery, while JD.com used them to deliver food and medical supplies in restricted areas (Shen et al., 2021). However, because of issues regarding capacity constraints, delivery ranges, speed, and other factors, no single automated delivery system is well suited for all delivery scenarios (Li et al., 2021). Household freight will therefore become much more specialised. For now, however, the adoption of these innovations by LSPs is still low due to some remaining technological issues and a lagging regulatory framework.

In addition to automation, different types of distribution terminals were used during the pandemic. Already before the pandemic, parcel lockers were identified as a more cost-efficient delivery alternative, but its uptake showed high regional variations (Cárdenas et al., 2017). The pandemic further strengthened the business case for lockers, as self-collection offers benefits in terms of flexibility and health risk mitigation (Shen et al., 2021; X. Wang et al., 2021). Moreover, with consumers showing increased awareness of LSPs, package drops prevent possible bad impressions resulting from face-to-face contact between LSPs and consumers (Inoue et al., 2022). On the other hand, the delivery terminal infrastructure would need to be updated significantly to deal with added demand-side complexity and customer *on-demand* expectations, which requires a strategic view on urban logistics (*14.3*) (Suguna et al., 2022). The current company-driven expansions, however, threaten the potential collective benefits of these infrastructures (Beckers & Verhetsel, 2021). As a consequence, the inequality in terms of access to logistics services between well served areas, and areas with less demand and traditionally underserved populations (e.g. more rural areas) further grew during the pandemic (Figliozi et al., 2021a; Sanchez-Diaz et al., 2021; Schaefer & Figliozi, 2021). Figliozi et al. (2021a) than suggest public authorities should encourage LSPs to improve accessibility to deliveries in general, or to leverage the existing delivery networks of national post operators.

Automation in the last mile goes beyond using driverless vehicles or rolling out distribution terminals though. Intelligent warehouses, for example, provide higher agility and helped companies respond quickly to early pandemic disruptions (Qin et al., 2022). The logistics sector is in effect expanding its services, becoming retail infrastructure service providers, and providing software and automation solutions to the wider e-commerce industry (Qin et al., 2022). Different modelling exercises furthermore demonstrated GHG emissions and costs savings, and improved resilience due to automation in different parts of the e-commerce supply chain (*14.2*) (Figliozi et al., 2021b; Kemp et

al., 2022; Wu et al., 2021). These logistics optimisations are set to further widen the efficiency gap between LSPs and major online players on the one hand, and smaller online retailers on the other.

#### 4. Discussion: post-COVID-19 evolutions

Online shopping increased significantly during the COVID-19 pandemic, not only in intensity but also in terms of socio-demographic profiles using e-commerce. Profiles that did not shop online pre-COVID-19 were increasingly forced to move online, though most growth was still due to *traditional* e-commerce clients. At the same time, retailers and producers reformed their operations and opened online channels, also in sectors that previously were reluctant to make the shift. The increases in demand and supply, and thus origins and destinations, resulted in an expansion of household freight flows in terms of volumes, geography, and organisation that was only expected to occur by 2025-2030 (McKinsey & Company, 2020; Szasz et al., 2022). Hence, half a decade of growth and innovation in the e-commerce sector occurred in the span of two COVID-19 years.

Now that more retailers are online and consumers gained online shopping experience, short term expectations are that e-commerce and its induced last-mile effects will continue at a significantly elevated level (Itani et al., 2020; Lo et al., 2021). Rossolov et al. (2022), for example, found that 35% of young adults in developing and a quarter in developed countries wanted to continue their new purchasing patterns with increased e-commerce use post-COVID-19. There are important sociodemographic differences though. The probability of returning to physical shopping is, for example, higher for those that went online mostly for health-related reasons (Leone et al., 2020; X. Wang et al., 2022b). Physical shopping is also a social event, which e-commerce might never be able to fully replace. This might be particularly important for older age groups. On the other hand, learned habits combined with a loss of mobility could also entice the elderly to stay online (Bezirgani & Lachapelle, 2021).

