Centre for Transportation and Logistics

INDIAN INSTITUTE of MANAGEMENT AHMEDABAD

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NEWSLETTER

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CTL Thought Article

Effective City Planning Can Accelerate India's EV Transition

When a Mumbai resident was denied permission to install an EV charger in his housing society, he challenged the decision in court. The Bombay High Court found that while Maharashtra's EV Policy encourages EV adoption, it did not mandate housing societies to have a system of reviewing and permitting charging infrastructure. The Court directed the competent authorities to finalise the draft conditions and rules for installation of charging stations in cooperative societies under the Maharashtra Cooperative Societies Act, to circulate those conditions, and to consider issuing directions to societies to amend their bye-laws to permit chargers (Bombay High Court, 2024). This case emphasises that policy prescriptions alone may not be enough to translate into on-ground change unless supported by statutory backing and the effective implementation of rules.

India's Long-Term Low-Carbon Development Strategy, submitted to the UNFCCC under its Paris Agreement commitments, mentions electrification as one of the key strategies in building an integrated, efficient, and inclusive transport system (Ministry of Environment, Forest and Climate Change, 2022). This vision is not entirely new; India had already set the stage in 2013 with the launch of the National Electric Mobility Mission Plan (NEMMP) 2020, to guide future initiatives, schemes, and policies on electric mobility (Ministry of Heavy Industries, 2013). Since then, the policy landscape has expanded, with a national target of 30% EV sales by 2030, supported by initiatives such as PM E-Drive, which subsidises two- and three-wheelers, buses, and charging infrastructure, along with PLI incentives for automobile and advanced battery manufacturing. Yet, electrification in India comes with its own hurdles, and the Mumbai case exemplifies one of them.

National-Level Guidelines

The Ministry of Power has set an ambitious benchmark: one charging station in every 1 km × 1 km grid (Ministry of Power, 2024). This technical target reflects the scale of India's EV aspirations, but it cannot operate in isolation. Land availability, ownership, accessibility, traffic volumes, waiting times, and proximity to points of interest must all be factored in to ensure an efficient and spatially balanced charging network.

Building on this, operational guidelines for deploying public charging stations were recently introduced under the PM E-Drive scheme (Ministry of Heavy Industries, 2025). They are a welcome step, offering generous subsidies for upstream infrastructure in metro cities and prioritising government, PSU, and other public land for siting. The guidelines also task nodal agencies with demand aggregation and location identification. Yet without robust, data-driven city-level feasibility studies, there is a risk that chargers will be placed sub-optimally, leading to poor utilisation. For the scheme to succeed, deployment must be anchored in urban planning tools and local mobility data, not just the availability of land.

EV adoption, after all, depends on infrastructure readiness: where chargers go, who can access them, how much land they occupy, and whether rules mandate their provision. These are fundamentally urban planning questions. Without embedding EV infrastructure into statutory planning, the transition may slow down.

State-Level Implementation

The problem is not a lack of ambition: nearly every state now has an EV policy, with targets, tax rebates, and glowing visions. For instance, the Gujarat EV Policy exempts charging stations from 100% electricity duty during its tenure, but stops short of prescribing strategy and targets for the same (Ports and Transport Department, Gujarat, 2021). That gap is partly addressed by an amendment in Gujarat's development control norms, which now requires charging facilities in parking areas of new residential and non-residential buildings; this underscores how development regulations can turn intent into implementation (Urban Development and Housing Department, Gujarat, 2021).

Additionally, the Model Building Bye-Laws were amended in 2019 to recommend EV charging provisions in the State Development Control Regulations (DCR) (Ministry of Housing and Urban Affairs, 2019). Adoption, however, has been slightly uneven. For DCRs, some states embraced the norms, others adapted their own versions, while some are yet to take concrete steps. Among those that included EV provisions, most did so through parking requirements, typically mandating that around 20% or more of the total parking capacity be equipped or ready for EV charging. These inclusions show that EV integration is already finding its way into planning frameworks, offering a base to build upon.

Cities in this Picture

In parallel, the Ministry of Housing and Urban Affairs amended the Urban and Regional Development Plans Formulation and Implementation (URDPFI) Guidelines, a framework for preparing city master plans (Ministry of Housing and Urban Affairs, 2019). Here, adoption has been even more uneven. While a few cities such as Thane, Delhi, and Thiruvananthapuram have attempted to introduce EV charging-related provisions in their drafts, progress remains limited as nearly 65% of India's urban settlements operate without a master plan (NITI Aayog, 2021).

Master plans can be among the most impactful planning tools, given their legal legitimacy. From an EV planning perspective, however, their long approval timelines and 20-year horizons can make them less flexible and slower to adapt when setting targets, allocating space, and defining related norms, particularly in the context of a rapidly evolving technological landscape and volatile EV adoption trends.

Another potential legal anchor for EV integration is the city-level 'Comprehensive Mobility Plan' (CMP). The Ministry of Housing and Urban Affairs has even issued supplementary guidelines on integrating EVs into CMPs and provides support to cities for this (GIZ, 2022). Yet CMPs suffer from inconsistency: many cities lack updated plans, and those that exist often function more as procedural documents to unlock central funding under the Metro Rail Policy (MOHUA, 2017).

Originally envisioned as statutory tools of Unified Metropolitan Transport Authorities (UMTAs), CMPs are now largely drafted by metro rail corporations, and their authority is often questioned (Kalra et al., 2020). In this set-up, EVs are relegated to "last-mile" add-ons for the envisioned metro systems, rather than being treated as a core urban transport infrastructure requirement. The absence of institutionalised UMTAs in most cities has reduced the authority of CMPs, making it harder for them to fulfil their intended role in EV integration.

The Way Forward

Beyond the formal avenues, cities are flooded with ad hoc guidance documents by various institutions on EV charging. However well-intentioned, and sometimes impressively detailed, they lack legitimacy. India has so far relied on a 'pull' strategy for EV adoption through subsidies and charging tariffs. To accelerate adoption, however, the country may have to consider a 'push' approach that includes clear mandates. This shift will require grounded, data-driven planning, where development control norms, master plans, and mobility plans actively enable the rollout of charging infrastructure. At the Centre for Transportation and Logistics (CTL), we are exploring these avenues: assessing how cities are integrating EV infrastructure, whether these approaches are holistic, and how planning frameworks can be strengthened.

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Decoding Truck Buying Behavior of Indian Truck Owners

New OEMs focus on wide-ranging digital solutions to boost sales, but the real sales driver remains initial acquisition cost and aftermarket support.

Any product we use - like groceries, clothes, or gadgets, has likely traveled in a truck before landing in our hands. Road freight accounts for 66% of the total freight movement in India, with medium and heavy-duty trucks being the dominant vehicle.[1] Estimates suggest that the number of trucks on Indian roads will hit 17 million in 2050, a four-fold jump from 4 million trucks in 2022.[2] Despite a positive growth outlook, the industry has seen the exit of numerous truck makers in the last decade and the continued dominance of Tata Motors and Ashok Leyland, raising a critical question: How do truck owners decide what to buy?

Based on our insights on truck buying behavior from field visits, discussions with truck owners, and a primary survey, three most prominent factors emerge: initial acquisition cost, fuel efficiency and aftersales service. In this article, we discuss these factors and assess technology's impact in shaping buying behavior of truck owners.

Upfront Cost Steers Buying Decisions

As an unorganized and fragmented market, the Indian trucking market is dominated by single, small and medium truck operators, with 75% of operators owning less than 5 CV carriers. A medium truck in India can cost anywhere between INR 25 lakhs and INR 80 lakhs, while heavy-duty trucks range between INR 40 lakhs and INR 1 crore, making truck purchase a major decision. These small owner-operators purchase trucks through debt, serviced via equated monthly installments (EMI). The purchase price, broken down in monthly EMIs, along with monthly expected revenue and operating costs largely dictate the desirability of a truck variant for a potential buyer. Consequently, truck buyers prefer trucks with lowest EMI that fulfill their minimum requirements w.r.t. performance, capacity and application requirements.

