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Urban Logistics Factors and Last-Mile Delivery Performance in Malaysian E-Commerce

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Abstract

The rapid growth of e-commerce has heightened the strategic importance of last-mile delivery (LMD) in urban logistics. However, limited empirical evidence exists on the determinants of LMD performance in emerging economies. Grounded in Resource-Based Theory (RBT), this study examines the effects of traffic conditions, infrastructure, technology, and regulatory frameworks on last-mile delivery performance in Malaysia's e-commerce sector. A quantitative approach was adopted using survey data collected from 390 e-commerce sellers and delivery couriers. Data were analysed using descriptive statistics, Pearson correlation, and multiple regression techniques. The findings indicate that all four factors significantly and positively influence LMD performance. Infrastructure emerged as the strongest predictor, followed by technology, highlighting the importance of logistics facilities, transportation networks, digital capabilities, and operational efficiency. Traffic conditions and regulatory frameworks also contribute significantly to delivery effectiveness. This study extends the application of RBT to urban logistics and provides practical insights to enhance delivery performance and support sustainable e-commerce development in emerging markets.

Keywords: Urban Logistics, last-Mile Delivery Performance, E-Commerce, Infrastructure, Technology, Regulation, Resource-Based Theory, Malaysia.

Introduction

Electronic commerce, often known as e-commerce, is a business transaction in which information is exchanged using electronic systems or computer networks, such as the Internet [1]. In recent years, the growing popularity of e-commerce in Malaysia has prompted a renewed review of last-mile delivery (LMD) performance. According to Malaysia's e-commerce market is growing rapidly, with projections indicating a compound annual growth rate (CAGR) of around 8.1% between 2023 and 2028 [2]. The increase is being driven by reasons such as growing internet penetration, larger smartphone usage, and shifting customer preferences toward online purchasing.

As more people turn to e-commerce platforms for their purchasing needs, demand for efficient last-mile delivery services is growing. In the era of Web 2.0, it might be challenging and time-consuming for individuals to visit retailers and supermarkets to make purchases due to busy lifestyles and overreliance on the Internet. Therefore, e-commerce has altered people's lives by saving time, providing more alternatives and options, and offering 24-hour access. Apart from the rise in internet penetration, the e-commerce market in Malaysia has grown rapidly due to the COVID-19 pandemic. According to the E-commerce Consumers, Malaysia's E-commerce customer percentage reached 78.3%, an increase of 27.1 percentage points from 2018 [3]. The rise can be explained by advancements in technology and connectivity, as well as COVID-19 pandemic-related limitations in recent years. New Straits Times (2022) said that 9 out of 10 Malaysians would choose to purchase online. During the COVID-19 pandemic, Malaysians became accustomed to e-commerce and delivery services, and now consider them a part of their daily lives [4]. To maintain competitive advantages, logistics compa-

nies must create and improve the customer experience by providing effective, better last-mile delivery.

The rise in online transactions has put major pressure on logistics networks, particularly in urban areas where last-mile delivery is essential for the survival of e-commerce businesses. Despite being the most expensive and time-consuming stage of the shipping process, it is essential to ensure customer satisfaction [5]. Effective management of last-mile deliveries and satellite depots is crucial for supply chain and logistics success, especially in e-commerce and the on-demand economy [6]. Last-mile delivery is frequently the most difficult and expensive part of the logistics process because it requires complex relationships with urban infrastructure, traffic conditions, and the unique demands of densely populated locations. In urban environments, several factors affect last-mile delivery performance, including road infrastructure, traffic conditions, technological factors, and local regulations. In Malaysia, there are a lot of logistics service providers (LSPs), including GDEX, DHL, POS Malaysia, J&T, KGW Logistics, Ninjavan and LalaMove. To penetrate the market, competitiveness would be relatively high by balancing the technology used and operational costs. In Malaysia's urban areas, these concerns can be exacerbated by fast urbanisation, which frequently outpaces infrastructure development, resulting in inefficient transportation networks. To address the division of shipments in the supply chain created by e-commerce, innovation in last-mile logistics delivery is important, especially in the package delivery business. Over the years, several innovative options for home delivery have emerged, including reception boxes, pickup points, crowdsourced logistics, drones, robots, and smart lockers, to address the problem. Furthermore, customer expectations for timely, dependable delivery have risen, making last-mile logistics an important differentiator in a competitive e-commerce landscape [7]. As a result, understanding how urban logistics factors influence last-mile delivery performance has become a top concern for Malaysian e-commerce investors seeking innovative and flexible solutions to these obstacles.

