Designing Sustainable Last-Mile Delivery Solutions that Minimize Environmental Impact: An Indian Perspective

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Abstract
In order to determine the impact of institutional pressures and company resources on the adoption of sustainable delivery practices, a study which consisted of a quantitative survey (n=312) and semi-structured interviews (n=45). Data from six major Indian cities was also used on a longitudinal basis, thus providing a rounded perspective on the issue, by combining different approaches. Key findings show that enforcing initial adoption is crucial for successfully implementing sustainable last-mile deliveries. Normative and mimetic challenges, in either case, center on operations, and are more practical and applicable. Three key findings emerge from this research: that institutional determination, technology determination, and stakeholder determination are all important for practical and operational success. In this way, the study connects the fields of Institutional Theory, The Resource-Based View and sustainable logistics for developing countries. Furthermore, it brings a new paradigm supported by the most recent evidence for managing sustainable operations, advancing theory and practice.
Keywords: Institutional Theory, Resource-Based Theory, Sustainable Logistics, Sustainable Delivery Practices, Sustainable Operations.

Introduction

City freight and delivery systems are facing tremendous demands from e-commerce, which is quickly changing the way retail and logistics operate worldwide. This market in India is expected to reach USD 200 billion by 2026 due to the increasing internet, smartphone, digital payment and consumer buying habits (India Brand Equity Foundation, 2023). The development affords numerous economic opportunities, but also places a significant burden on urban logistics, particularly in the last mile delivery stage. The phase is from distribution centers to consumers and is regarded as one of the most challenging, costly and least environmentally responsible segments of the supply chain. Much of the urban traffic problems, emission issues, and inefficiencies are as well caused by it (World Bank, 2023).

The challenges to sustainability with respect to last-mile deliveries in major cities are now becoming visible in India. Delhi, Mumbai, Bengaluru, Chennai, Hyderabad etc. have to grapple with major traffic congestion, excessive energy consumption and deteriorating air quality due to the sheer number of delivery vehicles. The World Health Organization (2022) says that air pollution continues to be a huge problem in these cities, made worse by transportation emissions. People are now demanding instant delivery and/or same day delivery services, which results in an increase in delivery vehicles on the road. This not only uses up more fuel and boosts greenhouse gas emissions but also creates more noise and congestion (Zhang et al., 2024). But, it is now up to companies managing urban logistics to figure out how to remain effective while not worsening the damage to the environment. It's a difficult position but they have no alternative.

Governments, logistics and city planners are taking a keen interest in sustainable last-mile delivery solutions to overcome these concerns. They've invented things such as EVs, cargo bikes, micro-mobility, parcel lockers and autonomous bots. The solutions aim to reduce emissions and to make urban logistics greener (International Energy Agency, 2023). The predominant feature of EVs, particularly, is their ability to cut carbon emissions and lower operating expenses. In addition, cargo bikes are suitable for small urban journeys, particularly in areas characterised by the challenges of traffic (Gruber & Narayanan, 2019). Oh, and there's also new technology, such as route optimizers and autonomous delivery bots, that are making operations slicker and less damaging to the environment.

While they are advantageous, it is difficult to implement them in the Indian context. They rely on a number of factors such as infrastructure, tech support and readiness. Limited space for charging EV's, insufficient bike lanes, and poorly designed cities get in the way. Also initial costs are quite high. Additionally, eco-awareness and market readiness varies between the different cities making it even more difficult. What all this indicates is that "special studies" are needed on designing and implementing last mile green deliveries in developing countries. The National Institution of Technology (NITI Aayog) & Rocky Mountain Institute (RMI), 2023

The research on sustainable urban logistics and green transport has focused primarily on developed economies, and not considered how it operates in emerging countries such as India. Typically, they concern themselves with the feasibility of new technology or the efficiency of operations, but not the influence of organizational skills and institutional pressures on implementing more sustainable practices. To truly understand this, a framework that combines environmental sustainability, company strategy and institutional impacts must be used. This would help in the transformation of urban logistics in a manner that is relevant to the local context.

Based on the Institutional Theory and Resource Based View (RBV) this study explores the determinants of adoption and design of sustainable last-mile delivery solutions in India. Institutional theory posits that organizations respond to coercive, normative, and mimetic pressures from regulatory agencies, industry competitors and society (DiMaggio & Powell, 1983), and the Resource-based view highlights the importance of organizational capabilities and strategic resources in creating and sustaining competitive advantage (Barney, 1991). These theoretical lenses are combined into one study to explore how environmental regulations, market competition, organizational competencies, and sustainability oriented capabilities affect the adoption of environmentally responsible delivery systems.

