Abstract _ The purpose of this paper is to provide a clear understanding of distribution system design. Firstly, we present the three distribution systems (Push-centric, Pull-centric, Hybrid-centric) in last mile logistics. Then, we exposed the research methodology used in this study. Based on a systematic literature review, we conclude this research by determining relationships between factors impacting the distribution system design and strategic decisions (structure of distribution system/ management policy). In terms of implications, our paper provides practitioners and researchers insights on the most critical factors, as well as configurations options within limited conditions.

Keywords _ Distribution System Design ; Last Mile Logistics ; Systematic Literature Review.
1. Introduction

Distribution system design is an extremely complex process. According to (Rushton and Saw, 1992; Mourits and Evers, 1996; Mangiaracina et al., 2015), this activity can be divided into three main steps: (1) generation of configuration proposals; (2) preliminary and quantitative evaluation of different proposals, (3) system implementation (e.g.: finding the relevant localisation of facilities).

A detailed review of literature has allowed us to identify several articles that deal with the distribution system design. Indeed, most of these articles focus on mathematical models. This is the case of Vidal and Goetschalckx (1997) who modelled characteristics of these systems and factors influencing their design. Similarly, Bilgen and Ozkarahan (2004) suggested an optimisation model for facility management. In consequence, existing literature reviews ignored articles based on qualitative methods. Furthermore, they only listed a limited number of factors related to the distribution system design in last mile logistics. For this reason, we decided to carry out a detailed review of studies that address the research topic, with five main objectives: (1) clarify the important decisions based on those identified in the literature; (2) elaborate factors affecting the distribution system design in last mile logistics; (3) Examine how factors affect strategic decisions, providing practitioners with useful insights to facilitate the distribution system design process.

Our paper is structured as follows. Firstly, we present a background of distribution system in last mile logistics. Next, we describe the methodology followed. Then, we discuss the results obtained. Finally, we present the summary, limitations and implications of this paper.

2. Background: A review of distribution systems in last mile logistics

![Distribution Systems in Last Mile Logistics](image-url)

MS: Manufacturer Storage / DS: Distributor Storage / RS: Retailer Storage
B&M S: Local Brick & Mortar Store / IS: Information Store (Dematerialisation)
CDP-A: Attended Collection & Delivery Point / CDP-U: Unattended Collection & Delivery Point

Fig.1. Distribution Systems in Last Mile Logistics (Authors)
Before defining each of the last mile logistics systems, we will try to classify them according to certain criteria (Fig 1).

2.1 Push- System

Push distribution system (The product is sent to the consumer's home by a person other than him/ Fig 2) is actually the dominant form of distribution. According to (Mckinoon and Tallam, 2003 ; Boyer and Hult, 2005 ; Wang et al, 2016), the destination may be the consumer’ home or office. The delivery mode can be internal (by using the company's own fleet of cars), outsourced to a logistics service provider (3PL) or through independent operators. When retailers choose a distribution channel, they have to make trade-offs between stock levels (Netessine and Rudi, 2006), product variety and availability (Agatz et al, 2008), shipping costs (Rabinovich et al, 2008) and responsiveness (Chopra, 2003). The responsiveness of this channel increases as the source point (manufacturer's site or retail shop) gets closer to the consumer's home (Rai et al, 2020).

![Diagram of Push System](image1.png)

Fig.2. Manufacturer Storage ; Distributor/Retailer Storage / Push Sys (Chopra, 2003)

2.2 Pull- System

In the context of Pull distribution system (The product is picked up on the site by the consumer/ Fig 3), the customer must participate in the whole process of distribution. There is two options, the first refers to the classical way of buying a product in a shop, the second option concerns information flows, this option takes into account the fact that material flows (Warehousing, unloading, loading, handling, delivering & product returning) are generally more costly than information flows (Lee and Whang, 2001 ; Forman et al, 2009). It is necessary to note that despite online shopping becoming very popular, some consumers opt for traditional shopping, this can be due to several reasons, notably : theft of personal informations.
2.3 Hybrid-System

Hybrid distribution system (the product is sent to an intermediate site, and from there, the product can be collected by the consumer/ Fig 4) allows the use of transport means such as the double train, to deliver large quantities of goods into distribution centers. Then, the distribution center selects the commands and delivers the merchandise to designated points by the consumer (Lim et al, 2018). These points are called relay points. there are two types of relay points (Pick-up points, Collection & Delivery Point):

- Attended Collection & Delivery Point: located (1) in the company’s shop or (2) in a partner's shop (Wang et al, 2014);

- Unattended Collection & Delivery Point: (1) installed at the customer’s location as a stand-alone unit, (2) equipped with a docking mechanism or (3) shared in one location by several users (Fernie et al, 2010; Savelsbergh and Van Woensel, 2016).

