



From Warehouse to Wheels: Rethinking Last-Mile Delivery Strategies in the Age of E-commerce

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Abstract

This study investigates the evolution and reconfiguration of last-mile delivery strategies in the U.S. e-commerce sector, focusing on both technological and operational innovations. The study was anchored on four research objectives with Theory of Constraint (TOC) providing the theoretical anchor. Quantitative Survey Research Method was used with questionnaire as the instrument of data collection. Using supply chain managers, warehouse coordinators, and last-mile delivery operators working in logistics firms engaged in e-commerce fulfilment as the population of the study, a total of 250 respondents were selected as sample size based on the recommendation of Comrey and Lee (1992) and that of Kline (2005) who posited that in a population without definite number, a sample of 100 is considered small, a sample of 100 to 200 is medium, and a sample over 200 is considered large. Finding revealed that the explosive growth of e-commerce has put significant strain on traditional last-mile delivery models, thus, e-commerce growth has significantly reshaped strategic decision-making in the US's last-mile logistics. While urban traffic and regulations, suburban route inefficiencies and rural infrastructure gaps were found as the geographical disparities in last-mile delivery efficiency and infrastructure, findings equally revealed that artificial intelligence and route optimization tools are the most widely adopted innovations (mean = 4.21) in last-mile delivery, followed closely by micro-fulfillment strategies (mean = 4.11), while autonomous delivery technologies as well as collaborative delivery platforms followed with (mean = 3.64), and (mean = 3.69) respectively. In light of the findings and guided by the Theory of Constraints (TOC), it was recommended that logistics firms operating within the U.S. e-commerce landscape adopt a constraint-focused approach to last-mile delivery strategy. Firms must first identify the primary bottlenecks, be they infrastructural, technological, labour-related, or geographic and apply tailored innovations to exploit and eventually elevate these constraints.

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Introduction

The exponential growth of e-commerce in the United States over the past decade has significantly reshaped consumer expectations and logistics practices, particularly in the domain of last-mile delivery, which according to Boysen *et al.* (2021)^[4] alongside Jaller and Pahwa (2020)^[16], is the final step in the logistics process where goods are transferred from distribution hubs to end consumers. As online retail sales reached over \$1 trillion in the U.S. in 2022 (U.S. Census Bureau, 2022)^[28], the pressure to optimize last-mile operations for speed, cost-efficiency, and customer satisfaction has intensified. This phenomenon has ushered in a paradigm shift in how businesses conceive logistics strategies, moving from traditional centralized distribution to more decentralized, customer-centric delivery models (Hübner *et al.*, 2016; Mangiaracina *et al.*, 2019)^[15, 19].

Last-mile delivery, while constituting a relatively small segment of the entire supply chain, accounts for more than 50% of total logistics costs and is fraught with operational inefficiencies, urban congestion, and environmental concerns (Gevaers *et al.*, 2014; Jaller & Pahwa, 2020)^[12, 16]. The rise of on-demand services and hyperlocal delivery platforms further compounds these challenges by necessitating faster, often same-day delivery options (Goodchild & Toy, 2018)^[14]. Consequently, logistics providers and retailers alike have been forced to innovate by leveraging micro-fulfilment centers, autonomous delivery vehicles, crowdsourced fleets, and data-driven route optimization to meet demand while controlling costs (Olsson *et al.*, 2019; Morganti *et al.*, 2014)^[24, 22]. The COVID-19 pandemic also amplified these logistical pressures, revealing vulnerabilities in supply chain resilience and accelerating consumer reliance on e-commerce channels across all demographic segments (McKinsey & Company, 2021)^[21].

With consumers demanding greater delivery flexibility, transparency, and sustainability, last-mile delivery has emerged not merely as a logistical concern but as a strategic differentiator in customer experience (Marcucci, *et al.*, 2017; Cairns, *et al.*, 2014)^[20, 5]. In response, companies are increasingly investing in adaptive last-mile models that integrate advanced technologies, including artificial intelligence (AI), predictive analytics, and digital twins, to enhance efficiency and competitiveness (Arslan & Gönül, 2021; Conway *et al.*, 2012)^[3, 10].

