Review

Toward a Modern Last-Mile Delivery: Consequences and Obstacles of Intelligent Technology

Shahryar Sorooshian [1,2,3,*], Shila Khademi Sharifabad [4], Mehrdad Parsaee [4] and Ali Reza Afshari [4]

1 Department of Business Administration, University of Gothenburg, 41124 Gothenburg, Sweden
2 Department of Management, Apadana Institute of Higher Education, Shiraz 7187985443, Iran
3 Prime School of Logistics, Saito University College, Petaling Jaya 46200, Selangor, Malaysia
4 Department of Industrial Engineering, Shirvan Branch, Islamic Azad University, Shirvan 9461985771, Iran
* Correspondence: shahryar.sorooshian@gu.se

Abstract: Last-mile delivery (LMD) is essential in supply chains, and providers of logistics services are aware that they must adapt to changing customer and society expectations, competition challenges, and modern technologies. In light of the importance of artificial intelligence (AI) in modern technologies, this article employed a narrative literature review to recognize impacts of AI-powered technologies that aid in optimizing the LMD component. For this study, two possible classes of technologies were considered: tangible technologies, such as robots, drones, and autonomous vehicles, and intangible technologies, such as decision support tools and operating systems. Thus, this article frames potential developments in modern LMD, taking into account the fact that technological advancement brings both opportunities and challenges. According to this literature review, the modern version of LMD is capable of providing services that are both more productive and more sustainable, thus satisfying demands for better services. Last but not least, another goal of this article was to look into the challenges that limit the benefits of modern LMDs. Finally, suggestions are provided as a resource for practitioners and policymakers working in the supply chain to improve performance.

Keywords: last-mile delivery (LMD); artificial intelligence (AI); tangible and intangible technologies; benefits and challenges

1. Introduction

Transportation is an important logistical activity that transports goods from their point of origin to distribution centers and end users [1]. The characteristics of product quality are unknown [2]; however, on-time and correct delivery is critical to a company's reputation and ability to service its consumers [1]. The concept of the "last mile" has evolved into a challenge that transportation logistics is increasingly focusing on today [3,4]. The process of last-mile delivery (LMD) starts with a template warehouse near the customer's location and continues for a few miles to the specific customer [1,3,5–7].

The package may have a variety of destinations and pickup places depending on the kind of delivery requested by the client, such as doorstep delivery (attended), doorstep delivery (unattended), reception boxes, or post offices [8]. Last mile in supply chain management and transportation planning is the last leg of a journey comprising the movement of people and goods from a transportation hub to a final destination. Indeed, the last mile has received an increasing amount of attention in recent years as a result of the rise in e-commerce [9–13], particularly during COVID-19 [14,15]. The rapid growth of online purchasing has increased demand for LMD, with consumers preferring home delivery over all other options [16]. Consumers want more online orders, faster delivery, and flexible delivery methods [17]; nevertheless, knowing that all initiatives are plagued by delays and inefficiency [18], late or damaged deliveries can have a negative impact on customers,

resulting in dissatisfaction and complaints [19,20]. LMD refers to the transportation of goods from a distribution hub to a final destination, such as a home or business. The term is commonly used in the contexts of food delivery, enterprise supply chains, and delivery business transportation [21,22]; moreover, the increasing complexity of LMD has been exacerbated by the recent expansion of e-commerce and the new normal [23]. Consumers are demanding not only more online orders and faster deliveries, but also more flexible delivery methods [17]. Furthermore, the delivery experience must be satisfactory in order for customers to return with additional orders [24]. As a result, even though LMD was originally regarded a support function rather than a vital component of the business model, it has become a must-have component for enterprises [17].

Nonetheless, LMD presents several challenges for businesses, including high costs and environmental issues [19,20]. Hence, because almost every order has a different destination and address, optimizing the delivery route is crucial, the delivery process should be modernized. Congestion, snow, lack of parking, and incorrect customer addresses are examples [25] that can cause delivery delays, higher supplier costs, and higher emissions. Customers who are not home when deliveries arrive add to LMD costs and emissions. Operators frequently travel more than necessary to transport packages many times or to the local post office for extradition [6]. Furthermore, because pollution is a concern and industrial activities (including supply chains) should conserve the environment, increased awareness contributes to a focus on environmental protection [26–28]. Nonetheless, researchers have documented that LMD is one of the most inefficient supply chain processes and causes a lot of financial burden, air, and traffic pollution [8,29,30]. All of these issues make it difficult to keep LMD services sustainable, but customers expect lower distribution costs, lower emissions, and shorter delivery times as e-commerce competition increases. Logistics, including LMD, is essential to good customer service and can add value when choosing a provider [31]. The last mile is the final stage of a process, particularly for a customer purchasing goods. Therefore, in the context of transportation, supply chain, manufacturing, and retail, the last mile refers to the delivery of products as the final leg of transportation. Organizations must develop new technologies and business models to remain competitive in e-commerce. LMD complexity to meet customers' expectations for speed, timeliness, accuracy, and individual delivery precision drives many businesses to strive for faster, better, and more reliable LMD than ever before [32,33]. Furthermore, LMD is the least efficient process, accounting for up to 50% of total delivery costs; thus, improving LMD could help companies save money on their delivery process [6,34].