High prices deter buyers from purchasing trucks of a particular brand and compel them to search for alternatives in the market. As a result, prominent truck OEMs engage in aggressive 'discount wars' to lower upfront cost for customers. Market leaders like Tata Motors and Ashok Leyland, which command a combined 80% market share, often resort to deep discounting during a dip in their sales volume or market share. Reports emerged in September 2023 that after sustained discount discipline, the market again witnessed a discount war due to a fall in Tata Motors' market share from 53% in FY 2022 to 44% in Q1 of FY 2023-24.[3] Consequently, challenger firms struggle in discount wars, as their limited market share restricts deep price cuts (up to INR 8,00,000 per vehicle).[4]

Minimizing OPEX through Fuel Efficiency

Multiple estimates by fleet operators suggest that fuel constitutes 45-60% of the total operational costs in trucking.[5][6][7] Majority of the Indian truck fleet runs on diesel, whose prices have displayed high fluctuations. For instance, the price per liter of diesel in Delhi in 2021 changed 107 times, out of which it rose in 91 instances.[8] Further, the price of diesel per liter in India is also higher than the neighboring countries like Bangladesh, Bhutan, Myanmar, Pakistan and Afghanistan (as of February 10, 2025).[9] This makes mileage a critical factor in truck buying decisions since any fluctuation in diesel price significantly impacts operational costs for a fleet operator. Infact, in the fleet owner survey conducted by the authors, fuel efficiency emerged as the most important factor influencing truck purchase (Figure 1).

Most of the OEMs claim a mileage of 3-4.5 kmpl for their medium and heavy-duty truck variants. However, truck owners rely on their own mileage tests and peer feedback to make buying decisions. In such a scenario, OEMs must undertake technical improvements considering the external factors that drive down their vehicle's fuel efficiency in the Indian operating environment. Overloading, poor road conditions and long wait times at toll are some of the factors that negatively impact fuel efficiency of vehicles.[10][11] To counter their negative impact, a study by the Lawrence Berkeley National Laboratory suggests improvements in tire and engine technologies.[12] While these improvements may be costly, OEMs can achieve a competitive advantage through these improvements. Afterall, a 1.1 kmpl increase in mileage could potentially reduce average trip expense by around 15% in India.11

The Critical Role of Aftersales Support

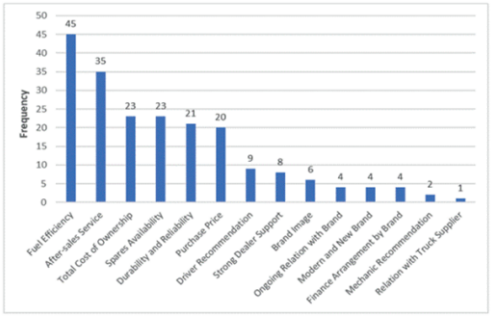

Figure 1: Factors determining truck buying behavior
Source: Fleet owner survey by authors

On the role of aftersales support, a fleet operator remarked, "Our goal is to keep the vehicle running and ensure timely delivery. Midway breakdowns affect us financially in multiple ways: clients penalize for delayed deliveries, idle vehicle impacts our ability to take the next load and add the cost of repair and maintenance to it." Truck owners seek to minimize vehicle downtime since trucks are the key revenue-generating asset. Ready availability of spare parts is critical to cut vehicle idle time and associated losses. Our survey also found aftersales service and spares availability among the top five factors influencing truck buying decision. Even OEMs understand this. Market leaders like Tata Motors and Ashok Leyland have significantly expanded their service network to maintain their leading position in the market. Tata Motors has a nationwide footprint with a network of 1600 customer touchpoint, closely followed by Ashok Leyland that has 399 authorised service centres and 491 dealers nationwide.[13] Additionally, companies compete on extended warranties, affordable annual maintenance contracts and prompt roadside assistance to woo customers. However, truck owners seem to rely on their own experience and prefer the established brands because of their extensive service network, widespread availability to spare parts and trained mechanics familiar with their vehicles' repair needs.

Is Technology Driving Disruption?

To counter the advantage gained by veteran companies like Tata Motors and Ashok Leyland, other OEMs have taken a slew of measures to enhance their value proposition, often driven by technology. For instance, Eicher introduced the first automated manual transmission truck in India in 2019.[14] It also provides eco mode in its truck to improve fuel efficiency when trucks are partially loaded or plying on flat lands.[15] Mahindra began deploying IoT in its vehicles in 2016 to provide data-driven insights to truck owners on vehicle performance.[16] Today, their iMAXX uses state-of-the-art technologies like artificial intelligence and digital twins to provide customers with intelligent business and engineering insights.

However, truck owners raise some concern over the impact of these services on the vehicle price. A truck owner's remarks perfectly sum up the issues, "As an owner of a small fleet, I do not require the full suite of technologies. These new tools inflate the vehicle prices, and their subscriptions are costly. Our drivers also do not know how to operate these technologies. They don't even use the eco mode. Technology may be good for us but unless it is customized to our needs, we may not get influenced by it to buy trucks."

As a result, truck owners continue to prioritize the fundamental factors (purchase price, fuel efficiency, and aftersales support) over digital technologies while making buying decision. Unless companies invest in widespread user training programs, or offer affordable or freemium subscription models, technology would hardly become a defining factor in swaying truck owners' (particularly small) buying choice. Technology can be a defining factor for electric trucks, which require highly integrated battery, powertrain and charging systems. However, until electric trucks develop product maturity and market acceptance, OEMs shall prioritize on cost optimization, fuel efficiency enhancement and service network expansion while making efforts at offering tailored technological solutions at affordable prices.

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CTL Research Webinars

Residential Battery Storage - Reshaping the Way We Do Electricity

The Centre for Transportation and Logistics, IIMA, organized a research webinar on 'Residential Battery Storage - Reshaping the Way We Do Electricity' by **Prof. Christian Kaps**, Assistant Professor in the Technology and Operations Management unit at Harvard Business School, on August 7, 2025.

The webinar was moderated by Prof. Debjit Roy, Professor in the Operations & Decision Sciences area and Co-Chair, CTL IIMA.

Talk Summary

Prof. Christian Kaps began the webinar by highlighting the consistent rise in emissions at the global level over the last few decades. Between 2003 and 2024, the installed solar capacity has risen by more than a thousand times. Households are increasingly installing rooftop solar panels to reduce their dependence on the grid. Households can choose to sell excess electricity to the grid during daytime, or invest in residential battery storage systems to consume the surplus during night. Despite being expensive, households continue to invest in residential storage options. The study aimed to understand the reasons behind storage adoption by households and its impact on carbon emissions.

A household utility nonmarket valuation model was developed by incorporating consumption benefits, feed-in revenue, and subtracting electricity and investment costs. The structural estimation model separated observed demand and consumer preferences, enabling estimating non financial utility. Shadow price was derived by subtracting Marginal Cost from Structural Model for highlighting optimal conditions for consumption, storage, and solar capacity. Based on data of 3,237 German households, the study found the median nonmarket valuation price to be €0.29, fairly similar to market price of grid electricity. Further, an average household was found to have paid €737 extra nonmarket valuation for solar storage.

Additionally, storage was found to increase electricity demand at the household level (storage rebound) and did not lead to emissions savings. However, with grid electricity transitioning towards solar and gas in future, storage may reduce emissions. As solar and battery prices fall, investing in solar would become more optimal for households and reduce residential grid load by an estimated 40%. However, it would also increase the variability by up to 150% in demand for grid electricity.

Predictive and Prescriptive Analytics toward Optimizing Wildfire Suppression

The Centre for Transportation and Logistics, IIMA, organized a research webinar on 'Predictive and Prescriptive Analytics toward Optimizing Wildfire Suppression' by **Prof. Alexandre Jacquillat,** Maurice F. Strong Career Development Professor & Associate Professor of Operations Research and Statistics, MIT Sloan School of Management, Massachusetts Institute of Technology, on August 18, 2025.

The webinar was moderated by Prof. Debjit Roy, Professor in Operations & Decision Sciences area and Co-Chair, CTL IIMA.