Despite the growing academic and industry interest in last-mile logistics, gaps remain in understanding how these innovations play out across different industries, geographic regions, and organizational scales within the United States. Moreover, there is a lack of consensus on the most effective configurations for last-mile delivery systems in e-commerce-dominated supply chains, particularly with regard to sustainability, cost, and customer satisfaction trade-offs (Boysen, *et al.*, 2021; Schoenherr & Speier-Pero, 2015)^[4, 26]. This study therefore aims to investigate the evolution and reconfiguration of last-mile delivery strategies in the U.S. e-commerce sector, focusing on both technological and operational innovations. Specifically, the study seeks to:

1. Assess how e-commerce growth in the U.S. is influencing last-mile delivery strategy formulation and execution.
2. Evaluate the operational and technological innovations adopted to improve last-mile efficiency, speed, and sustainability.
3. Find out the challenges and trade-offs inherent in last-mile delivery systems in urban, suburban, and rural contexts.
4. Identify industry-specific adaptations in last-mile logistics, particularly in sectors like grocery, fashion, and electronics.

This paper is structured as follows: Section 2 reviews relevant literature and theoretical frameworks underpinning last-mile logistics; Section 3 outlines the methodology employed; Section 4 presents findings from empirical and secondary

data; Section 5 discusses the implications of the findings; and Section 6 concludes with recommendations for industry, practice, and future research.

Literature and Theoretical Review

The E-commerce Boom and the Logistics Revolution

The past decade has witnessed a transformative surge in e-commerce, fundamentally altering the logistics landscape in the United States. Between 2012 and 2022, online retail sales in the U.S. escalated from approximately \$225 billion to over \$1 trillion, marking a significant shift in consumer purchasing behaviour (U.S. Census Bureau, 2022)^[28]. This exponential growth has necessitated a re-evaluation of traditional supply chain models, particularly concerning the "last mile" which is the final leg of delivery from distribution centres to end consumers.

Traditional logistics frameworks, which were predominantly designed for bulk shipments to retail outlets, are ill-suited for the fragmented and expedited demands of e-commerce. The proliferation of direct-to-consumer (D2C) models has intensified the need for rapid, reliable, and cost-effective delivery solutions. Companies like Amazon have set new benchmarks by offering same-day or next-day delivery services, compelling competitors to enhance their logistics capabilities to meet heightened consumer expectations (Hübner *et al.*, 2016)^[15]. This paradigm shift has led to the emergence of decentralized fulfilment strategies, including the establishment of micro-fulfilment centres (MFCs) in urban locales to expedite delivery times. These localized nodes reduce delivery time and cost, though they often raise inventory and space utilization challenges (Morganti *et al.*, 2014)^[22]. Companies like Walmart, Target, and Kroger have also begun integrating store-based fulfilment with last-mile dispatch to maintain competitiveness and reduce last-mile costs (Accenture, 2020). Additionally, the integration of advanced technologies such as artificial intelligence (AI) and machine learning for demand forecasting and route optimization has become increasingly prevalent (Mangiaracina *et al.*, 2019)^[19] to address the complexities introduced by the e-commerce boom and ensure that logistics operations remain agile and responsive to dynamic market demands.

Last-Mile Delivery: Operational Innovations and Urban Challenges

The "last mile" of delivery presents unique challenges, particularly within urban environments characterized by high population densities, traffic congestion, and infrastructural constraints. Studies indicate that last-mile delivery can account for up to 53% of total shipping costs, underscoring its significance in the overall logistics equation (Gevaers *et al.*, 2014)^[12]. Urban areas, with their limited parking availability and stringent delivery time windows, exacerbate these challenges and lead to inefficiencies and increased operational costs (Jaller & Pahwa, 2020)^[16].

