DIGITAL ADOPTION OF TAM IN LAST-MILE LOGISTICS: A SYSTEMATIC LITERATUR REVIEW OF CPP-SLA IMPACTS

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Abstract: *Although various digital technologies have been implemented to enhance distribution efficiency, systematic evidence linking technology acceptance to operational performance remains limited and fragmented. This study aims to analyze the application of the Technology Acceptance Model (TAM) in the context of digital technology adoption in last-mile logistics and its implications for operational performance, particularly Cost per Parcel (CPP) and Service Level Agreement (SLA) achievement. A Systematic Literature Review (SLR) method was employed, following stages of identification, screening, and article selection based on predefined inclusion and exclusion criteria. From 600 articles identified across six academic databases, 39 articles met the eligibility criteria and were systematically synthesized. The findings indicate that perceived usefulness and perceived ease of use, together with external factors such as trust, organizational readiness, and infrastructure support, play significant roles in driving technology adoption. The level of actual system use is associated with route optimization, enhanced real-time visibility, reduced delivery failures, and improved service timeliness, ultimately contributing to CPP efficiency and SLA attainment. This study integrates technology acceptance perspectives with operational performance indicators into a unified conceptual framework, providing a strategic foundation for decision-making in last-mile logistics digital transformation.*

Keywords: *Technology Acceptance Model (TAM); last-mile logistics; Cost Per Parcel (CPP); Service Level Agreement (SLA)*

Introduction

A Systematic Literature Review (SLR) is a research method used to analyze, review, and summarize the results of previous studies, where the findings can be used as a reference for further research (Maniah et al., 2022). In this study, the SLR method was applied to select and evaluate relevant articles based on predetermined inclusion and exclusion criteria. The selection process was carried out through several stages, including identification, screening, eligibility, and final review of articles obtained from several scientific databases (Maniah et al., 2022). The focus of this study is the application of the Technology Acceptance Model (TAM) in the context of last-mile logistics, particularly in relation to Cost Per Parcel (CPP) efficiency and Service Level Agreement (SLA) performance.

The rapid growth of electronic commerce (e-commerce) has significantly increased parcel delivery volumes and placed substantial pressure on logistics systems, particularly at the last-mile stage, defined as the distribution phase from a fulfillment center to the final customer. The last-mile stage is widely recognized as the most complex and costly component of the supply chain due to its fragmented operational characteristics, including inefficient delivery routes, urban traffic congestion, variability in customer availability, and relatively high delivery failure rates. These conditions contribute substantially to total supply chain costs and reduce compliance with established service standards (Correia et al., 2021; World Economic Forum, 2021).

Two critical operational performance metrics for courier companies in the last-mile context are Cost Per Parcel (CPP), which measures cost efficiency per processed parcel, and Service Level Agreement (SLA), which reflects compliance with timeliness and service quality targets. The increasing volume of parcels and rising customer expectations require courier operators to reduce CPP while simultaneously maintaining or improving SLA performance. However, performance improvement efforts are often constrained by limitations in route planning, real-time delivery visibility, and coordination among stakeholders, ultimately affecting cost efficiency and service reliability (Escudero-Santana et al., 2022).

On the other hand, technology-based solutions including route optimization systems, real-time tracking, administrative task automation, and customer communication platforms offer significant potential to reduce operational inefficiencies and lower CPP without compromising SLA performance. Nevertheless, the successful implementation of these solutions depends not only on technological availability but also on the level of acceptance and actual usage among actors within the logistics ecosystem (e.g., operational managers, couriers, and customers). The Technology Acceptance Model, originally developed by Davis (1989), provides a conceptual framework for understanding how perceived usefulness (PU) and perceived ease of use (PEOU) influence technology adoption intentions. In the last-mile context, recent studies have extended TAM by incorporating social, organizational, and technical infrastructure factors that influence the adoption of logistics service technologies (Sultan et al., 2023).

Although the literature on technology adoption in the logistics sector continues to expand, there remains a lack of systematic studies that explicitly link technology acceptance constructs (based on TAM) with quantitative operational indicators such as CPP and SLA. Many studies assess adoption intention or user satisfaction; however, few synthesize empirical evidence regarding how technology adoption measurably affects cost efficiency per parcel and service target achievement. The absence of a systematic synthesis limits policymakers and operational managers in understanding causal relationships and contextual conditions under which technology adoption leads to CPP reduction while simultaneously improving SLA performance.

Based on the identified research gap, this study aims to conduct a systematic literature review to identify the factors influencing TAM-based technology adoption in last-mile logistics and to synthesize its impact on operational performance, particularly cost efficiency reflected in Cost Per Parcel (CPP) and service performance associated with Service Level Agreement (SLA) attainment. The findings are expected to provide an integrated conceptual framework, along with practical recommendations and directions for future research, to advance both theoretical development and logistics management practice.

