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### E-Commerce and the Evolution of Last-Mile Delivery in Supply Chain

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**ABSTRACT:** The advent of e-commerce has revolutionized the way consumers shop, ushering in a new era of convenience, choice, and accessibility. With the click of a button, customers can browse a vast array of products, compare prices, and place orders from the comfort of their homes or mobile devices. However, behind the seamless online shopping experience lies a complex and dynamic supply chain ecosystem, with last-mile delivery playing a pivotal role in ensuring timely and efficient fulfillment of orders. This essay explores the evolution of last-mile delivery in the context of e-commerce, examining the challenges, innovations, and trends shaping the future of supply chain logistics.

#### **I.THE RISE OF E-COMMERCE**

E-commerce, or electronic commerce, refers to the buying and selling of goods and services over the internet. While the concept of e-commerce dates back to the 1970s with the advent of electronic data interchange (EDI), it wasn't until the late 1990s and early 2000s that e-commerce gained mainstream acceptance with the proliferation of the internet and advancements in digital technologies.

#### The Evolution of Last-Mile Delivery:

Last-mile delivery, also known as final-mile delivery, refers to the movement of goods from a distribution center or fulfillment center to the end customer's doorstep. It is often considered the most challenging and costly segment of the supply chain due to the complexities involved in navigating urban environments, managing multiple delivery points, and meeting tight delivery windows. Despite a number of contributions to the LML domain, the literature on LML models is still somewhat fragmented, which makes it difficult to have a thorough grasp of the subject and to focus research efforts. Thus far, available research offers (Agatz et al. (2008), Fernie et al. (2010), Mangiaracina et al. (2015), Lagorio et al. (2016), Savelsbergh and Van Woensel (2016) provide little to no information regarding how contingency variables affect the selection of LML configurations

#### **Defining LML**

The phrase "last-mile" designates the last segment of a network and has its roots in the telecommunications sector. These days, LML refers to the final part of a delivery process, which is frequently thought to be the most costly, inefficient, and environmentally problematic part of a supply chain (Gevaers et al., 2011). The term "extension of supply chains directly to the end consumer" was used in early definitions of LML to refer to consumer home delivery services (Punakivi et al., 2001; Kull et al., 2007).

#### **II.RESEARCH METHODOLOGY**

In addition to offering direction for theory building and future research directions, a structured literature review seeks to identify the conceptual substance of a quickly expanding field of knowledge (Meredith, 1993; Easterby-Smith et al., 2002; Rousseau et al., 2008). The obligation to give a thorough explanation of the review process in order to minimise bias sets structured reviews apart from more narrative-based assessments and promotes transparency and replicability (Tranfield et al., 2003). Consequently, doing a systematic review guarantees the accuracy, comprehensiveness, and meticulousness of the study itself (Greenhalgh and Peacock, 2005). The categorization of contributions across methodological domains is part of our review. In subsequent



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sections, we employ the knowledge gained from the literature study to create an LML design framework that employs a collection of structural and related contingency variables to represent the interactions between distribution structures.

#### Planning

In order to conduct this study, a panel of experts in retail operations and LML was assembled from the academic community and business sector. These specialists took part in organised sessions where the important areas of research for LML design were covered. Next, using the emerging themes as a guide, the following study questions were developed:

RQ1. How far along are studies and applications of LML distribution in e-commerce? RQ2. Which related contingency variables are there that might affect the choice of LML distribution structures? RQ3. How may the choice of LML distribution structures be influenced by the contingency variables found in RQ2?

#### Searching

The study's scholarly content spans the years 2000 to 2017. Important industrial developments, such the rise and eventual fall of the online grocer Webvan, occur during this time. In order to guarantee the quality of the corpus, the review is restricted to peer-reviewed papers (Saenz and Koufteros, 2015). It examines 16 journals, including one practitioner journal (MIT Sloan Management Review), in order to capture theoretical viewpoints on industry best practices. This review contains only works that were published in the designated journals, with the exception of one article by Wang et al. (2014) that was published in Mathematical Problems in Engineering. The essay was considered essential because it is the only one that links and expands on earlier studies on CDP evaluation. The selection of the 16 journals was not based on their analysis of analytical modelling, but rather on their primary focus on empirical and conceptual growth. The focus of this review led us to primarily consider how scholars conceptualize LML distribution structures and apply theoretical variables to LML design through quantitative, qualitative, or conceptual approaches, rather than through mathematic-based models, even though we acknowledge that there are significant research studies in this area (e.g., operations research). Mathematic-based model literature focuses on the development of stylized and optimization models for a variety of applications, including discrete location-allocation, buy-online-pick-up-in-store services, vehicle routing problems (Savelsbergh and Van Woensel, 2016), pricing and delivery choice, inventory-pricing, delivery service levels, channel design, and optimal order quantities via newsvendor formulation for various fulfilment options (Agatz et al., 2008). In order to propose closed-form or heuristicbased prescriptive solutions, these studies usually make a number of assumptions to simplify real-world procedures (Agatz et al., 2008; Savelsbergh & Van Woensel, 2016). Journals that primarily focused on operations research or mathematical modelling were therefore not included in this review.

