This is a post-peer-review, pre-copyedit version of an article published in The International Journal of Logistics Management. The final authenticated version is available online at: https://doi.org/10.1108/IJLM-02-2021-0096

To cite this article: Seghezzi, A., Mangiaracina, R. and Tumino, A. (2022), "E-grocery logistics: exploring the gap between research and practice", The International Journal of Logistics Management, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/IJLM-02-2021-0096

E-grocery logistics: exploring the gap between research and practice

Purpose – This paper investigates the logistics management in the e-grocery sector. It contrasts the key issues faced by practitioners and the topics addressed in the academic literature, to identify potential misalignments between research and practice, and propose avenues for future efforts.

Design/methodology/approach – This work adopts a twofold methodological approach. From an academic perspective, a systematic literature review is performed to define the topics addressed so far by scholars when analysing e-grocery logistics. From a managerial perspective, a Delphi study is accomplished to identify the most significant issues faced by logistics practitioners in the e-grocery context, and the associated significance.

Findings – The study develops a conceptual framework, identifying and mapping the 9 main logistics challenges for e-grocery along 4 clusters, in the light of a logistics-related revision of the SCOR model: distribution network design (area to be served, infrastructures), order fulfilment process (picking, order storage, consolidation, delivery), logistics-related choices from other domains (product range, stock-out management) and automation. These elements are discussed along three dimensions: criticalities, basic and advanced/automation-based solutions. Finally, the main gaps are identified – in terms of both under-investigated topics (order storage and stock-out management) and investigated topics needing further research (picking and automation) – and research questions and hypotheses are outlined.

Originality/value – This paper provides a threefold contribution, revolving around the developed framework. First, it investigates the state of the art about e-grocery logistics, classifying the addressed themes. Second, it explores the main issues e-grocery introduces for logistics practitioners. Third, it contrasts the two outcomes, identifying the misalignment between research and practice, and accordingly proposing research directions.

Introduction

In recent years, online purchases have been steadily increasing in many industries. Among the sectors experiencing the disruptive transformation posed by e-commerce, one of the major players is the food-and-grocery.

Food and grocery e-commerce may have a threefold configuration. First, the enogastronomic e-commerce, i.e., the non-fast delivery of non-fresh products such as wine, coffee, or typical local canned food (e.g., *Nespresso*). The associated distribution problem is comparable to that of "generic" parcels: the dimension of the order is low and items are not characterised by high perishability or fragility (Fernie et al., 2010). Second, the so-called On-Demand Food Delivery, i.e., the delivery of freshly prepared meals enabled by online platforms (e.g., *Deliveroo*). This is a new and disruptive business, with the first players born between 2013 and 2015. As a result, both the managerial and the academic knowledge about the topic is still at early stages. Third, the e-grocery, i.e., the online sale of grocery products, intended as an alternative to shopping in supermarkets (e.g., *Walmart*). E-grocery has very peculiar characteristics. Some products (e.g. cheese) are fresh or frozen, and their shelf-life may be very low; accordingly, they require specific storage and transport conditions (Boyer et al., 2003). In addition, differently from online sales in the two other models, e-grocery orders are composed by a significant number of order lines (Fernie et al., 2010). As a result, e-grocery is the configuration that has gained the most the interest of academics, investigating both transport (e.g., Hübner et al., 2016) and warehouse operations (e.g., Fernie et al., 2010).

Scholars have been recently showing attempts to review literature addressing food e-commerce, despite disclosing some shortcomings concerning e-grocery.

Hübner et al. (2016) develop a framework for last-mile order fulfilment in omni-channel grocery retailing, discussing the advantages and disadvantages of different design concepts. Yet, the analysed literature, is not specifically focused on food and grocery, but on "generic" online retailing. Lagorio and Pinto (2020) perform a systematic literature review on food and grocery, illustrating the main trends and shortcomings. The major challenges opened by e-commerce are acknowledged, but the scope of the work is broad (food and grocery in general). Finally, Martin et al. (2019) examine the academic literature investigating e-grocery by means of a bibliometric analysis; the proposed "content analysis" is a search made by an unsupervised learning algorithm, automatically extracting the topics based on the abstracts. Hence, a deep analysis and elaboration of the content of the works is missing. Based on the above, the path towards a deep and structured understanding of e-grocery logistics is still at low maturity stages, and a clear overview of the main challenges and solutions in the field has not been reached yet.

In addition to this content-based gap, a methodological one may be identified. Literature reviews, especially if focussing on emerging logistics-related fields (e.g., logistics for B2C e-commerce), are showing a methodological shift towards a twofold direction. On the one hand, the search for more theory-oriented approaches, which is endorsed by both recent papers (Durach et al., 2021) and editorials

(Wong, 2021). Literature reviews should not simply summarize extant works, but rather “advance knowledge” and provide theoretical contribution (Swanson et al., 2020), often delivered by means of the development of a conceptual framework (e.g, Seuring and Müller (2008); Pfoser et al. (2021)). On the other hand, there is a methodological trend in literature reviews urging for an increasing involvement of the managerial community. As a matter of fact, sometimes there is a potential different perception between practitioners and academics, and introducing “interactive research” may be beneficial in analysing the logistics challenges opened by new phenomena (Sandberg et al., 2022). The majority of e-grocery studies do not meet these two trends: they neither develop theoretical frameworks, nor present great contribution from practitioners (Lagorio and Pinto, 2020).

These being the premises, e-grocery is gaining momentum, opening new and significant logistics challenges for grocery retailers. Literature in this direction has been flourishing, but there is no clarity about the alignment of academic research with the actual issues currently faced by logistics practitioners. Addressing this (mis?)alignment is the scope of the present work, which aims to investigate whether and to what extent academic literature about e-grocery may really support logistics managers in facing the challenges opened by this business. In other words, this work addresses the following questions:

RQ1: What are the most significant logistics challenges opened by e-grocery according to practitioners?

RQ2: What is the state of the art in academic literature about such challenges?

RQ3: What are the research directions towards which e-grocery logistics literature should move to meet managerial needs?

In answering these questions, the present work develops a framework with a threefold goal: (i) identifying and classifying the main e-grocery logistics challenges; (ii) providing a structured and comprehensive view of academic knowledge in the field concerning these challenges, in terms of choices, criticalities and solutions; (iii) guiding future research in the field, mapping the potential directions for forthcoming contributions defined in collaboration with practitioners. Hence, this work develops along three macro-steps.

First, it identifies, through a Delphi study, the main e-grocery logistics challenges, which are also assigned a score based on their significance for the managerial community. These challenges are then grouped into clusters, according to a classification scheme deductively derived from the revision of the SCOR (P*lan, Source, Make, Deliver, Return*) model proposed by Lim et al. (2018), specifically targeting e-commerce logistics. The identified challenges (presented according to the four clusters) are:

- Distribution Network Design (*Plan*): (1) Infrastructure and (2) Area to be Served
- Order Fulfillment: (3) Picking (*Source*), (4) Storage and Consolidation (*Make*), (5) Delivery (*Deliver*)
- Logistics-related choices from other domains: (6) Product range (*Plan*) and (7) Stock-out management (R*eturn*)

- Automation: (8) Automation, intended as a cross-theme class encompassing all the *Source*, *Make*, *Deliver* and *Return* phases.

A framework is developed according to the presented scheme.