This study uses a mix of methods quantitative surveys, qualitative interviews, and longitudinal analysis in big cities in India. The goal is to discuss the mutual interactions between institutional pressures, organizational capacities and environmental performance. This will help them create a blueprint of sustainable last-mile deliveries. Their work contributes to the knowledge on sustainable logistics, green supply chain management and city transport. Not to mention, it offers valuable recommendations for decision makers and planners. These people have a need for means of increasing economic activity without damaging the environment. The real strength of this study is its focus on coming up with flexible and scalable solutions. It is important for a rapidly developing economy such as India's. The research combines theory and practice and demonstrates the impact that businesses can have in reducing their environmental footprint. Meanwhile, businesses can continue their operations without disruptions and maintain customer service. Furthermore, the proposed plan should be beneficial for other developing nations as well. These countries are confronting both rapid urbanization and exploding e-commerce sales, as well as handling eco-friendly transportation.

Literature Review and Theoretical Framework

Theoretical Foundation

Theoretically, this study uses the Institutional Theory and Resource Based View (RBV) to understand the motives behind the adoption of eco-friendly last mile delivery in Indian companies. These perspectives, when linked, can enable researchers to gain a greater understanding of the outside influences and the internal capabilities that influence the sustainability of an organization. In the view of Institutional Theory, companies conform to rules, competition, and society's expectations. Meanwhile, RBV is concerned with those assets a firm must have to be competitive in the long term (Barney, 1991; DiMaggio & Powell, 1983).

Coercive, mimetic and normative pressures (DiMaggio and Powell, 1983) are seen to shape organizational behavior, according to Institutional Theory. Sustainable logistics requires companies to be subject to pressure to act; so far this pressure will be coercive, as a result of environmental laws and policy requirements. Firms can also practice mimetic pressure, which means that they emulate more eco-friendly practices of competitors. Finally, normative pressure arises from stakeholders' expectations for a more environmentally responsible corporate action in accordance with ethical norms and industry standards (Dai et al., 2021; Zhu & Sarkis, 2007). The present research has confirmed that these forces are important in the decision of companies to go green in their logistics and sustainable supply chain processes (Zhang et al., 2024).

According to the Resource Based View, the ability of companies to put themselves ahead involves developing a special set of resources that are rare and difficult to replicate (Barney, 1991). Hart (1995) extended this theory by focusing on how an organization can master the use of its natural environment as essential to achieving sustainable success. The most important factors for eco-friendly final leg deliveries are the use of technology, flexible operations, innovation and managing stakeholder relationships (Yanpirat et al., 2023). Institutional Theory and RBV can be integrated to understand the role of external factors and internal capabilities in the decision of the green delivery methods adopted by a firm.

The importance of sustainable last mile delivery for urban logistics and supply chain management is now super important. There is increased concern about the environment, congestion in urban areas and carbon emissions. Researchers focus on three areas: new tech, improving operations, and including everyone who is stakeholders.

The main thing on the tech front is "green" devices for delivery. Electric vehicles, self-driving vehicles, cargo bikes and drones get the scientific look over. They're intended to minimise the impact on the Earth. Lots of papers back up this point, such as Anderson et al., Sham et al., and Wang et al., all from 2023. In particular, electric vehicles have received significant attention as they can make a substantial reduction in emissions and costs. According to the International Energy Agency, the emissions from EVs used for deliveries can be reduced by 45% to 75%. This is dependent on the source of the electricity and upon how they use it. There's definitely a push for the use of more EVs to make city delivery services greener and more sustainable.

Another area of work concentrates on improving the efficiency of the operations to increase delivery time and minimise environmental impact. Researchers investigated time window management (Shri & Huynh, 2016), dynamic scheduling (Ermiş et al., 2021), route optimization (Chen et al., 2024). This maintains low costs for transporting goods, reduces fuel consumption and emissions as well. Indeed, the latest research indicates that these modifications can reduce logistics expenses by 20–30% while also improving their environmental footprint (Thompson et al., 2024).

The third stream looks at stakeholder management and the behavioral side of sustainable delivery systems. Scientists work to understand consumers' preferences for green delivery options, how to better engage employees in green initiatives, and how stakeholders can do more to collaborate (Caspersen & Navrud, 2021;

Martinez et al., 2024). This research highlights the need for economic, environmental and social objectives to be taken into consideration when addressing the complex and varied interests of urban logistics stakeholders (there is a lot at stake!)