Last-mile delivery customer satisfaction is a mostly unexplored aspect of logistics [8]. There are still many gaps in knowing customer experiences during the delivery process. With the growing popularity of e-commerce in Malaysia, demand for effective last-mile delivery has increased, introducing new challenges in urban logistics. Last-mile delivery, the final phase of the supply chain, is critical to assuring customer satisfaction in e-commerce. Furthermore, the current city infrastructure often fails to handle the increasing volume of deliveries. Many cities were not constructed with modern e-commerce logistics in mind, resulting in narrow streets and little parking space for delivery trucks. As a result, vehicles frequently spend extra time seeking suitable unloading locations, worsening delays and increasing costs associated with wasted fuel and time.

Furthermore, consumer expectations have shifted significantly in the on-demand economy, with customers seeking faster, more flexible delivery options. This increased expectation puts more pressure on logistics companies to innovate and modify their operations quickly. According to Siegfried and Zhang (2021), the difficulty is exacerbated by the fact that last-mile delivery accounts for a large amount of total logistics costs—up to 41%—making it important for enterprises to optimise this sector to remain competitive. Hence, this study aims to determine the impact of urban logistics factors on last-mile delivery performance for e-commerce in Malaysia and provide targeted information to help develop more effective and sustainable logistics solutions.

Literature Review

Last-Mile Delivery Performance

Last-mile delivery (LMD) represents the final stage of the logistics process in which products are transported from distribution facilities to end customers. Although this stage constitutes only a small portion of the total supply chain distance, it is widely recognised as the most costly, complex, and customer-sensitive segment of logistics operations [9]. argue that LMD encompasses all logistics activities associated with the distribution of goods to customers in urban settings, while emphasise that successful LMD requires the effective integration of transportation modes, storage facilities, and delivery interfaces [10]. Existing literature consistently identifies delivery performance as a critical determinant of logistics effectiveness and customer satisfaction. Delivery performance is commonly assessed using dimensions such as delivery reliability, timeliness, responsiveness, flexibility, and order accuracy [11]. However, traditional logistics performance indicators, particularly cost-focused measures, have been criticised for failing to capture service quality outcomes that directly influence customer experiences. As e-commerce customers increasingly demand rapid and reliable deliveries, logistics providers are compelled to optimise delivery operations while balancing operational costs and service quality. Consequently, understanding the factors that influence LMD performance has emerged as a strategic priority for both researchers and practitioners. Despite extensive research on delivery performance, studies remain fragmented regarding the urban logistics factors that contribute to operational success. Most studies examine individual determinants separately, creating a need for a more integrated understanding of how urban logistics conditions collectively shape last-mile delivery outcomes.

Traffic Conditions and Last-Mile Delivery Performance

Traffic conditions are among the most influential external factors affecting urban logistics performance. The increasing concentration of population and commercial activities in urban areas has intensified road congestion, creating significant challenges for logistics service providers. According to the growth of e-commerce has substantially increased freight traffic in metropolitan areas, contributing to congestion, delays, and operational inefficiencies. Similarly, contend that urban traffic environments are characterised by heterogeneous road users and dynamic traffic patterns, making route planning and delivery scheduling increasingly complex [12-14].