It did, however, include pertinent mathematical modelling articles that were published in any of the 16 journals that were chosen, provided that they clarified the various kinds of LML distribution structures and/or the related contingency variables. To meet the operational focus of this research, general management periodicals were also eliminated from this analysis.

The databases used for the literature search were ABI/Inform Global, Science Direct, ISI Web of Science, and Scopus. To ensure that all pertinent articles were included, two search rounds were conducted. The search phrases "urban logistics," "city logistics," "last-mile logistics," and "last mile logistics" were used to conduct the initial literature probe.

In the second phase of our investigation, we supplemented a protocol-driven methodology with the "snowballing" technique, which involves tracing citations backward and forward to identify leads to more relevant papers. our allowed us to expand the corpus. As the investigation progressed, this method produced fresh search phrases and the identification of scholars to help the search plan get more focused (Greenhalgh and Peacock, 2005). The terms "home delivery," "B2C distribution," "extended supply chain," "final mile," "distribution network," "distribution structure," and "grocery delivery" were found to be among the newly discovered search terms.

Then, further search strings were created using these new keywords and Boolean connectors (AND, OR, AND NOT). Finally, we conferred with two supply chain professors from Arizona State University and the University of Cambridge to double-check the searches. Therefore, it is suggested that the review coverage is fairly extensive.

#### Screening

Each paper's abstract was examined for the sake of this review in order to determine how relevant it was to LML in the context of e-commerce. In cases where an abstract was lacking or proven equivocal, the whole manuscript was analysed to



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ascertain its pertinent contribution to the LML topic. To ensure objectivity and integrity, we used the following criteria to assess the relevancy of the article:

- 1. Exclusion criteria: editorial opinions, conference proceedings, textbooks, book reviews, dissertations, and unpublished working papers were all excluded, as were paper titles that contained the terms "urban logistics," "city logistics," "last-mile logistics," or "last-mile" but only provided a limited amount of coverage on distribution structures and the related design variables (such as public policy, urban traffic regulations, logistics infrastructure, urban sustainability, and environment).
- 2. Regardless of their true study emphasis, papers covering distribution mechanisms and design variables in the context of e-commerce were included. We used a variety of research techniques in order to produce emergent theories in addition to existing ones.

We found 425 articles that referenced our subject phrases during the search phase. We excluded items that met the exclusion criteria and removed duplicates based on author names and titles. For instance, although the term "urban logistics" appears in the title of Gary et al.'s (2015) research, the approach of engaging stakeholders is logistics prototyping rather than LML models. Thus, this paper was not included. After the elimination phase, 100 articles were deemed suitable for additional examination. The results were exported to EndNote version X8, a reference management programme, for additional examination and easier data administration. Next, in order to choose the final articles, we implemented the inclusion criteria. Ultimately, we classified the articles into two groups: the related contingency variables and the LML distribution structures. Ultimately, the corpus of this review consists of 47 journal papers in total.

#### Extraction, synthesis, and reporting

Using a spreadsheet format adapted from Pilbeam et al. (2012), a summary of each of the 47 articles was created after an initial review. The spreadsheet was arranged under descriptive categories (year, journal, title), methodology (article type, theoretical lens, sampling protocol), and thematic categories (article purpose, context, LML distribution structures, design variables, others).

In light of this, we performed three analyses: methodological, thematic, and descriptive (Richard and Beverly, 2014). The descriptive analysis provides an overview of the journals' distribution statistics as well as the evolution of research during the relevant time. The thematic analysis synthesises the principal findings from the retrieved literature and gives a summary of the review structure, whereas the methodological analysis emphasises the research methodologies used in the field. The arrangement of the reporting structures addresses the prior research topics in a progressive fashion.

#### Descriptive analysis

Table I lists the publications where, surprisingly, contributions have not yet been made, author affiliations, summary statistics of the reviewed works, and contributions identified.

