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***Abstract:***

*The concept of the physical internet (PI) is changing and reshaping the business environment of logistics along with the cutting-edge technologies and innovations and is rapidly evolving towards last mile delivery (LMD). Implementing new solutions in LMD are particularly essential to meet growing demand, respond to increased operational complexity and enhance efficiency and sustainability. The PI-driven LMD requires new features and capabilities to combat all these challenges. Therefore, there is a need to understand the performance requirements that contextualize the relationships among people, process, and technology (PPT). In this study, a PI-driven LMD framework based on PPT theory is proposed. First, a systematic literature review is conducted to explore the state of the art of academic and practitioner articles and projects on LMD and PI. Then, a thematic analysis is carried out to analyze the requirements of the PI-driven LMD from the perspective of PPT to interpret performance challenges and successes. The main contribution of this study is to investigate the performance related requirements of PI-driven LMD according to PPT perspectives. The findings show that PI-driven LMD improves delivery performance, security, privacy, transparency, and traceability performance as well as customer service performance.*

***Keywords:*** *last mile delivery, physical internet, collaboration, hyperconnectivity, technology adoption, performance, logistics operations, city logistics*

***Conference Topic(s):*** *business models & use cases; distributed intelligence last mile & city logistics; omnichannel & e-commerce logistics; PI impacts; technologies for interconnected logistics (5G, 3D printing, Artificial Intelligence, IoT, machine learning, augmented reality, blockchain, cloud computing, digital twins, collaborative decision making).*

***Physical Internet Roadmap*** *(Link): Select the most relevant area for your paper: ☐ PI Nodes, ☒ PI Networks, ☒ System of Logistics Networks, ☒ Access and Adoption, ☐ Governance.*

## 1 Introduction

The Physical Internet (PI) is a new logistics paradigm that aims to create a hyperconnected and standardized global logistics network by applying the principles of the digital Internet to physical objects and transportation systems (Montreuil 2013). The PI vision allows for large-scale collaboration among logistics stakeholders, including shippers, carriers, warehouse operators, and retailers through shared assets, information, procedures, and standards, as well as flow alignment (Montreuil, 2011). Due to these characteristics, hyperconnectivity reduces the separation of individual companies and enables them to collaborate more closely in their delivery operations. Hyperconnectivity helps create a more efficient and resilient logistics network.

Last-mile delivery (LMD) logistics, particularly in urban areas, is often inefficient and costly. It is estimated that up to 40% of the transport costs for a product are incurred in the LMD (Mangano et al., 2021). Additionally, city logistics is responsible for over 20% of urban traffic congestion (World Economic Forum, 2020), which can cause delays and increase the overall cost of delivery. The continued growth of e-commerce has also led to an increase in the number of smaller deliveries being made more frequently to more destinations. These challenges can potentially result in inefficiencies such as idle capacity of assets, poor use of transport mode infrastructure, and inadequate and non-integrated business systems (Plasch et al., 2021). These challenges can be overcome by applying a PI in LMD that supports a structural shift from the current way of operating to an open and shared delivery system.

This study proposes a theory-based framework for PI-driven LMD to investigate the performance requirements of the concept from the viewpoint of people, process, and technology (PPT). The framework aims to provide insights into the challenges and successes of PI-driven LMD and to contextualize the relationships between PPT and their impact on system performance.

The study includes a systematic literature review combined with a thematic analysis to identify the performance requirements of PI-driven LMD. The findings suggest that PI-driven LMD can improve (i) delivery performance through improved delivery speed, increased delivery reliability, cost effective delivery; (ii) security, privacy, transparency, and traceability performance through increased transparency, as well as (iii) customer service performance through increased convenience and increased customer loyalty. PI-driven LMD achieves these goals by providing seamless hyperconnectivity and scalability in the LMD network, standardizing processes, automating tasks, and promoting interoperability. However, such expositions are unsatisfactory from the perspective of PPT and the effect of these aspects on the performance of the PI because there is no systematic study in the literature to explore this context. This is the main aim of this research.