Prior studies generally agree that traffic congestion negatively affects delivery efficiency by increasing travel time variability, fuel consumption, and labour costs emphasise that real-time traffic information is essential for effective route optimisation and operational decision-making. Likewise, found that fluctuating traffic conditions significantly influence travel times and directly affect delivery reliability and service performance [15]. However, some scholars argue that the adverse effects of traffic congestion can be partially mitigated through technological interventions and adaptive logistics strategies. For example,

dynamic routing systems and predictive traffic analytics allow logistics providers to respond proactively to changing traffic conditions. This suggests that although traffic conditions present a substantial operational challenge, their negative impact may depend on the firm's ability to leverage technological and organisational capabilities. Therefore, traffic conditions should be viewed not only as an environmental constraint but also as a test of the adaptability and resilience of urban logistics systems.

Infrastructure and Last-Mile Delivery Performance

Infrastructure is widely regarded as a fundamental enabler of logistics efficiency and economic development. Urban logistics activities depend heavily on the availability and quality of transportation networks, logistics facilities, warehousing infrastructure, and loading and unloading zones. Bosona (2020) argues that inadequate infrastructure remains a primary barrier to efficient last-mile logistics operations, particularly in rapidly urbanising regions where demand often exceeds transportation capacity.

Existing studies suggest that infrastructure influences delivery performance by reducing operational uncertainty and facilitating smoother freight movements observed that rapid growth in vehicle ownership and urbanisation has placed considerable pressure on Malaysia's transportation infrastructure, creating inefficiencies within urban logistics systems. Similarly, highlighted the importance of logistics infrastructure innovations, including urban consolidation centres, dedicated delivery zones, smart parking facilities, and collection points in enhancing delivery efficiency [16, 17]. Nevertheless, infrastructure investment alone may not guarantee superior logistics performance. Some researchers contend that the effectiveness of infrastructure depends on integrating physical assets with technological and policy support. Underutilised logistics facilities or poorly coordinated transportation systems may generate limited operational benefits despite substantial infrastructure investments. Consequently, the literature suggests that infrastructure should be viewed as a strategic resource whose value is maximised when combined with complementary organisational capabilities and institutional support mechanisms.

Technology and Last-Mile Delivery Performance

Technology has emerged as a transformative force in modern urban logistics, enabling firms to improve operational visibility, routing accuracy, and customer service quality. As e-commerce transactions continue to expand, logistics providers increasingly rely on digital solutions to address the complexity of last-mile delivery operations. emphasises that technologies such as intelligent delivery applications, digital tracking systems, and automated dispatching platforms contribute substantially to improved delivery management and operational efficiency [18].

The literature demonstrates strong consensus regarding the positive role of technology in enhancing delivery performance. Technologies such as real-time GPS tracking, artificial intelligence (AI), Internet of Things (IoT) applications, automation, and predictive analytics have been associated with reductions in delivery delays and improvements in customer satisfaction. Sorooshian et al. (2022) argue that AI-driven decision-making systems allow organisations to optimise resource allocation and forecast operational disruptions more effectively. However, technology adoption is not without challenges highlights that many logistics service providers face financial constraints that limit their ability to invest in advanced technological systems [19]. Furthermore, implementing technology requires organisational readiness, employee competence, and sufficient infrastructure support to achieve expected outcomes. Consequently, while technology possesses significant potential to improve delivery performance, its effectiveness depends on the firm's capacity to integrate technological innovations into operational processes and strategic decision-making frameworks.

Regulation and Last-Mile Delivery Performance

Regulatory frameworks shape the operating environment of urban logistics systems by establishing rules and standards that govern transportation activities. Regulations influence delivery practices through traffic restrictions, environmental policies, safety requirements, urban access controls, and competition laws. defines regulation as a mechanism through which governments influence economic activities and ensure compliance with policy objectives, while Tamplin (2024) emphasises the role of regulations in promoting fair competition and consumer protection [20].

