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Technological Disruption in Indian Logistics: A Study of Autonomous Vehicles in Last- and Mid-Mile Delivery

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Abstract

Purpose: *The last-mile and mid-mile delivery landscape in India are undergoing a significant transformation driven by the growing adoption of Autonomous Delivery Vehicles (ADVs). These include various types, such as ground delivery robots, aerial delivery drones, and self-driving trucks and vans, which are set to impact the logistics sector fundamentally. Th study proposes a conceptual model based on Technology Readiness Theory and Innovation Resistance Theory to understand improvements in operational efficiency, cost reductions, and increased sustainability, addressing challenges high labor costs, environmental impacts, and urban transportation congestion.*

Methodology: *use a survey method with a questionnaire to identify the barriers and challenges faced by ADVs in India and explore user perceptions of technological innovation in this context. PLS-SEM is to validate the model.*

Result: *The analysis indicates that the adoption of ADVs in India is likely to be gradual and essential for ongoing innovation, with careful consideration of social stability.*

Keywords: *Autonomous Delivery Vehicles (ADVs), Last-Mile Delivery, Mid-Mile Delivery, Technology Readiness Theory, Innovation Resistance Theory*

1. Introduction

In the recent years, it has been seen that drone technology has emerged as one of the transformative forces in the logistic sector, capturing considerable attention from both researchers and industry practitioners (Moshref-Javadi, & Winkenbach, 2021; Zieher et al., 2024; Jazairy et al., 2025). The growing interest in changing logistics technology stems from reimagining shift from traditional transportation system. With the constrained by traffic congestion, urban density, and other environmental concerns. At the same time issue related to societal awareness carbon emissions and sustainability have amplified the search for greener and more resource–efficient delivery methods. Autonomous Delivery Vehicles (ADVs) are a new method of Artificial Intelligence (AI) used in transportation, and to facilitate autonomous driving technology using last-mile delivery from the distribution centre to the end consumers (Lim & Winkenbach, 2019; Olsson,2023; Jiang, 2025). This process is proved to be an efficient and credible delivery system (Peppel et al., 2022). The global robot delivery market was estimated to be valued at 592.8 million in 2024, and the projected value will increase to USD 795.6 million in 2025 to USD 3236.5 million by 2030, at a CAGR of 32.4% as per the forecast period (marketand market, 2025).

By 2030, India is expected to emerge as a significant market for last-mile autonomous delivery, driven by e-commerce, urbaniation, and the growing need for faster delivery without traffic congestion. To avoid this, technology has been adopted includ autonomous delivery vehicles and drones. The concept of the “Little Indian” robot s designed to understand the Indian condition, which also includes global players and self-driving vehicles for various applications. With autonomous delivery vehicles transforming Indian roads both last mile and mid mile delivery system are promising for future enhanced efficiency, reduced cost and improve sustainability.

1.1 Last – Mile Delivery System in Indian Market

he last mile delivery system introduced in the Indian market via e-commerce and healthcare

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sector has been significant in autonomous delivery robot and bot. These vehicles leverage Artificial Intelligence, use sensors and use robotics for safety and easy navigation in diverse terrains and promptly deliver goods directly to the end users, pick-up points and can be around the clock. From the above-mentioned initiative, like "Little Indian" has demonstrated the viability of the use of robots in the last mile delivery in the real urban settings, these showcase improvements in delivery speeds, cost-effectiveness and also towards the emissions (Bonilla et al., 2024). The use of advanced algorithms enables route optimiation, real-time tracking and enhanced logistic efficiency and customer satisfaction.

1.2 Autonomous Vehicles as a Disruptive Technology

Autonomous delivery vehicles (ADVs) have emerged as a solution to play a crucial role in meeting these demands and ensuring the competitiveness of logistics providers in the future. Autonomous delivery robots (ADRs) represent a developing technology with the potential to provide effective last-mile solutions, particularly in urban environments (Alverhed, 2024). These robots are designed to navigate sidewalks and pedestrian areas and deliver packages directly to customers' doorsteps. Robots, drones, and autonomous vehicles, all powered by artificial intelligence (AI), are tangible technologies that can be employed to optimie last-mile delivery processes (Sorooshian et al., 2022). Drones offer the advantage of aerial delivery, bypassing traffic congestion and reaching remote locations, whereas autonomous vehicles provide a more traditional mode of transportation for larger shipments. A comprehensive review of the literature identified primary methods for last-mile delivery, including autonomous drones, trucks, bicycles, and robots (Zhu et al., 2023). This diverse range of options highlights the ongoing innovation and experimentation within the logistics industry as companies seek to find the most efficient and cost-effective last-mile delivery solutions. he following research objectives can be framed a conceptual research model as in Fig.1

