



CHALLENGES AND SOLUTIONS OF LOGISTICS OPERATORS IN THE LAST MILE OF SUPPLY CHAINS

Ermin Muharemović, Amel Kosovac, Muhamed Begović, Edvin Šimić

University of Sarajevo, Faculty of Traffic and Communications, Bosnia and Herzegovina

Abstract

The paper explores the key role of the last mile in the evolution of supply chains, with a focus on identifying challenges and solutions applied in the last phase of delivery. Today's challenges for logistics operators have significantly evolved over the past two decades due to current and growing trends. With the rise of e-commerce and urbanization, the last mile becomes a crucial point of competition, where fast, customized, and sustainable delivery emerges as an imperative for all involved stakeholders. The paper is divided into three parts. The first part refers to the identification of challenges faced by logistics operators in the last phase of the supply chain. The second part of the paper provides an overview of existing solutions and strategies that can be used to respond to challenges in the last mile of delivery. The third part offers case studies that provide a comparative cost analysis using different strategies in the last mile of delivery. Through the analysis of various solutions and strategies in the final stage of the supply chain, different aspects of efficiency and costs are illuminated in various scenarios. Understanding these dynamics is crucial for shaping the future of delivery that is efficient, sustainable, and tailored to the needs of the modern consumer.

Keywords: solutions, challenges, supply chain, logistics operator, last mile delivery

1 Introduction

In today's global economic restructuring, the supply chain represents one of the crucial links for the success of companies worldwide. Supply chains are complex networks of various modes of transportation that transport billions of packages. These networks are controlled and coordinated to facilitate the flow between different modes of transportation. They use specific routes and specialized vehicles to transport packages over long distances. Without a well-organized and efficient supply chain, modern economic activity would be significantly constrained, leading to production delays, product shortages in the market, and increased costs for all involved parties.

The supply chain enables the global exchange of goods in a way that helps companies optimize production, reduce costs, and increase efficiency. Through this system, manufacturers can ensure a timely supply of raw materials and components from around the world, allowing them to maintain competitiveness in the market. At the same time, end consumers have access to a diverse range of products, regardless of their geographical location. Looking at it from a global perspective, the importance of the supply chain is reflected in its ability to ensure stability, growth, and prosperity worldwide. The supply chain can be divided into three phases: the first phase, the middle phase, and the final phase. The first phase of the supply chain is considered the part of the chain from the manufacturer to the origin hub. The middle phase extends from the Origin hub to warehouses of finished products near the customers.

The final phase is considered the part of the supply chain related to warehouses of finished products near the end customers, transportation, and delivery to the end consumers. Faced with complex challenges such as urbanization, the growth of e-commerce, changes in consumer habits, geopolitical tensions, the recent global pandemic, and rapid technological advancement, the supply chain is constantly adapting to remain efficient and competitive. In this work, we focus on the final phase of the supply chain, which accounts for 41% of the total delivery costs [1]. The dynamics of the modern business environment are extremely complex and dynamic, shaping the challenges that logistics operators face in the final phase of supply chain delivery. The most significant factors influencing the challenges faced by logistics operators in the final phase of delivery are urbanization and e-commerce [2, 3]. These two factors have become catalysts that have significantly changed the dynamics and impact of the last mile on the overall supply chain.

Urbanization is a global phenomenon that has been profoundly shaping our society and economy in recent decades. Across the world, people are increasingly moving from rural areas to cities in search of better employment opportunities, education, and living standards. Estimates suggest that by 2050, 68% of the world's population, approximately 6.3 billion people, will reside in large cities [4, 5]. The growth of urban populations presents numerous challenges, but also opportunities, particularly in the context of supply chains and last-mile delivery. Urbanization influences changes in consumer habits, infrastructure, population density, and the demand for fast and adaptable delivery. Cities are becoming hubs of trade, consumption, and economic activity, leading to increasing pressure on the infrastructure and resources required for the final stage of distribution.