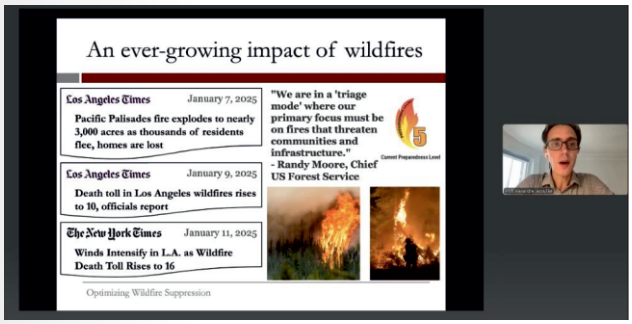
Talk Summary

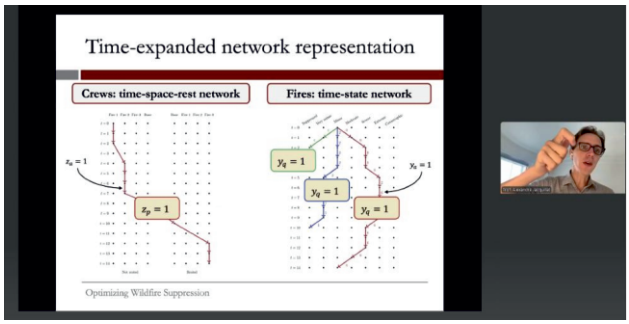
Prof. Jacquillat commenced with a discussion on the utility of operations in solving problems of social good, like vaccine allocation, wildfire suppression and organ transplant. He highlighted the negative impact of wildfires on communities and infrastructure. His study aimed to explore the optimal allocation of scarce resources for wildfire suppression in a spatial region over time. He used historical, topological and environment data in the form of wildfire maps from US Forest Service and Google Earth Engine along with new data on historical crew and machine assignments to wildfires.

He introduced a joint predictive–prescriptive framework to optimize the allocation of firefighting crews. The model integrated two components in a two-sided set partitioning: a time-space-rest network capturing crew routing and rest requirements, and a time-state network modeling wildfire dynamics. This resulted in a combinatorial resource allocation problem, combining elements of vehicle routing & triage, where unattended fires grow endogenously over time.

To solve the problem, a branch-and-price-and-cut algorithm was developed with a two-sided column generation scheme to overcome the optimality gap. A robust cut was generated from knapsack constraints when the demand for crew exceeds the number of idle crew. Novel branching rules were incorporated to handle non-linear wildfire dynamics. He displayed the benefit of augmented GUB cuts, dual-aware branching and primal heuristic in generating an optimal solution. Computational experiments showed that the approach solved medium-scale problems exactly (20–30 crews, 5–10 fires) and scale to larger cases (~70 crews, 20 fires) with near-optimal solutions.

Prof. Jacquillat also discussed a case study on wildfire spread prediction that used satellite data, meteorological variables, vegetation, and fire history to build predictive models to estimate fire spread under different suppression levels. The study utilized double machine learning to estimate wildfire spread while correcting for endogeneity between suppression actions and fire growth. The results showed that the DML approach captured the true non-linear, non-monotonic relationship between suppression efforts and fire growth.





To watch, visit: https://www.youtube.com/watch?v=gAbQhXR-dSw or scan

CTL Workshops

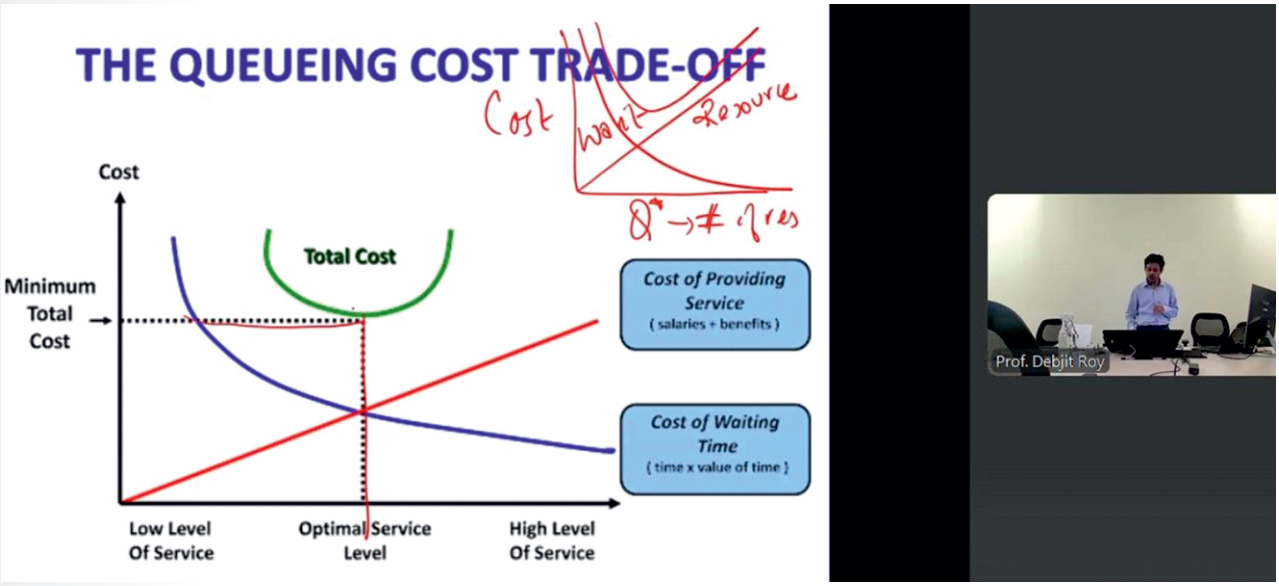
Online Capacity-Building Workshop on Advanced Teaching and Research Methods for Transportation and Logistics

The Centre for Transportation and Logistics at IIMA organised the second edition of the month-long 'Online Capacity-Building Workshop on Advanced Teaching and Research Methods for Transportation and Logistics'. The six sessions of the workshop series, each led by the experienced IIMA faculty members, were curated to align researchers, practitioners, and students with the latest research methods and tools in the field of transportation, logistics, and supply chain management.

The workshop provided a comprehensive exploration of advanced analytical frameworks, covering a diverse range of topics from real-time dynamic decision-making in intralogistics and mathematical optimization for facility location, to the application of machine learning for prediction. It also delved into sophisticated econometric techniques like panel data modelling for value chain analysis, innovative experimental methods to gauge consumer behaviour for policy-making and strategic approaches to decarbonization in line with national and global climate targets.

The workshop began on August 5, 2025, with a welcome address delivered by Prof. Satish Deodhar and our workshop faculty to the participants. Prof. Debjit Roy commenced the first session on 'Transitioning from assessing performance to real-time decision making in intralogistics systems'. Prof. Roy highlighted that India's logistics costs, at 10-14% of GDP, are significantly higher than in other nations (as low as 6%), underscoring the need for improved efficiency. The central theme was the critical transition from traditional static, long-term planning to dynamic, real-time decision-making within intralogistics systems—defined as logistics inside facilities like warehouses, ports, and quick-commerce dark stores. Time was established as a key performance measure, with real-world case studies including electric vehicle charging queues, airport & port congestion, and online delivery delays being used to illustrate the significant financial costs, such as detention and demurrage(D&D) and customer-loyalty impacts of waiting. This framed the core operational challenge as a trade-off between the cost of providing resources and the cost of customer wait times, with the goal of finding an optimal service level.