- To analye the level of technological readiness among stakeholders in the adoption of Autonomous Delivery Vehicles (ADVs) in the last mile and mid-delivery in the Indian logistics system
- To identify the barriers and elements of innovation resistance that affect the adoption of ADVs in Indian Logistics.
- To examine the barriers and elements of innovation resistance that affect the adoption of ADVs in the logistics market.
- To examine the effect of technology readiness and innovation resistance towards the adoption of ADVs
- To develop and validate the conceptual model explaining the different contextual factors such as regulations, environment and customer.
- To suggest recommendations for policymakers and logistics companies to facilitate ADV adoption while addressing socio-economic concerns

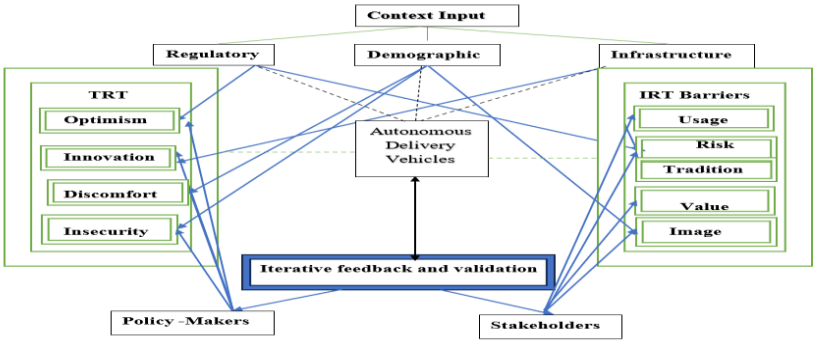

Figure 1: Conceptual framework, Source: Author

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2. Components of Conceptual Framework

a. Challenges and Opportunities in Mid-Mile-Sector & Last- Mile- Delivery

Last-mile delivery poses unique challenges, including infrastructure limitations, environmental concerns related to CO2 emissions, and pressure to meet stringent delivery timeframes (Alverhed et al., 2024). xisting infrastructure in many urban areas may not be adequately equipped for efficient last-mile delivery, resulting in traffic congestion and delays. The use of traditional delivery vehicles contributes to CO2 emissions and air pollution, raising environmental concerns regarding their . Furthermore, customers' demands for faster and more reliable deliveries exert significant pressure on logistics providers to optimie their last-mile operations. Failed first-time deliveries, often due to customer absence at the delivery location, significantly impact carrier costs and operational efficiency (Balaska et al., 2022). These failures necessitate rework, additional delivery attempts, and increased fuel consumption, all of which contribute to higher costs and profits. Conversely, autonomous vehicles offer substantial potential to reduce costs, improve delivery times, and enhance the overall efficiency of last-mile operations (Alverhed et al., 2024). By automating the delivery process, autonomous vehicles can reduce labour costs, improve route planning, and minimie the risk of human error, leading to significant cost savings and improved service quality in the long term.

b. Autonomous Delivery Vehicles: Technology and Implementation of ADVs

Autonomous delivery robots (ADRs) represent an emerging technology with considerable potential enhanc last-mile delivery solutions, particularly in urban environments (Elin Alverhed et al., 2024). These robots re designed to navigate sidewalks and pedestrian areas, enabling the direct delivery of packages to customers' doorsteps. Technologies such as robots, drones, and autonomous vehicles, all powered by artificial intelligence (AI), are tangible innovations that can be employed to optimie last-mile delivery processes (Sorooshian et al., 2022). Drones offer the advantage of aerial delivery, bypassing traffic congestion and reaching remote areas, autonomous vehicles provide a more conventional mode of transportation for larger consignments. A comprehensive literature review identifie nine primary methods for last-mile delivery, including autonomous drones, trucks, bicycles, and robots (Zhu et al., 2023). This diverse array of options highlights the ongoing innovation and experimentation within the logistics industry as companies strive to identify the most efficient and cost-effective solutions for last-mile delivery.