To mitigate these issues, logistics providers have adopted various operational innovations. Among the innovations, the deployment of parcel lockers and pickup points in strategic locations allows for consolidated deliveries and reduce the number of trips required, thus, alleviating traffic congestion (Goodchild & Toy, 2018)^[14]. Moreover, the utilization of AI-driven route optimization tools enables dynamic adjustment of delivery routes in response to real-time traffic conditions in order to enhance efficiency and reliability (Chen *et al.*,

2020). Emerging technologies such as autonomous delivery vehicles and drones are also being explored to revolutionize last-mile logistics. These innovations promise to reduce labour costs and expedite deliveries, although regulatory hurdles and public acceptance remain significant barriers to widespread adoption (Conway *et al.*, 2012)^[10]. Furthermore, the integration of electric vehicles (EVs) into delivery fleets addresses environmental concerns and aligns with sustainability goals to reduce the carbon footprint of logistics operations (Arslan & Gönül, 2021)^[3].

Sector-Specific Strategies in Last-Mile Logistics

Different sectors within the e-commerce landscape exhibit distinct last-mile delivery requirements, necessitating tailored logistics strategies to meet specific operational demands and consumer expectations. In grocery sector, the perishable nature of grocery items imposes stringent requirements on delivery speed and temperature control. Companies like Instacart and Amazon Fresh have developed specialized cold-chain logistics solutions to maintain product freshness during transit. Additionally, the implementation of scheduled delivery windows accommodates consumer preferences for receiving groceries at convenient times (Hübner *et al.*, 2016)^[15].

In fashion retail, the fashion industry contends with high return rates due to issues related to fit and style. Efficient reverse logistics systems are crucial to manage returns seamlessly. Retailers have introduced features such as virtual fitting rooms and detailed sizing guides to reduce return rates (Olsson *et al.*, 2019)^[24]. Moreover, aesthetically pleasing packaging and unboxing experiences have become integral to brand differentiation in this sector (Olsson *et al.*, 2019)^[24].

For electronics, high-value electronic products necessitate secure handling and delivery verification. Retailers like Best Buy offer services including in-home installation and setup, extending the last-mile into a comprehensive customer service experience (Trkman *et al.*, 2015)^[27]. These value-added services not only enhance customer satisfaction but also foster brand loyalty (Trkman *et al.*, 2015)^[27]. Essentially, these sector-specific strategies recognise the importance of customizing last-mile logistics to align with product characteristics and consumer expectations so as to enhance operational efficiency and customer satisfaction.

Consumer Expectations and the Experience Economy

Consumer expectations have evolved significantly, with a growing emphasis on convenience, speed, and transparency in the delivery process. The "Amazon effect" has conditioned consumers to anticipate rapid delivery times, with same-day or next-day delivery options becoming increasingly standard (Olsson, *et al.*, 2019)^[24]. Moreover, consumers demand real-time tracking capabilities which will allow them to monitor their orders throughout the delivery journey. A study by Deloitte (2021)^[11] reports that nearly 70% of online shoppers in the U.S. consider delivery speed and flexibility as crucial determinants of satisfaction.

Flexibility in delivery options has also become a critical factor in consumer satisfaction. With features such as; the ability to schedule deliveries, choose alternative pickup locations, or modify delivery instructions, mid-transit cater to diverse consumer lifestyles and preferences. Additionally, environmental consciousness among consumers has led to increased demand for sustainable delivery practices, with many willing to pay a premium for eco-friendly shipping

options.

These heightened expectations necessitate that e-commerce retailers and logistics providers prioritize customer experience in their last-mile delivery strategies. Investments in technology, such as AI for predictive delivery and IoT for real-time tracking, are essential to meet these demands and maintain competitive advantage in the evolving e-commerce landscape (Choi, Wallace, & Wang, 2018)^[8].

Theoretical Framework: The Theory of Constraints (TOC)

The Theory of Constraints (TOC), developed by Eliyahu M. Goldratt in the 1980s^[13], serves as a valuable lens for analyzing and optimizing last-mile delivery strategies in the age of e-commerce. The TOC is a systemic approach to identifying and managing the most critical limiting factor or constraint that stands in the way of achieving a goal. In logistics and supply chain contexts, the goal is typically to deliver products in the shortest possible time, at the lowest cost, and with the highest customer satisfaction. In the context of last-mile delivery, constraints manifest in various forms, traffic congestion, warehouse inefficiencies, limited delivery personnel, technological gaps, and urban infrastructure limitations. TOC posits that improving the performance of the system's constraint will lead to significant enhancements in overall system performance (Goldratt, 1990)^[13].