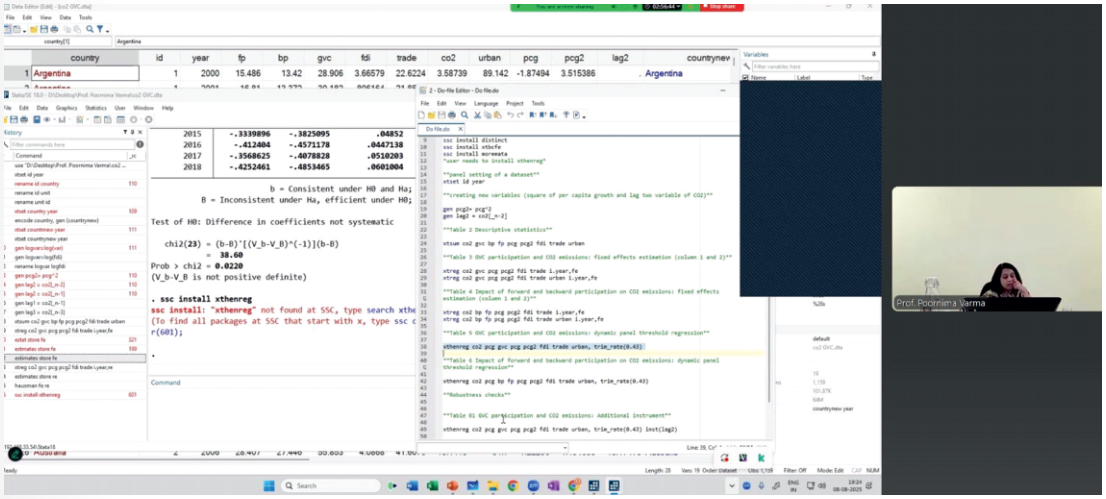
A detailed quick-commerce case study was used to demonstrate how a fulfilment process could be modelled and analysed. Simulation Modelling was introduced as a tool to optimize resources, such as the number of pickers and delivery agents, and it was shown how dynamic, state-based rules for allocating orders outperform static policies. The second part of the workshop focused on how this shift to dynamic decision-making is enabled by modern technologies, particularly the Internet of Things (IoT) in Intralogistics systems. It was explained how real-time IoT data can be used to dynamically optimize facility layouts, improve worker well-being, manage staff at large events and control warehouse congestion. The session concluded with an introduction to sequential decision models, such as Markov Decision Processes (MDPs) and their key components: states, actions, rewards, and transition probabilities were defined. A simplified quick-commerce problem was solved using dynamic programming to illustrate how an optimal, state-dependent policy is derived by weighing immediate rewards against expected future value, reinforcing the workshop's central theme of moving from reactive to proactive, data-driven decision-making.



First session on 'Transitioning from assessing performance to real-time decision making in intralogistics systems' conducted by Prof. Debjit Roy

The second session of the workshop, delivered by Prof. Poornima Varma, was held on August 8, 2025, on the topic 'Analysing Global Value Chain Participation - Linear and Non-linear Panel Data Models'. The session began by laying a strong foundation, clearly defining panel data as a powerful combination of cross-sectional and time-series data and explaining the difference between balanced and unbalanced panels. A central theme was the distinct advantages of this approach. Prof. Varma explained how panel data provides more degrees of freedom, mitigates statistical issues like collinearity and is better suited for studying the dynamics of change over time. It was particularly emphasized how panel data reduces aggregation bias by capturing the unique, individual-specific heterogeneity that is often lost when data is grouped into broad categories.

To bring these theories to life, the workshop centred on a compelling case study from a published paper examining the impact of “Global Value Chain (GVC) participation” on CO emissions. Various modelling approaches were introduced, starting with the linear Fixed Effects model, which is used to control for unobserved, time-invariant characteristics like a country's culture or geography. The discussion then progressed to more complex, non-linear relationships, leading to a detailed explanation of Dynamic Panel Threshold Regression. This advanced technique identifies if an effect changes once a variable crosses a critical threshold. The case study revealed a pivotal finding: the link between GVC participation and emissions is not linear but is conditional upon economic growth. For economies with per capita growth below a certain threshold, GVC participation was associated with an increase in emissions. However, once growth surpassed that point, the impact became negative, suggesting that economic development can help turn global integration into a positive force for environmental outcomes. The workshop concluded with a practical software demonstration in Stata and an insightful Q&A that touched on advanced topics like the use of internal instruments in dynamic models.

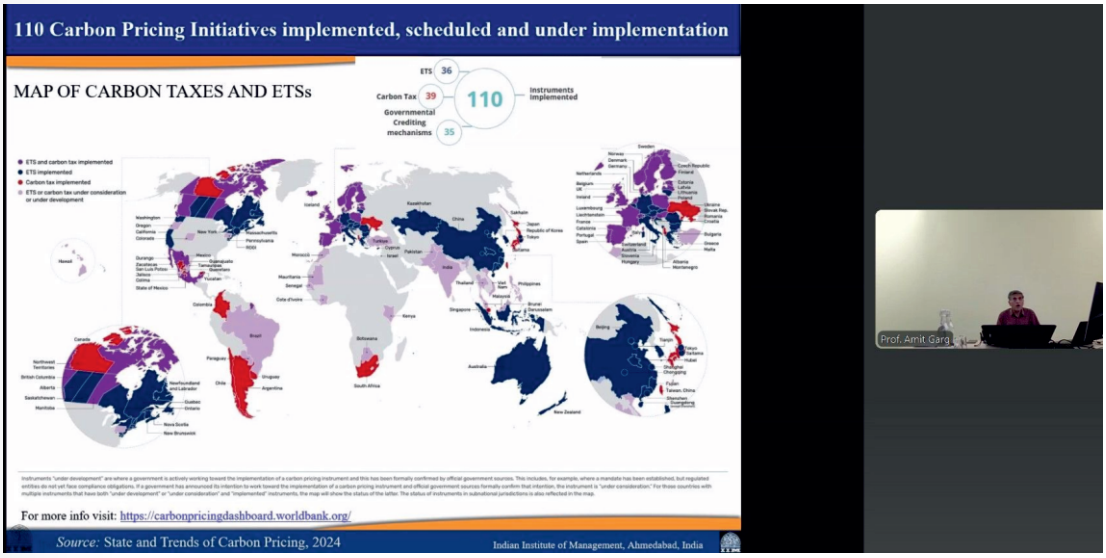


Second session on 'Analysing Global Value Chain Participation - Linear and Non-linear Panel Data Models' conducted by Prof. Poornima Varma

Prof. Amit Garg conducted the third session on August 11, 2025, on 'Modal Shift: Implications of Transport Transitions in India Towards Sustainable Development Goals & Paris Climate Change Agreement'. Prof. Garg commenced the session by underscoring that India's transport sector contributes about 10% to the nation's total greenhouse gas emissions, which are over 3 billion tons annually. The primary source within the sector is road transport, accounting for roughly 9.4% of all emissions. To align with global climate targets set by the Paris Agreement, a multi-pronged approach is essential. To address this, India is pursuing several decarbonization pathways as part of its Nationally Determined Contributions (NDCs), which include ambitious goals like reducing the economy's emissions intensity by 45% by 2030.

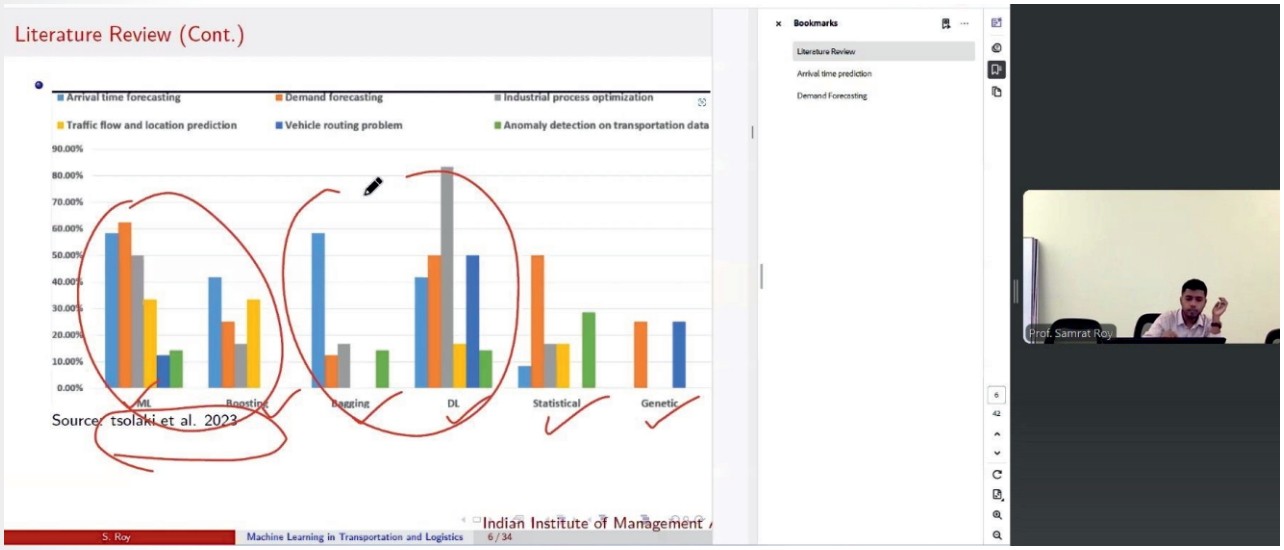
A central strategy discussed was the modal shift from road to rail for freight, with a national goal to increase the railways' share of land transport from its current level of about 36% to 45%. However, this is a significant challenge, especially as the country continues to build approximately 38kms of new roads daily, encouraging more truck usage. Other key strategies include vehicle electrification and biofuel blending. While EVs are promising, their true environmental benefit is critically dependent on being charged with renewable energy. Meanwhile, India is on track to meet its 20% biofuel blending target by 2025.