c. Technological Aspect of Vehicle Operations

Perception and cognition systems are essential for the safe and reliable operation of autonomous vehicles, as they enable to comprehend and react to their environment (Balaska et al., 2022). These systems integrat sensors, cameras, and radar to perceive the surroundings, identify obstacles, and make informed decisions regarding navigation and path planning. Li et al. (2020) a technical solution for autonomous last-mile delivery challenging traffic conditions. This solution likely incorporates advanced algorithms and sensor technologies to facilitate vehicle navigation in complex urban environments and adapt to unpredictable traffic patterns. The methodologies employed in each module of the company's vehicles are presented, along with comprehensive safety guarantee strategies. Safety is of utmost importance in the development and deployment of autonomous vehicles, and these strategies are designed to mitigate risks and ensure the well-being of both vehicle and surroundings.

d. Infrastructural Requirement for Autonomous Delivery Vehicles

The widespread adoption of autonomous delivery robots necessitates modifications to the existing foundational infrastructure to facilitate their operation and integration into urban environments (Alverhed et al., 2024). This may entail alterations to sidewalks, traffic signals, and delivery zones to accommodate the specific requirements of these vehicles. Existing infrastructure, such as cellular networks and traffic cameras, can be utilied to ensure the economic viability of deploying autonomous vehicles (Chong et al., 2011). Cellular networks provide essential communication and

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connectivity for autonomous vehicles, s traffic cameras supply real-time data on traffic conditions and potential hazards. Streamlining infrastructure development through integrated planning is essential for the seamless incorporation of autonomous vehicles into the current transportation network (Maran et al., 2024). This process necessitates collaboration government agencies, logistics companies, and technology providers to ensure that infrastructure investments align with the needs of autonomous delivery systems.

2.1 Impact of cost reduction on Autonomous Delivery Vehicles

a. Quantifying Efficiency Gains with Autonomous Vehicles

Autonomous vehicles present a substantial opportunity to enhance time utiliation in delivery operations, thereby improving efficiency and expediting delivery times (Alverhed et al, 2024). Through automation of delivery processes and optimiation of routes, autonomous vehicles can decrease the time required for deliveries, enabling logistics companies to manage a greater volume of deliveries with existing resources. Autonomous vehicles and robots address critical challenges related to cost and time efficiency in the logistics sector (Feng, 2021). These technologies facilitate the automation of tasks such as loading, unloading, and transportation, thereby reducing reliance on human labour and minimiing the likelihood of errors. The primary objective is to examine whether and how autonomous vehicles and robots can effectively resolve persistent issues of cost and time efficiency that affct traditional delivery methods (Feng & Ye,2021). By quantifying the efficiency gains associated with autonomous vehicles, logistics companies can make informed decisions technology adoption and investment.

b. Operational efficiencies can be improved through the implementation of autonomous vehicles

Operational efficienc can be markedly enhanced through the implementation of autonomous vehicles, which serve to reduce costs across multiple facets of the delivery process (Alverhed et al., 2024). The adoption of automation diminishes reliance on human drivers, thereby lowering labor expenses, insurance costs, and vehicle maintenance requirements. Furthermore, autonomous vehicles mitigate the incidence of rework to unsuccessful deliveries, thereby directly influencing carrier costs and overall operational efficiency (Balaska et al, 2022). By optimiing delivery routes, enabling real-time tracking, and offering flexible delivery options, autonomous vehicles decrease the probability of failed deliveries and the associated financial implications. Additionally, optimiing routes and facilitating the strategic sharing of trucks among various companies can yield significant efficiency improvements and reduce the number of truck trips necessary to meet delivery demands. This collaborative strategy not only reduces operational costs but also promotes environmental sustainability by decreasing fuel consumption and emissions.

c. Comparative Analysis of Costs: Traditional vs. Autonomous Delivery

primary aim of current research is to identify efficient frameworks for autonomous vehicles operating on designated delivery routes to determine the most effective configurations for these vehicles (Feng, and Ye, 2021). This involves examining factors such as vehicle size, payload capacity, and route optimiation strategies to enhance efficiency and reduce costs. Research efforts have focused on evaluating whether autonomous vehicles are indeed more efficient and cost-effective than traditional delivery vans operated by human drivers (Feng and Ye, 2021). This comparative analysis evaluating various cost components, including fuel consumption, labour expenses, and vehicle maintenance, to assess the overall economic feasibility of autonomous delivery systems. Th study further investigates the role of innovations and advancements in logistics in fostering economic progress, emphasizing the potential of autonomous vehicles to drive efficiency improvements and cost reductions throughout the supply chain (Maran et al., 2024). By quantifying the economic advantages of autonomous delivery, this seeks to inform investment decisions and expedite the adoption of these technologies within the logistics sector.