The relationship between regulation and logistics performance remains complex. On one hand, effective regulations can improve delivery efficiency by establishing standardised operational procedures and reducing market uncertainties argue that supportive regulatory policies can enhance supply chain coordination and facilitate service improvements. Additionally, regulatory frameworks can encourage sustainable logistics practices, particularly through environmental policies that promote cleaner transportation solutions [21].

On the other hand, excessive or poorly designed regulations may create operational barriers and increase compliance costs for logistics providers. Restrictions on delivery hours, vehicle access limitations, and administrative requirements may reduce operational flexibility and increase delivery complexity. Therefore, the effectiveness of regulation depends not only on the existence of policies but also on their alignment with logistics industry requirement. This suggests that regulatory frameworks function both as facilitators and constraints, requiring a balance between public policy objectives and operational efficiency considerations.

Resource-Based Theory

This study is grounded in Resource-Based Theory (RBT), which posits that the effective deployment of valuable, rare, inimitable, and non-substitutable resources influences organisational performance [22]. According to the resource-based perspective, organisations achieve sustainable competitive advantage when they possess and effectively utilise strategic resources that competitors cannot easily replicate.

Within the context of urban logistics, infrastructure, technology, traffic management capabilities, and regulatory support can be conceptualised as strategic resources that affect operational performance. Infrastructure provides the physical foundation for logistics activities, while technology enables information processing, coordination, and decision-making. Effective traffic management improves resource utilisation and delivery respon-

siveness, whereas supportive regulatory environments facilitate organisational efficiency and long-term sustainability. Previous logistics studies have emphasised the applicability of RBT in explaining variations in logistics capabilities and supply chain performance. The theory suggests that organisations that integrate infrastructure, technology, and institutional support more effectively than competitors are more likely to achieve superior last-mile delivery performance. Therefore, RBT provides a robust theoretical foundation for examining how urban logistics factors influence operational outcomes in Malaysia's rapidly evolving e-commerce sector.

Although previous studies have explored individual aspects of urban logistics, research remains fragmented in its explanation of how traffic conditions, infrastructure, technology, and regulatory frameworks collectively influence last-mile delivery performance. Furthermore, empirical evidence from emerging economies such as Malaysia remains limited, particularly when examined through the lens of Resource-Based Theory. Existing studies predominantly focus on customer-centred outcomes and often overlook the perspectives of operational stakeholders, including sellers and delivery couriers. Therefore, a comprehensive investigation of the combined effects of key urban logistics factors on last-mile delivery performance within Malaysia's e-commerce sector is needed to advance both theoretical understanding and practical application.

Methodology

Research Design

This study employed a quantitative research approach grounded in the positivist paradigm and guided by a deductive reasoning process. Quantitative research is particularly suitable for examining causal relationships among variables through systematic measurement and statistical analysis. Given the study's objective of investigating the influence of urban logistics factors on last-mile delivery (LMD) performance, a quantitative design provides a rigorous framework for testing the relationships between the independent variables, namely traffic conditions, infrastructure, technology, and regulation, and the dependent variable, last-mile delivery performance. The study adopted an explanatory research design to examine the extent to which variations in urban logistics factors explain differences in delivery performance outcomes. This approach enables the empirical assessment of theoretically derived relationships and contributes to the development of evidence-based insights relevant to urban logistics and e-commerce operations.

Research Setting and Time Horizon

A cross-sectional research design was adopted, whereby data were collected from respondents at a single point in time over three months. Cross-sectional studies are widely used in logistics and management research to examine relationships among variables within a specific contextual setting. They are particularly effective for capturing prevailing perceptions and operational realities. The study was conducted in Malaysia, focusing on stakeholders directly involved in last-mile delivery activities within the e-commerce sector, specifically e-commerce sellers and delivery couriers. Malaysia provides a particularly relevant context for this investigation due to the rapid expansion of its e-commerce market, increasing urbanisation, and growing dependence on efficient logistics systems. By examining respondents working in real-world logistics environments, the study enhances the ecological validity of the findings and provides practical insights into contemporary urban logistics challenges.