Prof. Garg emphasized India's unique "double challenge": the need to foster economic growth to become a developed nation (Viksit Bharat) by 2047 while simultaneously working towards a net-zero target by 2070. This requires a pragmatic approach to energy security, balancing the use of available resources with a strong push for renewables. The workshop concluded that there is no single "silver bullet" solution. The path forward demands a multifaceted strategy combining technology, robust policy and crucial behavioural changes like reducing consumerism and improving road discipline. For a developing nation like India, building resilience through climate adaptation was highlighted as being just as critical as emissions mitigation.



Third session on 'Modal Shift: Implications of Transport Transitions in India Towards Sustainable Development Goals & Paris Climate Change Agreement' conducted by Prof. Amit Garg

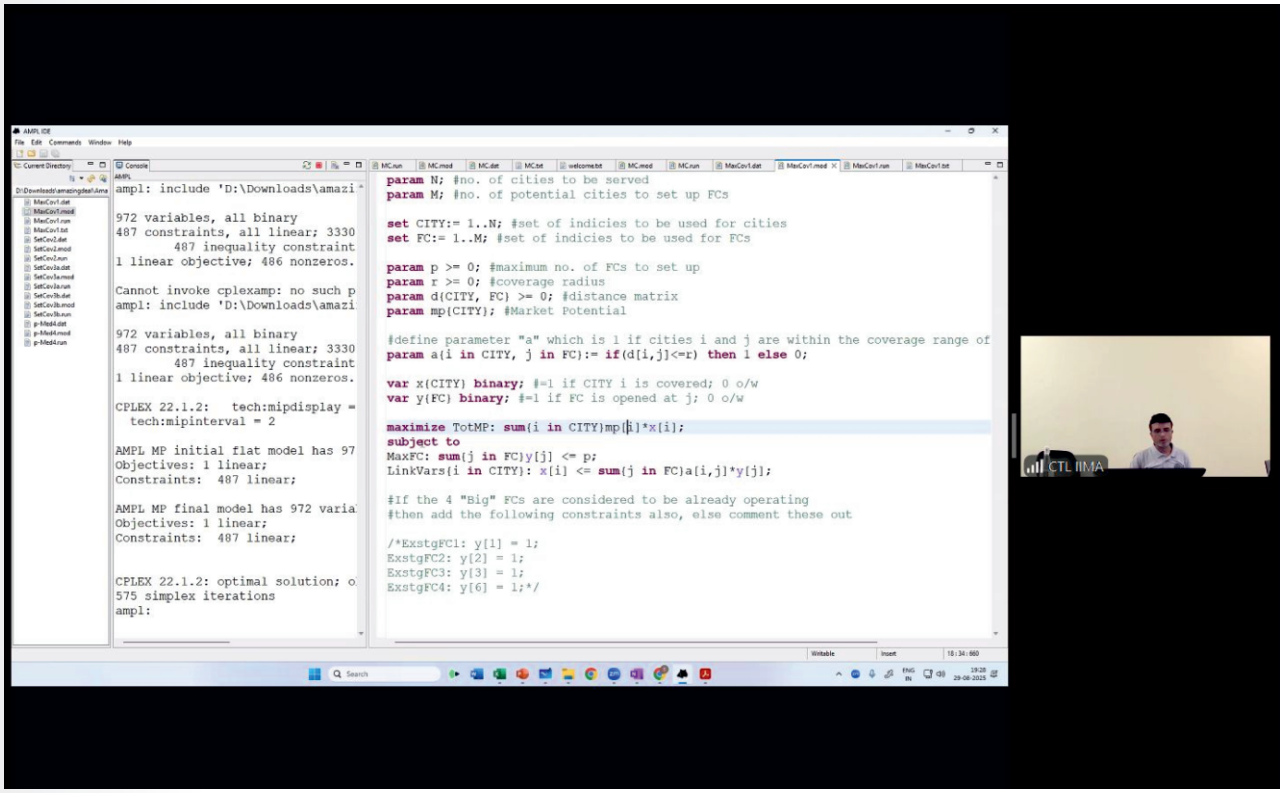
Prof. Samrat Roy conducted the fourth session on August 22, 2025, on 'Application of Machine Learning in Transportation and Logistics'. Prof. Samrat Roy provided a comprehensive overview of machine learning (ML) applications in transportation and logistics. The session first explores Linear Regression as a fundamental tool for prediction tasks like estimating delivery times. The importance of proper model evaluation was emphasized, with key metrics like p-values and R-squared being explained to assess predictor significance and model fit. A critical challenge, the risk of overfitting, was addressed, where a model becomes too complex and fails to generalize to new data. To combat this, the necessity of feature selection was discussed. Techniques such as stepwise selection using adjusted R-squared and LASSO regression, which automatically simplify models, were presented as effective solutions. As a highly interpretable alternative, Decision Trees were introduced for both classification and regression tasks, and it was shown how their performance can be evaluated using tools like the confusion matrix. The power of Ensemble Methods was then explored, based on the "wisdom of crowds" principle of combining multiple models to improve accuracy. These were broken down into parallel methods like Bagging and Random Forest, and sequential methods like Gradient and Adaptive Boosting, where models are designed to learn from the errors of their predecessors. Finally, more specialized and advanced models were covered. Logistic Regression was identified as the correct tool for binary classification problems. Powerful "black box" models like Neural Networks (NNs) were also discussed, with their effectiveness in handling large datasets noted. A key variant, Recurrent Neural Networks (RNNs), was highlighted for its unique ability to process sequential data with practical applications in time-series demand forecasting and text-based sentiment analysis were demonstrated.



Fourth session on 'Application of Machine Learning in Transportation and Logistics' conducted by Prof. Samrat Roy