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Autonomous Delivery Vehicles: Their Environmental Impact and Sustainability

Autonomous Vehicles and reducing CO2 emissions

Autonomous vehicles present a promising avenue for addressing externalities, particularly in the context of reducing CO2 emissions, a pressing environmental challenge (Alverhed et al., 2024). By enhancing route efficiency, minimizing fuel usage, and encouraging the integration of electric vehicles, autonomous delivery systems can significantly diminish the logistics sector's carbon footprint. The broad implementation of eco-friendly vehicles in urban logistics hs the potential to issues such as environmental pollution, climate change, and heavy reliance on fossil fuels (Patella et al., 2020). Electric vehicles, in particular, offer a sustainable and clean alternative to conventional gasoline-powered vehicles, thereby contributing to lower emissions and improved air quality in urban environments. Additionally, electric vehicles, cargo bikes, and other sustainable transportation options can support the shift towards more intelligent and environmentally conscious urban areas (Goliska-Dawson et al., 2023). These alternative transportation methods provide several benefits including reduced emissions, decreased noise pollution, and enhanced energy efficiency, thereby fostering a more sustainable urban landscape.

Energy Efficiency in Autonomous Delivery Systems

Smart cities transportation solutions that are both energy efficient and characterized by low emissions, thereby ensuring the sustainable movement of both individuals and goods (Golinska-Dawson & Sethanan, 2023). Autonomous delivery systems can significantly contribute to this objective by optimizing routes, reducing fuel consumption, and promoting the adoption of alternative fuels and electric vehicles. Energy efficiency can be markedly enhanced through the strategic utilization of parcels in micro-and parcel lockers, which diminishes the need for long-distance transportation and reduces the number of delivery vehicles on the road (Golinska-Dawson & Sethanan, 2023; Andrei & Scarlat, 2025). These decentralized delivery points also facilitate the use of electric vehicles and other sustainable transportation modes for last-mile deliver. Technologies such as the Internet of Things (IoT) and artificial intelligence (AI) are pivotal enabling efficiency by decreasing fuel demand, optimizing delivery routes, and enhancing overall operational planning (Boopathi, 2024). By leveraging real-time data and advanced algorithms, logistics companies can make informed decisions regarding resource allocation and optimize their operations maxim energy efficiency.

Sustainable practices and Green Logistics

Th study examines freight transportation, with emphasis on the expanding influence of e-commerce (Patella et al., 2020). This study explores various strategies and technologies aimed at fostering sustainable practices in freight transportation, including the implementation of alternative fuels, route optimization, and collaborative logistics models. Sustainable solutions have become a paramount concern for logistics companies as they navigate crisis situations and strive to reduce their environmental impact (Gupta et al., 2023; Gupta, 2025). This encompasses the adoption of green technologies, waste reduction, and promotion of circular economy principles throughout their operations. Contemporary social trends are driving a substantial transformation of supply chains, with the last mile identified as the most complex and costly segment (Krstic et al., 2022; Borghetti et al., 2022). As consumer expectations for faster and more sustainable deliveries increase, logistics companies face mounting pressure to adopt innovative solutions that mitigate their environmental impact and advance sustainable practices. (Bonilla et al., 2024; Borghetti et al., 2022; Oláh et al., 2023; Parhamfar et al., 2025).

Impact on Employment and the Workforce

The advent of disruptive technologies such as autonomous delivery vehicle raises legitimate concerns regarding potential job displacement and its implications for the workforce (Anjanappa, 2025). As these vehicles assume tasks traditionally performed by human drivers, there a possibility that certain occupations may become obsolete, leading to unemployment and financial hardship for those

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affected. Job polariation, characteried by the replacement of middle-skill jobs with those either high or low skill levels, is a conceivable consequence of automation and technological advancement in the logistics sector (Gupta, 2025). This phenomenon could exacerbate the disparity between the highest and lowest income earners, thereby intensifying income inequality and presenting social challenges. Automation, artificial intelligence, and digitaliation profoundly reshap traditional job roles and skill requirements across various industries, including logistics (Gupta, 2025). This scenario necessitates proactive strategies to retrain and upskill workers, thereby preparing them for new roles and opportunities in the evolving job market.