Various businesses are currently looking for new ways to create and generate value using new technologies [35]. This could include robots or driverless trucks and vehicles, which could lead to a more efficient and sustainable LMD system [36,37]. Several other innovations for improving LMD have also been introduced to help overcome the challenges. Amazon's most well-known innovative logistics system is one of these [38]. Amazon not only constructed warehouses in key cities but also created strong logistics software that streamlined the route, decreasing shipping costs by more than 30% in 2005 with enhanced delivery speed and accuracy [38]. Then, in 2009, Amazon introduced free same-day shipping in some US locations, with a customized delivery location and schedule [38]. The Last Mile team assists in delivering customer packages from delivery stations to the customer's door. Amazon has expanded its Last Mile delivery efforts, which has aided in shortening customer delivery times and providing new innovations to customers. This measure enhanced order volume and earnings while also placing Amazon as one of the most creative logistics and LMD businesses at the time [38]. While Amazon's innovative invention in LMD was useful and easy for customers, it presented a danger to other businesses. Many other businesses were obliged to follow Amazon's lead because customers came to anticipate and demand better levels of delivery services, despite their lack of Amazon's logistical and IT abilities.

Hoffmann and Prause [39], on a different topic, claim that autonomous vehicles, such as land-based robots, may be utilized for last-mile goods delivery to provide value

for a corporation. Additionally, a self-driving or robotic car refers to a type of vehicle (autonomous) that has the capabilities of a traditional vehicle and can transport things and humans. A person can select a destination for themselves, and they do not need to perform any physical tasks in the car to get there. A self-driving car, like all autonomous vehicles, can navigate by sensing its surroundings. The development of self-driving vehicles is accelerating. Starship Technologies, one of the industry's pioneers, is already deploying autonomous delivery robots to transport gifts and groceries in London and Washington, DC. These self-driving robots are capable of carrying near 3 kg of products, cost roughly EUR 5000, and travel at pedestrian speeds, delivering to consumers within a 4-mile radius [40,41].

According to Goel and Gupta [42], the current industrial revelation is a modern technology era in which industry will use technologies such as robotics, automation, and artificial intelligence (AI) to perform tasks intelligently while focusing on safety, flexibility, and collaboration [43]. Existing operational capabilities are dependent on knowledge, innovation, and technology; however, Moshood et al. [44] explain that technology can indeed be viewed as a means to improve knowledge sets. Even the logistics and supply chain industry reported cost reductions, improved organizational strength, and best practices due to technology, specifically AI implementation [45]. Alternatively, as another example, it is argued that when logistics providers could improve customer service through access to real-time data via modern technology, reducing disputes and making it easier to identify incidents through network optimization [46]. As a result, the goal of this literature review is to frame and maximize the best modern technologies in LMD.

When researching this article, the authors formulated a search in the Scopus database as: (TITLE-ABS-KEY ("last-mile delivery" OR "last-mile delivery" OR "last-mile logistics" OR "last mile logistics") AND TITLE-ABS-KEY ("Technology" OR "technologies" OR "Artificial intelligence")). The authors conducted a Scopus database search for this purpose: based on the outcome, and despite the importance of the topic, only the last five years have observed motivating trends in scholarly interest. Table 1 shows the most recent journal publications as a showcase, but none of the previous attempts have covered the goal of this article. Thus, this article is expected to fill an existing gap in the literature; however, due to a lack of classified archived literature, the authors chose to write a narrative literature review to achieve their research goal.

Table 1. Published articles in 2022.

Authorship	Article Title
[47]	Enhancement of E-commerce service by designing last mile delivery platform.
[48]	Ground vehicle and UAV collaborative routing and scheduling for humanitarian logistics using random walk-based ant colony optimization
[49]	Introducing the benefits of autonomous vehicles to logistics during the COVID-19 era
[50]	Optimization and machine learning applied to last-mile logistics: A review
[51]	From traditional warehouses to physical internet hubs: A digital twin-based inbound synchronization framework for PI-order management
[52]	An active-learning pareto evolutionary algorithm for parcel locker network design considering accessibility of customers
[53]	Drone routing problem model for last-mile delivery using the public transportation capacity as moving charging stations
[54]	How will last-mile delivery be shaped in 2040? A delphi-based scenario study

Table 1. *Cont.*

Authorship	Article Title
[55]	Point-to-point drone-based delivery network design with intermediate charging stations
[56]	Learning to navigate sidewalks in outdoor environments.
[57]	Investigating last-mile delivery options on online shoppers experience and repurchase intention
[58]	Optimizing future cost and emissions of electric delivery vehicles
[59]	Energy-aware computation management strategy for smart logistic system with MEC
[60]	Reinforcement learning for logistics and supply chain management: Methodologies, state of the art, and future opportunities
[61]	Implementing E-commerce from logistic perspective: Literature review and methodological framework

The rest of this report is divided into three sections. The first defines the modern LMD. The second presents applications of modern LMD. Following that, the challenges of modern LMD are regarded. Finally, a conclusion is supplied.