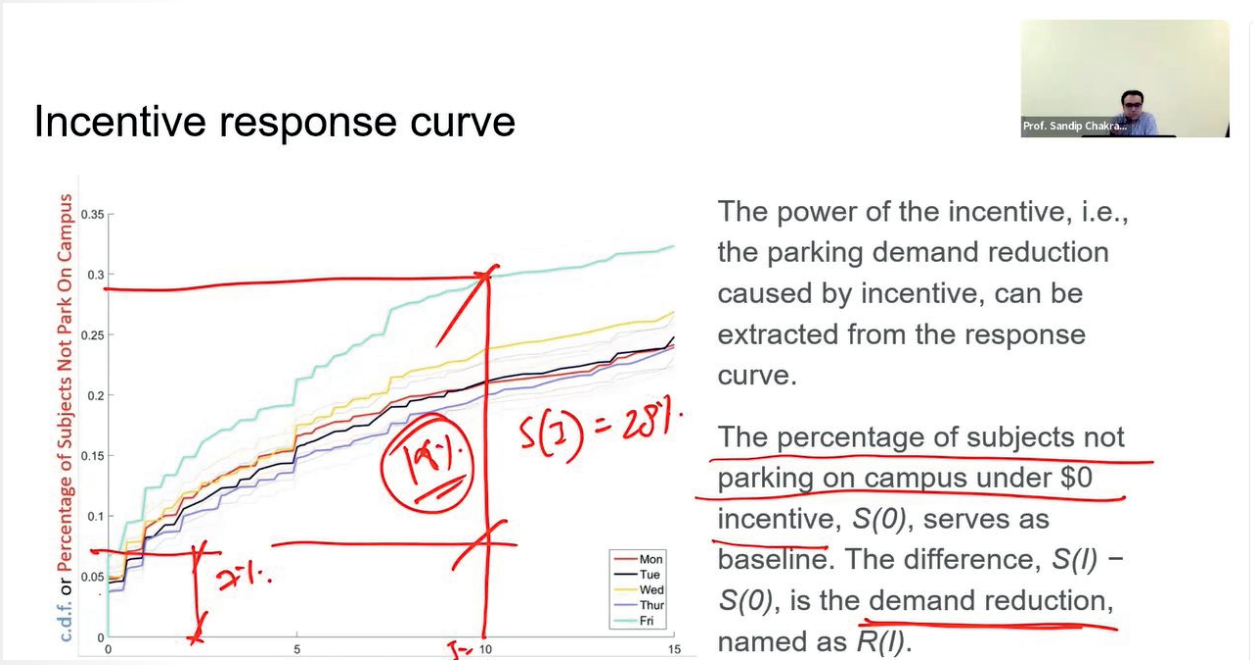
The fifth session on the topic 'Location of E-Commerce Fulfilment Centers', was delivered by Prof. Sachin Jayaswal on August 29, 2025. This workshop on logistical optimisation, conducted by Prof. Jayaswal, provided a comprehensive guide for solving complex business problems using mathematical modelling. The session was centred on a detailed case study of the e-retailer AmazingDeal.com. The company's significant challenge of expanding its fulfilment centre network to support ambitious growth and meet expedited delivery demands was presented. The primary business problem was framed as a strategic task where the optimal locations for new fulfilment centres had to be selected to maximize market potential while adhering to strict budgetary and operational constraints.

To address this challenge, the core principles of mathematical modelling were introduced. The concept was first illustrated with simple linear and non-linear examples before being applied to the main logistics problem. A detailed demonstration was provided, showing how the fulfilment centre location problem could be structured as a formal optimization model. This model was built with a clear objective function, specific decision variables representing which centres to open and a set of defined constraints. The solution to this complex model was then found using two distinct computational tools. First, a solution was derived using the widely accessible Microsoft Excel Solver. Subsequently, the problem was modelled and solved again using the more specialized and powerful AMPL (A Mathematical Programming Language) integrated with the CPLEX solver. Through this demonstration, the session effectively showcases how a real-world, high-stakes business decision can be systematically analysed and solved using quantitative optimization techniques, providing a clear framework for strategic decision-making in logistics and supply chain management.



Fifth session on 'Location of E-Commerce Fulfilment Centers' conducted by Prof. Sachin Jayaswal

The sixth and final session of the workshop was conducted by Prof. Sandip Chakrabarti, held on September 4, 2025, offering a deep dive into the topic 'Experimental Methods for Transportation Demand Analysis'. The workshop addressed how pricing and incentives influence consumer behaviour in transportation and outlined advanced methods to measure these effects accurately for effective policy-making. The session began by identifying the core limitations of standard survey methods like Revealed Preference (RP) and Stated Preference (SP), which are often hampered by a lack of real-world price variation and the presence of hypothetical bias. The concepts of "Willingness to Pay" (WTP) and "Willingness to Accept" (WTA) were discussed, with an emphasis on the common finding that people tend to understate their WTP and overstate their WTA. As a more accurate alternative, the Becker-DeGroot-Marschak (BDM) auction mechanism was introduced. Prof. Chakrabarti demonstrated how this experimental design creates an incentive structure where the participant's dominant strategy is to reveal their true valuation, thereby overcoming the biases inherent in traditional surveys. A detailed application was presented in the context of managing employee parking demand through a "cash-out" policy. Prof. Chakrabarti outlined an experiment where employees bid their true WTA to relinquish their daily parking spot. It was shown how data from such an experiment can be used to generate a precise incentive response curve, which shows policymakers the demand reduction achievable at various incentive levels. A second application for testing congestion pricing was also explored. Since real-world pilots are often infeasible, a digitally facilitated field experiment was proposed. In this setup, participants use a smartphone app with a virtual wallet containing funds that convert to real money. A fee is deducted for travelling on congested routes, creating a real financial trade-off that reveals their true WTP. This was presented as a viable way to generate a price response curve to inform effective road pricing strategies. Prof. Chakrabarti concluded the session by acknowledging the limitations of these methods, such as potential self-selection bias among participants, while underscoring their immense value for practitioners and policymakers in the transportation sector.



Sixth Session on 'Experimental Methods for Transportation Demand Analysis' conducted by Prof. Sandip Chakrabarti

This write-up has been prepared by

Ms. Gurpreet Kaur

Research Associate, CTL IIMA

Workshop on Accelerating Electric Vehicle Adoption in India

On September 12, 2025, the Centre for Transportation and Logistics, IIMA, and the Centre for Sustainability and Corporate Governance Research (CSCG), IIMA, jointly organized a workshop on 'Accelerating Electric Vehicle Adoption in India.' The session was moderated by **Prof. Sandip Chakrabarti,** JSW Chair in Innovation and Public Policy, IIMA and **Prof. Anish Sugathan,** Chair, Centre for Sustainability and Corporate Governance Research, IIMA.

The event began with a welcome address by Prof. Sandip Chakrabarti, who highlighted the importance of viewing EV production, marketing, and adoption as part of an integrated ecosystem. He emphasized that the workshop is designed to engage stakeholders from across this ecosystem and generate actionable insights for advancing interdisciplinary research aimed to promote EV adoption in India. Prof. Anish Sugathan further stressed the inevitability of India's transition to EVs and expressed confidence that the workshop would help address many pressing questions surrounding this shift.

The keynote address by **Shri JP Gupta, IAS (Retd.),** Former Additional Chief Secretary (Finance), Government of Gujarat, gave an overview of growth of EV in India. He underlined the importance of integrating EV technology with solar power to achieve a sustainable and economically viable shift in mobility and energy usage.

In the first invited talk, **Shri Anil Kumar Choudhary**, Chief General Manager & Head, Operations, Energy Efficiency Services Limited, shared insights on business models for public sector EV transition and strategies for meeting energy demand. In the second invited talk, **Shri Suveer Sahdev,** Lead, EV & Strategic Supply at Uber India, shared innovative ideas about how fleet operators can integrate EVs into ride-sharing models.

The workshop featured a panel discussion on "The Future Landscape of Electric Vehicles in India." Each panelist brought a unique perspective to the table:

Dr. Ranga Srinivas Gunti (Tata Motors) stressed the need for innovations in EV battery research and the importance of indigenisation.

Shri Awadhesh Kumar Jha (Glida India) talked about the role of consumer awareness in faster EV uptake & highlighted the need for skilled human resources in EV dealerships.

Shri Dippy Vankani (Flipkart) shared Flipkart's experiences in integrating EVs into logistics, the challenges encountered, adoption strategies and the promising road ahead.

Shri Saurabh Gupta (KPMG India) outlined five critical dimensions of the EV market – adoption, deployment, infrastructure, finance, and innovation – and interventions needed along each.




CTL Sponsored Student Projects

Role of AI/ML and Robotization in Warehouses

Authored by-

Aniket Kumar Biswas
PGP Batch 2024-26

Kishor Khilare
PGP Batch 2024-26

Guided by- Prof. Debjit Roy

This study states how the use of Artificial Intelligence (AI), Machine Learning (ML), and robotization has the potential to transform Indian warehousing as the country looks at the challenges and opportunities for the Food and Beverage (F&B) sector as well as the new Quick Commerce (Q-commerce) paradigm. Indian warehousing has reached an inflection point where tight logistics costs, scattered cold chain infrastructure, and high growth in consumer demand bring systemic weaknesses hindering reliability as well as sustainability. Through cross-industry practice comparison as well as case studies of industry giants such as Blinkit, Swiggy Instamart, Zepto, and Flipkart Minutes, the study presents diagnosis of the current limitations as well as the phased adoption map for the automation technologies.