# 2 Research Background

## 2.1 Physical Internet

The PI is an ongoing novel approach to performing logistics operations that has been investigated in various studies. This concept fundamentally changes the process of how goods are transported and delivered by creating a global, open, and interconnected logistics system. It is based on the idea of creating a logistics network like the Internet, where goods are transported using standardized containers and protocols, and where logistics providers can collaborate and share resources to increase efficiency and reduce waste. The PI is defined as a “hyperconnected global logistics system enabling seamless open asset sharing and flow consolidation through standardized encapsulation, modularization, protocols and interfaces” (Montreuil, 2015). Although there is no unique definition of hyperconnectivity, it refers generally to intense collaboration through shared assets and information, common standards, procedures, and alignment of flows.

In the current logistics system, data and asset sharing are limited because of the lack of open connections and collaboration among the system actors. Concerning the collaboration in the hyperconnected network setting, various stakeholders can share the same transport network by using standardized transport units and protocols (Ballot et al., 2014). It is important to acknowledge that hyperconnectivity alters the way logistics operations are carried out in comparison to the current system. Many actors are involved in the PI-enabled hyperconnected logistics networks, and they are not always bound by an agreement based on previous collaboration or performance. The PI operations are unique in that they allow users to connect with others through an open, shared, and transparent network structure. Due to these characteristics, the requirements of the PI and its influence on the overall network performance play an important role in successful PI implementation.

To achieve the vision of the PI, various technologies and innovations are required, such as the development of intelligent transport systems (ITSs), the standardization of container sizes and interfaces, and the use of data analytics and artificial intelligence (AI) to optimize logistics operations.

## 2.2 PI-driven last mile delivery

By creating a network of interconnected logistics hubs, the PI changes the way goods are transported and delivered, similar to the way the Internet connects computers and servers. The PI concept has the potential to make LMD more efficient and sustainable, where goods are transported from a local hub to the end customer. Last-mile logistics is regarded as the most challenging and expensive part of the logistical system (Brown and Guiffrida, 2014). This involves navigating through congested urban areas, dealing with traffic, and finding appropriate parking. By breaking down traditional barriers between companies and fostering collaboration between logistics providers, the PI could enable seamless and cost-effective delivery of goods in last-mile logistics. For example, the PI could enable a more efficient use of resources, such as vehicles and urban hubs, by sharing them among different logistics providers (Treiblmaier et al., 2020). It could also enable more efficient routing and scheduling of deliveries, based on real-time traffic and demand data (Crainic and Montreuil, 2016). Moreover, the PI concept offers innovative business models towards hyperconnectivity such as crowd-sourced logistics to provide cost-efficient and environmentally friendly LMD alternatives (Rougès and Montreuil, 2014; Raviv and Tenzer, 2018). Overall, the PI vision has the potential to transform the way goods are delivered, making LMD more sustainable, efficient, and cost-effective. However, it is obvious that collaboration between stakeholders is crucial to realize the benefits of the PI.

## 2.3 PPT Framework

This study is based on PPT theory which consists of people, process, and technology perspectives. The PPT framework considers that people, process, and technology are all important factors in achieving organizational efficiency, and that optimizing the interactions between these three elements can lead to better outcomes in overall system performance (Morgan and Liker, 2020). Employing this perspective, PPT is recognized as a framework aiming to improve the overall organization (Prodan et al., 2015). From the LMD perspective, this framework can improve and optimize logistics operations by defining the value streams of PPT and mapping these by considering system performance.

By understanding how these factors interact, businesses can identify opportunities for improvement and implement strategies that enhance performance and drive success. Balancing between the PPT factors can result in optimal system performance (Morgan and Liker, 2020). The framework proposed in this study is used to reveal the interactions of people, process, and technology to bring better performance outcomes in PI-driven LMD.

# 3 Methodology

## 3.1 Systematic Literature Review

A systematic literature review (SLR) was conducted to search the related literature to identify requirements of PI-driven last mile from a people, process, and technology perspective. According to Tranfield et al. (2003), the SLR follows the following protocol.

(i) Identifying academic databases: The academic research databases were identified:

Databases. Web of Science, Scopus, Science Direct, Springer, IEEE Xplore, Emerald, Sage.