Population, Sample, and Sampling Procedure

The target population comprised e-commerce sellers and delivery couriers engaged in last-mile delivery operations across Malaysia. These groups were selected because they possess direct operational knowledge and experience regarding the factors influencing delivery performance. The minimum sample size was determined using the sample size estimation procedure developed by Krejcie and Morgan (1970), which recommends a minimum sample of 385 respondents for studies conducted at a 95% confidence level and a 5% margin of error. A total of 390 usable responses were obtained and retained for analysis, exceeding the minimum requirement and enhancing the study's statistical power and reliability.

To ensure adequate representation of the key respondent groups, stratified random sampling was employed. This sampling technique is particularly appropriate when the target population consists of distinct subgroups and allows for proportional representation within the sample [23]. The sampling frame was stratified according to respondents' roles, namely sellers and delivery couriers, to ensure that perspectives from both stakeholder groups were sufficiently represented. The use of stratified random sampling minimises sampling bias and improves the generalizability of the findings.

Data Collection Instrument

Primary data were collected using a structured questionnaire developed from established studies on urban logistics and last-mile delivery (LMD) performance. The questionnaire comprised three sections. Section A gathered respondents' demographic information, including gender, age, occupational role, frequency of delivery service usage, and business sector for seller respondents. Section B measured the dependent variable, namely LMD performance, through items assessing operational efficiency and delivery outcomes. Section C measured the independent variables, namely traffic conditions, infrastructure, technology, and regulatory frameworks.

All constructs were measured using a six-point Likert-type scale ranging from 1 (strongly disagree) to 6 (strongly agree). The use of an even-numbered response scale was intended to minimise central tendency bias by eliminating the neutral midpoint and encouraging respondents to indicate a clear position regarding each statement. This approach has been widely adopted in quantitative research to enhance response differentiation and improve measurement sensitivity. Higher scores indicated stronger agreement with the statements representing each construct.

Data Analysis

First, Pearson correlation analysis was performed to assess the strength and direction of the relationships between urban logistics factors and last-mile delivery performance. Correlation analysis enabled the identification of the degree of association between the independent and dependent variables [24].

Second, multiple regression analysis was employed to evaluate the relative influence of traffic conditions, infrastructure,

technology, and regulation on last-mile delivery performance. Multiple regression is particularly suitable for determining the explanatory power of multiple predictors simultaneously and identifying the most influential factors affecting the dependent variable. The analysis also facilitated the assessment of the overall model fit and the proportion of variance in last-mile delivery performance explained by the proposed urban logistics factors.

Methodological Justification

The methodological approach adopted in this study provides a robust and systematic framework for investigating the determinants of last-mile delivery performance within Malaysia's e-commerce sector. By integrating a quantitative design, stratified random sampling, and multivariate statistical analysis, the study ensures methodological rigour and enhances the reliability and validity of the findings. Furthermore, the focus on both sellers and delivery couriers enables a more comprehensive understanding of urban logistics challenges from multiple operational perspectives, thereby contributing meaningful empirical evidence to the urban logistics and supply chain management literature.

Correlation Analysis

Table 1: Correlation Analysis

Correlations					
	Last-Mile Delivery	**Traffic Condition**	**Infrastructure**	**Technology**	**Regulation**
Pearson Correlation	1	0.642**	0.698**	0.700**	0.672**

**. Correlation is significant at the 0.01 level (2-tailed).

Correlation Analysis

Table 1 presents the results of the Pearson correlation analysis examining the relationships between urban logistics factors and last-mile delivery performance. The findings reveal that all four urban logistics factors are positively and significantly associated with last-mile delivery performance ($p < 0.001$), providing preliminary support for the proposed conceptual framework. These results suggest that improvements in traffic conditions, infrastructure, technological capabilities, and regulatory support are associated with enhanced delivery performance within Malaysia's e-commerce sector.