The project objective was to demonstrate that without automation, Indian warehouses will remain prone to high error rates, food spoilage, and operational inefficiencies. Primary data obtained through the study indicated that nearly half the users of Q-commerce surveyed had been supplied with spoiled or inaccurate goods, evidence that problems are not abstract but directly affect the confidence of the consumer. Comparatives at the international level using highly automated centers such as Amazon's Shreveport Fulfillment Center and Save Mart's dark stores with robots serve only to highlight the gap between India's labour-intensive "brute force" model of fulfillment and the accuracy and volume created by end-of-the-line automation. The study thus contends not only as an efficiency booster but as strategic requirement for the Indian warehousing industry.

Food and Beverage warehousing was the highest priority sector emerging in the study due to the fact it had critical problems of perishability as well as de-integrated supply chains. India annually loses nearly 30–40% of vegetables and fruits after being plucked due to inadequate cold storage as well as logistics, while in the developed economies below 5% gets wasted. Q-commerce platforms, promising 10–15 minute delivery in highly populated urban areas, adds further stresses by reducing time turnovers as well as demanding almost perfect picking as well as consolidation. According to the study, dark stores without intervention perpetuate seasonal problems of fatigue, mis-picks, non-uniform cold storage checks, as well as peak hour shortage of riders. Thereby operational weaknesses in turn compromise the long-term sustainability of the model as well as erode consumer confidence.

To overcome these issues, the study recommends a two-stepped automation path. The first is semi-automation through technologies such as Put-to-Light (PTL) systems, handheld scanners, as well as zoned and optimized layouts. These technologies reduce picking errors, double or triple throughput, and break-even points in just two or three years, thereby appealing to the vast majority of city-based fulfillment centers. The second involves full automation through AutoStore-type robotic grid systems integrated with modular cold store as well as AI-based

demand planning. It has never-before-seen accuracy of nearly 99.9%, 75% storage density gains, as well as five times higher throughput. But it requires higher capital outlays, eight to eleven years for break-even points, making it best for high-volume nodes or multi-node networks. The phased model therefore allows the business corporations to achieve short-term financial viability as well as long-term strategic change.

The study also reveals how automation adds value as well as speed. IoT-enabled automatic cold storage warehouses with temperature control and spoilage notification can greatly reduce wastage of perishes. Robotic picking and packing not only improve order accuracy but also reduce physical exertion for employees, removing the rampant report of worker fatigue and turnover among Indian warehouses. Automated zoning and high-density robotic grids also optimize space utilization, reducing rent costs in the city by as much as 70%. All together, the benefits point toward an Indian warehousing future capable of competing on the global stage both in the realm of efficiency as well as sustainability.

A comparison between global and Indian practices highlights that India's warehousing industry is still evolving. Advanced economies have already incorporated automation, sustainability, and employee protection in their design, while Indian warehouses are still stuck with strong reliance on manual labor. This dependence is in response to low-cost labor availability but, at the same time, poses long-term risks, particularly as consumption habits change in urban India and consumer demands grow. By framing automation as a competitive imperative and a public good (reducing food waste, improving safety, and enabling resilient supply chains) the research makes the case for immediate investment in scalable models appropriate to India's situation.

This project's contribution is in three ways. First, it gives a comparative cross-industry model, comparing warehousing requirements in seven industries and several channels of distribution. Second, it introduces empirical research through consumer surveys, illustrating that systemic inefficiencies directly impact consumer dissatisfaction and brand risk. Third, it presents a pragmatic plan that integrates semi-automated technologies for near-term viability with full automation for long-term revolution. By situating technology adoption in the context of India's distinctive socio-economic and logistical limitations, the paper demonstrates how warehouse innovation is tied up with overall objectives of food security, sustainability, and economic competitiveness. Finally, this study indicates that India's Food and Beverage warehousing industry, as well as its Q-commerce environment, cannot be highly manual and hope to achieve sustainable growth. Semi-automation provides a viable starting point with rapid payback, and full automation lays out the roadmap for long-term competitiveness and resilience. By integrating AI, ML, and robotics into their operational DNA, Indian warehouses can transcend the compromise between speed and quality so that future supply chains are efficient and reliable. The larger implication is obvious: technological adoption in warehouses is the key to creating a resilient, future-proof India.

Threading the Future: A Digital Roadmap for India's Textile Industry

Authored by-

Akshat Gupta
PGP Batch 2024-26

Anshaj Gupta
PGP Batch 2024-26

Guided by- Prof. Debjit Roy

As India positions itself as a global manufacturing powerhouse, a critical question emerges about how can traditional, foundational sectors like textiles evolve to compete in the age of Industry 4.0. This report offers a deep-dive analysis into this challenge. Moving beyond theory, the report delivers a strategic, data-backed roadmap for the Indian textile industry, a sector identified as having immense growth potential but dangerously low digital maturity. The study integrates conceptual frameworks, primary field research, comparative industry deep dives, and quantitative patent analysis to chart a viable path forward.

The report first maps the Indian manufacturing landscape with a Digital Maturity vs. Growth analysis, plotting eleven sectors to identify strategic outliers. This revealed a stark contrast: the automotive industry stands out as a digitally mature leader, while the textile industry is a laggard, despite its high growth prospects. This pairing, a mature leader and a high-potential laggard, forms the core of the report's comparative analysis. To understand the drivers behind this gap, the report introduces a Digitalization Adoption Framework. It argues that manufacturers are motivated by three primary factors:

1. Efficiency Gains: A proactive quest for bottom-line improvement.
2. Prevention of Obsolescence: A competitive necessity for survival.
3. Regulatory Compliance: A reactive, often mandatory, adoption of technology.

This model provides a critical lens to understand why the heavily regulated automotive sector has advanced, while the margin-driven textile sector has hesitated. The analysis is grounded in primary research, including expert interviews and a factory visit to a textile MSME. These interactions uncovered critical, systemic challenges crippling digital adoption: a profound lack of capital due to razor-thin margins (as low as 5-7%), a severe skills gap, deep-seated cultural and union resistance to automation, and a fundamental lack of awareness among MSME owners about affordable, scalable digital solutions.

To bridge the gap from problems to solutions, the report employs two key analytical methods: a technology-process fit matrix and a deep comparative analysis. First, a Technology–Process Fit Matrix maps key Industry 4.0 technologies (e.g., AI, IoT, Robotics) against different manufacturing process types. When applied to the textile value chain, this reveals that foundational technologies like IoT sensors, AI, and Big Data have broad applicability across all stages, from spinning to finishing. In contrast, technologies like industrial robots are best suited for high-volume, standardized stages like weaving, while AR/VR and 3D Printing offer the most value in high-variety, customized stages like garment design and prototyping. This granular analysis allows for targeted recommendations rather than a one-size-fits-all approach.

Second, the report's comparative analysis uses the automotive sector as a benchmark to derive scalable lessons for the textile industry. While high-cost automotive solutions, like BMW's factory-scale digital twins, are not directly transferable, their underlying principles are. The report argues for adapting this logic into affordable solutions, such as using 3D virtual prototyping (a product-level digital twin) to slash the waste and cost associated with physical samples.

This qualitative comparison is powerfully reinforced by a quantitative patent analysis of the WIPO database (2019–2025). The findings were stark:

- Overall, Artificial Intelligence is the most innovative Industry 4.0 field, while the Internet of Things (IoT) shows the fastest growth with a 23% compound annual growth rate (CAGR).
- The automotive industry generated nearly five times more Industry 4.0-related patents than the textile industry, highlighting a massive innovation gap.
- Critically, while a decline in automotive patent activity (-9% CAGR) suggests digital maturity, the similar decline in textiles (-7.6% CAGR) points to a more troubling trend of diminished research focus and investment, validating insights from expert interviews regarding the industry's precarious low-margin structure.

The synthesis of these analyses leads to the report's central conclusion: the Indian textile industry is caught in a vicious cycle where low margins prevent investment in technology, which in turn perpetuates inefficiency and suppresses margins. To break this cycle, the report proposes a pragmatic, two-stage roadmap:

Short-Term (High-Impact, Low-Cost):

- Retrofit Machinery with IoT Sensors: Install affordable sensors on existing equipment to enable predictive maintenance and gather crucial operational data.
- Implement AI-Enabled Defect Detection: Apply the principle of automated quality control using low-cost AI vision systems to reduce waste and improve quality.
- Adopt Cloud-Based ERPs: Digitize foundational processes like inventory and order management to improve operational visibility.