Second, the framework is informed, thanks to a SLR (Systematic Literature Review), with literature-based knowledge for the identified challenges. Concerning the *Plan* phases, the major choices to be addressed by e-grocers are presented. Concerning the *Source*, *Make*, *Deliver* and *Return* phases, three main elements are discussed: the major criticalities of the considered e-grocery logistics process, and – where proposed – the potential solutions (from the more "basic" to the more "advanced" automation-based ones).

Third, gaps are identified in correspondence of the areas that are concurrently significant for managers and under-investigated by scholars (picking, storage and consolidation, and stock-out management, especially concerning the implementation of automation). Research opportunities and questions are accordingly identified, which are then translated into research hypotheses to be tested.

The remainder of this paper is organised as follows. The second section presents the methodology. The third and fourth sections exhibits the results of the Delphi study (answering RQ1) and the SLR (answering RQ2) respectively. The fifth section presents the framework (combining the answers to RQ1 and RQ2). The sixth section identifies the major pitfalls in the research, accordingly suggesting avenues for future efforts (RQ3). Finally, the seventh section discusses the main results, and the last one draws the final conclusions.

Methodology

The methodology adopted in this paper (summarised in Figure 1) combines a Delphi study, to gain the perspective of practitioners, and a Systematic Literature Review (SLR), to investigate the academic side (similarly to Huscroft et al. (2012)). The main outcome of the Delphi study is a list of the most significant logistics challenges for e-grocery practitioners, and their importance. Such challenges are then used as classification axes in the literature review, to classify the found papers and analyse whether, how, and to what extent they have been analysed by scholars so far. The comparison between the managerial significance of the challenges and their academic coverage allows to identify those towards which further research efforts should be directed.

Please take in Figure 1

Methodology – Delphi study

Delphi studies are recommended to address fields that are gaining increasing managerial relevance, and have been widely adopted in SCM literature to identify and classify challenges and issues related to specific topics (Kembro et al., 2017). After the panel definition, the study followed three rounds (please refer to Table 1).

Please take in Table 1

Phase 0 – Panel definition. Despite it is not possible to determine the optimal number of experts for Delphi studies (Giunipero et al., 2012), it should ideally range between 20 and 30 to grant a sufficient coverage (Kembro et al., 2017). In case subgroups exist within the panel, each of them should count between 10 and 18 individuals (Okoli and Pawlowski, 2004). Considering the composition of the panel, Kembro et al. (2017) recommend including three clusters: managers, consultants and academics. Since in this study the academic perspective is represented in the SLR, managers and consultants were involved in the Delphi study.

The response rate in Delphi studies is typically lower than 100%, and decreasing along the different phases (MacCarthy and Atthirawong, 2003). Accordingly, 35 experts (19 managers and 16 consultants) were initially invited to join the research, and a total of 13 managers and 10 consultants completed the study.

Phase 1 – Round 1, first comprehensive list. The candidates were sent an invitation via email, clearly illustrating the context and purpose of the research. The aim of this presentation was to allow individuals to self-evaluate their degree of expertise, and their consequent ability to contribute to the study (Kembro et al., 2017). Beside the explanation, the email embodied a link to the web questionnaire.

The purpose of the first round (which was open for 21 days) was to generate a comprehensive list of all the potential issues entailed by the management of logistics for e-grocery. Hence – aligned to round 1 of previous Delphi studies (e.g., Huscroft et al., 2012) – an open-ended question was asked all the experts: '*What are the most significant logistics challenges and issues that have to be addressed in the e-grocery?*'
In line with the purpose of the phase, the question was broad and general; this allowed not to influence the participants, who were then forced to identify the issues by themselves (Lummus et al., 2007). As a result, the collected answers (which were lists of challenges) were not perfectly overlapping. In line with Kembro et al. (2017), the different expressions referred to the same topic were identified and combined in one option, and the challenges were grouped in theme-related clusters.

Phase 2 – Round 2, revision of the list and first rating. The aim of the second round of the Delphi study (which was open for 21 days) was to gain a first understanding of the importance of the challenges for the different experts. They were asked "*How would you rate the importance of these challenges based on a seven-point Likert scale?"*. In line with other Delphi studies in SCM field (e.g., Kembro et al., 2017; MacCarthy and Atthirawong, 2003), the ratings were defined based on a seven-point Likert scale (1 not important at all, 4 neither important nor not important, 7 very important).

As recommended by different scholars (e.g., Huscroft et al., 2012), both the definition of the issues and the meaning of all the values of the scale were clearly stated at the beginning of the survey, to ensure alignment among the experts. The ratings provided by managers were collected and analysed.

Phase 3 – Round 3, final rating. In round 3 – similarly to Huscroft et al. (2012) – the practitioners were asked to repeat the rating process for the identified issues, showing them the outcome of round 2 (the overall results in terms of average and standard deviation). Also in this case, the questionnaire was open for 21 days, and repeated the same question posed in Round 2.

Before ending the Delphi study, the level of agreement among the different experts was evaluated. The homogeneity of the ratings was measured by means of Cronbach's alpha α (Mondal and Mondal, 2017), as both recommended by methodological papers (Tavakol and Dennick, 2011) and implemented in previous Delphi studies (e.g., Chamberlain, et al., 2020). The result was 0.868. This outcome proofs a great agreement within the panel, since values higher than 0.7 are associated with high consensus (O'Leary-Kelly and Vokurka, 1998).

Methodology – Systematic literature review

To gather the perspective of scholars, a systematic review of the literature (48 papers) about e-grocery logistics was performed. The review followed four steps, as suggested by Seuring and Müller (2008): material collection (papers retrieval and selection), descriptive analysis (analyse "formal" characteristics), category selection (define the analytic dimensions to be applied), and material evaluation (review and classify works based on the selected categories).

Phase 1 – Material collection. The first phase – i.e., collecting and selecting the papers – was composed of three sub-steps, aligned with steps 2 to 4 of those proposed by Durach et al. (2017).

(i) *Determine required characteristics of primary studies*. The requirements for the papers were defined, and expressed as inclusion and exclusion criteria. The focus of the study is the management of logistics for online sales of grocery products. As a result, criteria were defined along a twofold direction. On the one hand, the analysed processes have to fall within the logistics field; as a result, papers only addressing other issues (such as the demand forecasting or the marketing levers) were excluded. On the other hand, the reference industry is the grocery one. Accordingly, both papers addressing the online sales of non-food parcels, or the fulfilment of orders for enogastronomic e-commerce or On-Demand Food Delivery were discarded.

(ii) *Retrieve sample of potentially relevant literature*. A search was performed in library databases (i.e., Scopus and ISI), based on the combination of keywords related to the e-grocery sector (e.g., e-grocery, "e-commerce" AND "grocery") and keywords related to logistics (e.g., logistics, transport). As suggested by Durach et al., (2017), they were searched for in the title, abstract, and keywords of papers. In addition, in line with Nguyen et al. (2016), a further "snowballing" step was performed, to include in the search relevant articles listed in the references of the works initially retrieved.

(iii) *Select pertinent literature*. The outcome of phase (ii) was a set of 104 papers, which were then filtered. First, papers were selected based on the title (resulting in 90 contributions). Second, they were filtered based on the abstract (coming to a total of 63 contributions). Finally, the selection of those for which a decision still had to be made were entirely read. In the end, 48 journal articles were included.