Among the independent variables, technology exhibited the strongest positive relationship with last-mile delivery performance ($r = 0.700$, $p < 0.001$). This finding indicates that adopting advanced technological solutions, such as real-time tracking systems, route optimisation software, automation technologies, and digital logistics platforms, plays a critical role in improving delivery efficiency and service quality. The strong correlation suggests that technology enhances operational visibility, facilitates informed decision-making, and improves responsiveness to dynamic delivery conditions, thereby contributing substantially to last-mile delivery effectiveness. This finding is consistent with the growing body of literature that identifies technological capabilities as a key driver of logistics competitiveness and operational excellence. Similarly, infrastructure demonstrated a strong positive correlation with last-mile delivery performance ($r = 0.698$, $p < 0.001$). The strength of this relationship highlights the strategic importance of transportation networks, logistics facilities, urban consolidation centres, delivery hubs, and supporting physical infrastructure in facilitating efficient delivery operations. Adequate infrastructure reduces operational bottlenecks, shortens delivery lead times, and improves accessibility across urban areas.

The result suggests that investments in logistics infrastructure remain fundamental to enhancing delivery reliability and operational performance, particularly in rapidly urbanising environments where freight demand continues to increase. The analysis also revealed a significant and positive relationship between regulation and last-mile delivery performance ($r = 0.672$, $p < 0.001$). This finding underscores the importance of supportive regulatory frameworks in shaping efficient logistics operations. Effective regulations can facilitate smoother freight movements, improve operational consistency, ensure compliance with safety standards, and provide clearer guidelines for logistics providers. The relatively strong correlation indicates that an enabling regulatory environment positively influences delivery performance by reducing operational uncertainties and fostering better coordination among stakeholders in the urban logistics ecosystem.

Furthermore, traffic conditions were found to be significantly and positively related a last-mile delivery performance ($r = 0.642$, $p < 0.001$). Although this represents the lowest correlation coefficient among the independent variables, the relationship remains substantial and statistically significant. The finding suggests that favourable traffic conditions, characterised by reduced congestion, efficient traffic management, and improved road accessibility, contribute to enhanced delivery reliability and operational efficiency. Given that traffic congestion is a persistent challenge in urban logistics, the result emphasises the importance of effective traffic management strategies in supporting timely and cost-efficient last-mile delivery operations.

Overall, the correlation coefficients ranged from 0.642 to 0.700, indicating strong positive associations between the urban logistics factors and last-mile delivery performance. According to commonly accepted interpretations of correlation strength, these values represent robust relationships, suggesting that the selected urban logistics factors are important determinants of delivery effectiveness. While correlation analysis does not establish causality, the findings provide empirical evidence that improvements in technology, infrastructure, regulation, and traffic conditions are closely associated with superior last-mile delivery outcomes. Consequently, these results provide a strong foundation for the subsequent regression analysis, which further examines the relative contribution of each factor in explaining variations in last-mile delivery performance. The results lend empirical

support to the Resource-Based Theory (RBT), which posits that the effective deployment of valuable resources and capabilities influences organisational performance. In the context of urban logistics, infrastructure and technology can be viewed as strategic resources that enhance operational efficiency. At the same time, favourable traffic conditions and supportive regulatory frameworks constitute enabling environmental conditions that facilitate resource utilisation. The strong and significant relationships observed in this study suggest that organisations possessing superior logistics capabilities are more likely to achieve higher levels of last-mile delivery performance. These findings reinforce the argument that effective urban logistics management requires an integrated approach that combines physical infrastructure, technological innovation, and institutional support to achieve sustainable competitive advantage in the e-commerce sector.