3. Research Methodology

Authors of this study adopted an objective and systematic methodology (Fig 5). As Tranfield et al (2003) state, this type of studies carried out in three stages: planning, implementation and
evaluation. First of all, we present the research scope (Fig 6) to give an overview of the research topic. Next, we select articles that deal with our research. Finally, we conduct a detailed analysis of these papers and propose concrete recommendations for practice.

3.1 Selection of articles

This process was based on 3 steps:

Classification of context: we examined the literature related to the design of distribution system in last mile logistics taking into account the upstream and downstream supply chain, reverse logistics, but also the flow of goods transported in the city.

Collection of publications: we conducted a keyword search using internationally known databases (Scopus, Web of Science). Keywords and expressions such as "distribution system", "last mile logistics", "network design" and their combinations - allowed us to collect a high number of articles dealing with our research questions (173 articles).

Field Delimitation: After collecting a large number of papers in the previous step, we made a second selection, abstracts were assessed by authors to check whether the scope of selected papers was in line with the scope of our study. Finally, a sample of 106 papers was retained.

3.2 Review Method

In this phase, we will conduct a descriptive analysis of selected papers.
Characteristics of the reviewed papers: The first step in descriptive analysis is to identify the year of the first publication that refers to the topic of distribution system design in last mile logistics. The first paper was published in 1972 by Khumawala. The aim was to propose an efficient solution for warehouse location problem.

Selected papers were divided on the basis of their year of publication (see table 1). Three were published in the period 1970-1979, and five were published in the decade 1980-1989. The issue of distribution system design has been little discussed in the 1990s (22 articles published). The rest of papers (76) were published between 2000 and 2021. This significant increase can be justified by several factors, namely: the progressive development of global economy, the rise of e-commerce and the development of consumer consumption patterns (El Moussaoui et al, 2021).

<table>
<thead>
<tr>
<th>Period</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970 - 1979</td>
<td>3</td>
<td>0.028</td>
</tr>
<tr>
<td>1980 - 1989</td>
<td>5</td>
<td>0.047</td>
</tr>
<tr>
<td>1990 - 1999</td>
<td>22</td>
<td>0.207</td>
</tr>
<tr>
<td>2000 - 2021</td>
<td>76</td>
<td>0.716</td>
</tr>
</tbody>
</table>

Table 1: Year of publication of selected articles (Authors)

These 106 articles were published in 41 different journals. As the table 2 shows, European Journal of Operational Research is the dominant journal, followed by International Journal of Production Economics and International Journal of Operations & Production. It should be noted that these journals have multiple orientations, namely: logistics, transport, production management...

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Journal</th>
<th>Number of Publications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>European Journal of Operational Research</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>International Journal of Production Economics</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>International Journal of Operations &amp; Production</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>International Journal of Logistics Management</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Journal of Business Logistics</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Transportation Research Part E: Logistics and Transportation Review</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Transportation Research Part A: Policy and Practice</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Supply Chain Management: An International Journal</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 2: Journal pool for reviewed papers (Authors)

In the figure below, we highlight the top ten countries that published the majority of articles. United States represents the most productive country for articles, followed by China and Great Britain.
Research methods in the reviewed papers: It is possible to classify the research methods (see table 3) under three categories (Perego et al., 2011; Mangiaracina et al, 2015): (1) Conceptual models: general classifications/frameworks ; (2) Quantitative models: simulation techniques/ mathematical models ; (3) Empirical models: case studies/ investigations/ interviews.