Research Methodology

This study uses the Systematic Literature Review (SLR) method to analyze, review, and summarize the results of previous studies in order to obtain conclusions that can be used as references for further research (Maniah et al., 2022). The SLR approach was chosen because it allows the selection and evaluation of relevant articles through several stages, including identification, screening, eligibility, and final review based on predetermined criteria. In this research, the SLR method is used to examine the adoption of technology based on the Technology Acceptance Model (TAM) in the context of last-mile logistics and to analyze its impact on Cost Per Parcel (CPP) efficiency and Service Level Agreement (SLA) performance.

The SLR process was conducted through the stages of identification, screening, and eligibility assessment of articles based on predefined inclusion and exclusion criteria.

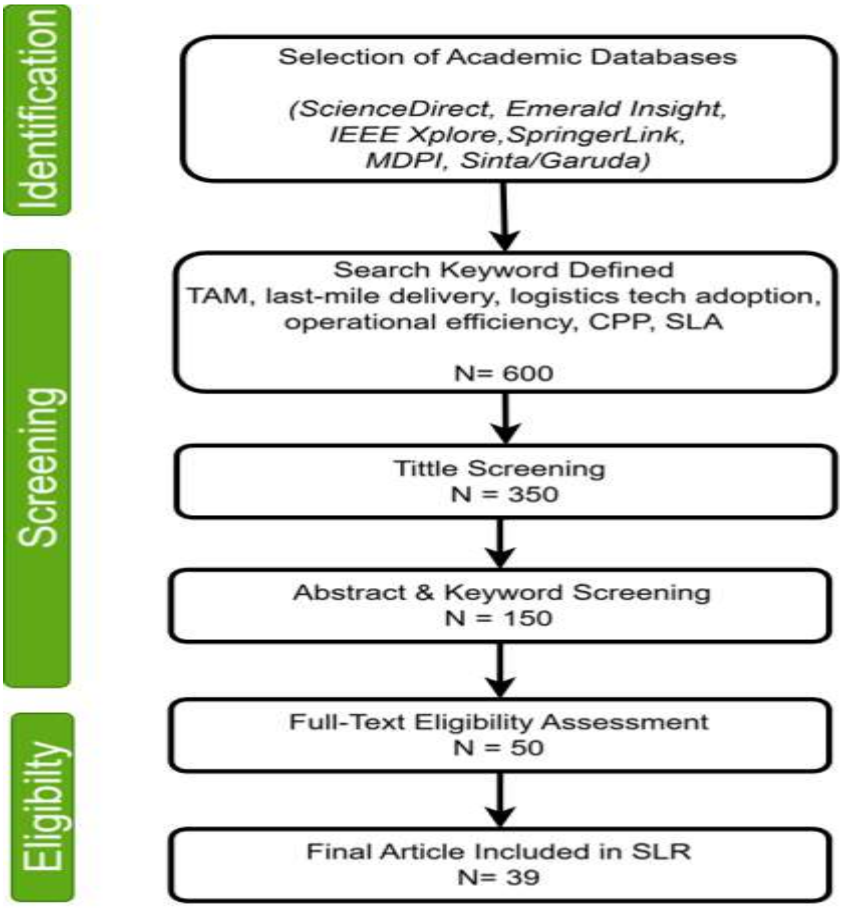

Figure 1: Flow Diagram of the Systematic Literature Review Process

1. Literature Search

The first stage involved identifying relevant scientific literature through the following academic databases:

a. ScienceDirect
b. Emerald Insight
c. IEEE Xplore
d. Springerlink
e. MDPI
f. Sinta/Garuda Journals

The search was conducted using the following keywords: "Technology Acceptance Model," "last-mile delivery," "courier mobile application," "logistics technology adoption," "operational efficiency," "cost per parcel," and "service level agreement."

2. Selection and Screening

At this stage, articles were screened using predefined inclusion and exclusion criteria. The inclusion criteria were as follows:

a. Articles discussing last-mile logistics, the application or extension of TAM, and technology adoption
b. Studies examining the relationship between technology adoption and cost efficiency or service performance

c. Articles published between 2012 and 2025
d. Publications in English or Indonesian.

3. Literature Analysis and Synthesis
The final stage involved analyzing and synthesizing the selected literature. Each article was examined to identify:
a. The TAM factors most influential in technology adoption;
b. The relationship between technology adoption and CPP efficiency
c. The impact of technology adoption on SLA achievement.

