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NEWSLETTER

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![Centre for Transportation and Logistics, IIMA — Indian Institute of Management Ahmedabad](logo)

Decarbonizing Urban Transport in India: Possible Pathways

Source: Ertico Network

The world is warming up, and data from the World Meteorological Organization attests to that. February 2024 was the warmest February on record since global record-keeping began, and was also the ninth successive month to break such a record (World Had Warmest February on Record, 2024). According to the State of Global Climate report, 2023 was the hottest year in recorded history, with global temperature averaging +1.45° Celsius above pre-industrial levels (Climate Change Indicators Reached Record Levels in 2023: WMO, 2024). The scenario isn't much different for India. Five warmest years in India's recorded history occurred in the last 15 years, while the average maximum temperature rose by 1.01°C during the previous 100 years (Nandi, 2024). To tackle the problem of global warming and climate change, many countries declared and amended their Nationally Determined Contributions (NDCs) from COP21 (Paris - 2015) onwards. India has also joined the global bandwagon and announced its intent to achieve net zero by 2070 and reduce its economy's carbon intensity by 45% by 2030.

As India embarks on its journey of decarbonizing its economy, the transportation sector will play a crucial role in achieving these NDCs. The sector is responsible for almost 10% of total GHG emissions, with road transportation contributing to 88% of it. The fleet on Indian roads is largely run on fossil fuels, and the sector is India's third-largest energy consumer (Jain & Rankavat, 2023). The problem becomes particularly acute in Indian urban areas, which struggle with the problem of pollution. Indian cities are regularly featured on the list of the most polluted cities in the world. According to IQAir rankings for 2017–23 (World's Most Polluted Cities, n.d.), 21 Indian cities featured in the top 25 most polluted cities of the world. The corresponding figure for the top 50 was 41 for India. Vehicular emissions contribute to a third of PM pollution in Indian cities (Ceew, n.d.) and between 20-30% of the overall urban pollution (Executive Summary – Transitioning India's Road Transport Sector – Analysis - IEA, n.d.). The problem further compounds in winter, when vehicular emissions contribute to almost 50% of the total pollution (Bhatt, 2021). India's emissions reduction targets and urban pollution problem clearly call for decarbonizing road transport systems, particularly in urban areas. This article focuses on the different pathways towards decarbonizing urban mobility in India.

Electrification of Mass Transit → Expanding EV Charging → Promoting Non Motorized
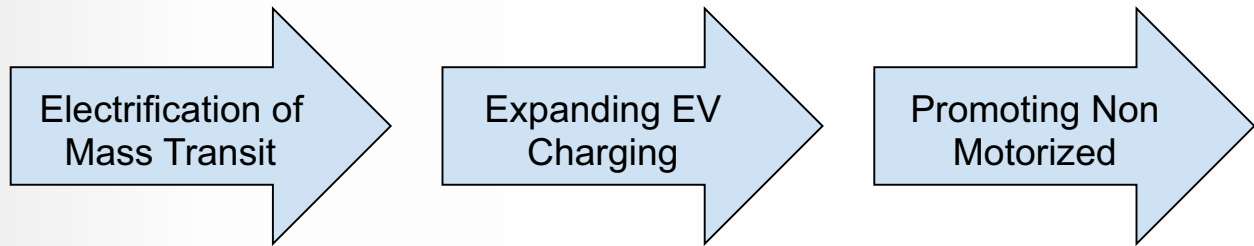
1. Expanding Green and Sustainable Mass Transit Systems in Urban Areas