Phase 2 – Descriptive analysis. While in papers only devoted to SLR the descriptive analysis is very detailed, aligned to the purpose of this work, the papers were classified based on the research method.

Phase 3 – Category selection. The categories used to classify the papers by theme are the challenges identified through the Delphi study. Hence, the category definition process followed a deductive approach, as recommended by different methodological papers about literature reviews for SCM (e.g., Tranfield, 2003).

Phase 4 – Content analysis. The by-topic analysis was performed according to the following process: first, 10 papers were jointly classified by all the three authors to get to an agreement about the classification. The remaining papers were subsequently independently analysed by the authors, whose percentage agreement was 0.94 (the value is good according to Wowak and Boone (2015)). Agreement was considered achieved in case all the authors had obtained the same result. Those papers for which there was not initial agreement were jointly discussed and classified again by the three authors together, until a consensus was reached.

(RQ1) The main logistics challenges (*Delphi study*)

The identified challenges, which represent the outcome of Round 1, are related to the following decisions (which – as anticipated – were clustered in 4 main groups by the research team).

Cluster 1 – Distribution network design:

- *Area to be served*: design of the distribution network, intended as the definition of the area to be served from the different infrastructure (i.e., allocation of the demand).
- *Infrastructure*: design of the infrastructures in which online orders are fulfilled (i.e., stores or warehouses), in terms of layout, allocation of the different areas to specific functions, equipment to be used.

Cluster 2 – Order fulfilment process:

- *Picking*: retrieval of online ordered items from the picking area (influenced by the definition of the different policies, e.g., batching/traversal).
- *Order storage*: storage of online orders that have already been picked (usually in a dedicated area).
- *Consolidation*: assembly of the different stored parts of the orders before delivering them to the customers (e.g., assembling room-temperature, fresh and frozen items of the same customer order).
- *Delivery*: delivery of online orders to customers.

Cluster 3 – Logistics-related choices from other domains:

- *Product range*: number and type of items to be sold online.
- *Stock-out management*: management of missing items among those ordered by customers (e.g., definition of substitute products).

Cluster 4 – Automation:

- *Automation*: implementation of automated solutions in the different phases of the order fulfilment.

Table 2 displays the importance assigned by managers to the different challenges in Round 2 and Round 3. It presents the average and standard deviation of the ratings, and the details for the single categories.

Please take in Table 2

The issues arising as the most important ones are delivery, picking and automation, followed by stock-out management, order storage and infrastructure. Lower importance was attributed to product range, consolidation and area to be served.

(RQ2) The state-of-the art (*SLR*)

Research method

The research method-related analysis of the papers is based on the classification proposed by Meixell and Norbis (2008), who identified three main clusters of methods: quantitative models (analytical models and simulations), empirical analyses (surveys, interviews, and case studies) and conceptual models or frameworks (which also include literature reviews). The classification of the found contributions based on these clusters is the following: 28 quantitative, 20 empirical, 17 conceptual. In case multiple methods were applied (17 papers), the work was accounted for in all the related categories.

The majority of contributions is quantitative, followed by empirical and conceptual ones. Nonetheless, there is not a clear predominance of a cluster over the other, and it is possible to state that scholars have been addressing e-grocery logistics by means of different methodologies.

Content-based analysis

Table 3 offers a view of the main results of the content-based analysis. The first two columns show the challenges and the percentage of papers (over the total corpus) addressing them; the challenges that have gained the most the interest of the academic community are (in descending order) delivery, infrastructures and area to be served, followed by picking and automation. Lower attention has been devoted to order storage, consolidation, stock-out management and product range. The "content" column reports the main topics addressed by scholars, clustered according to the provided codes; these codes were derived from the analysis of the literature itself applying an inductive approach, which is useful to analyse and read the characteristics of the topic allowing for literature-driven insights (Tranfield et al., 2003). The following columns present the associated percentage of papers, and the main references.

Please take in Table 3

(RQ1 + RQ2) The framework

The framework in Figure 2 combines and structures the results of the two previous phases, shaping the knowledge concerning e-grocery logistics according to a twofold direction.

Please take in Figure 2

At a first level, classifying it based on the revision of the SCOR model proposed by Lim et al. (2018), subsequently adjusted to fit the identified e-grocery steps. In their work, Lim et al. (2018) introduce a version of the SCOR model specifically targeting e-commerce logistics, which associates the traditional phases to the corresponding ones for the fulfilment of online orders. The research team adapted these phases to the specific e-grocery context, identifying:

- the more strategic *Plan* phase (Distribution Network Design and definition of the Product Range);
- the set of more operative phases corresponding to the Order Fulfillment – i.e., *Source* (Picking), *Make* (Storage and Consolidation), *Deliver* (Delivery), and the reverse *Return* phase (Stock-out management);
- and Automation, included as an additional cross-class theme as emerged by the Delphi method.

At a second level (please refer to the different grey horizontal bands), the main angles from which e-grocery logistics challenges may be discussed are defined.

The plan-related works (strategic level) are discussed along the major choices to be made. Conversely, the order fulfilment-related contributions (operative level) are further classified based on three clusters of addressed themes. From the lowest to the highest maturity stage, they are:

- description and analysis of the Characteristics/criticalities of the considered process
- proposal and investigation of "Basic" solutions
- proposal and investigation of more Advanced solutions. As displayed, the "Automation" category overlaps with the "Advanced solution" one, since the found advanced solutions all resort to the implementation of automation.

Both the classifications were inductively derived from the results of two analyses (the Delphi study for the former, the literature review for the latter).

Distribution network design

Infrastructure. The challenge referred to as infrastructure encompasses the design of the infrastructures in terms of layout and identification of different functional areas. When dealing with the design of infrastructures, two main clusters of works may be identified, based on the facility from which online orders are fulfilled: warehouses or stores (which are associated with different choices).

The design of dedicated facilities typically starts from a "green field": the definition and organisation of the layout is not strictly bound by constraints on existing buildings, and these facilities are typically placed in strategic but non-central areas (Agatz et al., 2008). In addition, warehouses represent the option in which automated solutions may be applied to a greater extent (Kämäräinen and Punakivi , 2002).

Conversely, if considering in-store fulfilment, points of sale are often characterised by design restrictions deriving from both their dimension and their location (Fikar, 2018; Vazquez-Noguerol et al., 2020). In this second case, the infrastructure-related decisions typically relate to a better organisation of the area traditionally dedicated to the reserve stock or, in the more "advanced" cases, to the creation of an ad-hoc area dedicated to the picking of the most required online items (Mangiaracina et al., 2018).

Area to be served. The area to be served is intended as that decision – belonging to the field of the distribution network design – defining the area to be served from the different infrastructures (i.e., the allocation of the demand). The literature highlights two main perspectives from which the topic is addressed referring to the major choices to be made.

According to the first one, the area to be served with e-commerce is the same already covered by offline shops (Mangiaracina et al., 2018). This is the typical choice when adopting the click-and-collect delivery mode; as a matter of fact, the served area is constrained by the maximum distance the customer is willing to travel to reach the point of collection (Pernot, 2020)

Based on the second perspective, the online service could be used to enter new zones, which are still not served by offline stores (Eriksson et al., 2019). This may be applied if the delivery is in charge of the e-grocer, even if starting from the stores themselves; the covered demand will be greater, as the operator will be able to perform delivery tours in zones that are farther from the facility (Agatz et al., 2008).