Regulatory and Policy Considerations

Current Regulatory Gaps in Autonomous Delivery

The absence of clear and comprehensive regulations in the autonomous delivery sector creates a degree of uncertainty and confusion within the market, hindering the widespread adoption of these technologies (Alverhed et al., 2024; Jackson et al., 2024). Without well-defined rules and guidelines, companies may to invest in autonomous delivery systems concerns about liability, safety, and operational requirements. Shortcomings in the existing regulatory framework regarding the usage of autonomous vehicles need to be addressed to provide clarity and ensure the safe and responsible deployment of these technologies (Hoffmann & Prause, 2018). This includes establishing standards for vehicle safety, data privacy, and cybersecurity as well as defining the roles and responsibilities of various stakeholders. The regulatory questions that need to be addressed range from data protection and liability for torts to the overall performance and reliability of autonomous delivery systems (Hoffmann & Prause, 2018; Wang et al., 2020; Aslam and li, 2025; Atakishiyev et al., 2024). Addressing these concerns is essential for building public trust and fostering the responsible development and deployment of autonomous delivery technologies.

Government Initiatives and Support for Technological Adoption

The PM Gati Shakti initiative, introduced by the Indian government, aims to optimize infrastructure development through integrated planning and coordinated implementation across various governmental departments (Patil et al., 2023; Alzoubi, 2024) (Maran et al., 2024). This initiative to enhance connectivity, reduce logistics costs, and improve the overall efficiency of the Indian economy. The National Logistics Policy (NLP) offers a comprehensive framework for the advancement of the logistics industry in India, delineating key objectives, strategies, and policy measures to foster growth, innovation, and sustainability (Panghal et al., 2023; Roy & Mohanty, 2023; Maran et al.,2024). This policy endeavours to create a favourable environment for investment in the logistics sector and to facilitate the adoption of new technologies, such as autonomous vehicles. The Unified Logistics Interface Platform (ULIP) functions as a digital platform to enable real-time information exchange among various stakeholders in the logistics ecosystem, thereby simplifying logistics planning and enhancing coordination (Maran et al., 2024). This platform promotes seamless communication government agencies, logistics providers, and end customers, thereby fostering greater transparency and efficiency in the supply chain. (Balaska et al., 2022; Bányai, 2018; Biswas et al., 2025)

Policy Recommendations for Enabling Autonomous Delivery in India

trategic planning and well-crafted policy interventions are vital harness the potential benefits of autonomous delivery technologies while effectively mitigating associated risks. This involves conducting detailed risk assessments, setting clear safety standards, and creating appropriate liability frameworks (Brass and Sowll, 2021). A comprehensive understanding of the dynamics of disruptive technologies, such as autonomous delivery, can guide policymakers in developing policies that encourage innovation, support entrepreneurship, and promote inclusive development (Hwang & Christensen, 2008). This

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necessitates a forward-thinking regulatory approach that fosters experimentation and innovation while ensuring public safety and addressing potential social and economic impacts. Effective strategies, targeted investments in infrastructure and technology, and strong collaboration between government, industry, and research institutions are essential for enhancing resilience and minimizing the negative consequences associated with technological disruptions (Kanike, 2023). This cooperative approach ensures that the advantages of autonomous delivery are broadly shared and that risks are effectively managed (Karanam et al., 2024; Oláh et al., 2023).

Social and Public Perception

Public Acceptance of Autonomous Delivery Vehicles

The societal acceptance of autonomous delivery vehicles poses a considerable challenge to their widespread adoption, primarily the novelty and unfamiliarity of this technology many individuals (Alverhed et al, 2024). Concerns regarding safety, security, and potential job displacement may engender resistance to the integration of autonomous vehicles into the transportation sector. public perception and acceptance of automated parcel delivery options is essential for facilitating technology-driven transformation of the logistics and delivery industry (Kassai et al., 2021; Lee & Seo, 2017) (Maher Said, 2023). This necessitates engaging with the public, addressing their concerns, and emphasizing the potential benefits of autonomous deliver such as enhanced convenience, cost reduction, and improved environmental sustainability. Customer preferences for various autonomous delivery modes, including autonomous vehicles, aerial robots, and bipedal robots, are actively investigated to inform the design and implementation of these technologies (Said, 2023). By understanding the factors that drive customer acceptance, logistics companies can tailor their services and communication strategies to align with the needs and preferences of their target audience. (Pakusch et al., 2018; Edwards et al., 2023; Shuaibu et al., 2025)