Due to the physical, digital, social, and business nature of last-mile logistics, we also included grey literature (i.e., technical papers, consulting reports, project deliverables and white papers written by practitioners) that can be collected from search engines (e.g., Google) in our search to better capture the state-of-the-art performance indicators.

(ii) Identifying search string: The databases are searched by using the following search string in title, abstract, and keywords:

Search strings. TITLE-ABS-KEY {("logistics" OR "deliver*" OR "transport*" OR "distribution") AND ("last mile" OR "last-mile" OR "lastmile" OR "parcel") AND ("Physical Internet" OR "collaboration" OR "cooperation" OR "cooperative" OR "collaborative" OR "joint*" OR "interconnect*" OR "hyperconnect*")}. Limit to: Doctype (article, review, grey literature)

Since there is not enough PI research in LMD, we extended the scope of the literature search by integrating collaboration and hyperconnectivity. Based on the search strings used, 58 initial studies were found from identified databases.

(iii) Screening of the studies: The following inclusion and exclusion criteria were applied. Duplications were removed.

Inclusion criteria: Title, abstract, and keywords shall demonstrate last mile logistics as the clear focus/object of the research. The search has not been limited to specific journals to include all potentially relevant studies. Articles shall be written in English, as English is the dominant language in logistics and supply chain management research. Articles shall be published in peer-reviewed journals. Only peer-reviewed journals as articles and review papers were taken to ensure quality control. Refer to grey literature sources used for related evidence syntheses. Published non-commercial grey literature was searched.

Exclusion criteria: Studies focusing on humanitarian logistics, telecommunications networks, public transportation, crisis management, tourism, and agriculture shall be excluded. This review focuses on the last mile from a business logistics and management perspective.

After applying inclusion/exclusion criteria, 45 studies were selected to review.

(iv) Selection of primary studies: The authors reviewed the studies according to introductions and conclusions. Then they read the full text of the remaining studies. The studies that are out of scope were excluded from the list. Thus, the primary list of studies was finalized. We found 39 studies to pursue a thematic analysis.

## 3.2 Thematic Analysis for SLR

Thematic analysis is done to extract the data. In this method, data obtained and refined in the SLR is analyzed to identify, analyze, and report themes (Braun and Clarke, 2006). Thematic analysis focuses on summarizing studies by identifying themes in the literature that are appropriate for the research. Since this study focuses on the performance requirements of PI-driven LMD, the themes identified should be aligned with the purpose of the study. The steps of thematic analysis method are as follow (Braun and Clarke, 2006):

(i) Familiarize the data: The authors get familiarized with the data by repeated reading of data. This will also help understand the performance requirements of PI-driven LMD.

(ii) Code the data: Initial codes are generated accordingly to answer the research question. For this, this circle is applied: Identify the requirement, identify where this requirement is needed. Categorize the study how the requirement is identified as an empirical or non-empirical. Repeat the steps, until all requirements identified in the literature are mapped.

(iii) Translating the codes into themes: All codes that are identified in the previous step are studied, narrowed down, and categorized.

(iv) Reporting the themes: All codes are mapped. Three different themes were created according to the PPT framework from the analyzed data, and the answers were evaluated to ensure the research gap was answered correctly. The results are presented in the findings section.

# 4 Findings

In this section, the results of thematic analysis are presented. The refined data is analyzed, and the requirements are identified according to the PPT framework provided in the Appendix. Then, the findings for PI-driven LMD requirements are categorized into three PPT themes. The details of the findings are as follows:

## 4.1 Person Requirements

For PI-driven LMD, it is important to identify human resources requirements.