On the other hand, e-commerce has experienced explosive growth in the past few decades and has become a key segment of global economic activity. Through the internet, consumers now have access to a vast array of products and services from the comfort of their homes or any other location via mobile devices. This phenomenon is transforming the way businesses operate and consumers make purchases, impacting all stages of the supply chain, including last-mile delivery. According to estimates, e-commerce has an average annual growth rate (CAGR) of 15.3% [6]. E-commerce has become a vital link in the supply chain, given the increasing demand for fast and reliable product delivery to customers worldwide [7].

Key change factors, such as urbanization and the growth of e-commerce, create specific challenges in the last-mile delivery phase that require careful consideration and tailored strategies by logistics operators. Below, these challenges are systematically explored, and relevant solutions applied in the industry are identified. This approach enables a deeper understanding of the dynamics of the last-mile delivery phase and enhances the efficiency of supply chains.

2 Identifying challenges in the last mile

The complex and dynamic environment in which last-mile logistics operators conduct their business activities requires constant effort and adaptation of strategies and approaches to address challenges. Among the key challenges faced by last-mile logistics operators, issues related to urban logistics, limited delivery capacity and efficiency, as well as increasing consumer expectations regarding the speed and reliability of delivery, stand out. From the perspective of logistics operators, the challenges they face include [3, 8, 9]:

- Increased volume
- Costs
- Infrastructure
- Time pressure
- Workforce
- Sustainability
- Technology

The increase in volume primarily stems from two global trends, urbanization, and e-commerce, driving increased demand for last-mile services. Urbanization entails more people moving to urban areas, while easier internet access facilitates a higher number of orders. The significance of the e-commerce market is evidenced by data [10] showing a revenue of \$3.3 trillion from e-commerce in 2022, accounting for approximately 14.1% of global trade. Regional shares are illustrated in Figure 1.



Figure 1 Total e-commerce retail revenues worldwide in 2022, by regions [10]

According to this statistic, Asia stands out as the leading region in e-commerce. This is not surprising given the size and diversity of the market in Asia, as well as the advancement of technology and the expansion of internet access in many Asian countries. Despite having a lower revenue than America and Asia, Europe still remains a significant e-commerce market with a high level of digital literacy and developed infrastructure. The region of Australia and Oceania has significantly lower e-commerce revenue compared to other continents. This may be due to the smaller population and the isolation of some of the island nations in the region. Africa shows the lowest e-commerce revenue among all continents. This could be a result of challenges such as lack of infrastructure, limited internet access, and economic inequalities present in many African countries. In 2021, 159 billion packages were shipped worldwide. Over the past seven years, this number has tripled, as shown in Figure 2 [10].

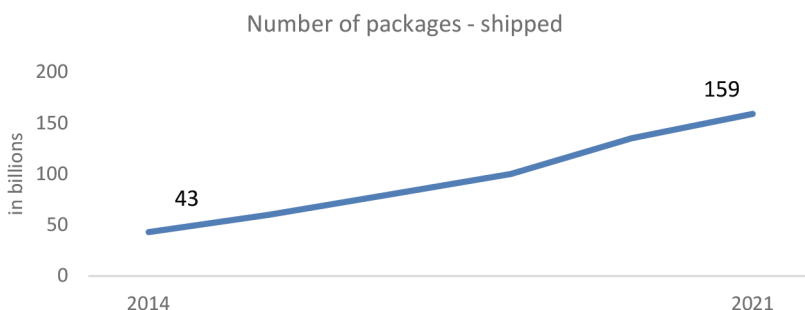


Figure 2 Number of packages shipped during the period from 2014 to 2021 [10]

Due to the increased volume of shipments and the proportional decrease in transportation costs per unit, last-mile companies are under increasing pressure due to costs. To adequately address this challenge, logistics operators must develop strategies that enable business volume growth. Simultaneously, they need to address other key aspects such as costs, infrastructure, time pressure, workforce, and technological innovations.