India, with a humongous population and rapid urbanization, needs a strong public transport infrastructure to facilitate the mobility of its masses. Indian public transportation systems include metro systems, private and public-operated buses, and paratransit/intermediate public transportation modes like three-wheelers and e-rickshaws. Various studies have pointed to the inadequacy and accessibility of public transport systems in Indian cities. The MoHUA service level benchmark requires every city to have 60 buses per 1,00,000 people, while most Indian cities struggle to reach even 40 buses per 1,00,000 people (Dawda, 2024). A survey by Trummoc revealed that 85% of the respondents find public transportation systems inadequate (Banerjee, 2023). Policymakers have also recognized this need and provided a continuous thrust towards expanding public transportation in Indian cities over the past few decades. Schemes like Jawaharlal Nehru Urban Renewal Mission (JNNURM), Smart Cities, National Urban Transport Policy (NUTP), National Electric Mobility Mission Plan (NEMMP), and Atal Mission for Rejuvenation and Urban Transformation (AMRUT) were introduced over the last couple of decades to expand and modernize public transportation infrastructure. Today, the country has metro systems in 17 cities and Bus Rapid Transit Systems in 12 cities. However, with more than 65 million plus cities in India, there is a lot of ground to cover for establishing mass rapid transit systems in India.

This presents a golden opportunity for India to leapfrog in making urban mobility sustainable. With ample scope for expansion of public transport, India can introduce low carbon and net zero mass transit systems for Indian cities. There also exists a huge disparity in metro coverage in India, with Delhi representing almost 40% of India's total metro operational metro network. Significant investments are required in other metro cities to expand metro rail infrastructure. However, city planners can use this opportunity to develop multimodal terminals connecting mass transit systems like metro, buses and IPT to boost public transport ridership, which has faced a substantial decline post-COVID-19. Modernizing India's bus fleet is also long overdue. Cities need to grab this opportunity by incentivizing replacing old diesel buses with EV buses. However, city administrations would be required to prepare comprehensive plans for locating charging stations for buses and factor in associate time lags to maintain optimal service levels. Many Indian cities have already experimented with e-buses. For instance, the fleet of Ahmedabad BRTS consists of electric buses only. Delhi also operates the world's second-largest electric bus fleet. City administrations across India can learn from these cities and align their bus electrification accordingly. Further, governments across all levels should devise innovative schemes that incentivize the conversion of ICE buses to EV buses for private bus operators. The government can provide interest subvention schemes to private bus operators to offset high upfront costs. Further, incentives like toll exemptions, subsidized charging tariffs, tax credits and carbon savings points can help operators reduce their operational costs.

City authorities need to plug the prevailing gap in mass transit service levels by adopting clean and green systems since, sooner or later, the pressure to provide clean public transportation systems would build up.

2. Expanding EV Charging Infrastructure for Personal Vehicles

The rising middle class of our country is aspirational about vehicle ownership. As the Indian economy grows and more people migrate to urban areas, the increase in personal vehicle ownership is inevitable. The sprawling expanse of Indian cities also creates a demand for personal vehicles among city residents. The government has already introduced numerous schemes to promote EV manufacturing and adoption, like FAME I & II, Phased Manufacturing Programme, PLI in Advanced Cell Chemistry, National Mission on Transformative Mobility and Storage and Electric Mobility Promotion Scheme (EMPS). These schemes, along with state-level EV policies, are helping automobile manufacturers in bridging the acquisition cost between ICEVs and EVs.

However, a closer look at EV sales data reveals India's vehicle electrification is led by 2W and 3W categories. The ease of charging plays a big role in vehicle owners' purchase decisions. India is severely lagging in developing a public charging network for EVs. As revealed by a report by GIZ on EV Charging Infrastructure, India faces the double problem of inadequate charging stations and imbalance distribution of that infrastructure. A driving force behind the rapid electrification of 2W and 3W lies in the ease of charging such vehicles at home and their low-range use in daily commutes. However, it is important to induce customers to buy 4W EVs to make a tangible difference in emissions reduction. By creating an

expansive EV charging infrastructure, the government and automobile manufacturers can influence the purchasing decisions of car buyers and make EVs the preferred choice for 4Ws. However, for that, city authorities must conduct a comprehensive study to understand the charging behaviour of existing and potential EV users. Different types of charger sockets and charger types (would be required for 2W, 3W and 4W. Trends indicate that the battery prices would continue to fall with increasing energy density, meaning a higher battery storage capacity for EVs. This would require an optimal mix of slow and fast charging points to support on-the-way charging needs of customers. The scholarship also reveals that while node-based charge point locations are suitable for residential areas, tour-based charge points are suitable for highways (Metais et al., 2022).