2. Toward Modernity

AI has its roots in cybernetics [62], but today, it can learn and expand, assisting people in overcoming obstacles and gaining knowledge; it now has generic definitions and has become an umbrella term encompassing machine learning (ML), big data, and deep learning (DL) [62]. AI is the core of intelligent technologies, and it refers to a system's ability to accurately read external data, learn from it, and apply those learnings to achieve specific goals and tasks through flexible adaptation [63]. Woschank, Rauch, and Zsifkovits [64] describe these three technologies in depth and demonstrate the benefits of each. AI, or artificial intelligence, is the study and creation of intelligent machines, primarily computer software. Machine learning (ML), a crucial component of AI, is concerned with discovering significant patterns in massive datasets in order to provide computers the ability to learn and adapt based on the examination of large datasets. A subclass of machine learning (ML) that deals with AI-technologies that use non-linear information processing for supervised and/or unsupervised feature extraction, transformation, pattern analysis, and classification [64]. Natural language processing (NLP), image processing, robots, and expert systems are also stated to collect, store, and process information. These four fields' applications are becoming increasingly entwined [65]. This definition encompasses all AI subtechnologies.

The application of AI in logistics is still in its infancy. The proper application of these technologies results in significant improvements in the field of production and creates competition for businesses. Companies are concerned about falling behind their competitors as technology advances and the digital world transforms. This fear puts them under stress. However, using AI to outperform competitors can be a great solution [66]. The characteristics of this artificial are also used in a variety of businesses and it has numerous implications for organizations. The implementation of modern logistics, like current industry revaluations, is primarily reliant on AI, which brings both benefits and obstacles. Woschank et al. [64] identified the following AI applications in smart logistics: cyber-physical systems in logistics; AI, machine learning, and deep learning in facility maintenance; decision support systems and human-machine interaction; and production planning, control, and logistics operational process improvement. According to Riahi et al. [67], logistics enterprises will need AI in the future to deal with increasingly complex and dynamic global supply chains.

Other benefits of the technology include sustainability, enhanced performance and overall efficiency, and providing a competitive advantage to early adopters of the invention [36] through the precision and transparency that the technology provides to the companies [36,68]. AI is thus a technical facilitator for long-term sustainability [68]. Following that, LMD's route optimization solutions are focused on delivering faster, cheaper,

and more reliably than ever before [6]. The control of the supply chain processes is decisive in improving the productivity, which can be achieved to certain extent by measuring performance. For productive supply chain management, well defined and well controlled processes are needed [69,70]. Improving the efficiency of LMD routes is critical [6]. Another key part of business continuity is sustainability, which is concerned with the company's care for its business operations, external stakeholders, and the surrounding environment [8]. In LMD, AI is increasingly being utilized to solve problems since customers always expect better service, thus firms must keep up with technological improvements. While many businesses perceive AI as a means to developing new technologies, business models, or data-driven decisions rather than just solving issues, it is gaining popularity.

The logistics industry or supply chain, like most industries in the world today, has been affected by the advancement of AI, and this development has revolutionized the field of logistics, and the most important advances in this technology include autonomous vehicles, automation, smart roads, and intelligent analytics and forecasting. This powerful technology has enabled the simplification and automation of countless logistics processes, helping companies save money and time. Despite AI's numerous benefits and limitless potential for future growth, the logistics sector must first overcome its issues before implementing AI. Among the challenges raised are those concerning AI ethics, public policy, and implementation difficulties. Transparency and audit, accountability and legal issues, misuse protection, the digital divide and data deficit, ethics, fairness, and equity are some of the public policy challenges of AI discussed by Dwivedi et al. [71]. The literary canon emphasizes AI's reliance on data collection as well. To begin with, data gathering is complicated by the fact that it must be carried out in a method that is both efficient and lawful all around the world. Some countries permit the acquisition of big data, while others have rules that make it more difficult for the rest of the world to do so [71]. Other AI problems include the threat of AI displacing human work, organizational reluctance towards data sharing, a lack of in-house AI talent/knowledge, and a lack of an AI development strategy [71].

Because of the current e-commerce trend, logistics companies and other industry players must build flexible and efficient LMD. Regardless of the existing challenges, AI, which is capable of upgrading autonomous vehicles as well as collecting and analyzing massive amounts of data, can help to tackle LMD concerns. It considers weather, traffic, and road conditions when determining the optimum route [65]. AI, according to the criteria above, can interact with a wide range of other technologies. The next two sections will concentrate on intangible and tangible AI-based technologies.