Based on these stages, the results of the literature search and screening process are summarized in the following table.

Table 1: Summary of Literature Search and Screening Process

No	Database Source	Records Identified (Stage 1)	Title Screening (Stage 2)	Abstract & Keyword Screening (Stage 3)	Final Articles Included (Stage 4)
1	ScienceDirect	150	90	40	10
2	Emerald Insight	50	30	15	5
3	IEEE Xplore	30	20	10	5
4	SpringerLink	250	140	60	12
5	MDPI	100	60	20	6
6	Sinta/Garuda Journals	20	10	5	2
	Total	600	350	150	39

Why Is Digital Adoption Important in Last-Mile Logistics?

Digital adoption in last-mile logistics plays a crucial role in improving cost efficiency and operational performance. The implementation of digital technologies enables route optimization and reduces delivery failures, thereby lowering operational costs and allowing companies to focus on their core business activities rather than infrastructure management (Escudero-Santana et al., 2022). Several primary reasons encourage companies to adopt digital technologies in last-mile operations: (1) scalability to accommodate fluctuating delivery demand, particularly during periods of significant growth such as the COVID-19 pandemic, which substantially increased parcel volumes (Liu et al., 2024); (2) automatic updates and system configuration provided by technology vendors, which reduce technical maintenance burdens and allow firms to focus on innovation, including the development of rapid urban delivery systems (Alhothali et al., 2024); and (3) high-performance data centers and advanced computing capabilities that support efficient data processing, demand forecasting, and operational analytics, thereby contributing to more accurate planning, improved resource allocation, and reduced operational costs (Ricardianto et al., 2023). Overall, digital adoption in last-mile logistics represents not merely a technological enhancement but a strategic necessity for achieving greater efficiency, flexibility, and service reliability in increasingly complex logistics environments.

Based on industry trends, the rapid growth of e-commerce has become a major driver of digital adoption in last-mile logistics, with projections indicating a substantial increase in digital logistics workloads through 2025. Supporting factors include greater virtualization, enhanced real-time visibility, and AI-based optimization, all of which contribute to improved operational coordination and efficiency (World Economic Forum, 2021). Furthermore, digital adoption can mitigate operational risks such as parcel theft and enhance delivery security through technologies such as automated parcel lockers (Yick & Selamat, 2024; Sultan et al., 2023). Nevertheless, several challenges must be addressed to maximize these benefits, including perceived security risks and environmental regulatory constraints that may influence technology deployment and operational practices (Shuaibu et al., 2025).

To illustrate the growth trend, a conceptual figure adapted from Grand View Research (2026) presents the global last-mile delivery market size by region from 2018 to 2030 (in USD billion). The data indicate significant post-2019 growth, with the global market reaching approximately USD 143.1 billion in 2022 and projected to expand to approximately USD 258.7 billion by 2030, distributed across regions such as North America, Europe, Asia Pacific, Latin America, and the Middle East & Africa. This upward trajectory reflects the accelerating impact of e-commerce expansion and digital adoption on logistics workload and operational transformation in the last-mile sector.

Figure 2: Growth Trend of Digital Adoption in Last-Mile Logistics (2018–2030)

Source: (Grand View Research, 2024)

Result and Discussion

Based on the processes of identification, title and abstract screening, and full-text eligibility assessment, a total of 39 (thirty-nine) articles met the inclusion criteria and were deemed relevant to the research topic, namely the application of the Technology Acceptance Model (TAM) in last-mile logistics and its implications for operational performance, particularly Cost Per Parcel (CPP) and Service Level Agreement (SLA). The article selection process was structured around two primary focal areas: (1) recent state-of-the-art studies examining the application and extension of TAM within the context of last-mile logistics; and (2) recent studies analyzing the impact of technology adoption on operational performance indicators, specifically CPP and SLA. Based on these two categories, the results of the analysis are presented through the distribution of publication years, the geographical distribution of studies, the methodological approaches employed, and a synthesis of empirical findings regarding the relationship between technology adoption and operational performance.

Publications year

The analyzed studies cover the period 2012–2025, with a notable increase in publications after 2019, likely associated with the acceleration of e-commerce activities during the COVID-19 pandemic. Geographically, the studies are predominantly concentrated in Asia, followed by Africa and the Middle East, Latin America, and Europe and North America. A detailed distribution of publications is presented in the following table.