Product range. The product range designates all the choices related to the definition of the number and type of items to be sold online. These decisions impact different logistics issues, first and foremost the space to be allocated to the storage of the different products (Punakivi and Tanskanen, 2002). Despite there are very few academic contributions addressing this issue, it is possible to identify three main clusters of works, based on the definition of the product range to be offered online.

The majority of works proposes an online range of products that is the same as the offline one (Pan et al., 2017; Pernot, 2020). A slightly lower number of scholars suggest instead to offer a lower range online, corresponding to a selection of the overall assortment (Durand and Gonzalez-Feliu, 2017; Fikar, 2018). Only one work – which is not recent – was found analysing a case in which the online range is higher than the offline one (Tanskanen et al., 2002).

Order fulfillment

Picking. Picking, which refers to the selective retrieval of the ordered pieces, is addressed in literature from two main angles: the analysis of the criticalities and some policy-based (basic) solutions.

Characteristics/criticalities. E-grocery picking implies significant additional challenges if compared to offline shopping. In traditional commerce, picking is performed by customers: people move within the aisles retrieving the products they want. With the introduction of the online commerce, the picking process is instead transferred to the grocers (De Leeuw et al., 2019). Picking is recognised as very critical due to a twofold reason. On the one hand, it is very expensive (Kämäräinen et al., 2001). Grocery orders are typically much larger than traditional e-commerce ones, thus requiring a long time to retrieve all the different pieces (Mangiaracina et al., 2018). On the other hand, grocery products may be fresh, frozen or fragile (e.g., eggs), thus implying stringent storage and handling requirements (Kämäräinen and Punakivi, 2002). As a result, there are many and diverse picking-related decisions to be made, which may strongly impact the expected performances.

Basic solutions. The second cluster of works investigates whether – and to what extent – the management policies (i.e., (i) batching policy and (ii) routing policy) may improve picking performances. Considering the (i) batching policy, it consists in defining the number of different orders to be picked in the same tour (Petersen, 2002). Order picking – i.e., one order per tour – is typically discarded since it is very inefficient. As a result, grocers usually opt for batch picking or zone picking (Mangiatacina et al., 2018). The choice depends on different variables (e.g., managed demand, number of pickers, dimension of the infrastructure). Considering the (ii) routing policy (i.e., the way pickers move within the aisle), the two most common alternatives are: traversal policy – in which pickers travel all the aisle once entered (Petersen and Aese, 2004) – in the stores (Mangiaracina et al., 2018); return policy – in which the picker exits the aisle from the same side it has been accessed – in dedicated warehouses, as it allow a most efficient storage of items (Henn et al., 2012).

Advanced automated solutions for picking in e-grocery seem to be missing so far in the academic discourse.

Order storage and Consolidation. The order storage refers to the storage of online orders that have already being picked, while the consolidation is the assembly of the different parts of stored orders before delivering them to the customers (De Koster et al., 2007). Both the processes are mainly discussed with reference to their criticalities.

Characteristics/criticalities. Grocery baskets are typically composed by three categories of products, with different temperature requirements (Boyer et al., 2003): products to be stored at room temperature (encompassing both canned food and non-food items, e.g., pasta, snacks, home&healthcare products), fresh products to be stored at a temperature between 0°C and 10°C (including for instance milk, yogurt and cheese), and frozen products to be stored at a temperature lower than 0°C (e.g., ice-creams and frozen fish). Once e-grocery orders are picked, they have to be stored (usually in a dedicated area) and the three classes of products need to be placed in different locations, namely shelves, fridges and freezers respectively (Fernie et al., 2010). Before being delivered to the customers, the different parts belonging to the same order have to be consolidated, and the three parts need to be assembled (De Koster et al., 2007). The major issue concerning the storage of orders is the occupation of space, which is often a scarce resource. This is especially true if considering existing physical stores, which were not designed to fit also the space to store (and perform consolidation activities of) online orders (Mangiaracina et al., 2018). On the one hand, the efficiency of the consolidation process strictly depends on the organisation of the storage areas in terms of layout, and their performances are often in a trade-off between each other. For instance, the smaller the different storage areas (dedicated to the different categories of products), the lower the distance among them, the faster the consolidation process (Eriksson et al., 2019). Nonetheless, small storage areas decrease the number of orders that can be concurrently stored (and managed). On the other hand, the equipment used to store products impacts the consolidation process. Some players – usually in case of click-and-collect (Milioti et al., 2020) – rely on the shopping cart (which are also used by customers) to store the room temperature-items: when the customer arrives, the picker takes the cart, reaches the fridges and the freezers, and collect the remaining part of the basket. Finally, he/she brings the cart to the customer (Vazquez-Noguerol et al., 2021). Other e-grocers opt instead for more efficient storing options, based on boxes stored on multi-layer shelves. This drastically increases the utilisation rate of the storage space, but requires a higher number of travels for the picker to move all the boxes, and thus a higher consolidation time (Mangiaracina et al., 2018).

No solutions (neither basic nor automated) for these phases have been proposed so far.

Delivery. The delivery is the process through which customers receive their grocery basket (Herrel, 2014). Considering academic works, it is possible to identify six main clusters, one concerning the criticalities, two proposing basic solutions, and three proposing advanced automated solutions.

Characteristics/criticalities. The first cluster focusses on the criticalities of the traditional Home Delivery (HD). In this delivery option, the transport is in charge of the grocer: an operator driving a van reaches the customer's home, and delivers the order (Fikar et al., 2019). The main challenges tied to this process are three. First, as any other home delivery, it requires travelling to geographically dispersed destinations, each one corresponding to one customer order (Boyer et al., 2009). Second, grocery deliveries are typically on-appointment, thus dramatically reducing the delivery density if compared to traditional e-commerce deliveries (Klein et al., 2019). Third, grocery orders typically include also fresh and frozen products, and they thus require the use of controlled-temperature vehicles, which are very expensive (Ndraha et al., 2018).

Basic solutions. Two main types of basic solutions may be identified concerning the delivery. The first type of basic solutions include some improvements to the traditional HD, and the implementation of the Click-and-Collect (CC). Among the innovations to improve HD, the most commonly recommended alternatives are: the collaboration with other grocery players (Zissis et al., 2018),), the tracing of customer's presence at home to accordingly schedule deliveries (Pan et al., 2017) and the implementation of dynamic pricing policies (Klein et al., 2019). Considering instead the CC, it is a different delivery option, which represents an alternative to HD. In this solution the transport is in charge of the customers, who autonomously reach the collection point to pick-up the goods (Pernot, 2021).

Advanced solutions. Two main types of advanced automated solutions are proposed by scholars, based on the phase(s) to which automation is applied. The first set of solutions include parcel locker and reception boxes, which introduce automation in the collection phase (Punakivi and Saranen, 2001). Parcel lockers are lockers, usually grouped into structures located in public places, for which the use is shared by different customers (Wang et al., 2014). The allocation of one locker to a specific customer is not fixed, but it dynamically varies according to the issued orders and the availability. Reception boxes are instead boxes installed at the customers' house (usually in the garage or in the home yard) (Punakivi and Tanskanen, 2002). The main advantage pursued by both these options is the reduction of failed deliveries due to the absence of the customers (Mangiaracina et al., 2019). The second set of solutions include Automated Guided Vehicles (AGV) and robots. They are autonomous road vehicles that, moving on controlled and determined paths, reach the customers without the need of a driver (Liu et al., 2021). If compared to parcel lockers and reception boxes, they introduce automation not only for the collection, but also in the transport phase, thus improving the efficiency of the overall delivery process (Liu et al., 2020).