Important drivers of high costs include increased volume, traffic congestion, delivery delays, lack of parking spaces in congested streets, staff costs, customers not being home to receive their packages, inaccurate recipient information, and so on. Increased volume requires larger transportation and storage capacities, thereby leading to higher costs. Traffic congestion not only slows down delivery but also increases fuel consumption and vehicle maintenance costs, further burdening the operational costs of logistics operators. Waiting for deliveries, especially in urban areas with limited access and parking, can increase the time required for each delivery, affecting overall efficiency and operational costs. Staff costs, including wages, training, and benefits, represent a significant portion of total logistics operations costs, and increased workload may require additional manpower or working hours. Customers not being home to receive their packages results in additional costs for redelivery or storage. Inaccurate or incomplete recipient information often results in unsuccessful deliveries or returns. The infrastructure in the last mile delivery represents a challenge for logistics operators, encompassing issues such as the availability and capacity of warehouses, the condition of roads and pedestrian zones, as well as the availability of parking spaces for delivery vehicles. The lack of adequate infrastructure for last-mile delivery can significantly hinder the operational processes of logistics operators, leading to delays, increased costs, and customer dissatisfaction [11, 12]. In less developed countries, the construction and maintenance of road infrastructure are at a low level, requiring constant investments in fleet maintenance. The increasing volume of packages is largely driven by the rise in e-commerce activities [3, 13]. Most online retailers promise same-day or next-day delivery as one of their core service offerings, leading companies to face tight deadlines and significant time pressure. Factors directly affecting time pressure include short delivery deadlines, service personalization (delivery within specific time windows), unforeseen delays at delivery addresses, weather conditions, seasonal impacts and holidays, the impact of traffic infrastructure, and others. In last-mile delivery, labor, especially delivery personnel, plays a crucial role. However, the lack of a qualified workforce can significantly affect operational efficiency and service quality in last-mile delivery. Delivery personnel are often the only physical interaction between e-commerce and the customer, and therefore, their behavior, professionalism, and interaction with customers have a significant impact on creating a positive customer experience [14]. High workforce turnover further complicates this situation, requiring constant investment in training new employees to ensure meeting delivery expectations. Logistics operators are facing growing sustainability challenges as increased demand for fast delivery puts greater strain on the ecological balance, requiring innovative approaches to minimize negative environmental impacts. The increased demand for urban parcels leads to a higher number of delivery vehicles entering city centers, further burdening existing infrastructure, increasing congestion, and adversely affecting health, the environment, and safety. On the other hand, governments are pushing logistics operators to intensify efforts for sustainable operations that are environmentally acceptable [15]. One of the major challenges for logistics operators in sustainability is adapting existing operational models to reduce the environmental footprint of their activities while maintaining a high level of efficiency and competitiveness in the market. With rapidly evolving technological changes, the workforce must be prepared to adapt to new requirements and learn new skills to keep pace with the development of the delivery industry. Continuous education on various skills, including technological and communication skills, is crucial for the workforce to remain relevant and efficient in the last mile delivery. Reliability, accountability, and professionalism in delivery not only affect customer satisfaction but also have a broader impact on the entire supply chain, making them a key factor in the success of logistics operations.

3 Overview of existing solutions

In this section of the research paper, an overview of existing solutions and strategies is provided to address the challenges in the last-mile delivery of supply chains. The review of existing solutions considers a wide range of innovative technologies and approaches to addressing these challenges. Various approaches to solving challenges and technological innovations have been developed to improve efficiency, reduce costs, and optimize last-mile delivery. The focus is on identifying the most effective strategies that can be implemented in practice to enhance business operations and adapt to the demands of the modern market. Through the review of existing solutions and strategies, an attempt is made to provide comprehensive insight into diverse approaches used in the industry to tackle the challenges faced by logistics operators in the last-mile delivery of supply chains. The overview of existing solutions and strategies is presented in Figure 3 [16–22].



Figure 3 Overview of Existing Solutions

Real-time tracking and route optimization contribute to increased efficiency and reduced delivery costs. Outsourcing provides companies with flexibility and adaptability in managing the workforce according to needs. Automation of storage processes and inventory management helps optimize operations and reduce errors. Drones as solutions enhance delivery speed, reduce costs, and aid in addressing challenges. Pick Up and Drop Off (PUDO) technology offers customers alternative pickup options, reducing the challenges of home delivery. Electrification contributes to sustainability, and emission reduction, and aligns with trends of eco-conscious deliveries. Infrastructure sharing can improve efficiency and reduce costs through resource pooling. Staff education on new technologies, processes, and practices enhances their skills and contributes to long-term success. Business process reengineering enables companies to adapt to industry changes and enhances operational efficiency.