Applying this theory to e-commerce logistics encourages firms to continuously identify and address the weakest link in the delivery chain, whether it is slow order picking in warehouses, inefficient route planning, or delays due to failed delivery attempts. For example, many logistics firms have found that the constraint in last-mile delivery is not the movement of goods over long distances, but the unpredictability and fragmentation of delivering parcels to individual consumers. This has led to strategic innovations such as micro-fulfillment centers, real-time route optimization, and consumer-enabled delivery rescheduling. These are all aimed at easing the pressure on the identified bottleneck.

Furthermore, TOC's five focusing steps: (1) identify the constraint (2) exploit the constraint (3) subordinate everything else to the constraint (4) elevate the constraint, and (5) repeat the process, all align well with how logistics companies can continuously refine their delivery models. As e-commerce evolves, the constraints may shift, thus, necessitating an adaptable approach grounded in TOC.

This framework is particularly relevant for studying sector-specific dynamics in last-mile delivery (e.g., grocery vs. fashion) because different industries encounter different logistical bottlenecks. A fashion retailer might face returns handling as a constraint, while a grocery chain may find cold storage capacity as its limiting factor. In sum, the Theory of Constraints provides a practical, systems-thinking approach that helps uncover, analyze, and resolve the persistent challenges in last-mile delivery. Its emphasis on continuous improvement and focus on the most impactful operational bottlenecks make it highly applicable for understanding the complexities introduced by the rapid rise of e-commerce in the United States.

Methodology

This study employed a quantitative research design to examine the evolving strategies and operational responses

associated with last-mile delivery in the U.S. e-commerce landscape. A structured survey was used as the primary data collection instrument, targeting logistics professionals across key sectors, specifically grocery, fashion, and electronics. The rationale for adopting a quantitative approach lies in its ability to generate measurable insights, establish patterns, and facilitate generalization across industries and geographic contexts. The study's population comprised supply chain managers, warehouse coordinators, last-mile delivery operators, and technology leads working in logistics firms engaged in e-commerce fulfillment.

The sample size consisted of 250 respondents, selected through purposive sampling to ensure participation by individuals with direct experience in last-mile operations. The sample size was chosen based on the recommendation of Comrey and Lee (1992)^[9] and that of Kline (2005)^[17] who posited that in a population without definite number, a sample of 100 is considered small, a sample of 100 to 200 is medium, and a sample over 200 is considered large. The questionnaire contained close-ended items developed around the four research objectives, using a 5-point Likert scale to assess levels of agreement on constructs such as the impact of e-commerce growth, adoption of delivery innovations, urban-suburban-rural logistical challenges, and sector-specific adaptations. A pilot test with 30 respondents was conducted to refine the instrument for clarity and reliability. Cronbach's alpha was calculated at 0.86, confirming a high level of internal consistency and instrument reliability.

Data were analyzed using SPSS Version 27. Descriptive statistics such as frequencies, means, and standard deviations were used to summarize the data, while inferential tools

including cross-tabulations and multiple regression analyses were employed to explore relationships between variables. The study adhered to all ethical research protocols. Informed consent was secured from all participants, who were assured of confidentiality, voluntary participation, and the right to withdraw at any point. Data were anonymized and securely stored in password-protected systems.

Data Analysis and Presentation

This section presents and interprets the results from the quantitative survey conducted among logistics professionals across the grocery, fashion, and electronics sectors in the United States. The data were analyzed using SPSS Version 27, focusing on descriptive statistics (mean, standard deviation, frequency, and percentage distributions) and inferential patterns that align with the four stated research objectives. Tables are included after each interpretation to facilitate clarity and understanding of the statistical outcomes.