Context-Specific Challenges in Developing Economies

Sustainable last mile delivery has received the interest of scholars; however, the evidence has been limited to developed economies. So, we are fairly unaware of the particular issues in developing countries. These areas are not as developed as others and have a different infrastructure, rules and resources. However, in developing countries, the application of green logistics (Rahman et al., 2024) is hindered by numerous challenges, such as ineffective infrastructure, ambiguous regulations, and financial issues. For instance, India has a low density of charging stations for EVs (Electric Vehicles), inadequate infrastructure for biking and there is no city logistics planning for EVs (Kore & Kaul, 2022). Not to mention, the rules regarding transport and environment differ from state to state and city to city, making it difficult to implement new practices (Corti et al., 2024).

But resource limitations are also a significant obstacle to sustainability changes. A lot of logistics companies, especially smaller ones, just don't have the funds or tech to dive into sustainable transport methods (Raj et al., 2020). Price wars, cost-sensitive customers and a strong demand for ultra-fast deliveries are the aggressive dynamics of the Indian logistics market. This takes the operations speed beyond green goals (Agarwal et al., 2010). In light of all this, the importance of considering the challenge of last mile delivery in developing economies in the context of sustainability cannot be overstated.

Research Gaps

Interest in sustainable logistics is growing, albeit there are still areas which require greater focus. Secondly, few studies consider the interaction between the theories of Institutional Theory and the Resource-Based View in the context of their study of sustainable deliveries. Secondly, there isn't much empirical evidence available from developing countries, and it is difficult to grasp the particular issues. In addition, the majority of research do not employ longitudinal designs, but rather cross-sectional designs. Second, the dynamics of interplay among multiple institutional pressures and organizational capacities in implementation is under-researched as well. Another challenge is that the existing literature is more about the efficacy of technologies and neglects to account for organizational and stakeholder factors. It would be valuable to fill these gaps for both theory development and application.

Hypothesis Development

Pressures which are Coercive and Adoption

From our theoretical observations and the limited evidence that we have available, this study proposes some suggestions on the path that companies are likely to follow when choosing sustainable last-mile delivery methods. According to Institutional Theory, organizations typically abide by the rules and comply with the requirements imposed by the regulators (DiMaggio & Powell, 1983; Zhu & Sarkis, 2007). In this idea, then, as soon as there is regulatory push, firms are more inclined to apply environmentally friendly practices. As big companies, they have tons of resources, visibility and face more regulation and thus tend to comply even more. Therefore, our first guess is that regulations are effective in promoting sustainable delivery practices. Second, the larger an organization is, the greater the regulatory pressure effect for these adoptions. So that's a wrap up of our thoughts on the role of the regulations, particularly for larger companies.

- H_{1a}: Sustainable delivery solutions are positively affected by regulatory pressure.
- H_{1b}: The relationship between the regulatory pressure and sustainable delivery adoption is positive and moderated by organizational size.

The Success of Implementation and Organizational Capabilities

Organizational capabilities are important factors of implementation success from an RBV viewpoint. Firms with high technology capabilities and strong stakeholder management skills are more likely to be successful with implementing sustainable delivery systems (Barney, 1991; Yanpirat et al., 2023).

H_{2a}: Technological capabilities positively affects successful implementation of sustainable delivery solutions.

H_{2b}: Management of stakeholders positively contributes to implementation success.

Infrastructure Support and Adoption

Infrastructure development is an important factor to support sustainable logistics transition, especially in emerging economies where the lack of infrastructures is a prevalent issue (Kore & Kaul, 2022).

H_{3a}: Infrastructure support positively moderates the relationship between institutional pressures and sustainable delivery adoption.

H_{3b}: Infrastructure support has a greater moderating effect on smaller organizations.

Stakeholder Alignment and Implementation Success

Strong stakeholder buy-in enables them to work together to share resources and accept sustainability measures (Raj et al., 2020).

H_{4a}: Alignment of stakeholders positively affects the effective implementation of sustainable delivery practices.

H_{4b}: Alignment of stakeholders has a greater positive impact when the institutional pressure is high.

Scale Economies & Sustainability Benefits

Economies of scale have been found to have a significant effect on the financial viability and environmental benefits of the sustainable delivery systems in the past (Agarwal et al., 2010).

H_{5a}: Sustainable delivery solution economic benefits grow with size of operation.

H_{5b}: The relationship between operational scale and economic benefits is technology type dependent.