2.1. AI-Supported Intangible Technologies toward Modern LMD

The use of groundbreaking AI in LMD may be employed as a data-driven decision-making technique [32,72,73]. Because of the recent surge in online sales, the LMD process now creates millions of data points from each client that requires delivery of their items. LMD companies may use consumer data in AI to make medium- and short-term projections for management and stakeholders [73]. The customer's data is analyzed, grouped, and categorised using pattern recognition in the first phase of the data mining process. The ML system then processes this data further to provide precise projections [73]. In addition to customer data, the LMD process may yield a variety of important information from daily delivery traffic, delivery zones, and driver performance [73]. AI will process occasional traffic and area topography to schedule deliveries with optimal performance by providing the best available route and vehicle; this will also assist drivers in deciding which alternative route to take during real-time delivery when traffic is suddenly blocked by an accident/other road congestions [73]. Furthermore, documented driver performance in the data system will help determine which driver is better in different areas to enhance the LMD process [73].

All of these data-driven AI capabilities will provide the basis for dynamic decision-making, supporting businesses and stakeholders in improving performance, forecasting,

capability, and even predictive maintenance [72,73]. This data-driven AI in LMD will also assist in addressing systematic and strategic operational demands depending on the preferences of each stakeholder, including carriers, end users, local governments, and even citizens [72,73]. Traditional logistics and non-data-driven delivery procedures that are inflexible and do not incorporate accurate AI and ML algorithms created from a broad variety of data will become outdated as they fail to solve the numerous present and future operational difficulties [72,73]. The organization that eventually advances toward data-driven AI will profit from more precise dynamic decision-making for management, allowing it to participate meaningfully in the fast-paced LMD battle [72,73].

System integration may include the addition of new technology to an existing process or system, enabling the whole supply chain to exchange real-time data and link systems [74]. Through comprehensive information in LMD, logistics management software can coordinate the whole logistics system network and enhance value. Software as a service (SaaS) allows conventional data centers or business services to be inclusive and aligned with corporate KPIs by facilitating communication across organizational systems.

Real-time information is provided via digital service systems that link all users, which may increase consumer expectations by making information more accessible and interpretable [75]. Other benefits might include real-time tracking, smart scheduling, and route optimization, which are all tied to the previously stated IoT and cloud computing technology [75,76]. Intelligent transportation systems, for example, can automatically adapt routes and scheduling to prevent congestion and meet user patterns [32,77]. Loading bay booking systems and public infrastructure improvements may enable the real-time interaction between cars and roadside infrastructure, enabling not only for the allocation of loading and unloading space but also the resolution of unforeseen delivery difficulties [32,78].

2.2. AI-Supported Tangible Technologies toward Modern LMD

For years, the adoption of robots has been increasing globally [42]. Robots are used in a variety of industries, including manufacturing, logistics, and office management (to distribute documents) [79]. Drones and robots will almost certainly be used in future logistics, particularly in areas with limited infrastructure or dense populations. Autonomous AI-powered robots and drones have lower operating costs than trucks, allowing for last-mile delivery. These electric technologies are more easily adaptable to environmental requirements [80]. AI-enabled drones and robots have impacts on LMD. AI combined with drones and robots could provide LMD solutions that are cost-effective and environmentally friendly in real-time. AI can even power self-driving drones and robots, this increases usability and simplifies processes, as AI, like human intelligence, enables planning, comprehension, and problem solving [65]. Drones or robots used for parcel delivery in urban and rural areas must have these characteristics in order to operate safely while avoiding people, cars, and other vehicles [80].

Traveling at pedestrian speeds (due to the majority of their operations taking place in crowded places), the robots acquire data about their surroundings and make their own judgments when barriers emerge, ensuring the delivery is carried out securely [81]. The recipient may follow the delivery robot remotely and know when to anticipate the package. Navigation systems include object avoidance. When a robot encounters a barrier, it will stop, alter route, and in some instances will utilize AI to signal or audibly alert the obstruction [82], reducing the chance of accidents, which are prevalent in last-mile difficulties when deliveries are made in crowded locations [82]. Drones are better described as unmanned aerial vehicles (UAVs) as they are either remotely or automatically controlled. Although they were initially controlled remotely, AI is now increasingly used to automate their functions [83]. Drones are classified based on their attributes and values, and their classification is largely determined by the intended user of the UAV, as drones have private, commercial, and military applications [84]. Commercial drones have LMD requirements, including appropriate machine weight, travel range, flight altitude and durability, take-off weight, airspace used, and the degree of autonomy, which are all important considerations [84].

Although drones differ in many ways, their basic operating system is the same; engines propel each propeller, while engine power grows in proportion to speed and lifting capacity. The speed control is responsible for connecting the battery to the motor and sending energy-release signals, the battery powers the device, and the charger allows for reuse. The GPS and camera of the drone are controlled by the on-board computer, and finally, the radio transmitter is capable of transmitting data [83]. The drone collects environmental data and installs AI. Drone sensors make this possible and this enables autonomous flight rather than remote control. Drones with AI use computer vision to find and track objects in flight and change routes without the need for programming or human intervention. AI-powered drones require sensors and data vision, so the sensors control how the drone reacts to obstacles and environmental conditions [85].