#### Methodological analysis

Although there is variation in the research methodologies employed in this topic, the majority of the publications examined employed statistical methods (6 articles; 12.77 percent), survey (7 articles; 14.89 percent), and analytical modelling and simulation (19 articles; 40.43 percent). The remaining publications included case studies, literature reviews (4 articles (8.51 percent)), conceptual development (5 articles (10.64 percent)), and mixed-method scholarship (6 articles (12.77 percent)). In our study, we referred to these research techniques as mathematical modelling, empirical investigations, conceptual studies, literature reviews, and typology-oriented provision. Below, we go over each type's representative articles in brief:

- Typology-oriented provision: A typology-oriented approach proved especially useful for comprehending LML practices because of the recent spread of LML models. To aid in design under various customer and product qualities, Lee and Whang (2001), Chopra (2003), Boyer and Hult (2005), and Vanelslander et al. (2013) have all established LML structural types. The linearly "chain-centric" LML models that were common in the pre-digital period were mostly captured by these investigations.
- Review of the literature and conceptual studies: a number of reviews have made contributions in this area. Whereas some studies (Agatz et al., 2008; Lagorio et al., 2016; Savelsbergh and Van Woensel, 2016) addressed multiple subjects at once, others (Fernie et al., 2010) concentrated on particular issues, such as the development of British retailing and distribution network design. While more widely oriented publications investigated broader



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difficulties in urban, city, or multichannel logistics, narrowly focused papers highlighted limited LML structural types or variables influencing distribution network design. The selection of LML "types" based on specific performance criteria (e.g. Punakivi and Saranen, 2001; Chopra, 2003) or logistics service quality (e.g. Yuan and David, 2006) was generally guided by conceptual research.

- Empirical research: these studies mostly contrasted different forms of LML or illustrated how specific variables affected LML. Research aiming at the earlier goal (different kinds) used econometrics, field/mail surveys, and simulations to analyse CO2 emissions or performance (e.g. Punakivi et al., 2001). In order to comprehend how the physical distribution processes are organised in omnichannel supply networks, one study used a mixed-method approach (case research and modelling) (Ishfaq et al., 2016). In order to investigate the relationship between operational strategies and consumer behaviour, empirical studies with the latter study goal (evidencing impact) used field and laboratory experiments as well as statistical approaches on survey data (e.g. Esper et al., 2003; Boyer and Hult, 2005; Kull et al., 2007). To investigate the effects of cross-channel interventions, these research (Forman et al., 2009; Gallino and Moreno, 2014) also used econometrics. Furthermore, a few studies employed case research to offer operational direction through the creation of frameworks, such as LML design to represent the interests of many stakeholders and last-mile order fulfilment (Hübner, Kuhn, and Wollenburg, 2016) (Harrington et al., 2016).
- Mathematical modelling: studies (Campbell and Savelsbergh, 2005; McLeod et al., 2006; Aksen and Altinkemer, 2008; Crainic et al., 2009; Wang et al., 2014) also used a range of mathematical tools and techniques to formulate LML problems and find optimal solutions. Mostly for vehicle routing problems. Campbell and Savelsbergh (2006) used simulation and optimisation models in their study to show the benefits of incentives. Other research concentrated on finding the best distribution strategies (e.g., Netessine and Rudi, 2006; Li et al., 2015), developing new models to capture cutting-edge practices, like crowd-sourced delivery (Wang et al., 2016), and rationing inventory (Ayanso et al., 2006).

#### Thematic analysis

- Using the qualitative data analysis programme MAXQDA version 12, the grounded theory approach (Glasser and Strauss, 1967) was utilised to code and categorise newly emergent recurring concepts and terminologies. The two categories that define LML models—LML distribution structures and the contingency variables that go along with them—formed the basis of the classification. Two different authors independently coded the data. Where their opinions diverged, the matters were debated until an agreement was achieved on the defining words and ideas, which were recorded in a codebook. In order to bring crucial concepts together, terms related to each classification level were either introduced in this study or taken from the body of existing research.
- The push-centric distribution system was further divided into three modes of picking: manufacturer-based, distribution centre (DC)-based, and local brick-and-mortar (B&M) store-based. On the other hand, the pull-centric distribution system was divided into two modes of collection from the fulfilment point: local B&M store and information store. Lastly, the hybrid distribution system was divided into two modes of CDP: attended collection delivery point (CDP-A) unattended deliverv (CDP-U). and collection point The second group encompasses the correlated contingency variables frequently employed in previous research. This study compiled a comprehensive list of 13 factors that impact the structural configurations of last-mile distribution. These factors include consumer geographical density, consumer physical convenience, consumer time convenience, demand volume, order response time, order visibility, product availability, product variety, product customisability, product freshness, product margin, product returnability, and service capacity. These elements dictate the way in which a distribution structure meets customer wants and adapts to the unique characteristics of different product categories. These categories aid in comprehending LML models and allow for the consistent categorization of future structural variables. Figure 1 provides a comprehensive representation of the structural layout of the LML models documented in the literature.