- IT and digital skills: A diverse and skilled workforce is required in the PI-driven LMD. The workers must have a strong understanding of new technologies and services such as self-service parcel delivery service, self-service technology, and abilities to use them effectively (Laseinde and Mpofu, 2017; Chen et al., 2018; Yuen et al., 2019).
- Availability of skilled workforce: The future urban logistics systems involve new technologies such as AI enabled robotic delivery systems, where skilled workforce is required to use new systems (Genz and Schnabel, 2021) - not only for truck driving but also for local low-emission vehicles, e-cargo bikes, microhubs and curbside space management. In addition, the local logistics labor cost needs to be considered. Organizations might either face skill gaps already or expect gaps to develop within the next years (McKinsey, 2020).
- Adaptability to change: The workers must be adaptable to more specialized roles and responsibilities aligned with new technology changes and willing to learn new skills as needed (Genz and Schnabel, 2021). This might include training in new technologies, software systems and/or delivery methods for human capacity building, skills acquisition, and human capital building. To do this, there is a need for adequate reskilling services and new foundational education models (McKinsey, 2020).
- Customer-service skills: To ensure a positive customer experience, the workers need to interact effectively with last-mile customers and address their changing demands (flexible delivery time/delivery locations) and meet service expectations (e.g., same-day or on-demand delivery). Specifically, consumer service performance is affected by the features of the delivery service offered by the retailer or logistics service provider. These include but not limited to delivery time (Jara et al., 2018; Milioti et al., 2020), delivery cost (Gatta et al., 2021), reliability (Tang et al., 2021), and trust (Zhou et al., 2020) towards novel delivery services. Moreover, customer satisfaction and previous positive experiences with the use of the same technology

are expected to increase consumers' perceptions and motivation to use the service and eventually improve customer service performance.

- Health, safety, and security training: Workforce working with innovative technologies (e.g., autonomous delivery vehicles, drones, robots) must be trained to meet health, safety, and security requirements. It is essential that the workforce that needs to interact with new technologies and robots is adequately trained, equipped with the necessary tools and resources, and motivated to provide customers with the highest level of service (Janjevic and Winkenbach, 2020). Once LMD becomes familiar with automated delivery technologies, overall health, safety, and security will improve, as digital automation is thought to be safer than human activities (Kern, 2021). Automation of heavy lifting and repetitive tasks and automation of delivery vehicles will improve health and safety conditions, preventing worker injury and safety-related failures (Pauliková et al., 2021).

## 4.2 Process Requirements

Traditional LMD processes are transitioning to fit the PI-driven LMD business model. The LMD has business-to-business (B2B) and business-to-consumer (B2C) elements. The B2B element is larger than the consumer component in volume of goods, not in volume of delivery. One of the key trends in the LMD is the window for delivery for rapid order fulfillment, as more and more business and individual consumers are demanding improved tracking and quicker deliveries. The restructuring and designing processes aligned with adoption of smart technologies helps provide better customer experience in the PI-driven LMD. The process requirements below were identified concerning the PI-driven LMD.

- Standardized processes and data exchanges: PI-driven LMD offers the possibility of standardized processes, standardized data structures, integrated protocols to simplify the creation and operation of new partners (Montreuil, 2013). Standardization of processes and data exchanges is needed to increase the efficiency of processes and facilitate the consolidation of freight transport. This is also useful for having a neutral driving force to act on the basis of potential platform intelligence (Plasch et al., 2021).
- Real-time tracking and monitoring: The availability of a tracking and tracing feature can affect the reliability and trust towards a LMD service. For instance, the network of mobile parcel lockers can be redesigned in real-time, and the lockers repositioned to best serve the current demand situation (Schwerdfeger and Boysen, 2020; 2022). Additionally, utilising technologies such as GPS tracking and mobile apps can provide real-time updates to monitor and optimize and adjust delivery routes as needed (Laranjeiro et al. 2019). B2B shippers and customers can keep track deliveries via SMS, email notifications and even Google notifications. This can help to reduce delivery times and transportation costs by optimizing the use of available delivery resources.
- Flexible delivery options: Business processes for flexible delivery timing (e.g., scheduled delivery), flexible delivery speed (e.g., same-day delivery), and contactless delivery (no-contact delivery). Successful LMD operations refers to a flexible and dynamic system that can adjust to changing customer demand, traffic patterns, and other related factors that impact the delivery process (Snoeck, 2020). This type of network design can help companies optimize their LMD operations by improving delivery times, reducing transportation costs, and enhancing customer satisfaction. To develop an adaptive network design in LMD, companies can use different methods and techniques to analyse customer behavior and identify the areas with the highest demand for deliveries. This can help companies to adjust their network design in real-time, based on changes in demand patterns and other factors. For example, changing demand patterns can affect the locations of mobile parcel lockers in an area. Another key component of the PI-driven LMD operations is the use of multiple delivery channels, including

traditional delivery methods, such as trucks and vans, as well as alternative delivery methods, such as drones, droids, delivery robots and autonomous vehicles (Arishi et al., 2022; Yuan and Herve, 2022). By diversifying delivery channels, companies can improve their flexibility and responsiveness to changing customer needs, traffic patterns, and other factors that impact the delivery process.