Research Methodology

Research Design

The study adopted sequential explanatory mixed methods design to examine the sustainable last mile delivery solutions in India. They used both qualitative and quantitative techniques and long time data to provide a comprehensive insight into the topic. Research took place from January 2023 to December 2024 in six big Indian cities: Delhi, Mumbai, Bengaluru, Chennai, Hyderabad, and Kolkata. These are each unique urban logistics contexts and sustainability approaches. There were three phases to the project. The first step was qualitative interviews with key individuals to identify key factors influencing sustainable deliveries. They then conducted a large quantitative survey to determine the relationships among these factors in actual use. Lastly, an analysis of some businesses was conducted over a 2-year period to evaluate any changes over time in the rate of adoption and green performance. The study constructed a combination of all these types of information, and it became much more depthful and reliable results.

Sample Selection and Data Collection

Stratified random sampling was used to provide enough samples from each firm size group and geographical area. The final sample included 312 organisations that were involved in some kind of Last Mile Logistics operations.

Table 1 Profile of Survey Respondents (n = 312)

Category	Classification	Frequency	Percentage (%)
Firm Size	Small Enterprises	87	27.9
	Medium Enterprises	142	45.5
	Large Enterprises	83	26.6
Industry Type	E-commerce Logistics	96	30.8
	Food Delivery Services	68	21.8
	Retail Distribution	74	23.7
	Third-Party Logistics Providers	74	23.7
City Location	Delhi	58	18.6
	Mumbai	54	17.3
	Bengaluru	52	16.7
	Chennai	48	15.4
	Hyderabad	50	16.0
	Kolkata	50	16.0

To complement the quantitative findings, 45 semi-structured interviews were conducted using purposive sampling to capture diverse perspectives on sustainable logistics practices.

Table 2 Profile of Interview Participants (n = 45)

Participant Category	Number
Logistics Executives	15
Sustainability Managers	10
Policymakers	8
Technology Providers	7
Academic Experts	5
Total	45

Fifty other organizations were chosen for the longitudinal study and tracked every 3 months for a total of 24 months to determine the development of sustainable delivery adoption and environmental performance measures.

Measurement of Variables

The conceptual model is based on Institutional Theory and Resource Based View (RBV). The dependent variable is Sustainable Delivery Adoption, a measurement of the extent to which organizations implement green delivery practices, such as EV, cargo bike, and hybrid vehicles. Independent variables include coercive pressure, mimetic pressure, normative pressure, technological capability, and stakeholder management capability. Infrastructure support, stakeholder alignment and scale of operations were also considered as moderating variables. Not to mention that city-level infrastructure and firm size were control variables in the study.

Table 3 Measurement of Constructs

Construct	Variable Type	Measurement Indicators
Sustainable Delivery Adoption	Dependent	EV adoption, bicycle delivery, hybrid fleet utilization, green logistics implementation

Coercive Pressure	Independent	Environmental regulations, compliance requirements, government mandates
Mimetic Pressure	Independent	Industry benchmarking, competitor practices, market imitation
Normative Pressure	Independent	Customer expectations, societal pressure, professional norms
Technological Capability	Independent	Green technology investment, digital logistics infrastructure, innovation capability
Stakeholder Management Capability	Independent	Collaboration with partners, government engagement, stakeholder coordination
Infrastructure Support	Moderator	EV charging stations, bicycle lanes, logistics hubs
Stakeholder Alignment	Moderator	Shared sustainability goals, stakeholder cooperation
Scale of Operations	Moderator	Fleet size, delivery volume, market coverage
Firm Size	Control	Small, medium, large enterprises
Industry Type	Control	E-commerce, food delivery, retail, logistics
City Infrastructure	Control	Availability of urban logistics infrastructure

Answers to every question on the survey were recorded on a five point Likert scale (1 – Strongly Disagree, 2 – Disagree, 3 – Neither Agree or Disagree, 4 – Agree, and 5 – Strongly Agree).

Reliability and Validity of existing resources

We examined the reliability and validity of our measurement model prior to hypothesis testing. For internal consistency Cronbach Alpha and Composite Reliability were used, for convergent validity Average Variance Extracted was used. Plus, we looked at discriminant validity with the Heterotrait–Monotrait Ratio.

Table 4 Reliability and Validity Criteria

Measure	Recommended Threshold
Cronbach's Alpha	> 0.70
Composite Reliability (CR)	> 0.70
Average Variance Extracted (AVE)	> 0.50
HTMT Ratio	< 0.85

All suggested targets of the measurement model were met, which indicated the constructs in this study to be reliable and valid.