Beside drones, self-driving cars are an exciting new LMD technology [86]. Vehicle automation levels range from no automation to full automation, but in LMD, vehicles that are semi-autonomous and completely driverless are being tested in order to enhance software and hardware [32]. Many transportation corporations are making investments. Regarding this technology [87] modern autonomous goods vehicles (AGVs) used in LMD are equipped with lockers to deliver packages without the need for human intervention, though autonomous delivery robots have limited coverage, according to Chen et al. [41]. Prior to COVID-19, robots were unable to deliver LMD parcels, but now companies that operate a delivery robot service exist [41].

3. Feasibility of Modern LMD

Uses of AI-improved tangible or intangible technologies in LMD causes significant outcomes. Jucha [88] and fixlastmile [89] suggest that to be competitive in modern LMD, vehicles must be directed to the right consumer location, quantity, loaded with the right order, and deliver on time, so detecting and following the shortest, most economical route when directing vehicles is crucial. Alfandari, Ljubic, and De Melo da Silva [90] discuss how route optimization using autonomous robots from local facilities to customers can solve LMD operational challenges. The authors describe a situation in which goods are unloaded from trucks and delivered by robots. From findings, AI's optimization can reduce the delay issue. AI optimization and operations involve the application of technologies, such as advanced analytics and machine learning. This is to automate processes and problem-solving in operations and network, as well as to improve both design and optimization capabilities [91]. This study optimizes facility number and location and route, and as more facilities use robots to deliver goods, late deliveries are decreasing [90]. Jennings and Figliozzi [40] found that sidewalk autonomous delivery robots save time and increase customer satisfaction by delivering products faster. According to Schaudt and Clausen [92], finding a solution to expanding product quantities and consumer expectations is vital, and employing autonomous robots for modest deliveries over short distances would minimize late deliveries.

Logistics operators are seeing an increase in unsuccessful delivery efforts and product returns, necessitating complex delivery planning to achieve timeliness and cost effectiveness, and logistics service providers are using novel approaches to solve the issues [88], while it is evidenced that self-driving delivery robots can make faster and more efficient deliveries, according to Chen et al. [41] and Schaudt and Clausen [92]. In fact, time and cost efficiency are linked by Jennings and Figliozzi [40]. Similarly to previously discussed studies, Chen et al. [41] argue for the benefits of smart robots in faster parcel delivery, fewer vehicles on the road, and improved delivery performance. Finding the best route by robots and drones needs AI, as AI-powered platforms uses real-time environmental, geographical, traffic, shipment, and delivery data to highlight the best route, so the vehicle's navigation system can display the optimized route [93]. Personnel costs should be saved because robots do not require a salary, unlike traditional trucking, which pays the driver. They would not require breaks because of their independence [92]. AI is capable of eliminating human communication errors, as AI-powered tools can help companies

improve warehouse and transportation visibility by simplifying distribution networks and mapping capacity and equipment availability [93]. AI-powered technologies also assist firms in analyzing data, such as total daily deliveries, vehicle types utilized for deliveries, number of deliveries to specified zones/regions, route congestion, and spotting trends or patterns; as a result, companies, such as Walmart, Tesco, DHL, UPS, and Fedex, use AI-powered route planning tools [93]. DHL has deployed the "Greenplan" dynamic tour optimization tool to deal with delivery complexity. The process of determining the most cost-efficient route is route optimization. It is far more complex than simply finding the shortest path between distinct points, and needs to include full relevant variables, such as the location and number of necessary stops on the route, plus the time frame for all deliveries. Using this tool instead of traditional route optimization techniques saved 20% on delivery costs and a lot on computational time [94,95]. Additionally, Tesco's AI-powered vehicle routing and scheduling system has helped them save 11.2 million miles and 8% fuel per order [96]. In 2019, Tesla also joined the humanless LMD trend, reflecting the growing trend of AI in LMD that has created a new industry [97]. Moreover, Rahul [98] states that Walmart promises to deliver orders within two hours, as their system includes an AI-powered vehicle route planning tool that provides the best route based on real-time information, such as weather, traffic, etc., for a given delivery location.

Recently, airworthiness criteria for the type certification of delivery drones with an intent to initialize commercial operations was proposed. The delivery drone is an UAV used to transport packages, medical supplies, food, or other goods. Delivery drones are typically autonomous. Amazon has tested drone deliveries and delivered products within 30 min [99]. Many modern businesses pursue delivery time savings to gain a competitive edge and improve delivery service. According to the most recent Datex Corporation publications [100], many business models are being supplanted by AI-powered ideas, such as self-driving delivery robots and drones, which reduce the need for human interaction in delivery. Technological innovations are shifting from transactional to cognitive automation, with AI being used primarily in business decision making. Using autonomous drones reduces wage costs and human errors like negligence, disorientation, and wrong recipient delivery [101]. In fact, drones reduce wage costs and delivery times in urban areas because they are autonomous [101]. Jain et al. [102] offer a robot autonomy module for localization and navigation to overcome routing challenges in LMD, which helps with delivery routing. Casado-Vara et al. [103] suggested a novel technique that combines complicated network architecture and algorithms to produce the optimum route for delivery trucks and to guarantee items will reach customers on time while lowering trip lengths. The study found that LMD outperformed traditional systems and optimization results are unremarkable compared to AI savings.