- Adopting new delivery services: As the PI vision is considered an opportunity to interconnect people's mobility and freight logistics (Crainic and Montreuil, 2016), multiple last mile logistics services have been introduced recently aiming to improve the mobility of physical entities (Montreuil et al., 2013). While these services aim to connect passengers with freight movements in last mile logistics, they also lead to changes in consumers' decision-making processes. Rougès and Montreuil (2014) highlight several possibilities for making use of crowdsourced LMD and its advantages in the context of hyperconnected last mile logistics. Studies are showing a promising link between PI and interconnected crowdshipping (Rougès and Montreuil, 2014). Another delivery model for pickup is parcel lockers (Buldeo Rai et al., 2019). This service enables consumers to participate in the LMD operation by picking up their merchandise from a specific point. In the literature, parcel lockers are also referred to as delivery or pickup boxes, smart lockers, locker banks, and automated parcel lockers. Considering that the location of the lockers is one of the most important aspects of their use (Deutsch and Golany, 2018), there is an increasing trend towards lockers being located in dense urban areas, train stations, and other high traffic areas (Poulter, 2014). Smart and/or modular lockers have been examined in the context of complex urban fulfilment flows and it has been determined that they that can diminish logistics flows through consolidation (Pan et al., 2021). Mobile parcel lockers, like mobile microhubs, allow the location of the parcel locker to be flexibly changed during the day. This capability improves accessibility for customers who also have changing delivery requirements and locations. Mobile parcel lockers can be moved with a driver (fix or swap) or autonomously by being mounted on or loaded into vehicles (Schwerdfeger and Boysen, 2022). In the PI context, connecting these innovative services in a network becomes one of the possible research directions to explore how the performance of the LMD operations can be enhanced.

## 4.3 Technology Requirements

Technology plays a significant role in the performance of PI-driven LMD. This is due to the requirements of seamless connection among different technologies and services in the PI (Leung et al., 2022). Technology related requirements can be categorized into following four categories:

- Automatization: Due to the properties of the PI, hyperconnectivity provides large collaboration among firms (Ballot et al., 2021). This immense collaboration and standardization will also require automatization of last-mile logistics services such as handling, routing, and storage (Montreuil et al., 2010; Tran-Dang and Kim, 2018; Pan et al., 2021).
- Robotization: Robotization becomes another important aspect of the PI vision. Autonomous and self-organizing logistics systems can function as enablers of the PI implementation (Pan et al., 2021). ITSs (Crainic and Montreuil, 2016), robots (Montreuil et al., 2015) and automated guided vehicles (Pan et al., 2021) are some of the topics which have been discussed in the PI domain.
- Optimization: Most of the literature concerning PI enabled hyperconnected logistics systems focuses on the economic, environmental, and societal impacts of this paradigm, calculating these by applying either optimization models or simulation studies (Treiblmaier et al., 2020). Lowering the transportation cost and reducing the negative impacts of last-mile deliveries are two important aspects found in optimization studies (Ji et al., 2019; Crainic et al.,

2020). The possible impact of hyperconnectivity is studied in several research directions. Banyai (2018), for instance, uses heuristic optimization to explore the effect of hyperconnectivity on energy consumption. The study reveals varied energy savings depending on the optimization constraints. Finally, the research shows that collaboration among logistics service providers has the potential to reduce energy use. Another study focuses on modular production in the PI context (Fergani et al., 2020). By applying mixed-integer linear programming, the authors show computational performance of the developed model. The research provides evidence that PI has the potential to deal with economic and environmental drawbacks of the production process by enabling modular production in open facilities.