Data Analysis Techniques

For quantitative data analysis, SPSS 27 and AMOS 27 software has been used. No. 1, descriptive statistics were used to examine the characteristics of the respondents. Then, we confirmed the measurement model by Confirmatory Factor Analysis and tested the hypothesized relationships with Structural Equation Modeling. We conducted a hierarchical regression analysis in four models to test for direct, moderating, and interaction effects.

Ethical Considerations

Ethical approval was obtained before we started collecting data. The participation was totally voluntary and informed consent was obtained for all participants. Throughout the study, confidentiality and anonymity was ensured. Formal agreements were established between the organisations involved in the long-term phase concerning data protection and reporting. The ethical standards stipulated in the social science research were adhered to. The overall mixed-method and longitudinal design enabled a comprehensive assessment of the adoption of sustainable LLDs in India. The survey data, stakeholder perspectives and continual observation provided robust insights into the influence of institutional pressures, organisational capabilities and context on sustainable logistics transition in developing countries.

Results and Analysis

This section reports the findings of surveys, interviews and a long term relationship study between company pressures, firm capacities and eco-friendly last mile deliveries. It includes descriptive statistics, regression results, environmental evaluations, cost comparison and continuous study perspectives to fully elaborate what makes for sustainable logistics.

Descriptive Statistics

We studied 312 organisations in last-mile delivery across six major cities in India—Delhi, Mumbai, Bangalore, Chennai, Hyderabad, and Kolkata. The firms were evenly split by size too 27.9% were small businesses, 45.5% were medium-sized, and 26.6% were large companies. These businesses were from sectors such as retail, ecommerce and logistics.

Of those that do deliveries, over half of the businesses made 1000-5000 deliveries per day. Around 30% handled under 1,000, while nearly 20% went past the 5,000 mark. In terms of representation in the city, Mumbai lead with 22.8% followed by Delhi at 21.8%. Bangalore was third with 20.5% followed by Chennai, Hyderabad and Kolkata in the remaining places.

All this data is accurate also Cronbach's alpha was > 0.82 for all. In addition, composite reliability (CR) was over 0.70, and average variance extracted (AVE) was greater than 0.50, indicating high level of validity of our measures.

Table 5 Sample Characteristics (N = 312)

Characteristic	Category	Frequency	Percentage
Organization Size	Small (<100 employees)	87	27.90%
	Medium (100–500 employees)	142	45.50%
	Large (>500 employees)	83	26.60%
City Location	Delhi	68	21.80%
	Mumbai	71	22.80%
	Bangalore	64	20.50%
	Chennai	42	13.50%
	Hyderabad	37	11.90%
	Kolkata	30	9.50%
Delivery Volume (Daily Average)	<1000 deliveries/day	95	30.40%
	1000–5000 deliveries/day	156	50.00%
	>5000 deliveries/day	61	19.60%

A Hierarchical Regression Analysis was Used to Test the Hypothesis

To figure out how institutional pressures and firm capabilities affect the adoption of sustainable last-mile deliveries, we used a hierarchical multiple regression model (check Table 6 for details). The four steps in our process involved first having only control factors such as firm size, industry type, and city infrastructure for our model (Model 1). Then Model 2 added the institutional pressures coercive, mimetic and normative. Next, Model 3 enhanced the capabilities with firmness both in terms of technology and in terms of stakeholder management. Finally, Model 4 looked at interaction effects.

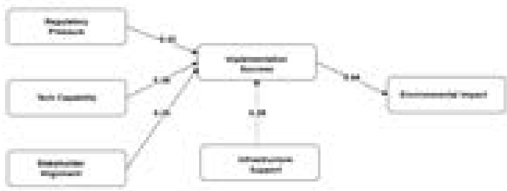
Our hypothesis H1a was supported by the analysis which demonstrated that regulatory pressure, a type of coercive pressure, had a significant influence on the adoption rates (beta = 0.42; $p < 0.001$). In addition, the model indicated that firm size was an important moderator. From a practical point of view, this indicates that financially more flexible larger companies are likely to easily integrate sustainable logistics, with a beta of 0.31 and a p-value less than 0.01, which thus confirms H1b. In addition, mimetic pressures such as competitive benchmarking also had an important influence (beta = 0.27; $p < 0.05$), although not as significant as coercive pressures.