Table 2: Model Summary

Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	0.855a	0.732	0.729	0.48327

a. Predictors: (Constant), Traffic Condition, Infrastructure, Technology, Regulation

Table 3: ANOVA and Coefficient Table

ANOVAa						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	245.112	4	61.278	262.377	0.000b
	Residual	89.917	385	0.234		
	Total	335.029	389			

a. Dependent Variable: Last-Mile Delivery Performance

b. Predictors: (Constant), Traffic Condition, Infrastructure, Technology, Regulation

Coefficientsa						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.784	0.103		7.616	0.000
	Traffic Condition	0.236	0.037	0.214	6.434	0.000
	Infrastructure	0.303	0.035	0.294	8.595	0.000
	Technology	0.285	0.034	0.289	8.353	0.000
	Regulation	0.299	0.035	0.279	8.483	0.000

a. Dependent Variable: Last-Mile Delivery Performance

Multiple Regression Analysis and Discussion

Multiple regression analysis was conducted to examine the extent to which traffic conditions, infrastructure, technology, and regulation explain variations in last-mile delivery performance within Malaysia's e-commerce sector. The regression model was statistically significant, as evidenced by an F-statistic of 262.377 ($p < 0.001$), indicating that the set of predictor variables collectively explains a significant proportion of the variance in last-mile delivery performance.

The model produced an R^2 of 0.732 and an adjusted R^2 of 0.729, indicating that approximately 73.2% of the variance in last-mile delivery performance is explained by traffic conditions, infrastructure, technology, and regulation. This level of explanatory power suggests that the proposed model provides a robust representation of the key determinants influencing delivery performance. The remaining 26.8% of unexplained variance may be attributed to other factors not included in the present study, such as customer behaviour, organisational capabilities, operational practices, environmental conditions, and market dynamics.

The regression coefficients further indicate that all four urban logistics factors exert a positive and statistically significant influence on last-mile delivery performance ($p < 0.001$). These findings provide strong empirical support for the study's conceptual framework and suggest that improvements in urban logistics capabilities substantially enhance delivery effectiveness within the e-commerce ecosystem. Moreover, the results are consistent with the Resource-Based Theory (RBT), which posits that organisations achieve superior performance through the effective utilisation of valuable resources and capabilities. In this context, urban logistics factors can be viewed as strategic resources that

enable logistics providers to improve operational efficiency, service reliability, and customer satisfaction.

Among the four predictors, infrastructure emerged as the most influential determinant of last-mile delivery performance ($\beta = 0.294$, $p < 0.001$), followed by technology ($\beta = 0.289$, $p < 0.001$), regulation ($\beta = 0.279$, $p < 0.001$), and traffic conditions ($\beta = 0.214$, $p < 0.001$). These findings indicate that infrastructure investments generate the greatest improvement in delivery performance, highlighting the fundamental role of physical logistics assets in supporting efficient urban freight distribution.

Infrastructure and Last-Mile Delivery Performance

Infrastructure was identified as the strongest predictor of last-mile delivery performance. This finding underscores the critical role of transportation networks, logistics hubs, urban consolidation centres, warehousing facilities, loading zones, and delivery infrastructure in facilitating efficient delivery operations. Well-developed infrastructure improves accessibility, reduces transportation bottlenecks, shortens delivery lead times, and enhances overall operational reliability.

The finding aligns with Bosona (2020), who argues that inadequate infrastructure remains one of the principal constraints affecting last-mile logistics efficiency. In rapidly urbanising environments such as Malaysia, continuous infrastructure development is essential to support the increasing volume of e-commerce transactions and freight movements. The result further suggests that investments in smart logistics infrastructure, dedicated delivery corridors, micro-distribution centres, and integrated transport systems are likely to generate substantial improvements in delivery performance. Consequently, infrastructure should be considered a strategic resource that provides a foundation for sustainable logistics competitiveness.

Technology and Last-Mile Delivery Performance

Technology was identified as the second most influential predictor of last-mile delivery performance. The significant positive effect indicates that adopting advanced technological solutions substantially improves delivery effectiveness and operational responsiveness. Technologies such as real-time tracking systems, route optimisation software, artificial intelligence (AI), delivery automation, and data analytics enhance operational visibility and facilitate informed decision-making throughout the delivery process.