#### **III.REVIEW OF LML DISTRIBUTION STRUCTURES**

In the previous section, it was explained that an LML distribution structure entails the direct transfer of a product from its origin to the end consumer. There are three fundamental forms of this process:

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(1) Push: The product is delivered to the consumer's location by a third party.

(2) Pull: The consumer retrieves the product directly from the source.

(3) Hybrid: The product is first sent to an intermediary location, from which the consumer retrieves it. Table II provides a concise summary of the corpus regarding LML distribution structures.

#### Push-centric system: n-tier direct to home

According to this report, the push-centric approach is the most widely used method of dissemination. Usually, it consists of several intermediary stages (n-tier) between the origin and destination to optimise distribution. The literature categorises three different picking methods based on the site of inventory fulfilment: manufacturer-based (also known as "drop-shipping"), DC-based, or local B&M store-based (such as a retailer's intermediary warehouse or store). Consumers have the option of having their purchases delivered to either their homes or their workplaces, with the latter becoming more common (McKinnon and Tallam, 2003).



Figure 1. Classification of literature review on LML models

#### Pull-centric system: consumer self-help

The literature has examined two variations of the pull-centric system. Both options necessitate consumer involvement throughout the whole transaction process, encompassing order fulfilment and transportation. The initial option depicts the conventional method of shopping at a physical brick-and-mortar store, where consumers themselves handle the final leg of the delivery process. The second type of the "information store" utilises a concept called "dematerialization," where information flow replaces material flow (Lee and Whang, 2001). This variation acknowledges that material or physical flows are generally more costly than information flows because of the expenses associated with loading, unloading, handling, warehousing, shipping, and product returns. This survey discovered that although online buying is widely popular, there are still instances where consumers prefer traditional offline purchasing. Challenges related to examining physical objects, the procedure of returning things, or lengthy and costly shipping can discourage consumers from engaging in online purchasing (Forman et al., 2009). This study also highlights additional advantages of a pull-centric system, such as reduced capital investments and potential carry-over impacts on in-store sales (Johnson & Whang, 2002).

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Level 1 classification	Level 2 classification	References			
Push-centric system	Manufacturer-based pick (manufacturer storage)	Chopra (2003), Ayanso et al. (2006), Netessine and Rudi (2006), Randall et al. (2006), Agatz et al. (2008), Dumrongsiri et al. (2008), Rabinovich et al. (2008), Ishfaq et al. (2016), Wollenburg et al. (2017)			
	Distribution centre (DC)- based pick (distributor storage)	Kämäräinen et al. (2000), Esnad et al. (2010), Wollenburg et al. (20 (2002), Kämäräinen and Punakivi (2002), Chopra (2003), Boyer a Hult (2005), Campbell and Savelsbergh (2005), Boyer and Hult (20 Campbell and Savelsbergh (2006), Boyer et al. (2009), Fernie et (2010), Wanke (2012), Vanelslander et al. (2013), Bell et al. (2014) Stembeck and Kuhn (2014), Wang et al. (2014), Hübner, Kuhn a Wollenburg (2016), Hübner, Wollenburg and Holzapfel (2016), Isl et al. (2016), Wollenburg et al. (2017), Yang and Strauss (2017)			
	Local brick-and-mortar (B&M) store-based pick (retailer storage)	Yrjölä (2001), De Koster (2002), Kämäräinen and Punakivi (2002), Chopra (2003), Boyer and Hult (2006), Netessine and Rudi (2006), Randall <i>et al.</i> (2006), Agatz <i>et al.</i> (2008), Dumrongsiri <i>et al.</i> (2008), Boyer <i>et al.</i> (2009), Fernie <i>et al.</i> (2010), Hübner, Kuhn and			
Pull-centric system	Local B&M store	Yrjölä (2001), Chopra (2003), Aksen and Altinkemer (2008), Forman <i>et al.</i> (2009), Lau (2012), Gallino and Moreno (2014), Sternbeck and Kuhn (2014), Li <i>et al.</i> (2015)			
	Information store (dematerialisation)	Lee and Whang (2001)			
Hybrid system	Attended collection delivery point (CDP-A) (click-and- collect/pick-up centre/ clicks-and-mortar/GRP)	Kämäräinen et al. (2001), Lee and Whang (2001), Chopra (2003), McKinnon and Tallam (2003), Boyer and Hult (2005), McLeod et al. (2006), Aksen and Altinkemer (2008), Weltevreden (2008), Fernie et al. (2010), Bell et al. (2014), Gallino and Moreno (2014), Wang et al. (2014), Hübner, Kuhn and Wollenburg (2016), Hübner, Wollenburg and Holzapfel (2016), Ishfaq et al. (2016), Savelsbergh and Van Woensel (2016), Wollenburg et al. (2017)			
	Unattended collection delivery point (CDP-U) (RB/ULB)	Småros and Holmström (2000), Kämäräinen <i>et al.</i> (2001), Punakivi <i>et al.</i> (2001), Punakivi and Saranen (2001), Kämäräinen and Punakivi (2002), Punakivi and Tanskanen (2002), McKinnon and Tallam (2003), Fernie <i>et al.</i> (2010), Wang <i>et al.</i> (2014), Hübner, Kuhn and Wollenburg (2016), Savelsbergh and Van Woensel (2016)			
Notes: GRP, urban logistic	goods reception point; RB, r rs boxes	eception box (independent/with docking mechanism/shared); ULB,			