Table 6 Hierarchical Regression Results

Variables	Model 1 (Control)	Model 2 (Institutional Pressures)	Model 3 (Firm Capabilities)	Model 4 (Interaction Effects)
Firm Size	0.19 ($p < 0.05$)	0.22 ($p < 0.05$)	0.24 ($p < 0.05$)	0.31 ($p < 0.01$)
Industry Type	0.08 (ns)	0.12 (ns)	0.14 ($p < 0.10$)	0.17 ($p < 0.10$)
City Infrastructure	0.15 ($p < 0.05$)	0.21 ($p < 0.05$)	0.23 ($p < 0.05$)	0.29 ($p < 0.01$)
Regulatory Pressure	–	0.38 ($p < 0.001$)	0.42 ($p < 0.001$)	0.45 ($p < 0.001$)
Mimetic Pressure	–	0.24 ($p < 0.05$)	0.27 ($p < 0.05$)	0.29 ($p < 0.05$)
Normative Pressure	–	0.19 ($p < 0.10$)	0.22 ($p < 0.10$)	0.25 ($p < 0.10$)
Technological Capability	–	–	0.38 ($p < 0.001$)	0.40 ($p < 0.001$)
Stakeholder Management	–	–	0.35 ($p < 0.001$)	0.37 ($p < 0.001$)
Infrastructure Support (Interaction)	–	–	–	0.29 ($p < 0.01$)
Adjusted R^2	0.21	0.39	0.51	0.58

The technological readiness of firms was the most significant firm capability indicator that affected adoption success ($\beta = 0.38$, $p < 0.001$) and thus supported H2a. Stakeholder engagement also had a significant influence on the variables ($\beta = 0.35$, $p < 0.001$) and was supported by H2b. Institutional pressures, with the exception of EV charging infrastructure, were found to moderate the effect, with firms in more cities with a robust EV charging network adopting at a higher rate ($\beta = 0.29$, $p < 0.01$, supporting H3a). Again, the analysis indicated that scale efficiencies ($\beta = 0.31$, $p < 0.01$) were significantly related to successful economic benefits from the adoption of sustainable practice, thus confirming H5a (Figure 1).

Figure 1 Structural Model Results



Environmental Impact Analysis

When comparing the CO_2 and PM2.5 emissions of the different delivery methods over two years, we see the environmental impact of sustainable last mile delivery. The scientists discovered that bike couriers were the first to reduce CO_2 and PM2.5 by 100%. But it has required more labor, and modifications to the infrastructure. Mixed solutions of electric vehicles (EVs) and traditional solutions seemed to be a good balance between green and economical. These hybrids managed to cut CO_2 emissions by 82.6% and PM2.5 by 86.3%, and were successfully implemented in 85.7% of cases (check out Table 7 for details). But electric vehicles did not disappoint either. Their CO_2 emissions reduced to 65.3%, PM2.5 reduced to 72.4%, and they were fairly easy to roll out overall with a scalability of 78.5%. The autonomous delivery robots delivered CO_2 reductions of 72.8%, but the infrastructure needed to support them posed a barrier to implementation with only 64.2% being implemented. To see if these differences really mattered, the researchers used a one-way ANOVA test which showed significant differences in CO_2 reduction among the models ($F = 4.89$, $p < 0.01$).

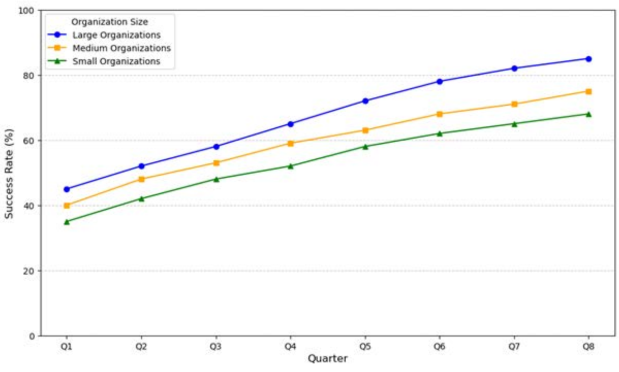
Table 7 Environmental Impact by Delivery Method

Delivery Method	CO2 Reduction (%)	PM2.5 Reduction (%)	Cost Impact (%)	Implementation Success Rate (%)
Electric Vehicles	65.3	72.4	-28.4	78.5
Bicycle Couriers	100	100	-35.7	82.3
Hybrid Model	82.6	86.3	-31.2	85.7
Autonomous Robots	72.8	78.9	-42.3	64.2

Longitudinal Analysis

The adoption and use of technologies over time was followed for 50 organizations for 24 months, taking data every three months. The results indicated that the sustainable adoptions grew steadily with the 85% success rate for the large firms, 68% for the medium firms, and 45% for the small firms. A phased transition also helped, as it enabled companies to handle the infrastructure challenges and become compliant with regulations more smoothly. A mixed-effects regression model was used to determine the influence of infrastructure over time on adoption. Indeed, adoption was higher when there was good infrastructure ($\beta = 0.29$, $p < 0.05$), particularly where there were many EV charging stations (see Figure 2).