Stock-out management. The stock-out management refers to the ways in which e-grocers manage potential missing items (i.e., items that have been ordered online, but are not available when picking is performed) (Vazquez-Noguerol et al., 2020). Despite it is significant for practitioners, the review of the literature highlighted a limited research effort in this direction, concerning both the criticalities and some basic solutions.

Characteristics/criticalities. In many instances, e-grocers do not manage stock-out in any way, meaning that no alternatives are proposed to customers when the required items are not available. This option is typically adopted in case of home deliveries, for which the orders are delivered to the customer's doorstep (Agatz et al., 2008). The delivery of incomplete orders has a twofold huge impact. Considering e-grocers, stock-outs result in lost sales, thus negatively affecting the profit. Considering the customers, missing items significantly decrease the satisfaction of customers, and this may lead them to change the player with which they shop their grocery (Fernie et al., 2010).

Basic solutions. In order to prevent the dissatisfaction of customers, grocers have been starting to implement two main policies to manage stock-outs. The first one is based on the interaction with customers. When there are missing articles, the picker makes a phone call (or sends a message) to the customers to propose some alternatives, and they may choose whether to accept them or not, as well as the preferred option (Colla and Lapoule, 2012). This option is very time-consuming, and implies a tremendous reduction in the picking efficiency. The second option is instead referred to as "the picker-choice". During the picking tour, when there are missing items, the operator picks a substitute product he/she believe to be the best alternative (Mangiaracina et al., 2018). It will then be proposed to the customers during the delivery phase, when they will decide whether to purchase it, or if they prefer to incur the stock-out. Despite it may be more efficient than the previous solution, the picker choice strongly relies on the decision of the operator, who does typically not have the needed elements to make an informed and conscious choice.

No advanced automated solution may be found concerning the stock-out management.

***Automation*.**

As described above, two application domains (and related literature trends) may be identified with reference to automation, all applied to the delivery phase. First, parcel lockers and reception boxes, which earned the attention of scholars in the early 2000s (Punakivi and Saranen, 2001). Second, and more recent, innovative delivery solutions, enabled by the latter technological advancements (i.e., AGVs) (Liu et al., 2021). The literature-based framework clearly shows how scholars interested in automation for e-grocery logistics mainly address it with reference to a specific part of the order fulfilment operative process, and specifically to the delivery, while the other phases have not gained their interest so far.

(RQ3) Gaps and directions for future research efforts

The comparison of the outcome of the Delphi study with that of the SLR, which guided the identification of the literature gaps, is graphically summarised in Table 4. For each challenge, it presents:

- the average rating from managers, as emerged from the Delphi study (with 7 points being the maximum of the Likert scale);
- the percentage of papers in the corpus that address the challenge, computed as the ratio between the number of papers investigating the challenge over the overall number of papers in the corpus (as reported in second column of Table 3). The reason why the total adds up to more than 100% is that numerous papers investigate more than one challenge concurrently.

Please take in Table 4

In line with previous literature reviews about logistics for e-commerce in the food industry (e.g., Seghezzi et al., 2021), gaps were identified on a twofold level: (i) under-investigated topics and (ii) partially investigated topics requiring further research efforts. The gaps were defined selecting those topics for which the following conditions are concurrently true: they are important for practitioners (based on the ratings of the Delphi study), and the interest of scholars is low. Picking and Automation – which are both very important for managers – have only been partially investigated so far, and they consequently fall in category (ii). Conversely, Stock-out management and Order storage are associated with a very limited number of contributions, and may thus be assigned the "Under-investigated topics" cluster (i). The remaining challenges either show alignment between the high (Delivery) or low (Product range, Consolidation) managerial and academic interest, or present an academic discussion that is greater than the importance attributed by practitioners (Infrastructures, Area to be served). All these cases are not classified as priorities for future research, while research directions are proposed for both categories (i) and (ii). These identified research directions are presented in Figure 3 within the developed framework (reported in bold italic font), and discussed in the following paragraphs.

Please take in Figure 3

(i) Under-investigated topics

Order storage. The storage of the e-grocery orders that have already been picked has been identified as a critical challenge by managers. Especially if considering in-store picking, the available space to stock the baskets represents one of the main constraints limiting the capacity of a node, intended as the overall daily number of orders that may be fulfilled from that facility. While many scholas recognise the significance of this issue, no solutions (neither basic nor advanced) to increase the number of orders that can be stored are proposed. Since many players have to start managing operations for online orders in already existing stores, which are though characterised by space constraints, a prolific field of research could address alternative ways in which the storage capacity of stores could be enhanced. This includes both basic solutions and more advanced automated solutions. Considering the former, e-grocers could build ad-hoc structures outside the point of sale, which may be used as pick-up point for customers, for instance through a drive and collect options (Jara et al., 2018)). Considering the former, more advanced automated solutions could be pursued, including high-dimension parcel lockers, which could be placed in strategically placed locations, such as the robotic ones offered by *Cleveron*.

Stock-out management. The management of stock-out is a very crucial issue for e-grocery, which is much more significant than in other industries. This is especially true if considering in-store picking, since online orders are fulfilled in traditional stores. As a matter of fact, it may happen that an item which is available when the customer issues the order online is out of stock when the picker has to retrieve it, if it has been bought by another (offline) consumer (Fernie et al., 2010). An inefficient management of missing items represents a criticality in terms of both efficiency and effectiveness. If a customer does not buy a substitute product, this results in a loss for the retailer, which fails in gaining the associated margin (efficiency side) and in a high dissatisfaction of the customer, who does not get the needed product (effectiveness side). Nonetheless, even in case the substitute product is accepted, the proposal of the alternative is time-consuming for both the parties involved. Nowadays most of the e-grocers rely on the experience of the pickers in defining the right product to be picked. Nonetheless, new solutions based on the use of technology could dramatically improve the performances of this process. As a result, the field related to the selection of the optimal substitute product to be picked for missing items opens fruitful research opportunities. More specifically, great potentialities may be identified in the application of advanced artificial intelligence-based solutions, which – based on the analysis of big data about previous purchases – may provide effective suggestions.

(ii) Partially investigated topics requiring further research efforts

Picking. The review of the literature shows that papers addressing picking with the aim to increase the efficiency of the process are mainly focussed on warehouses or dark store, i.e., to facilities dedicated to online orders. Conversely, there is a paucity of contributions devoted to the analysis and the improvement of the picking process in traditional stores. In-store picking is very different from the warehouse-based one, as it is characterised by much higher complexities: there is a high risk of incurring in stock-outs, since "offline" customers may buy products that had already been ordered online, but still not picked (Fernie et al., 2010). Stores are designed to show the products, and not to increase the associated storage or retrieval efficiency (Murphy, 2007). The presence of people within the aisles of the store hinders pickers' activities (Hübner et al. 2016). Nonetheless, many traditional grocers aim to offer their customers the possibility to order groceries online managing the operations in the physical stores. As a result, scholars should investigate solutions aimed to improve the performances of in-store picking, towards which much lower efforts has been dedicated so far (MacCarthy et al., 2019). Until now, in this context, scholars have typically proposed solutions based on management policies (e.g., batching policies). Nonetheless, more structural interventions could be considered, allowing to reach more significant improvements, including both basic and more advanced technology-based solutions. Considering the former, a promising option – which has very recently been investigated in literature (e.g., Seghezzi et al., 2022) – could be dedicating an ad-hoc area in the back of the facility to the storage and picking of the mostly required online items (Mangiaracina et al., 2018). Considering the latter, different automated picking systems are currently in use (or being tested), and have accordingly been capturing the interest of the practitioners: puzzle-based systems (such as Autostore) and Cobots.