<table>
<thead>
<tr>
<th>Type of models</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual Models</td>
<td>11</td>
<td>0,103</td>
</tr>
<tr>
<td>Quantitative Models</td>
<td>87</td>
<td>0,820</td>
</tr>
<tr>
<td>Empirical Models</td>
<td>08</td>
<td>0,075</td>
</tr>
</tbody>
</table>

Table 3: Research methods in the reviewed papers (Authors)

Conceptual Models: In this research, we have selected 11 theoretical and conceptual articles that aim to provide a framework and/or a classification of factors that have an impact on the distribution system design in last mile logistics. In terms of conceptual frameworks, Payne and Peters (2004) proposed a model for reducing costs and improving services. Similarly, Lovell et al (2005) developed a framework for configuring the last mile distribution system taking into account product availability and value. Other papers have focused on the classification of decisions (transport selection, inventory policy, facility location) which influence the design of distribution system (Ballou, 1977; Mangiaracina et al, 2015). Simultaneously, (Chopra, 2003; Lim et al, 2018; Alexander et al, 2019) have classified some factors impacting the design of this system, namely: product characteristics (e.g. product weight and volume), and service requirements (e.g. product return)...

Quantitative Models: The table above shows that 87 of the 106 articles focus on a quantitative approach. In order to detail these studies, we have classified them on the basis of the following criteria:

(1) Type of model (simulation techniques/ optimization models): (Klose and Drexl, 2005; Selim
and Ozkarahan, 2008; Barcos et al, 2010; Dasci and Verter, 2001; Lin, 2010; Gumus and Bookbinder, 2004; Han and Damrongwongsiri, 2005); (2) Objective of model (cost minimization, target service level, profit maximization, multi-objective) : (Dogan and Goetschalckx, 1999; Chopra, 2003; Verrijdt and de Kok, 1995; Canel and Khumawala, 1996; Melachrinoudis and Min, 2000; Beamon, 2000; Melachrinoudis et al, 2005); (3) Model assumptions (single product, single sourcing, single facility, limited capacity, multiple products, unlimited capacity): (Miranda and Garrido, 2004; Amiri, 2006; Eben-Chaime et al, 2001; Melkote and Daskin, 2001; Meepetchdee and Shah, 2007).

Empirical Models : As we mentioned above, empirical articles are based on case studies and interviews. Two of these articles were realised by (Abrahamsson, 1993; Abrahamsson and Brege, 1997) whose main objective was to study the impact of warehouse centralisation on distribution cost and service level. In contrast, researchers (Hilmola and Lorentz, 2011; Lim et al, 2018) have observed that warehouse capacity increases progressively over time. This finding has been justified by: the development of new consumption patterns and the improvement of the delivery process (El Moussaoui et al, 2021).

4. Results & Discussion

4.1 Review of identified decisions in the literature

After describing the different research methods, we will concentrate on decisions regarding the design of last mile distribution system. According to (Ballou, 1977 ; Mangiafaracina et al, 2015), there are two types of decisions (Table 4), namely : structure of distribution system (configuration of the network) and the management policies (activities carried out after the implementation of distribution system).

<table>
<thead>
<tr>
<th>Decisions</th>
<th>System Structure Decisions</th>
<th>Management Policy Decisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location of Warehouse</td>
<td></td>
<td>Transport Itinerary Planning</td>
</tr>
<tr>
<td>Number of Warehouses</td>
<td></td>
<td>Inventory Level</td>
</tr>
<tr>
<td>Demand Allocation</td>
<td></td>
<td>Safety Stock Allocation</td>
</tr>
<tr>
<td>Warehouse Capacity</td>
<td></td>
<td>Vehicle Fleet Management</td>
</tr>
<tr>
<td>Number of Echelons</td>
<td></td>
<td>Inventory Policy</td>
</tr>
</tbody>
</table>

Table 4 : Decisions influencing the distribution system design in last mile logistics (Authors)
As we see in the table above, decisions regarding the distribution system structure are: Location of the facility; Number of facilities; Allocation of demand; Capacity of the facility; Number of echelons. It should be noted that the first three decisions are the most discussed in the literature with 61 articles. These jointly address the topic of warehouse location with issues related to inventory level (Mangiaracina et al, 2015; Lim et al, 2018; Alexander et al, 2019). The fourth type of decisions 'facility capacity' has received little attention in the literature. According to (Melkote and Daskin, 2001), increasing the capacity of facilities leads to a decrease in their number, and thus in costs. The last type of decisions concerns the number of echelons, this aspect has been examined in theoretical and conceptual papers, unlike the remaining decisions which have been studied in quantitative and empirical papers. According to (Abrahamsson, 1993; Abrahamsson and Brege, 1997; Chopra, 2003), the number of echelons depends on demand predictability and product value.