4 Case studies

During the search across various databases (WoS, Scopus, etc.), a very small number of studies were found that are based on comparing multiple different strategies in the last mile delivery. During the research of studies, the authors decided to include two studies conducted in 2022 and 2023, which compare cost-effectiveness and greenhouse gas emissions for different types of technologies and strategies in last mile delivery. The research [23] showed that online shopping typically has fewer negative environmental impacts than in-store shopping because delivery trucks often consolidate orders and use optimal routes. However, fast deliveries can offset these benefits because e-commerce retailers must deliver individual packages more frequently, increasing overall costs, distances, and emissions [24]. Free returns of goods also present a challenge for e-commerce retailers competing for a larger market share. A study conducted by the authors [7] in 2022 on a population of 3.3 million residents and an average daily package volume of 147,849 provides a structured overview of costs based on the use of different strategies (Table 1).

Table 1 Comparative analysis of using different strategies in last mile delivery [7]

| Last mile strategy | Characteristics | Where to Use | Cost range per package |
|--|--|--|------------------------|
| Traditional delivery (diesel vehicles) | Sensitive to time constraints | E-retailers with stable demand and mild timeframes | \$1.4 - \$11.4 |
| Electric vehicle delivery | Zero emissions, low operational costs, high investment costs | E-retailers near urban areas, stable demand, and mild timeframes | \$1.7 - \$12.0 |
| Outsourcing | External delivery, risk transfer | Low distribution costs, resilient to time constraints, flexible at low market shares | \$1.5 - \$5.1 |
| PickupPoint | External delivery, customer responsible for last mile delivery | In dense urban environments | \$1.8 - \$5.3 |
| Cargo bike | Minimal emissions, small cargo capacity | In dense urban environments | \$1.9 - \$9.4 |

On the other hand, a study conducted in 2022 [25], aimed at analyzing CO₂ emissions per package for different delivery scenarios, shows the impact of pollution per delivered package. The results of the study are provided in Table 2 below.

Table 2 Average greenhouse gas emissions per parcel differentiated by modeled last-mile scenarios [25]

| Scenario | CO ₂ emissions per parcel in grammes |
|--|---|
| Combination of door delivery with light commercial vehicles and delivery to pick-up points | 32.366 |
| Third-party parcel stations | 20.013 |
| Bundling at existing pick-up points | 19.264 |
| Base scenario with an added "micro-depot" for delivery by cargo bike as a pilot project. | 32.366 |

Based on the two previous studies presented, it can be concluded that the cost efficiency and sustainability of a logistics operator in the last-mile delivery significantly depend on the chosen strategy.

5 Concluding remarks and future research

The last-mile delivery has become increasingly important in the dynamic world of logistics, driven by the growth of e-commerce and urbanization. This segment represents a critical point of competition where fast, reliable, and tailored delivery becomes imperative.

Research has identified key challenges faced by logistics operators in the last-mile delivery of supply chains, including increasing volume, costs, infrastructure, time pressure, workforce, sustainability, and technology. Through a review of existing solutions and strategies, several approaches have been highlighted for addressing these challenges, including real-time tracking, process automation, electrification, infrastructure sharing, and staff education.

Case studies provide a comparative analysis of costs and CO₂ emissions for different last-mile delivery strategies, emphasizing the importance of choosing the appropriate strategy to achieve cost-effectiveness and sustainability. Given the complexity of the environment and the dynamism of the industry, continuous adaptation and the application of innovative approaches are key to the successful operation of logistics operators in last-mile delivery.

For future research, studies can delve deeper into how logistics operators can be resilient to unforeseen events such as pandemics, natural disasters, and the rapid penetration of innovative technologies.

Last-mile delivery not only pertains to the final stage of delivery but also has a profound impact on customer satisfaction, sustainability, the economy, and the overall supply chain. Understanding these dynamics is crucial for shaping the future of delivery that is efficient, sustainable, and tailored to the needs of the modern consumer.

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