Table 2: Number of Studies By Years

Year	1989	2021	2022	2023	2024	2025
Number	1	4	7	7	6	14
Percent	2.56%	10.26%	17.95%	17.95%	15.38%	35.90%

State-of-the-Art Analysis of TAM Implementation and Its Impact on CPP and SLA

The synthesis of 39 selected articles indicates that the Technology Acceptance Model (TAM) has been widely employed to explain technology acceptance in logistics, particularly in route optimization systems, real-time tracking technologies, parcel lockers, and the integration of Warehouse Management Systems (WMS) and Transportation Management Systems (TMS). Consistent with the original model proposed by Fred Davis, perceived usefulness (PU) and perceived ease of use (PEOU) have been empirically validated as primary determinants in enhancing behavioral intention and actual system usage.Several studies have further extended TAM by incorporating additional variables such as trust, perceived risk, and organizational readiness to strengthen the model's explanatory power within operational contexts, particularly in complex last-mile logistics environments.

With regard to Cost Per Parcel (CPP), the review findings indicate that technology adoption driven by perceived usefulness and perceived ease of use contributes significantly to distribution cost efficiency (Klein & Popp, 2022; Mahmoodi et al., 2025). The implementation of route optimization and automated scheduling systems reduces travel distance and delivery time (Mo et al., 2023; Shuaibu et al., 2025), while consolidation strategies through parcel lockers decrease the number of courier stops and failed delivery attempts (ElSemary et al., 2025; Yick & Selamat, 2024; Zhang & Demir, 2025). Furthermore, the integration of information systems enhances operational coordination, improves real-time visibility, and minimizes delivery failures (Escudero-Santana et al., 2022; Ricardianto et al., 2023).Conceptually, the relationship can be formulated as follows:

PU and PEOU → Intention to Use → Actual Usage → Operational Efficiency → CPP Reduction.

Furthermore, the literature indicates that technology acceptance also has a significant impact on the improvement of Service Level Agreement (SLA) performance. Real-time tracking systems enhance the accuracy of estimated time of arrival (ETA) and delivery punctuality (Mo et al., 2023; Silva et al., 2023), while the integration of operational data strengthens process visibility and managerial control (Escudero-Santana et al., 2022; Ricardianto et al., 2023). Organizations with higher levels of technology adoption tend to demonstrate better delivery success rates and greater service stability (Alverhed et al., 2024; Boysen et al., 2021).Accordingly, the resulting relationship pattern can be conceptualized as follows:

Technology Adoption (TAM) → Improved Visibility and Process Control → Enhanced Reliability → Improved SLA.

Overall, the state-of-the-art analysis demonstrates that the Technology Acceptance Model (TAM) is no longer used solely to measure adoption intention; rather, it has evolved into a comprehensive framework capable of explaining the linkage between user behavioral factors and logistics operational performance, particularly in terms of CPP reduction and SLA improvement.

Based on Table 2, a total of 39 articles were identified as relevant to this study. The results of the state-of-the-art analysis of the selected articles are subsequently summarized in Table 3 to illustrate the relationship patterns among TAM implementation, CPP efficiency, and SLA enhancement.

Table 3: Summary of Literature Findings Related to CPP and SLA

Authors & Year	Study Title	Key Findings related to CPP/SLA
(Davis, 1989)	Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology	The foundation of the Technology Acceptance Model (TAM) demonstrates that perceived usefulness (PU) and perceived ease of use (PEOU) influence technology adoption intention, forming the basis for improved operational efficiency and last-mile performance.
(Sultan et al., 2023)	Barriers to Applying Last-Mile Logistics in the Egyptian Market: An Extension of the Technology Acceptance Model	Social and technological barriers tend to increase Cost Per Parcel (CPP), whereas digital collaboration and logistics system adoption reduce costs and enhance Service Level Agreement (SLA) performance.
(Yuen et al., 2022)	Consumer Acceptance of Autonomous Delivery Robots	Perceived value mediates technology adoption; contactless delivery improves SLA and has long-term potential to reduce CPP.
(Alverhed et al., 2024)	Autonomous Last-Mile Delivery Robots: A Literature Review	Autonomous Delivery Robots (ADR) reduce operational costs (CPP) and improve delivery punctuality (SLA), although infrastructure and regulatory constraints may limit effectiveness.
(Mo et al., 2023)	Predicting Drivers' Route Trajectories in Last-Mile Delivery	Machine learning–based route sequence prediction enhances operational efficiency (CPP) and delivery route accuracy (SLA).
(Shuaibu et al., 2025)	Last-Mile Delivery Optimization: Recent Approaches and Advances	Optimization approaches (linear programming, artificial intelligence, metaheuristics, GIS, and real-time routing technologies) significantly improve cost efficiency (CPP) and delivery reliability (SLA).
(Boysen et al., 2021)	Last-mile delivery concepts: a survey from an operational research perspective	Integrated last-mile concepts and hybrid fleet models enhance cost efficiency, reduce operational expenses (CPP), and improve service reliability (SLA).
(Silva et al., 2023)	Sustainable Urban Last-Mile Logistics: A Systematic Literature Review	Sustainable logistics practices contribute to lower operational costs (CPP) while enhancing service reliability and SLA achievement.
(Mathew et al., 2023)	Factors Influencing Technology Acceptance of Drones for Last-Mile Delivery	Perceived usefulness and trust significantly drive the adoption of drones and autonomous vehicles, potentially reducing CPP through operational efficiency and improving SLA via faster and more flexible delivery.
(Correia et al., 2021)	Last-mile-as-a-Service (LMaaS): An Innovative Concept for the Disruption of Urban Logistics	Last-Mile-as-a-Service (LMaaS) platforms reduce CPP through shared fleets and resource pooling while improving SLA through capacity flexibility and coordination efficiency.
(Yick & Selamat, 2024)	Perceived Ease of Use, Usefulness and Trust towards Consumer's Intention to Adopt Automated Parcel Locker as Last Mile Delivery	Trust is often identified as the most dominant determinant in last-mile service adoption, followed by PU and PEOU, all of which positively influence operational performance (CPP/SLA).
(Escudero-Santana	Improving E-Commerce Distribution through	Delivery flexibility in time and location reduces failed