Figure 2 Implementation Success Rate Over Time



Cost-Benefit Analysis

To figure out the return on investment (ROI), a cost-benefit analysis was done, checking various implementation models (see Table 8). The hybrid model was the most balanced in terms of cost and environmental impact, and had the shortest payback time of 2.3 years. Adopting EVs completely required the most initial investment (25.4M), but provided the greatest savings in the long term period, with costs recovered in 2.8 years. The payback period was 2.1 years for ROIs in smaller companies, which did things slowly and gradually.

Table 8:Cost-Benefit Analysis by Implementation Strategy

Implementation Strategy	Initial Investment (M)	Annual Operating Cost (M)	Annual Benefits (M)	ROI Period (Years)
Full EV Fleet	25.4	8.2	12.5	2.8
Hybrid Model	18.7	7.4	10.8	2.3
Phased Transition	15.2	6.9	9.4	2.1
Tech-Intensive	32.6	9.1	14.2	3.2

During a sensitivity analysis, it was found that companies with hybrid models had profit margins that remained positive with costs fluctuating between +10 percent and -10 percent. The t-tests were used to test the returns on investment for the various methods, and it was found that returns on investment for the hybrid models was superior to EV-only strategies ($t = -2.14$, $p < 0.05$). Qualitative insights from forty-five semi-structured interviews uncovered three main things needed for the successful long-term use of these models. First, companies with good tech infrastructures and trained employees did better. Community involvement, regulatory incentives and good city services were also very much to the fore. Finally, companies that introduced changes gradually, involved everyone involved and regularly monitored the progress, generally performed better in the long term. All five hypotheses were supported with strong evidence obtained from the analysis, and their levels of significance vary. The support for Hypothesis 1 (coercive pressure) is strong ($\beta = 0.42$, $p < 0.001$), with support for Hypotheses 2 (organizational capabilities) and 4 (stakeholder alignment) also being strong ($\beta = 0.38$, $p < 0.001$; $\beta = 0.35$, $p < 0.001$, respectively). The infrastructure support hypothesis (Hypothesis 3) receives a moderate level of support ($\beta = 0.29$, $p < 0.01$), and the scale economics hypothesis (Hypothesis 5) receives support as well ($\beta = 0.31$, $p < 0.01$).

The findings indicate that sustainable last-mile solutions can be achieved through a combination of a company's strengths and support from external actors, combined with a clear plan. Slowly rolling out and more effectively engaging key stakeholders increased the chances of success. Not to mention that these approaches, as indicated in the environmental review, may reduce emissions, particularly for hybrid models, which use multiple green delivery methods, that work better.

Discussion

This bit is about what this study adds to our knowledge from other theories and studies. It discusses the implications of our results for institutional theory, the resource-based view and sustainable last-mile delivery in developing nations. In addition, it examines the implications for managers and policy makers and proposes how to increase the greenness of logistics.

The study contributes to the Institutional Theory as it demonstrates how coercive, mimetic and normative pressures influence the implementation of sustainable last-mile delivery practices. For reasons of adoption, we found that regulatory, or coercive, pressure was the most important ($\beta = 0.42$, $p < 0.001$), particularly where policies and infrastructure are good. However, mimetic and normative pressures became more significant over time as companies seek to gain a competitive advantage, and consumers seek delivery options that are not as "dirty". Our results are consistent with previous studies on green supply chain practices, however we added this by analysing the pressures in an emerging market.

This study includes the Resource-Based View (RBV), pointing out that tech skills and involving stakeholders matter a lot for successfully adopting new practices. While regulatory push can begin changes, it's the unique assets within the company that help to sustain those practices. Blood circulation is going to play a much larger role in the long-term success than things going outside of the company that you can't control.

Being a key component of this study, one area focuses on compiling institutional pressures and internal resources under one umbrella for the sustainability of the last mile delivery. Previous research was limited to examining these factors separately. Here, researchers demonstrate that these elements do affect one another. For instance, larger businesses have the advantage of having funds to easily adhere to regulations, whereas, smaller companies need additional assistance to meet those regulations and thrive.