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Table II. Types of LML distribution structure

#### Hybrid system: n-tier to consumer self-help location

The extensive body of literature primarily examines and contrasts various methods of reception. Variants commonly had a setup that combined both pushing and pulling. To address the issue of "not-at-home" responses in attended home delivery (AHD), one possible solution is to send the product to a Consumer Delivery Point (CDP) where consumers can retrieve it. The literature examined two forms of CDP: CDP-A and CDP-U. According to Wang et al. (2014), retailers construct CDP-A by either creating new infrastructure, using existing facilities, or forming partnerships with a third party. Additional terms related to CDP-A include "click-and-collect," "pickup centre," "click-and-mortar," and "buy-online-pickup-in-store." According to the literature, retailers set up CDP-U (unattended reception) using independent RBs (receiving boxes) that have a docking mechanism. Alternatively, they may use shared RBs located in various places such as private homes or

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public sites like petrol kiosks and train stations, which can be accessed by multiple users (McLeod et al., 2006). Multi/omnichannel retailers often employ the CDP-A and CDP-U strategies to leverage their current store networks, offer convenient auxiliary delivery services to consumers, and streamline returns processing (Yrjölä, 2001). In addition, the study demonstrated that combining online technologies with physical infrastructures allows merchants to gain cost savings, boost brand differentiation, build consumer trust, and expand their market (Fernie et al., 2010). Research has also examined the financial benefits and effectiveness of adopting CDP-U compared to AHD and CDP-A (e.g. Wang et al., 2014). According to Punakivi et al. (2001), CDP-U can decrease home delivery expenses by as much as 60 percent. This is mainly achieved by taking use of the time window benefit, as stated by Kämäräinen et al. (2001).

#### Development of LML design framework

This section aims to solve the second and third research objectives by creating a framework that enhances the practice of LML design. The development process is regulated by contingency theory, as proposed by Lawrence and Lorsch in 1967, where the concept of "fit" plays a crucial role. The contingency theory asserts that the alignment of structural, contextual, and environmental variables is crucial for achieving organisational effectiveness. In the management literature, fit is defined as the extent to which there is consistency across various aspects of organisational design and context. This is often measured by profile deviation, as discussed by Jauch and Osborn (1981) and Doty et al. (1993). The likelihood of organisational success rises when the alignment between various types of variables improves (Jauch and Osborn, 1981; Doty et al., 1993). This research considers the environmental and contextual variables together as contingency variables. The goal is to investigate how these variables influence the structural shape of LML distribution. The LML design framework was established using a two-step process. Initially, we created a collection of LML structural and contingency variables and examined the connection between them by reviewing the existing LML literature. Next, we transformed the factual information gathered in the initial phase into actionable guidance. We utilised the contingency viewpoint in conjunction with Romme's (2003) approach to guide the process of knowledge reformulation.