Authors & Year	Study Title	Key Findings related to CPP/SLA
et al., 2022)	Last-Mile Logistics with Multiple Possibilities of Deliveries Based on Time and Location	deliveries, improves SLA performance, and enhances customer satisfaction.
(Ricardianto et al., 2023)	Determinants of Logistics Effectiveness on Port Operational Performance: Empirical Evidence from Indonesia	Organizational strategy, technological readiness, and competitive pressure positively influence last-mile technology adoption, contributing to CPP reduction and SLA improvement.
(Schmidt & Saraceni, 2024)	Consumer acceptance of drone-based technology for last mile delivery	High initial investment costs, infrastructure limitations, and vehicle range constraints negatively affect CPP efficiency and SLA reliability.
(Esmaili et al., 2025)	Autonomous delivery vehicle acceptance: The moderating role of perceived risk of theft	Soft Time Window (STW) models are more flexible and efficient than Hard Time Window (HTW) models; pre-booking improves SLA despite potentially increasing distance and costs.
(Ivanišević et al., 2025)	Factors Influencing Courier Drivers' Preferences and Safety Perceptions in Urban Deliveries	Parcel lockers and smart lockers reduce CPP by 25–70% compared to home delivery and significantly improve service reliability, flexibility, and SLA compliance.
(Ismail & Jokonya, 2023)	Factors Affecting the Adoption of Emerging Technologies in Last-Mile Delivery in the Retail Industry	Demand shifting toward pickup points or consolidated delivery reduces CPP, while aligning delivery modes with customer time preferences enhances SLA compliance.
(Kim Ngoc et al., 2025)	Barriers to the Adoption of Electric Cargo Vehicles in Vietnam	Open data integration improves route planning accuracy and SLA performance, even when travel distances slightly increase.
(Mahmoodi et al., 2025)	Optimizing Energy and CO_2 Efficiency in Last-Mile Delivery Using Hybrid Fleet Models	Outsourcing cost models primarily influence CPP, whereas route planning and capacity allocation decisions significantly affect SLA performance.
(Kartono & Tjahjadi, 2021)	Factors Affecting Consumers' Intentions to Use Online Food Delivery Services During COVID-19 Outbreak in Jabodetabek Area	Overall, technology-based logistics solutions improve security, convenience, delivery success rates, operational efficiency, and on-time performance, thereby strengthening both CPP efficiency and SLA achievement.
(Rahmaningtyas & Kusumawardani, 2025)	Technology Acceptance Model (TAM) and Perceived Risk in Online Purchase Decisions for Traditional Foods, Indonesia	Machine learning–based route sequence prediction enhances operational efficiency (CPP) and delivery route accuracy (SLA).
(Zhou et al., 2025)	Last-Mile Delivery Optimization: A Case-Study Using Meituan Dataset	Optimization approaches (linear programming, artificial intelligence, metaheuristics, GIS, and real-time routing technologies) significantly improve cost efficiency (CPP) and delivery reliability (SLA).
(Liu et al., 2024)	Determinants of Consumer Intention to Adopt a Self-Service Technology Strategy for Last-Mile Delivery in Guangzhou, China	Integrated last-mile concepts and hybrid fleet models enhance cost efficiency, reduce operational expenses (CPP), and improve service reliability (SLA).
(Antonios et al., 2022)	Investigating End-User Acceptance of Last-Mile Delivery by Autonomous Vehicles in the United States	Sustainable logistics practices contribute to lower operational costs (CPP) while enhancing service reliability and SLA achievement.
(Fagan et al., 2022)	Autonomous Delivery Vehicles: Why You Should Care and What You Should Do	Perceived usefulness and trust significantly drive the adoption of drones and autonomous vehicles, potentially reducing CPP through operational efficiency and improving SLA via faster and more flexible delivery.
(Montero-Vega et al., 2025)	Understanding the impact of socio-demographic differences on acceptance of last-mile delivery technologies: A comparative analysis	Last-Mile-as-a-Service (LMaaS) platforms reduce CPP through shared fleets and resource pooling while improving SLA through capacity flexibility and coordination efficiency.
(Klein & Popp, 2022)	Last-Mile Delivery Methods in E-Commerce: Does Perceived Sustainability Matter for Consumer Acceptance and Usage?	Trust is often identified as the most dominant determinant in last-mile service adoption, followed by PU and PEOU, all of which positively influence operational performance (CPP/SLA).
(Bergantino et al., 2025)	Innovating the last mile: Consumer acceptance and economic drivers of drone deliveries in urban logistics Angela	Delivery flexibility in time and location reduces failed deliveries, improves SLA performance, and enhances customer satisfaction.
(Alhothali et al., 2024)	Consumer Acceptance of Drones for Last-Mile Delivery in Jeddah, Saudi Arabia	Organizational strategy, technological readiness, and competitive pressure positively influence last-mile technology adoption, contributing to CPP reduction and SLA improvement.