- Digitalization: Digitalization and corresponding digital technologies are invading all aspects of the logistics chain. AI and big data optimization and planning systems, the Internet of Things for enabling ITSs, automated storage and retrieval systems are all potential elements of a future based urban logistics system. The individuals who operate these systems will no longer be hired because of their ability to handle the manual tasks of unloading, putting away, picking, and loading boxes. These tasks will be performed in an automated manner using robots or similar automated mechanisms. The individuals working in these highly automated systems will need to be capable of handling and controlling their automated partners and performing maintenance functions to ensure that the automation is able to provide the on-demand services that customers will require (Walwei, 2016; Konle-Seidl and Danesi, 2022).

## 5 Discussion

PPT is a useful framework to achieve optimal system performance outcomes through people, process, and technology innovations. The analyzed requirements of PI-driven LMD from the PPT perspective result in improved performance outcomes namely improved delivery speed, improved delivery reliability, increased transparency, cost effective delivery, increased convenience, increased customer loyalty. Figure 1 shows the proposed PI-driven LMD performance model according to PPT theory.

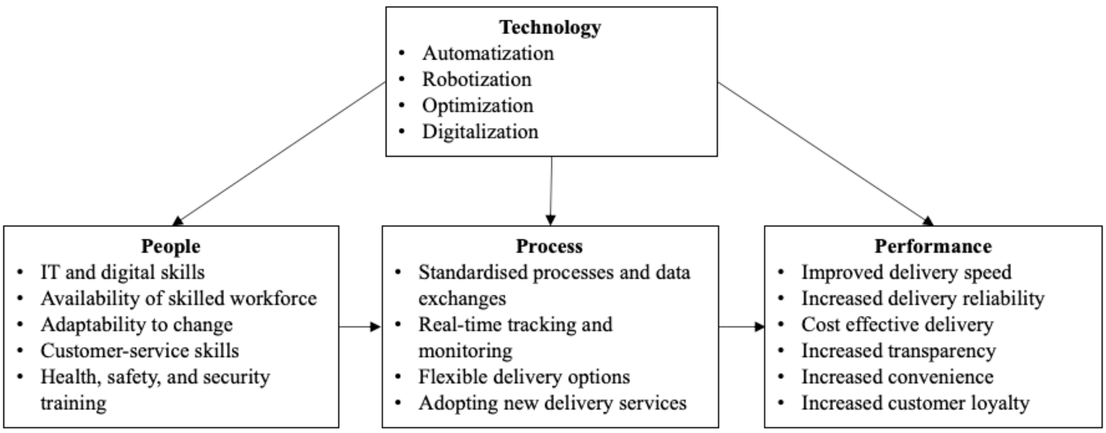


*Figure 1 Theory-based PI-driven LMD performance model according to PPT*

Based on both observations and qualitative data, the following performance outcomes are identified, and propositions can be proposed:

- Improved delivery speed: PI-driven LMD enables shorter travel routes and better geographical coverage through people, process, and technology innovations to increase operational efficiency, reduce complexity so that to improve delivery performance.

- Increased delivery reliability: People are prone to errors, including manual errors, judgement errors, and knowledge errors during the collection process. However, the use of innovative technologies such as smart lockers and improved processes can maintain a high level of technical delivery reliability which can positively influence functional benefit and provide error-free service performance.
- Cost effective delivery: the use of low- or zero-emission vehicles such as electric vans, e-cargo bikes, autonomous vehicles (road-robots, drones, droits) reduce greenhouse gas emissions and meet net-zero goals and achieves cost effective delivery performance standards.

P1: Developing a dedicated PI-driven LMD strategy will improve delivery performance.

- Increased transparency: PI-driven LMD enables higher transparency and traceability of information, improve governance standards, and engender trust across stakeholders through people, process, and technology innovations to increase value chain efficiency and improve information flow between different entities in supply chain.

P2: Adopting adequate technological solutions will improve security, privacy, transparency, and traceability performance.