#### Synthesizing LML structural variables

The three primary system dynamics found (push-centric, pull-centric, and hybrid) represent different variations in LML distribution architectures. Through a comparative analysis of these structures, we have developed a collection of structural factors that can account for the different kinds of last-mile distribution. The structural factors encompass the product source, geographical extent, mechanism of distribution, and number of nodes. The following variables are expanded:

- The term "product source" refers to the specific area where products are held upon acceptance of an order. This location serves as the starting point for an LML network. It can be defined as an entity that belongs to a supply network, such as a manufacturer, distributor, or retailer. To illustrate, the computer manufacturer Dell (customization services), online grocer Ocado (home delivery services), and the UK's main supermarket chain Tesco (click-and-collect services) acquire their products from manufacturer, distributor, and retailer sites, respectively.
- The geographical scope of an LML network refers to the distance between the starting point (where the product is sourced) and the intended destination place of the final consignee. An LML network can be categorized as either centrally based, such as Dell Services, or locally based, such as Tesco's click-and-collect.
- The mode of distribution refers to the method of delivering an order from the point of complete fulfilment to the final destination. It can be categorized into three types: self-delivery (such as Tesco's use of their own fleet for home deliveries), 3PL delivery which includes crowdsourcing (such as Dell Services), and consumer-pickup (such as Tesco's click-and-collect services).
- The term "number of nodes" refers to the processes where products remain stationary in a facility for processing or storage. Links, in contrast to nodes, symbolize the transitions between nodes.

#### Synthesizing LML contingency variables

There are two types of contingency variables: systematic construction of LML variables and empirical research of specific variables and their interactions. To demonstrate the former, Chopra (2003), Boyer and Hult (2005), and Gevaers et al. (2011) all created their own lists of contingency variables. Boyer et al. (2009) conducted a simulation analysis using two independent variables (customer density and delivery window size) and one dependent variable (delivery cost). The most



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common contingency-reported factors that have a direct impact on the structural form of the LML distribution are listed below, with commentary summarized in Table III:

- Consumer geographical density refers to the quantity of consumers within a given area, as defined by Boyer and Hult (2005), Boyer et al. (2009), and Mangiaracina et al. (2015).
- Consumer physical convenience refers to the level of effort that consumers put in to obtain their orders, as discussed by Chopra (2003) and Harrington et al. (2016).
- Consumer time convenience refers to the amount of time consumers dedicate to receiving their orders. This variable varies in accordance with the structural configuration of last-mile distribution, as described by Rabinovich and Bailey (2004) and Yuan and David (2006).
- Demand volume refers to the quantity of products that consumers order in relation to the distribution system (Chopra, 2003; Boyer and Hult, 2005).
- The order reaction time refers to the duration between when an order is placed and when it is delivered, as defined by Kämäräinen et al. (2001) and Mangiaracina et al. (2015).
- Order visibility refers to the capacity of consumers to monitor and trace their order from the moment it is placed until it is delivered (Chopra, 2003; Harrington et al., 2016).
- Product availability refers to the likelihood of having products in stock when a consumer places an order. It is a measure of the possibility of having the desired products readily available for purchase.
- Product diversity refers to the total number of distinct items or stock keeping units (SKUs) available to consumers (Punakivi et al., 2001; Punakivi and Saranen, 2001).
- Product customizability refers to the capacity of products to be modified according to the individual requirements of consumers (Boyer and Hult, 2005).

#### Synthesising the relationship between LML structural and contingency variables

After identifying the structural and contingency variables, we establish a correlation between these variables and the relationships that exist between them. This relationship is established by recording the disparities between these variables and determining the correlations between certain variations of structural factors and contingency variables. Chopra (2003, p. 125) argued:

That firms catering to clients who are willing to wait longer for a response can operate with fewer sites, even if they are distant from the customers. In this case, the focus should be on enhancing the capacity of each location. Conversely, companies that cater to customers who prioritize quick reaction times must be situated in close proximity to them.

This statement establishes a connection between a structural variable, specifically "geographical scope", and a contingency variable, specifically "order response time". In the literature, two variations were identified for each variable: centralised vs localised network for geographical scope, and long versus short delivery period for order response time. Specifically, centralised geographical scope is associated with a longer response time, whereas localised scope is more responsive. The findings illustrate that by understanding the underlying reasons for connections and the differences at various levels for each variable, we may establish correlations between two sets of data, namely structural and contingency variables. By applying this process to the pertinent statements in our collection of data, Table IV provides a summary of the results.

#### Reformulation from science-mode into design-mode knowledge

We utilised the methodology proposed by Romme (2003) to transform the factual knowledge (referred to as science-mode, which was discussed earlier) into prescriptive knowledge (referred to as design-mode). This was done to make the latter more easily understandable and applicable for practitioners in their LML design thinking. This method has previously been employed to provide context for different design situations (e.g. Zott and Amit, 2007; Holloway et al., 2016; Busse et al., 2017). For instance, Busse et al. (2017) used a modified version of the method to examine how purchasing companies with limited insight into their supply chain might leverage their network of stakeholders to identify significant sustainability risks in the supply chain.