Methodology

The scales used in this were adapted from validated scales in previous studies, with necessary modifications to fit the study scenarios. Appendix A provides details on the content and origins of these constructs, Usage barrier, Value barrier, risk barrier. We also collected information on the participants' demographic characteristics, included, educational background, employment type, monthly spending, and place of residence. These factors were evaluated using a 5-point Likert scale, with responses ranging from 1Strongly Disagree to 5Strongly Agree."

We conducted a two-phase pilot study to evaluate the accuracy and validity of the questionnaire measurement items. In the initial phase, we engaged two logistics experts and graduate students specializing in logistics engineering and management in a discussion regarding the questionnaire design, with a particular focus on the clarity and comprehensibility of the measurement items. Their feedback prompted us to revise and refine the wording to eliminate complex, ambiguous, or awkwardly phrased sentences. Subsequently, we randomly selected 50 individuals who regularly use ADVs to complete questionnaire. We pretested the scale measurement items to confirm their reliability and validity. The results indicated that all scales had consistency reliability (CR) scores exceeding 0.7 and average variance extracted (AVE) scores above 0.5, demonstrating the anticipated factor loading structure. The pretest results confirmed that our scales possessed acceptable content validity, structural validity, and reliability. 4.2. Descriptive statistics

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Table 2: Reliability, Validity and Correlation

Constructs	Cronbach's alpha	CR	AVE	OPT	INN	DISC	INSEC	US	RI	TRA	VA	IM	PM	SH
OPT	0.915	0.924	0.788	**0.833**										
INN	0.766	0.850	0.587	0.533	**0.776**									
DISC	0.818	0.893	0.736	−0.295	−0.198	**0.898**								
INSEC	0.794	0.884	0.689	−0.246	−0.189	0.483	**0.845**							
US	0.886	0.918	0.812	−0.139	−0.083	0.280	0.356	**0.922**						
RI	0.779	0.896	0.813	−0.240	−0.177	0.365	0.409	0.587	**0.911**					
TRA	0.806	0.882	0.633	−0.165	−0.155	0.398	0.318	0.277	0.247	**0.784**				
VA	0.710	0.838	0.618	−0.159	−0.074	0.425	0.310	0.354	0.511	0.264	**0.789**			
IM	0.824	0.890	0.741	−0.313	−0.214	0.336	0.355	0.573	0.483	0.298	0.497	**0.855**		
PM	0.872	0.917	0.728	0.419	0.281	−0.473	−0.363	−0.390	−0.531	−0.270	−0.351	−0.392	**0.858**	
SH	0.899	0.915	0.725	0.441	0.342	−0.320	−0.236	−0.388	−0.460	−0.180	−0.366	−0.427	0.750	**0.877**

Table 3: HTMT Testing result

		OPT	INN	DISC	INSEC	US	RI	TRA	VA	IM	IPM	SH
OPT												
INN		0.617										
DISC		0.342	0.241									
INSEC		0.288	0.249	0.596								
US		0.146	0.112	0.334	0.424							
RI		0.288	0.223	0.459	0.517	0.704						
TRA		0.186	0.203	0.486	0.379	0.324	0.301					
VA		0.175	0.099	0.548	0.356	0.411	0.761	0.322				
IM		0.366	0.270	0.408	0.455	0.673	0.607	0.375	0.609			
PM		0.468	0.331	0.561	0.426	0.443	0.644	0.308	0.397	0.461		
SH		0.377	0.427	0.412	0.261	0.438	0.566	0.211	0.413	0.488	0.839	

Data Analysis and Result

The study was conducted using an independent sample t-test to determine differences in results obtained. According to the result obtained, there s no significant difference testing the model. The data analyed using partial least square-based structural equation model (PLS-SEM) (Hair et al., 2017) used multidimensional variables and structures and validat preliminary model based on prediction.