Objective One: Influence of E-commerce Growth on Last-Mile Strategy Formulation and Execution

To assess how e-commerce growth influences last-mile delivery strategies, respondents were asked to rate several indicators, including the rise in delivery volumes, pressure for faster delivery, and the need for real-time visibility. From the findings, the mean scores were generally high, thus, indicating a consensus that e-commerce growth has significantly reshaped strategic decision-making in the US's last-mile logistics.

Table 1: Influence of E-commerce Growth on Last-Mile Strategy (N = 250)

Statement	Mean	SD	Agree (%)
Our last-mile strategy has changed significantly due to e-commerce boom	4.42	0.69	89.6
Delivery volume has increased drastically in the past three years	4.61	0.55	91.2
Speed is main strategic imperative in last-mile delivery strategy	4.47	0.73	87.4
Flexibility is main strategic imperative in last-mile delivery strategy	4.56	0.71	88.4
Customer tracking has become non-negotiable in last-mile delivery	4.39	0.67	88.1
Transparency has become non-negotiable in last-mile delivery	4.59	0.61	89.2

The data reveal that over 89% of respondents acknowledged that their organizations had restructured their last-mile strategies as a direct response to the e-commerce boom. These shifts include higher investment in flexible delivery scheduling, dynamic routing, and customer-centric applications to meet rising demand.

Objective Two: Operational and Technological Innovations in Last-Mile Delivery: Respondents were asked to indicate the extent to which their firms had adopted

key operational and technological innovations such as autonomous delivery, AI routing, micro-fulfillment centers, and crowdsourced logistics. Responses indicated significant movement toward innovation adoption, especially in metropolitan areas.

The findings indicate that artificial intelligence and route optimization tools are the most widely adopted innovations (mean = 4.21), followed closely by micro-fulfillment strategies (mean = 4.11), while autonomous delivery technologies as well as collaborative delivery platforms followed with (mean = 3.64), and (mean = 3.69) respectively.

Table 2: Adoption of Technological and Operational Innovations (N = 250)

Innovation Adopted	Mean	SD	Agree (%)
Use of AI for route optimization	4.21	0.71	85.3
Deployment of micro-fulfillment hubs	4.11	0.82	81.6
Experimentation with autonomous delivery methods	3.64	0.91	69.7
Crowd sourced/collaborative delivery platforms	3.96	0.87	77.1

Objective Three: Urban, Suburban, and Rural Challenges in Last-Mile Delivery: This objective explored the geographical disparities in last-mile delivery efficiency and infrastructure. Respondents were asked to rate their level

of challenge in three environments: urban, suburban, and rural. The findings show that urban areas are the most complex due to congestion, regulations, and delivery time windows, while rural areas face infrastructure limitations.

Table 3: Challenges Across Geographic Zones (N = 250)

Delivery Context	Mean	SD	High Challenge (%)
Urban traffic and regulations	4.56	0.68	92.0
Suburban route inefficiencies	3.91	0.89	74.3
Rural infrastructure gaps	4.02	0.83	78.6

Urban delivery emerged as the most challenging environment, with 92% of respondents reporting significant operational hurdles. These include strict delivery windows, customer density, and parking constraints. Meanwhile, rural last-mile challenges center on long distances, sparse delivery points, and a lack of centralized drop-off options came close with 78.6% responses identifying this as a challenge to last-mile delivery.

Objective Four: Sector-Specific Adaptations in Last-Mile Logistics

On the fourth objective, respondents from the three sectors (grocery, fashion, and electronics) were asked about how their firms had customized last-mile logistics to suit product characteristics and customer behaviour. The grocery sector emphasized cold-chain delivery and real-time tracking, while fashion prioritized flexible return systems. The electronics sector focused on secure packaging and scheduled delivery.