Automation. As highlighted by the analysis of the papers, automation – which emerged as a hot topic for practitioners – has been gaining the interest of academics in two main moments. In the early 2000s, different scholars studied the introduction of innovative automated-delivery solutions – i.e., parcel lockers and reception boxes (e.g., Punakivi et al., 2001) – to improve the efficiency of the last-mile delivery. In more recent years, some novel automated solutions, yet mainly concerning the delivery phase (e.g., autonomous vehicles), are being investigated. Nonetheless, the number of works addressing automation is still scarce if considering the huge managerial interest, which has also mostly been directed towards the delivery phase. Due to the great opportunities that recent advancements in the field of automation could offer to e-grocers, higher attention should be paid by scholars to new automated solution supporting logistics, to keep up with the innovations that the managerial community is facing. More specifically, in line with what discussed in the previous paragraphs, automation could be applied not only to the delivery, but also to the other phases of the order fulfilment, namely picking, order storage and consolidation.

Table 5 summarises the main shortcomings and proposed research directions for the four selected challenges. The first column reports the challenge, and the other columns outline the main shortcomings emerging from the analysis, the associated deriving directions for further research efforts, the proposed research questions to be addressed, and the corresponding proposed research hypotheses derived from the literature analysis. The questions and hypotheses referred to automation (which, as illustrated, is a cross-class theme) are reported in the section devoted to the phase of interest, in underlined font.

Please take in Table 5

Discussion

The Delphi study highlighted 9 main logistics challenges for e-grocery, which were attributed to 4 clusters: distribution network design (area to be served, infrastructures), order fulfilment process (picking, order storage, consolidation, delivery), logistics-related choices from other domains (product range, stock-out management) and automation. The review of the literature allowed to gather the academic knowledge concerning all of them, and the combination of the two methods lead to the development of a framework, mapping (i) the main choices referred to the plan phase, and (ii) both the challenges/criticalities and potential (basic and automated) solutions for the more operative phases related to the order fulfilment (and stock-out management).

(i) Considering the "Plan" phase, there is a clear understanding of the main choices to be made for all the three areas, and some manifest messages may accordingly be drawn. With reference to the *Infrastructure*, the choice is between dedicated warehouses and stores. Differently from what could be expected, an increasing attention is being devoted towards stores. On the one hand, former studies are mainly focused on dedicated warehouses, but stores have recently started to gain the attention of scholars. On the other hand, managers are currently interested in finding solutions to improve the performances of in-store operations. In fact, despite warehouse-based picking is much more efficient, relying on a dedicated facility is not an option for many traditional grocers, since it requires huge investments. Focussing instead on the *Area to be served*, the main choice is between serving an area already covered by offline stores and entering a novel one. The best option in this direction is not unambiguous, but it depends on a high number of variables, which influence the potential demand: the population density (Boyer et al., 2009), the diffusion of the online commerce (Wang et al., 2014), the number and location of other facilities (Liu et al., 2021) and the presence of competitors in the area (Mangiaracina et al., 2019). Finally, considering the *Product range*, the choice is among offering all the offline product range also online, just a portion, or even a higher number of items. Two main messages clearly emerge in this context: on the one hand, an aligned offline-online range is the preferred option; on the other hand, e-grocery initiatives should offer all the product categories (canned food and non-food, fresh, frozen items, but also products belonging to the deli/food court). As a matter of fact, a wide assortment is one of the main drivers of choice of online customers, who typically expect to access a range comparable to the one they find during their offline shopping (Fikar et al., 2019).

(ii) Considering the more operative *Source*, *Make*, *Deliver* and *Return*, the understanding – and related ability to draw clear messages – are not comparable to those of the Plan phase. Furthermore, they are very diverse and uneven among the different phases. The greatest efforts have been devoted towards the *Delivery*: beside discussing the challenges and criticalities, different both basic and advanced solutions are proposed. Despite the home delivery and the click-and-collect options are still the most commonly adopted solutions (Milioti et al., 2020), there is a clear interest in moving towards less traditional ones.

Technology is paving the way for innovative alternatives that allow to reduce delivery costs (e.g., AGVs and robots), which have been gaining the interest of both scholars and managers. The same call for solutions applies to *Picking*, but in this case also more basic options are contemplated. The literature not only stresses the additional challenges picking opens in the e-grocery sector (if compared to traditional logistics), but it also displays some attempts to improve the performances of such a critical process. Nonetheless, so far, the proposed solutions are still mainly based on a revision of the management policies, without contemplating more structural interventions. An aligned result is registered by the *Stock-out management*. The timeline of the academic works is in line with what is happening in the managerial context, which is moving towards the adoption of the picker-choice option to replace missing items. As a matter of fact, on the one hand, the absence of stock-out management dramatically decreases the satisfaction of customers; on the other hand, interacting with customers is very time-consuming, and it implies a tremendous reduction in the picking efficiency. Accordingly, the picker-choice emerges as the most promising option. However, to maximise its performances, it is fundamental to identify the right substitute product to be proposed to customers, and to accordingly define an effective selection strategy. Nonetheless, works addressing such issue seems to be missing. Finally, lower maturity is displayed concerning the order *Storage* and *Consolidation*, for which scholars mainly discuss the criticalities. Two major messages may be drawn: on the one hand, the space available to store orders typically represents one of the most stringent constraints to the number of online orders that can be managed daily (and it thus define the capacity of the e-commerce service). On the other hand, choices concerning the storage highly impact the consolidation process, and the two processes need to be carefully designed with an integrated approach. The proposal of both basic and advanced solutions seems to be missing.

To conclude, despite *Automation* has been discussed horizontally across all the addressed phases, besides reinforcing the significance of automation in logistics for e-grocers, the outcome of the analysis suggests a twofold consideration. On the one hand, there is an increasing interest in applying the latest technological advancements to the fulfilment of grocery orders, switching from more basic to more advanced automated one. On the other hand, there is a tendency towards the automation of new activities/processes, moving from a focus on very a limited set of activities (mainly delivery), to wider shares of the overall order fulfilment process. Accordingly, gaps and research directions were identified at the intersection of the under-investigated phases and automation.

Conclusions

This paper provides a threefold contribution. First, it investigates and categorises the state of the art about e-grocery logistics, providing an overview of the topics that have gained the interest of scholars in the last 20 years, and classifying them. Second, it identifies the main logistics issues e-grocery introduces for practitioners, and it delivers a classification of these challenges based on the importance perceived by logistics managers. Third, it contrasts the two outcomes, identifying the misalignment between research and practice, and accordingly proposing directions for future academic works, which may be beneficial also for the managerial community. Moreover, it develops a conceptual framework, which serves as a foundation to both discuss current knowledge, and define future research directions.