Authors & Year	Study Title	Key Findings related to CPP/SLA
(Suguna et al., 2022)	A Study on the Influential Factors of the Last Mile Delivery Projects during Covid-19 Era	High initial investment costs, infrastructure limitations, and vehicle range constraints negatively affect CPP efficiency and SLA reliability.
(Li et al., 2021)	Logistics Service Mode Selection for Last Mile Delivery: An Analysis Method Considering Customer Utility and Delivery Service Cost	Soft Time Window (STW) models are more flexible and efficient than Hard Time Window (HTW) models; pre-booking improves SLA despite potentially increasing distance and costs.
(Muharemović et al., 2025)	Cost Modeling for Pickup and Delivery Outsourcing in CEP Operations: A Multidimensional Approach	Parcel lockers and smart lockers reduce CPP by 25–70% compared to home delivery and significantly improve service reliability, flexibility, and SLA compliance.
(ElSemary et al., 2025)	An Empirical Study on the Determinants of Customers' Intentions to Switch to Smart Lockers as a Trending Last-Mile Logistics Channel	Demand shifting toward pickup points or consolidated delivery reduces CPP, while aligning delivery modes with customer time preferences enhances SLA compliance.
(Al-Rahamneh et al., 2025)	The Impact of Integrating Open Data in Smart Last-Mile Logistics: The Example of Pamplona Open Data Catalog	Open data integration improves route planning accuracy and SLA performance, even when travel distances slightly increase.
(Zhang & Demir, 2025)	Parcel Locker Solutions for Last Mile Delivery: A Systematic Literature Review and Future Research Directions	Outsourcing cost models primarily influence CPP, whereas route planning and capacity allocation decisions significantly affect SLA performance.
(Sang An et al., 2022)	Consumers' Adoption of Parcel Locker Service: Protection and Technology Perspectives	Overall, technology-based logistics solutions improve security, convenience, delivery success rates, operational efficiency, and on-time performance, thereby strengthening both CPP efficiency and SLA achievement.
(Wahab et al., 2025)	Parcel Locker Solutions for Last Mile Delivery: A Systematic Literature Review and Future Research Directions	Machine learning–based route sequence prediction enhances operational efficiency (CPP) and delivery route accuracy (SLA).
(Budiyanto et al., 2024)	The Future of Last-Mile Logistics: Pathways Toward Sustainable E-Commerce	Optimization approaches (linear programming, artificial intelligence, metaheuristics, GIS, and real-time routing technologies) significantly improve cost efficiency (CPP) and delivery reliability (SLA).
(Viu-Roig & Alvarez-Palau, 2020)	The Impact of E-Commerce-Related Last-Mile Logistics on Cities: A Systematic Literature Review	Consolidation strategies, route optimization, and digital solutions reduce delivery costs (CPP) and improve reliability and punctuality, thereby supporting SLA performance.

The results of the synthesis of the 39 selected articles were subsequently categorized based on TAM factors and their impact on Cost Per Parcel (CPP) and Service Level Agreement (SLA). The categories and supporting references for each finding are presented in Table 4.