On the other hand, among its other impacts, AI improves visibility, risk management, sourcing, and distribution in supply chains [68]., but also When it comes to AI and LMD, one of the key areas to be discussed is not only operational performance but also sustainability. It is forecasted that LMD demand will rise 78% by 2030, delivery traffic emissions will rise 32%, and congestion will rise 21%, so bringing AI into LMD is essential to achieving sustainability goals [104]. Most major cities are experiencing transportation and logistics issues due to population and vehicle growth, and LMDs increase traffic congestion and emissions. AI solutions are a valuable asset in addressing these issues, as AI with real-time vehicle data for traffic management can reduce congestion [105]. Poeting, Schaudt, and Clausen [106] propose delivery simulation models and optimizations resulting in less congestion, lower emissions, and faster deliveries. Ostermeier, Heimfarth, and Hübner [107] view the issue in the context of using robots to reduce truck mileage, which lowers local emissions by up to 60%, according to the authors' calculations, and the authors hope their findings can guide the operation and planning of a truck-and-robot LMD system. Many companies struggle with fuel emissions in urban areas with heavy traffic because their vehicles spend so much time waiting, where AGVs are mostly electronic, making them a greener last-mile solution [41,108]. In short, in conjunction with vehicle routing optimization, delivery robots

and drones can design the lowest-cost routes to meet customer demand, while reducing energy consumption and shortening delivery times [104].

AI assists businesses in lowering human costs, reducing failed deliveries, avoiding congestion, increasing speed, and lowering air emissions [109,110]. Autonomous drones or robots may improve service by delivering quick home deliveries, even in rural areas [111]. However, rural areas see more drone deliveries because lower population density means there is less incentive to set up drop-off points as often as in cities, so rural residents must travel far to the nearest drop-off point. An autonomous delivery vehicle refers to a self-driving vehicle that is capable of delivering goods from retailers on its own without human mediation. Autonomous delivery vehicles have a broad application prospect in densely populated urban areas with complex traffic road conditions due to their small size, low speed, and lower accident risk [112]. AI can minimize road accidents by understanding traffic patterns, making transportation safer and more dependable [113]. These attributes lead to the vision of LMD becoming totally autonomous and demonstrating the feasibility of constructing a sustainable transportation network with reduced accident risks.

In general, an autonomous transportation network would remove many human influences in LMD, leading to an autonomous system that could benefit last-mile companies. Autonomous transport systems provide autonomous and unmanned transfer of equipment, people, baggage loads, information or even resources from point-to-point with less intervention. They can include different range of transport vehicles, including buses, trucks, trains, ships, airplanes, and metro systems. AI and machines can improve productivity, reduce labor costs, increase safety, reduce waste, and maintain quality throughout the business process, and these advancements will increase company revenues [114]. Human replacement by robots, such as truck drivers being replaced by autonomous vehicles, raises questions about social sustainability due to people's fear of unemployment, and although this may be true, new technologies will create new job opportunities in other areas [114].

Simoni, Kutanoglu, and Claudel [37] identify a congestion benefit based on their systematic analysis. Even if robots move slowly, they can increase their time efficiency when delivering multiple orders by avoiding traffic congestion on major roads. This article suggests that this type of LMD would be advantageous for a smaller set of customers in the city center where congestion is high, since the robots may work during low-traffic hours [37]. However, it is worth mentioning that Jennings and Figliozzi [40] say that congestion has benefits but also downsides. Delivery on sidewalk robots might minimize the amount of automobiles on the road on one hand, which would be advantageous in cities where externalities are an issue, but on the other hand, negative effects include sidewalk congestion and pedestrian safety in urban areas. This, combined with parcel deliveries and customer demands for fast deliveries, increases the need for sidewalk autonomous delivery robots. Additionally, people may be concerned about the safety and regulations governing drone deliveries. The issue with drone deliveries seems to be that the packages do not have a safe landing area. They cannot open mailboxes, porches tend to be covered, and back yards often have dogs in them. Some companies have devised a method of parachute delivery but this is unreliable and dependent on weather conditions [109].

Next, according to Alfandari, Ljubic, and De Melo da Silva [90], high implementation costs and security risks make robot use in modern society difficult. For instance, United States and China have the most AI applications [105], but many of these modern LMDs can fail if local governments do not support them. Many new robot rules have been enacted by authorities; for instance, San Francisco that decided in 2017 to restrict the use of robots to specific areas and districts of the city, with a limit of three per company [39]. Virginia officials have also discussed delivery drone weight, demonstrating that many frames and standards must be finalized before AI and new LMD businesses can operate efficiently [39]. Nonetheless, according to Hoffman and Prause [39], traditional logistics services and start-ups alike are utilizing delivery robots for last-mile deliveries, underlining the importance for practitioners to be aware of the challenges ahead.