This finding corroborates previous studies suggesting that digital transformation is becoming increasingly important within urban logistics systems. Technological capabilities enable logistics providers to optimise fleet utilisation, reduce delivery delays, improve route efficiency, and enhance customer communication. Furthermore, emerging technologies such as autonomous delivery vehicles, drones, and smart logistics platforms have the potential to transform traditional delivery models by reducing operational costs while improving delivery accuracy and service reliability. Therefore, the results highlight technology as a key strategic capability that strengthens organisational competitiveness in the rapidly evolving e-commerce environment.

Regulation and Last-Mile Delivery Performance

The findings also demonstrate that regulation exerts a significant positive influence on last-mile delivery performance. This result suggests that well-designed regulatory frameworks contribute to operational efficiency by providing clear guidelines, reducing uncertainties, and facilitating coordination among logistics stakeholders. Regulations governing transportation operations, safety compliance, delivery standards, urban freight access, and emerging delivery technologies can create a more predictable and enabling environment for logistics activities.

The positive effect of regulation indicates that policymakers play a crucial role in shaping urban logistics performance. Supportive regulations can encourage innovation, improve service quality, and promote sustainable logistics practices. However, regulatory frameworks must balance operational efficiency with broader societal objectives such as environmental sustainability, traffic management, and public safety. As urban logistics systems continue to evolve, adaptive regulatory policies will become increasingly important in supporting efficient and sustainable last-mile delivery operations.

Traffic Conditions and Last-Mile Delivery Performance

Traffic conditions were also found to significantly influence last-mile delivery performance, although their contribution was comparatively lower than those of infrastructure, technology, and regulation. Nevertheless, the positive and significant coefficient indicates that favourable traffic conditions meaningfully contribute to delivery efficiency and reliability.

Urban traffic congestion remains a persistent challenge for logistics operators, often resulting in extended delivery times, increased fuel consumption, higher operational costs, and reduced service reliability. The findings suggest that improved traffic management systems, intelligent transportation technologies, and real-time traffic information can enhance route planning and reduce delivery disruptions. In addition, strategies such as dynamic route optimisation and integrated urban mobility planning may help mitigate the adverse effects of congestion on delivery operations. Therefore, effective traffic management remains an important component of successful urban logistics systems.

Conclusion

This study investigated the influence of urban logistics factors on last-mile delivery (LMD) performance in Malaysia's e-commerce sector by examining the effects of traffic conditions, infrastructure, technology, and regulatory frameworks. The findings demonstrate that all four factors significantly and positively contribute to delivery performance, confirming their critical role in enhancing the efficiency and reliability of last-mile logistics operations. The regression model explained a substantial proportion of the variance in LMD performance, highlighting the importance of urban logistics capabilities in determining operational outcomes.

Among the factors examined, infrastructure emerged as the strongest predictor of LMD performance, underscoring the pivotal role of transportation networks, logistics facilities, and distribution hubs in facilitating efficient delivery operations. Technology was identified as the second most influential factor, indicating the growing importance of digital solutions such as real-time tracking, route optimisation, and automation in improving operational responsiveness and service quality. Further-

more, supportive regulatory frameworks and favourable traffic conditions were found to contribute significantly to delivery effectiveness by reducing operational barriers and enhancing consistency in logistics processes.

From a theoretical perspective, this study extends the application of Resource-Based Theory (RBT) in the urban logistics domain by demonstrating that infrastructure, technology, regulatory support, and operating conditions constitute valuable organisational resources that drive performance improvements. The findings reinforce the argument that sustainable competitive advantage in e-commerce logistics depends on the effective development and integration of these complementary resources and capabilities.

Practically, the study provides valuable insights for logistics service providers, e-commerce firms, urban planners, and policymakers. Strategic investments in logistics infrastructure, digital technologies, traffic management systems, and supportive regulatory initiatives can collectively enhance last-mile delivery performance and strengthen the competitiveness and sustainability of the e-commerce ecosystem.

As demand for e-commerce continues to expand, the ability to optimise urban logistics capabilities will become increasingly important for achieving operational excellence and long-term sector growth.

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