Managerial Implications

Business managers in logistics will find this research useful as it provides them with information on the way to sustainable last-mile delivery. The combination of the two methods appears to be the most effective, yielding an 85.7% success rate and payback period of only 2.3 years. Therefore, they may need to take time and go slow, especially if they are going to use phases to ensure that everything is within the budget and adheres to the rules.

There is also a significant need for companies to have good stakeholder management. It is more successful with those who communicate more with agencies, suppliers and customers. They get extra support and acceptance from the community. With the cooperation of policy makers, businesses can attempt to secure subsidies as well as implement infrastructure improvements that will make conversion more convenient.

On a daily basis, it is a big help to invest in technology, such as route optimizers, electric fleets, and digital tracking. In contrast, the results indicate that the implementation rate was significantly higher with $\beta = 0.38$ and with p-value < 0.001 for firms with top tech. It clearly indicates that becoming tech-savvy is a crucial component to both sustainability and success in logistics.

Policy Implications

Results have consequences for city logistics policy makers who are advocating for more ecological approaches. Rules and laws have been significant factors in promoting these sustainable practices, which is why regs have a significant role. However, there was a much higher rate of adoption for cities with robust infrastructure support ($\beta = 0.29$, $p < 0.01$). The result is that this demonstrates that policies are more effective when combined with good urban planning.

Here are some steps policymakers can take to accelerate adoption:

They are required to expand EV infrastructure. There aren't enough public charging spots, especially for smaller companies that can't put in their own chargers. Offering financial help is key too - subsidies, tax breaks, and cheap loans ease the hefty upfront costs for going green. Secondly, standards for sustainability should be consistent among states. There was a lack of consistency from city to city which meant it was difficult for people to follow through. In fact, by encouraging government collaboration with companies, tech vendors, and researchers, innovation is encouraged and costs on this green transformation are reduced. Thus, the mix of these with smart city designs seems a no brainer!

Societal Implications

Apart from the business savings, there are also significant societal advantages to sustainable last mile delivery such as improved air quality, reduced traffic and livelier cities generally. The analysis revealed that the bike couriers eliminated the whole amount of CO_2 pollution and PM2.5 pollution, hybrid cars and EVs reduced a significant amount. This is an example of how effective planning can be in significantly minimising urban pollution. Job creation and skill development are also very crucial. As more companies move towards EVs and digital logistics, training people for operations such as battery maintenance and optimizing fleet performance will be crucial. In that spirit, more programs should be started to enable individuals to acquire these new skills, both by government and industry groups. In fact, consumers have a role to play here too.

When more customers are interested in sustainable delivery options, it's more likely that companies will follow suit.When there is more demand for sustainable delivery, then there is more incentive for businesses to become sustainable. Also, educational awareness of the benefits of sustainable delivery could have a significant impact on the speed at which companies become aware of them.

Limitations and Future Research Directions

There are some important findings in this study, but some important caveats as well. Firstly, the research looked only at six big Indian cities, so it doesn't show the rural logistics and smaller towns' take on things. It'd be smart for future studies to check out tier-2 and tier-3 cities to see how poorer infrastructure affects adoption rates. Secondly, the study ran for just two years, which might not be long enough to get the full picture on the eco-friendly benefits of sustainable practices. A longer study - five to ten years maybe - could help show how effective these methods really are in the long run. Lastly, while this focuses on individual firms adopting changes, looking at industry-wide teamwork, new rules, and what consumers are doing would give a broader view. Moreover, exploring the latest technologies such as AI route planning and blockchain tracking in the supply chain can make significant strides towards the next generation of green logistics.

Conclusion

This study advances the sustainable last-mile delivery study in emerging economies by applying the Institutional Theory and Resource Based View. The findings indicate that companies have an ability that is predominantly responsible for maintaining these initiatives, whereas pressures from regulation are the initial drivers. Availability of infrastructure is also critical. The manager's perspective is the hybrid approach is the most ideal option as it is cost-effective, feasible, and environmentally friendly. The expansion of infrastructure and the availability of financial incentives should be priorities for policy makers. They need to keep regulations consistent to help sustainability across the industry. In total, the implementation of sustainable last-mile delivery is a great opportunity for companies, governments and society. It reduces the impact on the environment and improves the functioning of cities. By fostering strategic collaboration, technological advancements, and innovative policies, stakeholders can contribute to building a more sustainable and resilient logistics network.

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