- Increased convenience: PI-driven LMD offers flexible delivery options including delivery to a specific location, such as a workplace or a locker, or delivery at a specific time. Offering such delivery options through people, process, and technology innovations can improve customer satisfaction and reduce the number of missed deliveries, leading to a more efficient and effective LMD system.
- Increased customer loyalty: In highly competitive LMD markets, great attention is paid to customer satisfaction in the service sector and improving service quality and maintaining customer loyalty through people, process, and technology innovations.

P3: A well designed responsive customer support in the PI-driven LMD will improve customer service performance.

# 6 Conclusion

The present study makes a significant contribution to identifying the performance requirements of a PI-driven LMD according to people, process, and technology, that drives stakeholders (e.g., LSPs, shippers) to be involved in a PI network. The requirements according to PPT were investigated and determined through the SLR combined with a thematic analysis. Then, the determined requirements were used to develop theory-based PI-driven LMD performance model, where the three propositions were proposed with several performance outcomes. This study has a limitation, as it is solely based on available literature to understand the current conditions of PI-driven LMD. In the future, an empirical study will be conducted with Living Labs (LLs) of European cities as open innovation ecosystems in real-life environments to reflect the future performance requirements of PI-driven LMD.

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**APPENDIX:** Thematic Analysis for identification of requirements according to the PPT framework

| Category | Category Features | Requirements Identified | Resources |
|---|---|---|---|
| Person | Distribution/warehouse center manager, dispatchers, drivers/deliverers, IT personal | Technological expertise, digital skills, technology acceptance, | Laseinde & Mpofu (2017); Chen et al. (2018); Yuen et al. (2019) |
| | Skill gap, digital divide | Skilled human power | McKinsey (2020); Genz & Schnabel (2021) |

| | | | |
|---|---|---|---|
| | Adequate reskilling services and new foundational education models; investment in human intellectual capacity | Change management, skills acquisition, human capacity/capital building, | Laseinde & Mpofu (2017); McKinsey (2020); Genz & Schnabel (2021) |
| | Positive customer experience, on-demand delivery requests | Customer-service skills | Jara et al. (2018); Milioti et al. (2020); Zhou et al. (2020); Gatta et al. (2021); Tang et al. (2021) |
| | Human-robot interactions, elimination of activities in a hazardous work environment | Health, safety, and security training | Janjevic & Winkenbach (2020); Pauliková et al. (2021); Kern (2021) |
| Process | Standardized processes and structured data exchanges | Standardized processes and data exchanges | Montreuil, (2013); Plasch et al. (2021) |
| | GPS tracking, mobile apps, RFID tags, sensors | Real-time tracking and monitoring | Laranjeiro et al. (2019); Schwerdfeger & Boysen (2020, 2022) |
| | Flexible timing, scheduling, on-demand services, contactless delivery | Flexible delivery options | Snoeck (2020); Arishi et al. (2022); Yuan and Herve (2022) |
| | Service design for B2B and B2C LMD processes. There are typically five B2C LMD processes: Online shopping, packing process, delivery process, pickup process, return process | Adopting new delivery services | Huang et al. (2009); Montreuil et al. (2013); Rougès & Montreuil (2014); Crainic & Montreuil (2016); Deutsch & Golany (2018); Buldeo Rai et al. (2019); Schwerdfeger & Boysen (2022); Pan et al. (2021) |
| Technology | Automated routing, storage, and routing | Automatization Self-service technology | Montreuil et al. (2010); Tran-Dang & Kim (2018); Chen et al. (2018); Pan et al. (2021) |
| | Innovative LMD services such as sidewalk robots, drones, droits, and smart lockers | Robotization | Montreuil et al. (2015); Crainic & Montreuil (2016); Pan et al. (2021) |
| | Delivery route optimization, cost minimization, minimization of negative environmental effects, profit maximization, energy consumption, stationary/mobile facility location optimization, low- or zero-emission vehicle integration | Optimized vehicle routing, shorter trip detour and better geographical coverage | Bányai (2018); Ji et al. (2019); Treiblmaier et al. (2020); Crainic et al. (2020); Fergani et al. (2020); Ghaderi et al. (2022) |
| | Mobile applications and digital platforms | Digitalization | Walwei (2016); Konle-Seidly & Danesi (2022) |