Romme (2003) differentiated between the scientific and design approaches to doing organisational research. The former refers to a type of study that is focused on representing, describing, and analysing data. It specifically examines the



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differences between variables across different time periods and/or geographical locations. The latter is practical, implementable, and exists in a more functional format to ease the transformation of existing organisational systems and situations into the desired states. In addition, Romme (2003) put out a paradigm that leverages the synergies between scientific and design modes. In order to connect science-mode and design-mode propositions, the following steps can be taken:

- If needed, redefine descriptive variables as imperative variables, which specify actions to be taken.
- Transform the probabilistic nature of a hypothesis into an action-oriented design proposition.
- Incorporate any relevant context-specific conditions and variables, drawing from other research findings in either science-mode or design-mode.
- If there are any interdependencies between hypotheses or propositions, formulate a set of propositions. For instance, consider the following scientific statement: If the time it takes for an LML network to respond to an order is short, then limited the LML network should be to specific geographical area. а The above statement can be restated as follows in terms of design-mode: [In order to obtain a short order response time, it is necessary to localise the geographical scope of an LML network]. The knowledge that describes the links between structural and contingency variables can be reconstructed into the design-mode, as illustrated in Table V, by following identical techniques. The combined knowledge gained from the design process forms a set of guidelines for LML practitioners.

		Structural variable				
	1	Product source		Geographical scope		
Contingency variable	Manufacturer	Distributor	Retailer	Locally based	Centrally based	
Consumer geographical density	n/a	n/a	n/a	n/a	n/a	
Consumer physical convenience	n/a	n/a	n/a	n/a	n/a	
Consumer time convenience	n/a	n/a	n/a	n/a	n/a	
Demand volume	Low	Medium	High/low <sup>a</sup>	High/low <sup>a</sup>	Low	
Order response time	n/a	n/a	n/a	Short	Long	
Order visibility	n/a	n/a	n/a	n/a	n/a	
Product availability	High	Medium	Low	n/a	n/a	
Product variety	High	Medium	Low	n/a	n/a	
Product customisability	High	Medium	Low	n/a	n/a	
Product freshness	n/a	n/a	n/a	High	Low	
Product margin	High	Medium	Low/high <sup>a</sup>	Low/high <sup>a</sup>	High	
Product returnability	n/a	n/a	n/a	High	Low	
Service capacity	n/a	n/a	n/a	n/a	n/a	
		Structural variable				
	Mo	Mode of distribution			Number of nodes	
Contingency variable	Self-delivery	Consumer-	3PL	Two-node	Multiple-node	
	- E.	pickup	delivery		<u></u>	
Consumer geographical density	High	n/a	Low	n/a	n/a	
Consumer physical convenience	High	Low	High	n/a	n/a	
Consumer time convenience	High	Low	High	n/a	n/a	
Demand volume	n/a	n/a	-	n/a	n/a	
Order response time	n/a	n/a	-	Short	Long	
Order visibility	Low	High	Low	High	Low	
Product availability	n/a	n/a		n/a	n/a	
Product variety	Low	n/a	High	n/a	n/a	
Product customisability	n/a	n/a	-	n/a	n/a	
Product freshness	n/a	n/a	-	High	Low	
Product margin	Low	High	Low	n/a	n/a	
Product returnability	High	High	Low	n/a	n/a	
Service capacity	Full	n/a	Fluctuated	n/a	n/a	
Consumer time convenience	High	Low	High	n/a	n/a	

Notes: "These four cells are interrelated. The two combinations, namely "high margin and low volume" and "low margin and high volume", can both lead to sufficient incentives for a localised operation and a retailersourcing strategy. Scale of rating – fast, medium, slow; low, medium, high; and full, fluctuated



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Table IV. LML design framework

#### Main research issues, gaps, and future lines of research

While the literature examined in this study provides comprehensive coverage of LML structures, it also has several shortcomings. According to the conclusions of this study, there are four primary areas that necessitate more investigation.