In second category of decisions, we observed that planning of transport routes and inventory level were the most discussed topics in the literature (with almost 40 articles). According to (Ballou, 1977), these two decisions designate the basis of strategic logistics planning. The third type of decisions "safety stock allocation" was examined in conjunction with inventory level, since warehouses must have sufficient safety stock to ensure a satisfactory service level (Sourirajan et al., 2009). The fourth type of decisions is fleet management, it involves the choice of transport mode and the scheduling of shipments (Stank and Goldsby, 2000; Chan, 2006). The last type concerns inventory policy, this aspect has been discussed in 9 papers. (Mangiaracina et al, 2015) defined it as an alternative to inventory strategy, which aims to reduce costs, (Ballou, 1977; Payne and Peters, 2004) and to item fill rate, which focuses on consumer satisfaction (Miranda and Garrido, 2009; Gebennini et al., 2009).

4.2 Review of identified factors in the literature

Several researchers (Chopra, 2003; Mangiaracina et al, 2015; Lim et al, 2018; Alexander et al, 2019; El Moussaoui et al, 2021) have presented factors affecting the distribution system design in their research. Although there are different categorisations, they always imply the notion of structural and contingency factors. Based on the 106 selected articles, we will classify all critical factors that can influence the design of last mile distribution system in the table below.
<table>
<thead>
<tr>
<th>Factor Group</th>
<th>Factors</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic characteristics</td>
<td>Rate of interest &lt;br&gt; Availability of transport modes &lt;br&gt; Existing infrastructure &lt;br&gt; Restriction of legislation/ Customs</td>
<td>Lovell et al. 2005; MacCarthy and Atthirawong, 2003; Mangiaracina et al., 2015; Lim et al, 2018; Alexander et al, 2019.</td>
</tr>
<tr>
<td>Product Characteristics</td>
<td>Product type &lt;br&gt; Product price &lt;br&gt; Product variety &lt;br&gt; Product margin &lt;br&gt; Product freshness &lt;br&gt; Product handling &lt;br&gt; Product weight &lt;br&gt; Life cycle of the product &lt;br&gt; Competition level</td>
<td>Fisher, 1997; Lee et al., 2002; Payne and Peters, 2004; Ballou, 1977; Chopra, 2003; Yuan and David, 2006; Punakivi et al., 2001; Punakivi and Saranen, 2001; Boyer and Hult, 2005; Campbell and Savelbergh, 2005; Mangiaracina et al., 2015; Lim et al, 2018; El Moussaoui et al, 2021.</td>
</tr>
<tr>
<td>Demand Characteristics</td>
<td>Customers number &lt;br&gt; Density of demand &lt;br&gt; Level of demand &lt;br&gt; Seasonality</td>
<td>Meshkat and Ballou, 1996; Canel and Khumawala, 1996; Gattorna and Walters, 1996; Christopher and Towill, 2001; Stank and Goldsby, 2000; Christopher and Towill, 2001; Harrison and van Hoek, 2001; Payne and Peters, 2004; Lovell et al., 2005; Boyer and Hult, 2005; Boyer et al., 2009; Mangiaracina et al., 2015; Chopra, 2003; Lim et al, 2018; El Moussaoui et al, 2021.</td>
</tr>
<tr>
<td>Supply Characteristics</td>
<td>Suppliers number &lt;br&gt; Suppliers localisation &lt;br&gt; Nodes distance &lt;br&gt; Flexibility of production &lt;br&gt; Production capacity &lt;br&gt; Transport cost</td>
<td>Korpela et al., 2001; Ashayeri and Rongen, 1997; Gumus and Bookbinder, 2004; Ambrosino and Scutella, 2005; Creazza et al.2010; Kämäräinen et al., 2001; Mangiaracina et al., 2015; Lim et al, 2018; Alexander et al, 2019.</td>
</tr>
<tr>
<td>Service Requirements</td>
<td>Order visibility &lt;br&gt; Cycle time &lt;br&gt; Customer experience &lt;br&gt; Product returnability &lt;br&gt; Capacity of truck</td>
<td>Ganeshan and Harrison, 1995; Chopra, 2003; Harrington et al., 2016; Rabinovich and Bailey, 2004; Yuan and David, 2006; Mangiaracina et al., 2015; Lim et al, 2018.</td>
</tr>
</tbody>
</table>

Table 5: List of factors impacting the distribution system design in last mile logistics (Authors)
4.3 Links between decision issues and critical factors

Following the identification of decisions and factors affecting the distribution system design, we will try to determine some links between them. It should be noted that these links are derived from the study of the effect of factors mentioned in the table 5 on the two types of decisions (distribution system structure and management policy associated with this system). Factors with qualitative character such as: customer experience and product return, were taken into account in conceptual frameworks, while quantitative variables (e.g. distance between nodes) were applied in mathematical models and simulation techniques.