Parcel volumes, even after a small decline following the 2020-2022 period, are expected to continue to grow steadily as (i) new generations will be more accustomed with online shopping, (ii) increasing numbers of retailers will be online, and (iii) LSPs invested heavily in warehouse capacity and operations. As a result, household freight volumes will only increase. The question is if and how LSPs, retailers, policymakers, and other stakeholders should evolve to cope with the potential economic, environmental and social impacts of this future growth. Although the Results section discusses some important takeaways from the literature, some key issues need more research. Hence, to help the various stakeholders face future challenges related to household freight, we present a set of unanswered research questions (Table 6).

**Table 6: Open research questions on household freight post-COVID-19**

|                 |                               | Household freight axes   |  |   |
|-----------------|-------------------------------|--|--|---|
|                 |                               | Household as freight actor   | Shifting logistics responsibilities from shipper to LSP        | Lack of density   |
| Research strand | Changes in consumer behaviour | <i>RQ1.1: How will e-commerce volumes and destinations evolve?</i> | <i>RQ2.1: How does logistics affect consumer satisfaction?</i> | <i>RQ3.1: Are there still geographical differences in household freight demand?</i> |

|                           |  |   |   |
|---------------------------|--|---|---|
|                           | <p><i>RQ1.2: What is hedonic and utilitarian shopping in an online context?</i></p> <p><i>RQ1.3: How do household orders result in household freight?</i></p> <p><i>RQ1.4: Is there a willingness to continue to pay for tailored delivery services?</i></p> |   | <p><i>RQ3.2: How does the emancipation of the consumer impact fragmentation?</i></p>  |
| Retail strategies         | <p><i>RQ1.5: How did/will online retailing evolve?</i></p> <p><i>RQ1.6: What role for short chains in online retail of the future?</i></p>   | <p><i>RQ2.2: What is the future role of physical touchpoints?</i></p> <p><i>RQ2.3: How to provide space for e-commerce in the urban fabric?</i></p>   | <p><i>RQ3.3: How to link local supply with efficient delivery?</i></p> <p><i>RQ3.4: Are retail platforms an opportunity or threat to small retailers?</i></p> |
| SCM evolutions            | <p><i>RQ1.7: What consumer-related KPIs should LSPs consider?</i></p> <p><i>RQ1.8: How can consumers and LSPs connect?</i></p>   | <p><i>RQ2.4: Will LSPs become brands in household freight?</i></p> <p><i>RQ2.5: How will roles and responsibilities change within the last mile supply chain?</i></p> <p><i>RQ2.6: What is the impact of household freight demand on logistics workers' conditions?</i></p> | <p><i>RQ3.5: How to cope with inequalities in last mile delivery services?</i></p>  |
| Technological innovations | <p><i>RQ1.9: How can last-mile innovations that improve service levels be implemented?</i></p>   | <p><i>RQ2.7: How to use e-commerce data for a more enjoyable and sustainable last mile?</i></p>   | <p><i>RQ3.6: How to use technology to cope with density deficiencies?</i></p>   |

Source: Own elaboration

#### 4.1 Household as freight actor

Accurate demand estimations are key. All other household freight logistics factors, e.g. distribution system optimisations and last mile innovations, are ultimately dependent on freight demand. We now

require studies that show how volumes and destinations evolved post-pandemic, and not just rough predictions (*RQ1.1*). That means surveying long-lasting gross shifts towards e-commerce usage, but also estimates per socio-demographic profile that allow to accurately model spatial demand variations. Such surveys should consider all relevant parameters (age, income, education, children, morphology, etc.), something that many studies lacked during the pandemic. Demand modelling should also take into account the possible long-term COVID-19 impact on housing patterns as increased remote work, a possible loss of urban amenities, cheaper real estate, and green and *safe* environments recently led to suburban growth (Liu & Su, 2021). Subsequently, more information is needed on the motivations of different types of consumers shopping online (*RQ1.2*). If consumers actually continue using e-commerce for hedonic reasons, this increases the obduracy of online shopping post-COVID.