Table 4: Categorization Of Selected Studies Based on TAM Factors And Operational Performance (CPP and SLA)

Category	Sub-Category	References (Selected Studies)	Total
TAM Factors	Perceived Usefulness (PU)	(Alhothali et al., 2024; ElSemary et al., 2025; Mathew et al., 2023; Rahmaningtyas & Kusumawardani, 2025; Schmidt & Saraceni, 2024; Yick & Selamat, 2024)	7
	Perceived Ease of Use (PEOU)	(ElSemary et al., 2025; Esmaili et al., 2025; Liu et al., 2024; Rahmaningtyas & Kusumawardani, 2025; Sultan et al., 2023; Yick & Selamat, 2024)	7
	Trust	(Alhothali et al., 2024; ElSemary et al., 2025; Esmaili et al., 2025; Kartono & Tjahjadi, 2021; Yick & Selamat, 2024)	5
	Perceived Risk	(Alverhed et al., 2024; ElSemary et al., 2025; Kim Ngoc et al., 2025; Klein & Popp, 2022; Rahmaningtyas & Kusumawardani, 2025; Sultan et al., 2023)	6
	Organizational	(Ismail & Jokonya, 2023; Montero-Vega et al., 2025; Muharemović et al.,	4

Category	Sub-Category	References (Selected Studies)	Total
	Readiness	2025; Ricardianto et al., 2023)	
	Social Influence	(Antonios et al., 2022; Bergantino et al., 2025; Klein & Popp, 2022; Mathew et al., 2023)	4
Impact on CPP	Route Optimization & Scheduling	(Al-Rahamneh et al., 2025; Escudero-Santana et al., 2022; Li et al., 2021; Liu et al., 2024; Mo et al., 2023; Shuaibu et al., 2025; Zhou et al., 2025)	7
	Consolidation (Parcel Lockers)	(Alverhed et al., 2024; Antonios et al., 2022; ElSemary et al., 2025; Ivanišević et al., 2025; Klein & Popp, 2022; Silva et al., 2023; Wahab et al., 2025; Yick & Selamat, 2024; Zhang & Demir, 2025)	9
	WMS/TMS Integration	(Ismail & Jokonya, 2023; Montero-Vega et al., 2025; Muharemović et al., 2025; Ricardianto et al., 2023)	4
	Digital tracking	(Al-Rahamneh et al., 2025; Alhothali et al., 2024; Schmidt & Saraceni, 2024; Shuaibu et al., 2025)	4
Impact on SLA	Delivery Punctuality	(Bergantino et al., 2025; ElSemary et al., 2025; Li et al., 2021; Mathew et al., 2023; Silva et al., 2023; Zhou et al., 2025)	6
	Delivery success rate	(Antonios et al., 2022; Esmaili et al., 2025; Mahmoodi et al., 2025; Mo et al., 2023; Sultan et al., 2023; Zhang & Demir, 2025)	6
	Reliability & visibility	(Budiyanto et al., 2024; Kartono & Tjahjadi, 2021; Klein & Popp, 2022; Montero-Vega et al., 2025; Ricardianto et al., 2023; Viu-Roig & Alvarez-Palau, 2020)	6

Based on the table above, several key factors influencing the implementation of the Technology Acceptance Model (TAM) and its impact on Cost Per Parcel (CPP) and Service Level Agreement (SLA) can be identified:

a. Perceived Usefulness (PU): This is the most dominant factor driving technology adoption, as users are primarily motivated by tangible benefits such as route efficiency, cost reduction, and SLA improvement.
b. Perceived Ease of Use (PEOU): Ease of use represents the second most influential factor, particularly for couriers and operational managers who rely on practical, user-friendly systems in field operations.
c. Trust: Trust in technology especially regarding data security and system reliability plays a significant role, particularly in developing countries where technological uncertainty may be higher.
d. Perceived Risk: Risk perception, including concerns about theft, system failure, and operational disruption, constitutes a major barrier, although its influence is generally lower than that of PU and PEOU.
e. Organizational Readiness: Organizational preparedness, including infrastructure availability, employee training, and strategic alignment, is a critical determinant of successful implementation.
f. Social Influence: Peer influence and workplace norms also contribute to technology adoption decisions within logistics organizations.
g. Route Optimization & Scheduling, Consolidation (Parcel Lockers), WMS/TMS Integration, and Digital Tracking: These represent the primary operational mechanisms contributing to CPP reduction.
h. Delivery Punctuality, Delivery Success Rate, and Reliability & Visibility: These are the main operational outcomes associated with SLA improvement.