Emerging technologies and innovations are increasingly recognized

pivotal for promoting economic growth within the logistics sector, with intelligent logistics solutions and smart transportation systems gaining prominence (K. Maran, 2024). These advancements involve the integration of cutting-edge technologies such as artificial intelligence, machine learning, and robotics to enhance logistics operations and improve efficiency. New technologies are facilitating increased efficiency by reducing resource demand, primarily through enhanced operational planning and optimized resource allocation strategies (Paulina Goliska-Dawson, 2023). include the use of data analytics to predict demand trends, improve delivery route planning, and reduce fuel consumption. The postal sector is actively adopting both service-oriented and technological innovations to address evolving customer demands and enhance competitiveness in the dynamic logistics landscape (Jayashree Saha, 2024). This encompasses the adoption of digital platforms for online ordering and tracking as well as the implementation of automated sorting and delivery systems.

The Impact of AI, IoT, and Big Data on the Progress of Autonomous Delivery Th study highlights that technological progress, especially the incorporation of IoT-enabled systems, plays a crucial role in propelling the growth of the logistics industry, as evidenced by strong statistical data

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(Maran, et al., 2024). The Internet of Things (IoT) enables the gathering and sharing of real-time data from various sources, offering valuable insights into logistics operation performance. Technologies IoT and artificial intelligence (AI) are essential for boosting efficiency by minimizing fuel usage, optimizing delivery routes, and enhancing operational planning (Goliska-Dawson et al., 2023). AI algorithms can analyze large datasets to detect patterns, predict demand, and improve delivery routes, leading to notable improvements and cost savings. Big Data and Blockchain technologies are increasingly utilized across different sectors to boost business process efficiency, significantly influenc business models and driv new transformations that align with global business trends (Natalie Septiani, 2024). These technologies provide opportunities to enhance transparency, security, and traceability in the supply chain, as well as to automate various logistics processes.

Conclusion

Summarizing the Potential Benefits of Autonomous Vehicles in Indian Logistics

Autonomous hold immense potential to transform India's logistics sector, offering numerous advantages that can boost efficiency, reduce costs, and enhance sustainability (Alverhed et al., 2024). Encouraging findings from various studies indicate that integrating autonomous vehicles into logistics operations can lead to significant improvements in delivery speed, reduced fuel consumption, and lower labour costs. These vehicles are a vital part of Industry 4.0, with their emphasis on automation and intelligent systems to revolutionize multiple facets of the logistics industry. utonomous vehicles allow human workers to focus on more complex and strategic tasks. AI-driven technologies, including autonomous vehicles, can optimize last-mile delivery and provide more efficient and sustainable services meet the evolving demands of customers and businesses (Sorooshian et al., 2022). This includes offering increased flexibility, convenience, and transparency in the delivery process. b. Addressing Challenges and Concerns for Successful Integration To autonomous vehicles into the Indian logistics sector, it is crucial to address the various challenges and concerns that may arise, such as infrastructure limitations, environmental impacts, and societal acceptance (Alverhed et al., 2024). This requires collaborative effort among government agencies, industry stakeholders, and research institutions to develop effective solutions and strategies. Regulatory frameworks must be meticulously developed and enforced to oversee the use of autonomous vehicles ensur safety, security, and compliance with relevant laws and regulations (Hoffmann, 2018). This involves establishing clear standards for vehicle operation, data privacy, and liabilit in the event of an accident. Potential issues such as job displacement and digital inequality need to be proactively addressed through strategic planning and targeted policy measures, ensuring that the benefits of autonomous delivery are widely distributed and that no one is left behind. This may include providing retraining and upskilling opportunities for displaced workers and promoting digital literacy and access to technology for underserved communities.

Recommendations for Stakeholders: Government, Industry, and Consumers

Policymakers d encourage to actively facilitate innovation, support entrepreneurship, and promote inclusive growth within the autonomous delivery sector. This entails allocating resources for research and development, establishing regulatory sandboxes for testing new technologies, and fostering the growth of startups and small enterprises in the logistics sector. By investing in autonomous delivery technologies and developing innovative business models that harness their potential, companies can adapt their strategies, enhance their technological capabilities, and seize new opportunities in the digital economy. This necessitates collaboration with technology providers, logistics companies, and other stakeholders to create integrated solutions that address the evolving needs of customers and business alike. Stakeholders should tailor their marketing and communication strategies to effectively with customer preferences, address any concerns or misconceptions about autonomous delivery technologies, and emphasize their potential benefits (Said, 2023). This involves providing clear and transparent information regarding the safety,

security, and environmental impact of autonomous delivery as well as offering personalized delivery options that cater to individual customer needs.

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