Another remaining open question related to online demand is the conversion of online orders into parcels (*RQ1.3*). This factor is dependent on the chosen retailer (e.g. platform or online retailer), the division of responsibilities within the supply chain, and the internal organisation of the LSP. Answering this question is also a prerequisite for any exercise comparing the supply chains of different retail channels, for example in a sustainability context.

Similar to demand, supply is key in modelling logistics flows. We mentioned that the retail literature on e-commerce adoption is remarkably small. Also in our corpus, the share of studies on retail strategies catering to new online consumers was limited. Many retailers were confronted with huge drops in physical shopping, but very little is known on which retailers moved online, how they approached online migration, and whether they were successful. Even less is known about their future (distribution) strategies: will they reprioritise physical shopping, or will they keep or even expand their online presence (*RQ1.5*)? These topics deserve more attention, also in the context of household freight, as it could help explain parameters of online attractiveness. An interesting associated question is about the relevance of short chains (*RQ1.6*). Small and familiar, i.e. trusted, were key selling points during the pandemic, but are they enough to withstand competition in the post-COVID-19 era?

The literature also revealed new and diversified customer expectations. Technological innovations hold huge potential in this regard, but were still rarely applied by LSPs, despite important incentives during the pandemic (*RQ1.9*). It was shown that consumers were willing to pay for a more personalised service, but the question remains whether they will be willing to do so post-pandemic, when the health incentive sinks (*RQ1.4*). If the answer to the latter question is positive and such markets exist, LSPs need to find a way to measure their performance in this new market (*RQ1.7*) and to connect to the receivers (*RQ1.8*) in order to further develop personalised services.

## **4.2 Shifting responsibilities**

The results show that delivery preferences are highly variable and that online consumers increasingly want a personalised service. Another calamity might result in completely new demands for last mile delivery services. For example, should environmental concerns surge, customers might develop strong preferences for deliveries by green vehicles. Regardless of any shocks, additional delivery services could also convince consumers to shop online more frequently.

It is therefore crucial for LSPs to fulfil their commitments towards consumers since negative delivery experiences such as missed time windows or delays reflect poorly on retailers. Conversely, excellent logistics services might provide a competitive edge for retailers, though consumer logistics requires a great deal of flexibility, which comes with a cost itself. Understanding the impact of logistics on the consumer (*RQ2.1*), and whether said flexibility requires more logistics outsourcing (*RQ2.5*) are two topics that deserve further attention.

Trust was obviously important during the pandemic. It allowed LSPs to differentiate themselves. Can LSPs, however, continue to develop themselves as brands towards consumers when that factor disappears, or would the customer return to a cost-minimising strategy (RQ2.4)? If there are obvious competitive advantages to personalised delivery services, and if LSPs can become household names, logistics has come to the forefront and the existing relationships between consumers, shippers, and LSPs need to be re-examined (RQ2.5). For example, it could be that fifth-party logistics will dominate future retailing, although that would imply retailers relinquishing control over service levels. Nonetheless, both in cases where LSPs, respectively online retailers serve as prime communication channels, more and better data exchanges are fundamental to customise service levels (RQ2.7).

As retail progressively influences logistics operations, its impact on the public domain now reaches beyond the storefront. To cope with the increasing pressure of logistics on the urban fabric, cities need to find a way to safeguard space for logistics (RQ2.3). Part of the solution for this issue could be found in upgrading the role of physical stores (RQ2.2). In addition to these recognized issues, the lack of labour or political-economy consideration in the corpus was striking. Despite an increase in critical voices (Fried et al., 2023), we do not know how the pandemic affected e-commerce's delivery apps and how the emergent gig economy is transforming in terms of quality and stability of work in both the van and warehouse (RQ2.6).