Economic variables are frequently discussed when we want to design the last mile distribution system on a global level. According to (MacCarthy and Atthirawong, 2003; Alexander et al, 2019), interest rate, availability of transport and existence of infrastructure are all parameters that determine the choice of facility location. This in turn can affect transport routes and vehicle fleet choice.

In terms of product characteristics, (Ballou, 1977; Campbell and Savelsbergh, 2005; Mangiaracina et al., 2015; Lim et al, 2018; El Moussaoui et al, 2021) indicate that strong competition induces retailers to provide higher service levels by locating warehouses close to customers. This shows that the group of factors "product characteristics: type, price, weight..." has a moderate effect on decisions regarding the structure of last mile distribution system and the management policy associated with this system.

The other group of factors, "Demand Characteristics", also affect strategic decisions. For example, seasonality and volatility of demand have a significant impact on inventory levels and location of facilities. Indeed, a reduced service rate engenders the need for a larger stock and for efficient transport means in terms of load and speed (Harrison and van Hoek, 2001; Chopra, 2003; Payne and Peters, 2004; Lim et al, 2018).

The fourth group of factors, "Supply Characteristics", contributes significantly to decision-making regarding the distribution system structure. For example, factors "distance between nodes" and "transport costs" allow the configuration of physical facilities, the choice of the most relevant transport mode, but also the planning of future deliveries (Ashayeri and Rongen, 1997; Chan, 2006).

From studies conducted by (Ganeshan and Harrison, 1995; Mangiaracina et al., 2015), we can say that production and inventory management are the most criteria influencing the service
quality. This allows us to note that service requirements affect both types of strategic decisions. For example, product returns (which occur when the product does not meet the customer's expectations) are expensive and cannot be easily implemented in the centralized distribution system, which leads to a decrease in customer satisfaction and consequently to a loss of their trust (Chopra, 2003).

5. Conclusion/ Limitations/ Implications

This systematic literature review led to the following conclusions: (A) There are two categories of strategic decisions, namely: the structure of distribution system and the management policy associated with this system. The first category, which includes: Location of Warehouse; Number of Warehouses; Demand Allocation; Warehouse Capacity; Number of Echelons, has been discussed in 63 articles. The second type of decisions which includes: Transport Itinerary Planning; Inventory Level; Safety Stock Allocation; Vehicle Fleet Management; Inventory Policy, was discussed in 41 papers. (B) We have developed 29 factors affecting the distribution system design in last mile logistics. These factors are divided into five groups: Economic characteristics; Product Characteristics; Demand Characteristics; Supply Characteristics; Service Requirements. (C) We examined the links between decision issues and critical factors. It was found that the factor groups: product characteristics, demand characteristics and service requirements are the most influential factors on the two types of strategic decisions mentioned above. Economic and supply characteristics also have a strong impact on decisions regarding the distribution system structure, but have little influence on decisions regarding management policies.

Like all scientific studies, our systematic literature review presents some limitations: (A) We examined a limited number of empirical studies to develop factors affecting the design of distribution system. This may impact the validity of the results. (B) Authors paid less attention to some strategic decisions, such as: type of warehouses. (C) Selected articles dealing with our research topic may have neglected some factors affecting the design of distribution system in last mile logistics.

This paper provides researchers and practitioners with valuable informations: (A) A clear and detailed view of the various strategic decisions gives researchers and practitioners an overview of the choice of the best decision that should be considered in the process of distribution system design. (B) The profound and structured knowledge of factors influencing the design of distribution system allows decision-makers to understand the nature of distribution problems.
that they are facing. (C) The links between strategic decisions and factors affecting the distribution system design allow practitioners to know whether necessary factors have been taken into account, and to understand the consequences of unexpected changes.

References


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