#### Operational difficulties in carrying out last-mile operations-

The existing body of literature has primarily concentrated on the planning component of LML, rather than delving into the operational difficulties. As a result, research generally adopts a simplified approach by focusing on individual links in the chain of LML. This is done in order to create straightforward guidelines for practitioners. Although this method may have been appropriate in the time before digital technology, it is insufficient for comprehending the intricacies of last-mile activities in the omnichannel setting (Lim et al., 2017). The exclusive emphasis on LML nodes as being only unifunctional is likewise insufficient (Vanelslander et al., 2013). Failure to recognise the multi-functionality of individual nodes hinders comprehension of the operational mechanisms of this variation. In order to overcome the shortcomings of existing research, we suggest expanding the current research to include the examination of interconnected networks, which are more commonly utilised in the industry, in addition to the analysis of linear point-to-point LML "chains" (e.g. Chopra, 2003; Boyer and Hult, 2005). Conducting research on the use of 3PL shared by several companies in LML systems is an essential area for future investigation. Additionally, we suggest that future study should focus on investigating the various functions performed by specific nodes within an LML system. The paper examines the capacity of an LML node to function as both a producer and a distributor, which introduces additional structural variability and requires theoretical consideration.

In addition, the current body of study mostly concentrates on comparing the performance outcomes of different structural variants and their associated consumer and product characteristics. Nevertheless, we contend that this emphasis restricts our comprehension of the ways in which LML distribution systems interconnect within the wider omnichannel system. To comprehensively study LML models, future research could incorporate configuration perspectives (Miller, 1986; Lim and Srai, 2018) alongside classic reductionist approaches (e.g. Boyer et al., 2009). Future research should explore the structural relationships between supply network entities and relational governance to facilitate information sharing and improve visibility.

#### Intersection between last-mile operations and "sharing economy" models

Except for one publication (Wang et al., 2016), most of the existing literature focuses on conventional LML models. There is a significant opportunity for research at the intersection of Last Mile Logistics (LML) and sharing economy models due to the rapid growth of the sharing economy. This growth has led to the emergence of innovative business models such as Airbnb, Uber, and Amazon Prime Now in various sectors including housing, transportation, and logistics. These models leverage collaborative consumption and logistics, as highlighted by Hamari et al. (2016, p. 2047) and Savelsbergh and Van Woensel (2016) Initially, we suggest conducting empirical research to investigate the optimal utilisation of crowdsourcing models by retailers for the final stage of delivery. This research aims to demonstrate the effective integration of these models into retailers' existing last-mile operations, including the incorporation of in-store fulfilment through delivery using solutions similar to those employed by Uber. Conducting this study is essential for comprehending the influence of crowdsourcing methods on retail operations and for encouraging their implementation. Furthermore, there is a growing number of studies that discuss omnichannel concerns, including those by Hübner, Kuhn, and Wollenburg (2016), Hübner, Wollenburg, and Holzapfel (2016), and Ishfaq et al. (2016). The rise of novel omnichannel distribution methods necessitates the advancement of theoretical frameworks and the identification of new design factors.

#### Data harmonization and analytics: collection and sharing platforms

The literature analysis indicated that up until now, there has been a preference for conducting studies based on geography and utilising simulated data. For instance, this review includes studies conducted in the USA (Boyer et al., 2009), England (McLeod et al., 2006), Germany (Wollenburg et al., 2017), and Brazil (Wanke, 2012), among other countries. Although these studies contribute to the creation of a valuable collection of contexts, comparing them is challenging due to variations in geography and the methods used for data collecting and analysis dependent on geographical factors. Furthermore, a significant portion (41.30 per cent) of the studies included in this evaluation relied on modelling and simulated data, which had little relevance to real-world data sets. This indicates a potential shortage of high-quality data sets. Simulated data



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hinders the expansion of domain knowledge, while the creation of real-world data sets could greatly accelerate improvement.

#### Moving from prescriptive to predictive last-mile distribution design

Existing research has shown relationships between changes in independent variables (such as order response time) and changes in dependent variables (such as degree of centralization) in order to offer specific recommendations for designing last-mile distribution architectures. Nevertheless, these correlations, whether linear or non-linear, are frequently complicated by additional factors stemming from real-world intricacies.

#### **IV.CONCLUSIONS**

This paper examines e-commerce last-mile logistics (LML) distribution patterns and the contingency variables associated with them. It uses a design framework to clarify the connection between contingency variables and operational characteristics of LML configuration. The study identifies three system dynamics (push-centric, pull-centric, and hybrid) and their associated contingency variables. Push-centric models are suitable for variety-seeking market groups, while pull-centric models improve order response time, visibility, and product return ability. Hybrid systems deliver excellent service capacity performance, particularly in availability-sensitive markets. The paper identifies four areas for further research: operational difficulties in last-mile operations, the connection between last-mile operations and sharing economy models, data harmonization and analytics, and the transition from prescriptive to predictive last-mile distribution architecture.

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