### **4.3 Lack of density**

Geographical perspectives were largely absent in the consumer behaviour studies in our corpus, despite a growing interest pre-COVID-19 (e.g. Hood et al. (2020)). Are suburban and rural delivery densities on the rise or does the discrepancy (and thus the cost difference) with urban areas remain unchanged (RQ3.1)? While the corpus pointed to national post operators or local authorities to alleviate inequalities in last mile services, the economic and societal effects of such initiatives deserve further research (RQ3.5). There are technological solutions to low densities issues, such as parcel lockers, that can be applied by LSPs. These became more popular during the pandemic as they permitted contactless delivery. Will they, however, remain acceptable for consumers as alternatives to home deliveries post-pandemic and is there a business case for their further rollout (RQ3.6)?

Quite fundamental in the rise of consumer logistics is understanding whether more demanding consumers benefit the overall system (RQ3.2). It is not unthinkable that conflicting desires and increasing personalisation increase the kilometres driven. Potentially, autonomous vehicles could conduct singular deliveries more efficiently (RQ3.6). However, even during COVID-19, when demand for such services was high, autonomous vehicles remained a very rare sight (European Commission, 2022). This implies they will not be implemented in the near future. Research is required in how to accommodate their use, both technically and legally.

Finally, 'buy local' behaviour also raises logistics questions (RQ3.3). Short chain trips reduce physical distances, but volumes are expected to be lower. E-commerce platforms might provide economies of scale in this case but the retailer would need to relinquish some of their organisational control to the platform owner. The repercussions of such platforms, which already dominate the e-commerce system, for small retailers require far more attention than currently given (RQ3.4).

## **5 Conclusions**

The economic and societal impacts of last mile logistics deserve academic and political attention. However, most research has focused on the optimisation of distribution operations. Insights in the volumes and geographies of the origins and destinations of flows are crucial for such research, yet remain limited. Given that the COVID-19 pandemic boosted and diversified e-commerce on both the

demand and the supply side, these insights became only more essential to support policymaking, strategic decision making, and last mile models. How origins and destinations will evolve in the post-pandemic era, moreover, remains unknown.

We found that the increased demand for the delivery of online ordered goods provides additional consolidation opportunities and should hence lead to more efficient logistics. However, last mile logistics also became substantially more complex. E-commerce demand diversified, i.e. was no longer limited to young, educated, urban households. As consumers diversified, so did preferences, which resulted in fragmentation at the most detailed level. In addition, product categories bought online diversified. A large variety of products are now bought online, including perishable and non-conveyable items that require specialised logistics. Moreover, due to changing consumer behaviour and lockdowns, offline retailers had to move online. These new market entrants increase the number of origins and potential services to be provided by the LSPs.

Hence, household freight growth came with significant challenges. Last mile operators need to provide tailored delivery services. Moreover, they have increasingly come in direct contact with consumers and mistakes reflect badly on suppliers. This evolution also holds benefits, however. Logistics has come to the forefront. While it's still derived demand, logistics providers can distinguish themselves towards the end consumer by offering delivery alternatives and personalised services. However, this requires a more dynamic, data driven connection between consumers and logistics, which in turn requires a revision of the existing relationships within the e-commerce system and a potential future for a last mile marketplace where stakeholders meet.

Through our structured literature review we identified a set of research questions that need to be answered in order to help the different stakeholders involved to cope with these exciting challenges. In summary, to better inform policymaking on sustainable logistics strategies, future research endeavours should consider:

- The increasing diversity of the demand for logistics services, dependent on supplier, consumer and product characteristics. This requires detailed behavioural models.
- Ways to connect LSPs and consumers, leveraging the enormous amounts of data that are being gathered.
- The many parameters defining the conversion of orders into parcels, which depend on varying retail strategies such as platforms, short chains and casual online vendors.
- Inequalities arising from retail and logistics strategies that go beyond emissions, including topics like accessibility, labour issues and land use.

In addition to the topical discussion, we encourage African and American studies, as a Eurasian bias exists in the literature. With the multidisciplinary lens applied in this paper, we hope to encourage similar research in the future.

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