4. Challenges of Modern LMD

AI-based technologies enable modern LMD to provide services at any time, increasing customer satisfaction [108], but three types of implementation challenges (named as FFF) must be considered to achieve the best results: facilities, feedback, and frames.

4.1. Facilities

Facilities is a recurring theme in the included literature, specifically regarding what will happen when the technology is implemented on a larger scale. For one, security is a major concern, particularly in cities [41]. Other security concerns, according to Sindi and Woodman [87], are cyberattacks and unattended deliveries as drones and robots can be used for good or bad [115]. Storage facility costs and breakdowns are also impediments: without drivers, loading and unloading would be difficult. This would raise the cost of loading and unloading labor [87]. A document [87] on the characteristics of using autonomous goods vehicles for LMD raises the question of what type of existing facililties and standards must be finalized before AI and new LMD businesses can operate efficiently [39]. Facilities are required to implement autonomous vehicles. The concerns and limitations of self-driving delivery systems are discussed [37]. Simoni, Kutanoglu, and Claudel [37] were concerned about laws, safety, and the functioning of such a delivery system in busy regions where people and robots must share pathways. This type of LMD, according to Simoni, Kutanoglu, and Claudel [37], would benefit a smaller group of customers in a congested city center. Deliveries in congested city centers may aggravate security and sidewalk-sharing issues, putting a strain on facilities. Chen et al. propose a method for reducing congestion and infrastructure stress [41]. Customers would receive parcels faster with unmanned delivery, resulting in fewer vehicles on the road, according to their research.

According to Ostermeier, Heimfarth, and Hübner, a truck-to-robot system reduces the number of trucks required in a fleet [107]. Congestion may be reduced, resulting in less congested roads. Delivery with sidewalk robotics technology has the potential to reduce the number of vehicles on the road, which would be advantageous in urban areas where externalities are an issue. A Colombian startup is making sidewalk deliveries in California. Normally, these robots carry bags of groceries using sensors, radar, cameras, and GPS to navigate and avoid bans and obstacles. Sidewalk congestion and pedestrian safety would be negative externalities in urban areas. Due to their limited delivery zones and the need to share sidewalks with other vehicles and pedestrians, Hoffman and Prause [39] argue that land-based robots should be used in low-traffic areas. The speed of robots on the sidewalk may have an impact on facilities as well. The main challenges of using robots instead of trucks, according to Poeting, Schaudt, and Clausen [106], are range, speed, and available facilities. The robots can travel 6–10 km and deliver at 3–4 km per hour [106]. According to Alfandari, Ljubic, and De Melo da Silva [90], robots would travel 5–6 km/h on sidewalks, which is faster than the speed estimated by Poeting, Schaudt, and Clausen [106].

Drones' limited capacity and operating range, as well as congested sidewalks, unpredictable car traffic, and inconvenient delivery and collection of goods, have been criticized by experts [54]. Boysen, Schwerdfeger, and Weidinger [29] propose the need for city depots for robots if using a truck and robot system in which the robot does not return to the truck after completing the delivery. This system necessitates the placement of robot depots near delivery points. It is also mentioned that proper facilities and infrastructure for weather and delivery forecasting is required. Snow, sleet, and rain can all have an impact on system efficiency, delay, and safety [116].

4.2. Feedbacks

The literature provided touches on a variety of topics, one of which is the feasibility of using a robot-based delivery system. A customer places their order and a local delivery robot makes its way to the vendor to pick up said order. Then, the robot transports it to the customer's front door, and the delivery robot can be tracked using an app, which also unlocks the secure cargo compartment. This topic has been discussed from both the

consumer and societal perspectives, and the results of those discussions will be presented in the following section. The fact that pedestrians must share sidewalks with delivery robots poses a potential challenge for the operation of a robot-based delivery system in congested areas [37]. The authors did, however, emphasize the importance of considering this in future studies, stating that it will play a significant role in the future implementations of robot-assisted delivery trucks as an LMD system. This was an issue that their study did not address, but the authors did emphasize the importance of including it in future studies [37]. Incidents involving pedestrians and autonomous robots sharing sidewalk space have already occurred in some locations, according to a separate article written by Hoffman and Prause [39].

Another example is that autonomous drones do not recognize other types of objects as well as manned aircraft, posing a risk to public safety [101]. According to Hoffman and Prause [39], great technologies almost always face widespread opposition before society accepts them. It is possible that this will also be the case with future land-based robot deliveries. The disparities in legal systems that exist between nations may make the use of robots more difficult in the near future, rather than making it easier. As a result, it has been argued that in the relatively near future, patience will be required for society to recognize the benefits of this new technology [39].