The main limitations of this work are two. Considering the Delphi method, as recognised by most of the authors of this type of studies (e.g., Hameri and Hintsa, 2009), there may be an issue in what is referred to as manipulated consensus, meaning that the outcomes (i.e., the importance attributed to the issues) may not hold the best judgment, but a compromised position. Nonetheless, the measured value of the Chronbach's alpha revealed alignment among the different members of the panel, thus suggesting a great reliability of results. Considering the SLR, similarly to previous literature reviews in the field (e.g., Seghezzi et al., 2021), some relevant contributions could have inadvertently been omitted.. Nonetheless, the authors are confident that the general picture emerged from the review is trustworthy, and that the presented results are representative of the up to date knowledge about the topic.

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	Participants	Asked questions	Supplementary material/notes provided
Round 1	35 19 managers, 16 consultants	*What are the most significant logistics challenges and issues that have to be addressed in the e-grocery?*	• Scope and motivation of the research • Brief explanation of the way the Delphi study would work
Round 2	29 17 managers, 12 consultants	*How would you rate the importance of these challenges based on a seven-point Likert scale (1 not important at all, 4 neither important nor not important, 7 very important)?*	• List of the challenges, with a clear definition of them (as shown in the (RQ1) section • Meaning of the values of the Likert scale
Round 3	23 13 managers, 10 consultants	*How would you rate the importance of these challenges based on a seven-point Likert scale (1 not important at all, 4 neither important nor not important, 7 very important)?*	• Aggregated outcome of round 2 (average and standard deviation of the ratings provided by the 29 participants, as per Table 2)

Table 1: Rounds of the Delphi study

	Round 2 – First rating						**Round 3 – Final rating**					
	Total		Managers		Consultants		**Total**		Managers		Consultants	
	Avg	σ	Avg	σ	Avg	σ	**Avg**	σ	Avg	σ	Avg	σ
Delivery	6.8	0.5	6.7	0.6	6.9	0.3	**6.7**	0.6	6.5	0.7	6.8	0.4
Picking	6.3	0.5	6.4	0.5	6.3	0.5	**6.6**	0.5	6.6	0.5	6.7	0.5
Automation	6.3	0.6	6.5	0.6	6.2	0.5	**6.5**	0.7	6.5	0.7	6.5	0.7
Stock-out management	4.4	0.6	4.5	0.6	4.4	0.6	**5.0**	0.8	4.9	0.8	5.1	0.9
Order storage	3.8	0.8	3.8	0.9	3.8	0.9	**4.0**	1.0	4.0	0.9	4.1	1.1
Infrastructures	3.5	0.6	3.5	0.6	3.6	0.6	**3.9**	0.8	3.8	0.8	4.0	0.7
Product range	3.2	0.7	3.3	0.7	3.2	0.8	**3.2**	0.7	3.2	0.8	3.2	0.6
Consolidation	3.1	0.7	3.2	0.8	3.1	0.7	**2.9**	0.7	3	0.8	2.8	0.6
Area to be served	3.0	0.7	2.8	0.8	3.1	0.7	**2.9**	0.8	2.6	0.7	3.2	0.8

Table 2: Ratings

Challenge	% of papers	Content	% of papers	Main references
Delivery	92%	HD	*79%*	Fikar et al. (2019); Emeç et al. (2013); Herrel (2014)
		Click and collect	*19%*	Colla and Lapoul (2012); Davies et al. (2019); Vyt et al., (2017)
		Innovative solutions	*38%*	Pan et al. (2017); Punakivi and Saranen (2001); Zissis et al. (2018)
Picking	29%	Criticalities	*29%*	Wollenburg et al., (2018); Kämäräinen et al., (2001); Vazquez-Noguerol et al. (2020)
		Policies	*15%*	De Leeuw et al. (2019); Eirksson et al. (2019)
Automation	25%	Parcel locker, reception boxes	*19%*	Kämäräinen et al., (2001); Punakivi and Tanskanen (2002)
		AGV, robots	*6%*	Liu et al. (2020); Liu et al., (2021)
Stock-out management	8%	No substitution	*2%*	Agatz et al. (2008)
		Interaction with customer	*4%*	Colla and Lapoule (2012)
		Proposal of substitute product	*4%*	Mangiaracina et al. (2018)
Order storage	10%	Constraint on number of orders	*10%*	Eriksson et al. (2019); Fikar (2018)
Infrastructure	58%	Warehouse	*54%*	Agatz et al. (2008); Wollenburg et al., (2018); Kämäräinen and Punakivi (2002)
		Store	*54%*	MacCarthy et al. (2019); Mkansi and Nsakanda(2019); Vazquez-Noguerol et al. (2020)
Product range	27%	Online = offline	*17%*	Pan et al. (2017); Pernot (2021)
		Online < offline	*13%*	Mkansi et al. (2019); Punakivi and Tanskanen (2002)
		Online > offline	*2%*	Tanskanen et al. (2002)
Consolidation	8%	Link with storage	*8%*	De Leeuw et al. (2019); Mkansi et al. (2018)
Area to be served	58%	Already covered area	*48%*	Davies et al. (2019); Ehrler et al. (2019); Pernot (2021);
		New area	*10%*	Siikavirta et al. (2002); Klein et al. (2019)

Table 3: By-topic distribution of the analysed papers

	Managers	Academics
Delivery	**6.7**	**92%**
Picking	**6.6**	**29%**
Automation	**6.5**	**25%**
Stock-out management	**5,0**	**8%**
Order Storage	**4,0**	**10%**
Infrastructures	**3.9**	**58%**
Area to be served	**3.2**	**58%**
Product range	**2.9**	**27%**
Consolidation	**2.9**	**8%**

Table 4: Comparison between managerial and academic perspectives

Content	Shortcoming	Directions for further research	Potential research questions	Research hypotheses
Order storage	Presentation of the criticality of limited space for order storage, but without proposing solutions to increase it	Proposal and analysis of solutions aimed to increase the capacity of the area dedicated to order storage	• How could the order storage capacity of stores be enhanced? • How could ad-hoc built order storage structures be used to increase the number of stored orders? What factors should be considered in their design? • How could parcel lockers be used to increase the number of stored orders? What factors should be considered in their design? • How – and to what extent – can automation be used in storing already picked orders and consolidating them? • How could robotic storage-consolidation lockers be used to enhance storage and consolidation performances?	• Ad-hoc built order storage structures to store already picked orders increase the overall capacity of a store to fulfil online orders • Parcel lockers employed to store already picked orders increase the overall capacity of a store to fulfil online orders • Robotic storage-consolidation lockers decrease the average cost to fulfil an order, and increase the number of orders that can be fulfilled daily
Stock-out management	Presentation of the criticalities of defining the substitute products, but without proposing solutions to support the picker in the selection	Proposal and analysis of solutions aimed to select the right substitute product for missing items	• What policies should be implemented to efficiently and effectively manage missing items? • What factors should be considered to identify the substitute products to be proposed? • How can artificial intelligence-based solutions be used define the best substitute product in case of stock-out?	• Proposing substitute products based on previous acceptance/rejection rates decreases the possibility to incur stock-outs • The advantages (in terms of stock-out cost reduction) achieved by proposing substitute products based on previous acceptance/rejection rates outweigh the disadvantages (investments and additional costs) to settle and manage it. • Artificial intelligence-based solutions provide better performances (in terms of both effectiveness and efficiency) in selecting the most suitable substitute product if compared to the picker choice option
Picking	Focus on management policies as the main solution to increase the picking efficiency in stores (but they only partially improve picking performances)	Proposal and analysis of innovative solutions (other than management policies) to improve picking performances in stores	• How should in-store picking activities be managed to improve their performances? • How should the back area be designed to increase picking efficiency? What factors should be considered in the design? • How – and to what extent – can automation be used in the picking process? • How could puzzle-based storage systems be used to enhance picking performances? • How could Cobots be used to enhance picking performances?	• Settling a back area dedicated to the most required online items decreases the average picking time per order • When designing a back area, the configurations that optimise the benefit-additional cost trade-off only includes dry items characterised by high picking frequency • Puzzle-based storage systems decrease the average time and cost to fulfil an order • Cobots decreases the average picking time per order