Table 4: Sector-Specific Last-Mile Adaptations (N = 250)

Sector	Key Strategy Implemented	Mean	SD	Sector Agreement (%)
Grocery	Cold-chain and time-sensitive delivery	4.48	0.63	91.4
Fashion	Seamless return policies and flexible logistics	4.36	0.69	88.7
Electronics	Secure packaging and scheduled home delivery	4.22	0.75	83.9

These responses confirm that sector-specific needs shape last-mile strategies. For instance, perishability in groceries mandates refrigerated trucks and delivery windows within 1–2 hours. In contrast, fashion emphasizes returnability and convenience while the electronics sector demands security and coordination due to the high value of products.

Discussion of Findings

This study examined the nexus between the rapid expansion of e-commerce and last-mile delivery systems in the United States. The following discussion addresses each research objective, situating the results within both TOC logic and existing literature.

E-commerce Growth and Its Influence on Last-Mile Delivery Strategy

The study found overwhelming evidence that the explosive growth of e-commerce which is driven by platforms such as Amazon, Walmart.com, and Shopify, has put significant strain on traditional last-mile delivery models. Surveyed logistics professionals across various sectors noted that existing infrastructure, fleet capacity, and labour models were not initially designed for the velocity and volume now characteristic of online retail. According to 78% of respondents, their organizations have had to either redesign delivery routes or restructure fulfillment nodes in the past three years to keep pace with demand.

These findings validate TOC's emphasis on identifying throughput-limiting constraints, which, in this context, manifest as urban congestion, inadequate sorting facilities, and limited delivery personnel (Goldratt, 1990) ^[13]. As e-commerce grows, the last-mile segment becomes the weakest link, threatening the throughput of the entire supply chain. This confirms earlier work by Gevaers *et al.* (2011) ^[12] and Lim *et al.* (2018) ^[18], who argue that e-commerce growth disproportionately affects the final leg of delivery and requires systems-wide adaptations. Furthermore, consistent with TOC's focusing steps, organizations have begun to elevate the constraint (i.e., last-mile inefficiencies) by redesigning fulfillment strategies, such as; leveraging micro-fulfillment centers and dark stores, which allow for shorter

delivery distances and improved order cycle times.

Operational and Technological Innovations to Improve Efficiency and Sustainability

The data revealed widespread adoption of technologies such as route optimization software, delivery management systems, and electric vehicle (EV) fleets. These were seen not merely as enhancements, but as strategic tools to address core limitations in the system. For example, 64% of respondents cited dynamic routing as the most effective solution to overcoming time delays caused by urban congestion which is a clear constraint.

In TOC terms, these innovations represent subordinate mechanisms introduced to support and alleviate the central constraint (Goldratt, 1990) ^[13]. Rather than spreading investments across all supply chain nodes, many firms are concentrating their resources on optimizing the performance of the last-mile bottleneck. This strategic focus reflects the TOC principle of exploiting the constraint before elevating it. This suggests that firms are first maximizing the utility of current assets before adding new ones. Prior literature supports this perspective. Winkenbach *et al.* (2016) ^[29] emphasized that last-mile technology must directly respond to the most pressing operational constraints to be effective. The adoption of alternative delivery modes (e.g., drones, parcel lockers, crowd-sourced delivery) also represents TOC-driven thinking: solutions must be localized and constraint-specific, as blanket strategies often fail to address the unique limitations of different delivery environments (Mangiaracina *et al.*, 2019) ^[19].

Geographic Trade-Offs: Urban, Suburban, and Rural Challenges

An important insight from the findings is the geographic variability in last-mile challenges. Urban respondents highlighted constraints related to parking restrictions, traffic congestion, and high-density delivery volumes. Suburban areas dealt more with capacity balancing and labour variability, while rural regions faced underutilized routes and fuel inefficiencies.

TOC posits that systemic constraints vary across

environments and must be treated contextually. In this study, each geographic setting presented a distinct constraint profile, requiring adaptive rather than uniform solutions. For example, while autonomous delivery robots are gaining attention in dense urban cores, they are impractical for rural landscapes where delivery distances are significantly longer. These findings align with the position of Allen *et al.* (2018)^[2], who argue that last-mile design must account for spatial constraints. Firms that ignore these differences often suffer from misallocated resources which is an attempt to elevate the wrong constraint. In contrast, companies practicing TOC-informed segmentation strategies were found to be more responsive, cost-efficient, and scalable in managing their geographic last-mile operations (Allen *et al.*, 2018)^[2].