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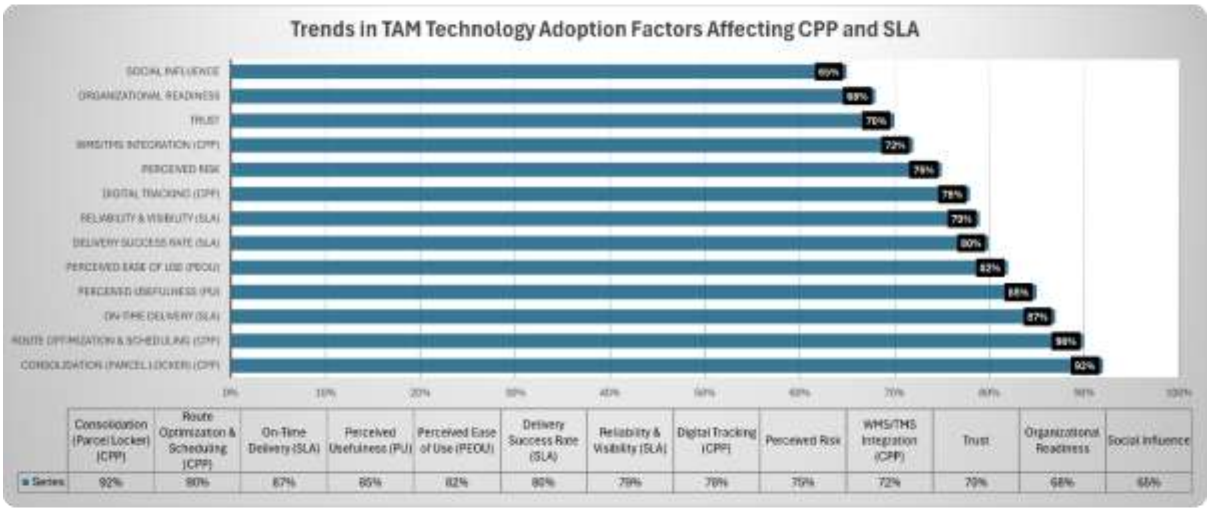

Figure 3: Trends in Tam Technology Adoption Factor Affecting CPP And SLA

From Figure 3, it can be observed the percentage contribution of each TAM technology adoption factor influencing CPP and SLA performance. The highest influence is shown by Consolidation (Parcel Locker) (CPP) at 92%, followed by Route Optimization & Scheduling (CPP) at 90% and On-Time Delivery (SLA) at 87%. Perceived Usefulness (PU) contributes 85% and Perceived Ease of Use (PEOU) 82%. Operational performance factors such as Delivery Success Rate (SLA) and Reliability & Visibility (SLA) contribute 80% and 79%, respectively, while Digital Tracking (CPP) contributes 78%. Risk and integration aspects, namely Perceived Risk and WMS/TMS Integration (CPP), show moderate influence at 75% and 72%. Finally, organizational and social readiness factors Trust (70%), Organizational Readiness (68%), and Social Influence (65%) demonstrate comparatively lower influence levels.

Conclusion

This study analyzes trends in technology adoption factors based on the Technology Acceptance Model (TAM) that influence Cost Per Parcel (CPP) and Service Level Agreement (SLA) performance in smart logistics operations. The analysis reveals that technological and operational optimization factors exert the highest level of influence on CPP and SLA performance. Parcel locker consolidation, route optimization and scheduling, and delivery punctuality emerge as the most dominant factors, confirming that logistics efficiency technologies are the primary drivers of improved last-mile delivery performance.

The core TAM constructs Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) also demonstrate a high level of influence, indicating that perceived benefits and ease of system utilization remain fundamental determinants in the adoption of logistics technologies. Operational visibility and reliability factors, such as delivery success rate, reliability & visibility, and digital tracking, show a moderate contribution, emphasizing the importance of real-time monitoring and service transparency in ensuring SLA compliance.

Conversely, perceived risk and system integration factors, including Perceived Risk and WMS/TMS integration, exhibit a moderate level of influence, suggesting that technological interoperability and uncertainty concerns continue to affect adoption decisions. Organizational and social dimensions Trust, Organizational Readiness, and Social Influence—show relatively lower contributions, indicating that adoption in smart logistics is more strongly driven by technological and efficiency requirements rather than social considerations.

Overall, the findings confirm that TAM-based technology adoption significantly affects CPP and SLA performance, with operational optimization technologies representing the most dominant factor in enhancing last-mile logistics performance. These results provide practical implications for logistics stakeholders to prioritize investments in technologies that directly improve distribution efficiency, delivery reliability, and service performance.

Declaration of Competing Interest

The authors declare that there are no financial conflicts of interest or personal relationships that could have influenced the work reported in this study.

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