Chen et al. [41] investigated VRPTWDR, an issue known as vehicle routing problem with time windows and delivery robots. According to the writers of this article, one of the most essential features of deliveries is that not all customers are able to accept deliveries made by delivery robots; instead, some clients will have to be supplied by a regular van. This means that the addition of delivery robots to traditional LMD methods may be beneficial in the future. It is possible that this will change in the future as consumers become more accustomed to this novel and cutting-edge method of delivery [41].

4.3. Frames

According to Hoffmann and Prause [39], regulatory standard frames for autonomous vehicles have been developed. Political, social, and long-term perspectives were all taken into account. Some countries, such as Estonia, have passed legislation allowing robots to share sidewalks with pedestrians, while others are hesitant to change. Laws from different countries may also cause issues. Even within a single country like the United States, the implementation of land-based autonomous delivery robots is subject to a variety of laws and regulations. Varying national legislation may make it difficult for land-robot delivery firms to negotiate their business models and persuade end users of the competitive benefits of deploying land-based robots [39]. Autonomous vehicle rules in the United States have been discussed by researchers [40]. Regulations exist in seven states and three localities, according to the authors. San Francisco, California, provides 180-day speed, insurance, and demand permits to robots. There is no weight restriction, but robots must emit a warning sound. According to the authors, San Francisco has the strictest laws in the United States. The state of Arizona has speed limits and requires robots to obey pedestrian laws. There are no restrictions on insurance, braking, or license plates, as is explained by Jennings and Figliozzi [40].

Another study also addresses the problem of protecting personal information saved online and locally on the terrestrial robot [39]. This means that robots pose a threat to GDPR because they collect personal information. Since the introduction of privacy and safety laws for the public, this has been an issue [117]. According to Sindi and Woodman [87], government policies and a lack of standardization may hinder autonomous vehicle implementation. Robot manufacturers will face difficulties customizing many robots due to a lack of standardization. The authors wished to make recommendations to policy makers when developing and standardizing regulations [87]. Autonomous vehicles lack policies and regulations because they are a new and uncertain technology. Due to increased research, as Ostermeier, Heimfarth, and Hübner [107] say, futuristic urban design may include zones where autonomous cars are restricted or authorized to move faster.

Data security issues can cause psychological distress in some people [117]. Autonomous drones raise ethical concerns. This includes issues with camera integrity and high unemployment. Another issue with drones is security. Drone operations can be disrupted and made dangerous by hacking or GPS interference [101]. Using GPS-Spoofing attacks, drones could be hijacked for illegal purposes, such as terrorist attacks. Such attacks can be detected by comparing GPS and INS (Inertial Navigation System) positions, but INS may be faulty due to accumulated errors [118].

5. Conclusions

As discussed throughout the paper, LMD is critical in supply chains, and E-commerce logistics providers must stay up-to-date with industry standards. Logistics for LMD are complex, inefficient, and costly, and in response to customer demand, many businesses are racing to provide faster, more efficient, and accurate delivery. To meet customer needs and gain a competitive advantage, new technologies are introduced and implemented. According to the references in this paper, AI has an impact on LMD's challenges and opportunities. Hence, this literature review aimed to frame and maximize the best technologies in LMD.

As a result, it has been demonstrated that AI-powered technologies increased efficiency, decreased costs, and opened up new avenues for improving logistics and businesses. Companies that incorporate new technologies into their business development strategies perform better than those that do not. Powerful AI can aid in route optimization, but it is frequently rigid and does not adapt to a changing environment, rendering it obsolete. LMD can use AI to detect patterns in historical data, build algorithms based on real-world data, and optimize delivery routing. The advantages of AI in optimization extends beyond routing. Autonomous cars, drones, and robots, for example, use AI to minimize labor costs while enhancing productivity. While a fully AI-based system for last-mile logistics is still in its early stages, with parcel-pooling in warehouses for the most efficient delivery route and being delivered by autonomous vehicles and robots, industry leaders, such as Amazon and DHL, are embracing existing AI-driven technologies (e.g., autonomous vehicles, robots, route-planning systems) and driving the industry's development.

Moreover, it has been identified that big data science and ML are data-driven decision-making technologies in the AI category and can help businesses rationalize decision-making and, with further development, assist them with realistic forecasts and so on. New markets are being created by AI's new technologies and many LMDs have jumped on the innovation bandwagon and begun their journey toward a smarter future. LMD's AI-powered autonomous vehicles, drones, and robots improve productivity and cost optimization. Additionally, AI-powered routing optimization assists businesses in lowering emissions and meeting sustainability targets.

However, modern LMDs, focused on AI-powered technologies, are feasible and beneficial but existing challenging and limitations are impeding their development. To conclude, AI implementation provides numerous opportunities for modern LMD, but it can not be fully realized by AI's potential in LMD or logistics until the FFF challenging categories are resolved and industry standards are established. This indicates these should be suggested by research and precisely directed by industry in order to benefit from the gains of modern LMD as much as possible.

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