Sector-Specific Adaptations in Grocery, Fashion, and Electronics

Industry-level analysis revealed significant variations in how last-mile strategies are formulated and executed. The grocery sector, due to perishability and immediacy, prioritizes cold-chain logistics and hyperlocal delivery hubs, often within two-hour windows. The fashion industry, on the other hand, emphasizes return flexibility and packaging aesthetics, while electronics firms focus on security, traceability, and high-value item handling.

TOC explains these variations through its lens of differentiated constraints. In groceries, the constraint is delivery time sensitivity; in fashion, it is the high volume of returns; in electronics, it is the need for secure handling. Each industry identifies its unique bottleneck and builds a logistics model that exploits, subordinates to, and ultimately elevates this constraint. This approach is more precise than generic models and aligns with Trkman *et al.* (2015)^[27], who stress the importance of tailoring operational models to domain-specific pain points. Furthermore, the theory supports the idea of buffering constraints, identified in grocery firms with the addition of local fulfillment partners or temporary delivery fleets during peak periods. Such dynamic constraint-buffering is consistent with TOC and reflects a maturing logistics ecosystem capable of identifying and adjusting to its most pressing limitations.

Conclusion and Recommendation

This study explored the dynamic evolution of last-mile delivery strategies in the United States in response to the unprecedented growth of e-commerce. Using a quantitative research design and the Theory of Constraints (TOC) as its theoretical lens, the research systematically identified the structural limitations impeding last-mile performance, analyzed the role of innovation in alleviating these constraints, and revealed the contextual and industry-specific adaptations shaping operational choices across urban, suburban, and rural environments.

The findings confirm that last-mile delivery has emerged as a critical constraint within the broader e-commerce logistics system. As e-commerce volume increases, this constraint becomes more pronounced manifesting in bottlenecks related to congestion, delivery density, labour shortages, and technological inefficiencies. In line with TOC, organizations have responded by introducing both exploitative innovations (e.g., dynamic routing, micro-fulfillment centers) and elevating mechanisms (e.g., electric vehicles, drones, and crowd-sourced delivery models) to optimize throughput without overextending operational capacity. Moreover, the

study highlights that last-mile delivery is not a monolithic problem. Instead, it is shaped by geographical context and sectoral disparities. Grocery, fashion, and electronics sectors each face distinct constraints, ranging from perishability to security which necessitate tailored strategies. This reinforces the need for TOC-based diagnosis and strategy development rather than one-size-fits-all solutions.

In light of the findings and guided by the Theory of Constraints (TOC), it is recommended that logistics firms operating within the U.S. e-commerce landscape adopt a constraint-focused approach to last-mile delivery strategy. Firms must first identify the primary bottlenecks, be they infrastructural, technological, labour-related, or geographic and apply tailored innovations to exploit and eventually elevate these constraints. Urban, suburban, and rural contexts each pose distinct operational challenges; thus, delivery models must be adapted accordingly. For example, micro-fulfillment centers and cargo bikes may be optimal in urban settings, while route consolidation and strategic partnerships with local retailers may be more effective in rural regions. In addition, industry-specific factors, such as perishability in groceries, return rates in fashion, or security in electronics should shape logistics planning to ensure responsiveness, cost-effectiveness, and customer satisfaction. Moreover, scalable investment in digital technologies (e.g., AI-driven routing, predictive analytics, and autonomous delivery solutions) should be aligned with identified constraints rather than adopted indiscriminately. Policymakers should support urban logistics with regulatory frameworks that reduce congestion, allocate space for delivery operations, and incentivize green mobility.

For researchers, future studies could examine longitudinal impacts of constraint-based interventions or expand to cross-country comparisons to enhance generalizability. Theoretically, applying TOC has proven effective in unpacking complex logistics dynamics, but further exploration alongside complementary theories (e.g., dynamic capabilities or socio-technical systems theory) may yield deeper insights.

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