Table 5: Future research directions and hypotheses

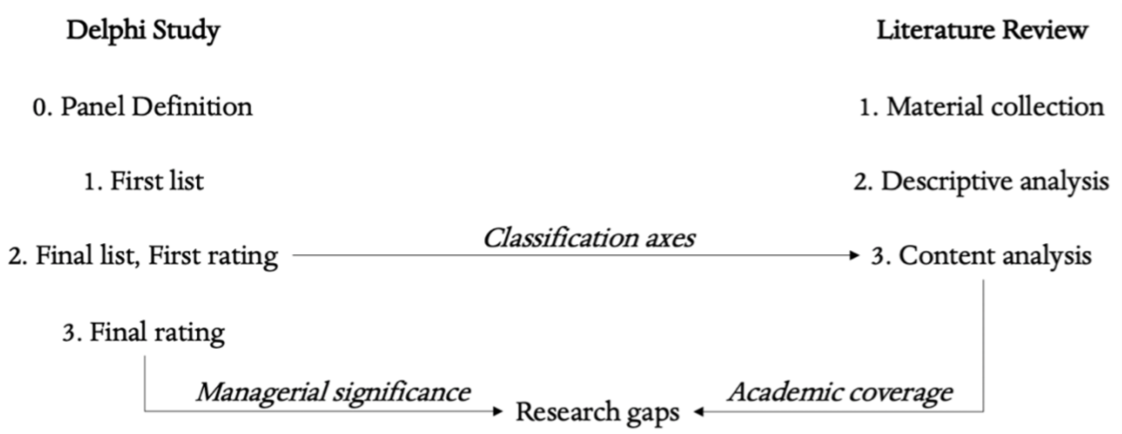

Figure 1: Research methodology

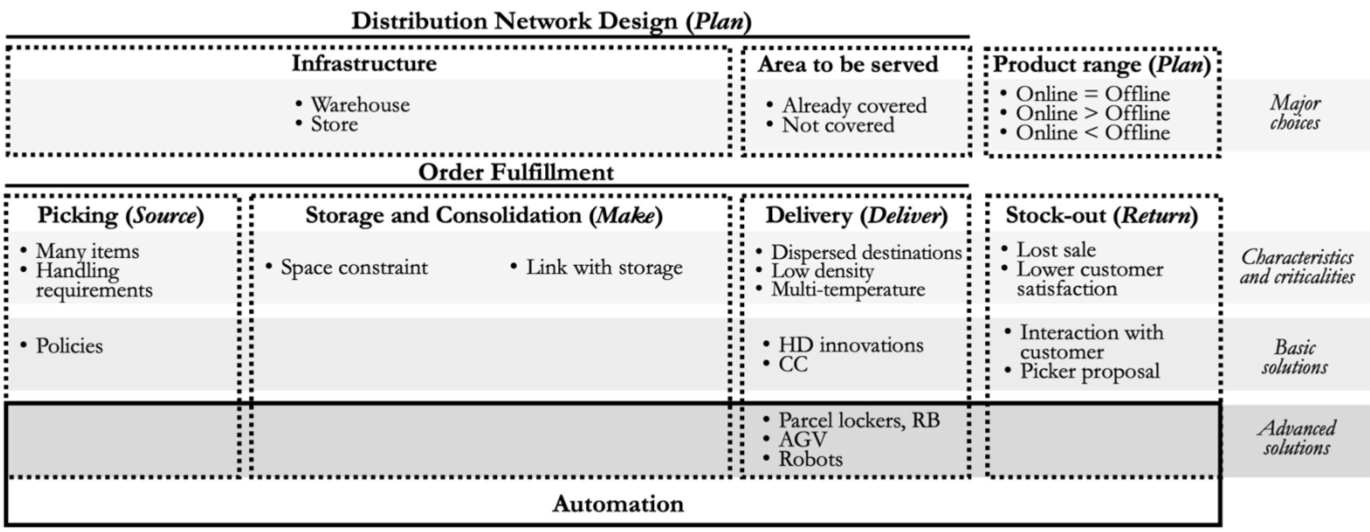

Figure 2: Literature-based framework

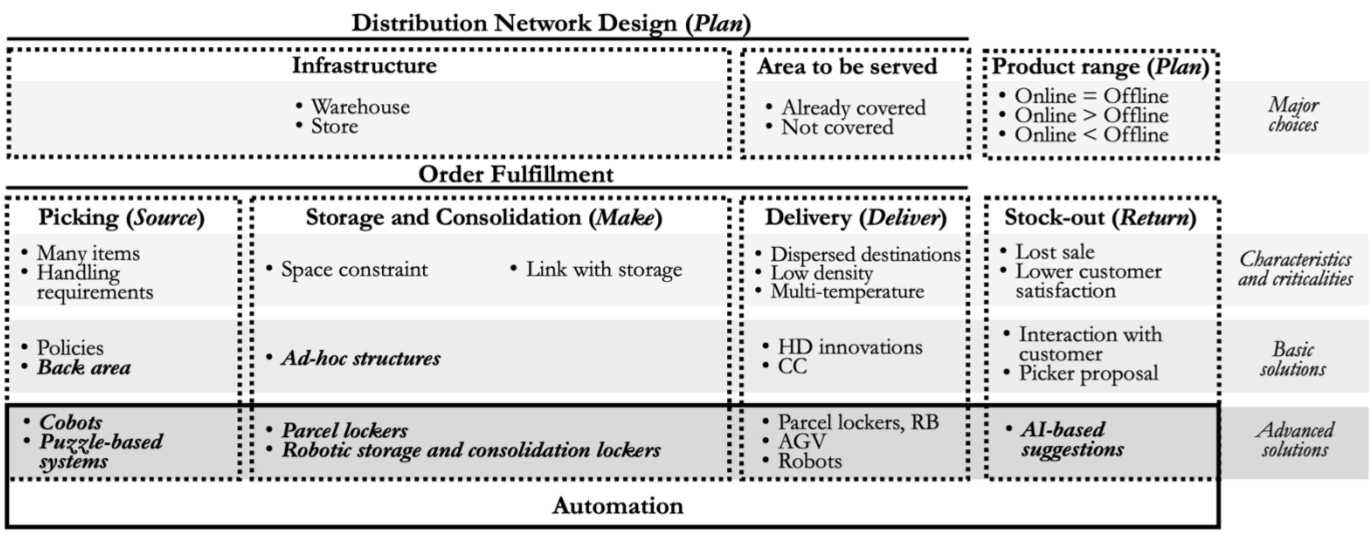

Figure 3: Framework including suggested research directions