Long-Term (Ecosystem Building):

- Invest in 3D Virtual Prototyping: Embrace digital design to reduce waste, shorten lead times, and enhance customization capabilities.
- Develop Shared Digital Infrastructure: Establish cluster-based tech hubs in textile centres to give MSMEs affordable, subscription-based access to advanced tools.
- Integrate Blockchain for Traceability: Build a transparent supply chain to meet growing global demands for sustainability and ethical sourcing.

By adopting this phased approach, the Indian textile industry can begin its digital transformation, ensuring it not only survives but thrives in the modern manufacturing era.

CTL Snippet

E12: Enhancing Resilience in Supply Chain Operations

Interaction with Prof. Vishwakant Malladi, Assistant Professor of Operations Management, Indian School of Business (ISB)

Prof. Vishwakant Malladi discusses his research on facility location problems, focusing on how disruptions such as natural disasters or political disturbances impact companies' supply chain and warehouse operations, and how firms can better prepare for these disruptions. He emphasizes the importance of accounting for the probability and correlation of such disruptions when choosing warehouse locations. Traditional models often assume either complete independence or complete correlation between disruptions, both of which are unrealistic. His research proposes a more nuanced model that captures partial correlations based on geographic proximity, enabling firms to make more cost-effective and resilient location decisions. These insights help businesses and policymakers improve supply chain reliability and reduce long-term operational risks.

Click to watch: https://www.linkedin.com/feed/update/urn:li:activity:7376119427613904898 or scan

Thought Leadership

Strategies for zero-emission truck adoption in India: From assets to processes

An opinion article titled 'Strategies for zero-emission truck adoption in India: From assets to processes' authored by Prof. Debjit Roy, Prof. Sandip Chakrabarti, and CTL Research Associate, Mr. Shubham, was published in Economic Times Auto (ET Auto) on August 6, 2025.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Strategies for zero-emission truck adoption in India: From assets to processes

India's trucking industry, a significant emissions contributor, faces pressure to decarbonise. While biofuels, hydrogen, and electric vehicles are potential solutions, each presents trade-offs. Achieving total cost of ownership parity, fostering local innovation, and establishing robust charging infrastructure are crucial for widespread adoption of zero-emission trucks, paving the way for a cleaner, more efficient freight sector.

Debjit Roy, Shubham & Sandip Chakrabarti • ETAuto
Published On Aug 6, 2025 at 09:30 PM IST • Read by 779 Professionals

The government has launched numerous initiatives and schemes to promote biofuels, electric vehicles and hydrogen for mobility.

Read more at: https://auto.economictimes.indiatimes.com/news/commercial-vehicle/accelerating-zero-emission-truck-adoption-in-india-effective-strategies-unveiled/123145635

CTL Faculty Research

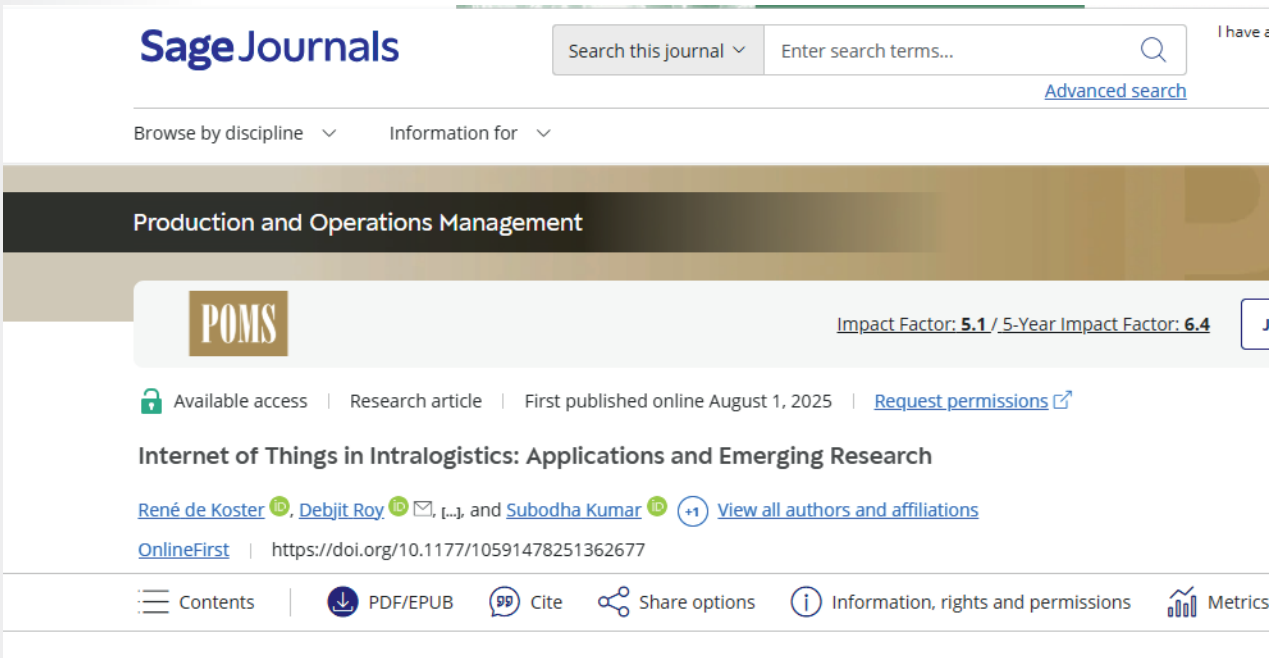
Internet of Things in Intralogistics: Applications and Emerging Research

Prof. Debjit Roy, along with Prof. René de Koster, Prof. Yun Fong Lim, and Prof. Subodha Kumar, published a research paper titled '**Internet of Things in Intralogistics: Applications and Emerging Research**' in the journal Production and Operations Management.

Abstract

Managing the performance of intralogistics operations, that is logistics operations within facilities such as manufacturing plants, order fulfillment warehouses, ports and terminals, and retail stores, is critical in fulfilling customer expectations. Traditional decision-making for intralogistics operations is based on historical data, typically collected over long-range intervals with significant processing delays. However, nowadays, Internet of Things (IoT) applications are used to gather detailed real-time data to make dynamic decisions. These new data sources provide challenges and opportunities for operations management. We provide an overview of prominent IoT technologies in four domains: Manufacturing, warehousing, ports and terminals, retail, and other emerging areas. We discuss four prominent research questions (cutting across multiple application domains) that can be addressed using new data sources, along with the methodological approach and managerial insights that may result. In particular, IoT can improve the tracking and tracing of objects, equipment, and humans and provide rapid alerts, allowing managers to make real-time decisions and improve asset use, uptime, and profitability.

To read the complete article, visit: https://doi.org/10.1177/10591478251362677



CTL Faculty Engagements

Prof. Debjit Roy participated as a panelist in a Panel Discussion on 'Opportunities for Accelerating ZET Adoption in Gujarat' as part of the Workshop on 'Accelerating the Shift: Transition to Zero Emission Trucks', organized by Smart Freight Centre India and GERMI (Gujarat Energy Research and Management Institute) on July 3, 2025. Our Research Associates, Mr. Shubham Siwach and Ms. Jesal Tejwani, represented the centre at the workshop and actively contributed to the discussions on the evolving landscape of ZET deployment in India.

Read more: https://www.linkedin.com/feed/update/urn:li:activity:7346586942332944385

Prof. Prashant Das presented a paper, 'Determinants of Warehouse Rents', co-authored with Prof. Pritha Dev, at the Asian Real Estate Society (AsRES) Annual Conference on July 9, 2025, at Melbourne Business School.

Prof. Sandip Chakrabarti was invited to the High Speed Rail (HSR) roundtable at the India Habitat Centre, an event co-hosted by the Rail Transportation and Equipment Division of the Confederation of Indian Industry (CII) along with The Infravision Foundation in New Delhi, on August 18, 2025.

Prof. Sachin Jayaswal presented an invited talk on 'Large-Scale Optimization and its applications in Defence' at College of Defence Management, Secunderabad, on September 2, 2025.

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