While numerous schemes exist to promote EV adoption at the vehicle level, the government needs to bring policy and regulatory directions to aggressively expand EV charging networks. Regulatory changes that enable seamless battery swapping and on-street residential charging can attract significant private investment in charging infrastructure. The government can also learn from leaders in EV charging networks to expand the charging network in India. In Beijing, the Chinese government has mandated equipping 25% of parking slots with EV charging points. Denmark offers a 50% concession in electricity connection fees for publicly available charging stations. The government of the UK covers 75% of the capital for installing a charger point at the residential unit/home of an EV user. Similar incentives exist for on-street residential charging as well. The US federal government has identified corridors along 25,000 miles of major highways to develop EV charging points every 50 miles. Automobile manufacturers must invest in developing interoperable batteries and V2X systems that universalize battery charging.

Creating a robust charging network is essential to accelerate 4W EV adoption. Public-private partnership is essential in rapidly expanding charging infrastructure in India to make EV purchases a no-brainer for Indian 4W purchasers.

3. Promoting Non-Motorized Transportation

Another way of decarbonizing urban mobility is by eliminating emissions causing motorized vehicles from the mobility landscape. While this is practically not feasible, city authorities need to look at different ways of motivating daily commuters towards using non-motorized (NMT) commuting, including walking and cycling. The core of most Indian cities are mostly compact and highly dense. While such city design is usually considered ideal for NMT, many Indian cities are already witnessing a decline in the share of NMT as a share of daily trips. This decline is worrisome and needs multiple policy interventions to reverse it.

NMT in India suffers from numerous challenges (Kumar et al., 2015). Walking on Indian roads can be a challenge for most. Indian roads are poorly designed, with most lacking sidewalks, forcing pedestrians to walk on the roads. Roads with sidewalks are often poorly constructed, non-standard, discontinuous and encroached upon. Further, infrastructure for various utility services like electricity poles, signboards and gas milestones are erected on these footpaths by the government agencies. The infrastructure for biking lanes is also either negligible or dysfunctional in most Indian cities. This results in pedestrians and cyclists being disproportionate victims of road accidents. Another challenge lies in the uncomfortable climate of most Indian cities, making biking and cycling difficult.

The government and city authorities must proactively address these concerns of NMT commuters by incorporating NMT-friendly design changes into cityscapes. This would require following a complete street policy where the requirements of all stakeholders are considered. The creation of dedicated sidewalks and biking lanes across the city that are well-lit, continuous, accessible and free from encroachments is essential to promote NMT. To ensure commuter safety, authorities must introduce traffic calming measures like speed bumps, medians, raised sidewalks, bulbouts and roundabouts. In order to make NMT comfortable, city authorities must implement artificial and natural shading measures for NMT dedicated lanes. Authorities must provide bike racks at public transit stations to improve the adoption of cycling in city commutes. Financial incentives like discounted transit fares, free bike-sharing programs, and employer incentives for employees who commute by foot or bicycle can be designed to promote NMT for daily commutes. Further, commuters must have a dedicated helpdesk to report any damage to NMT infrastructure, which must be followed by prompt redressal.

There are many other pathways for decarbonizing urban mobility, like adopting biofuels, improving fuel efficiency, changes in city designs, transportation demand management, smart transportation technologies and carbon pricing. However, Inda must exploit several low-hanging fruits that are affordable, accessible and compatible with its current system to accelerate the decarbonization of urban mobility. This includes ensuring that the new public transport infrastructure is green and sustainable, creating a robust EV charging network to reduce ICEVs' share in 4Ws and promoting NMT as the ideal daily way of commuting. In order to achieve this, it is important to follow a calibrated approach that involves an assessment of the current state of urban mobility, identifying gaps, creating short-term, mid-term and long-term targets, and developing a continuous monitoring and evaluation system to track city-wide progress. By adopting a proactive and agile approach, India can successfully decarbonize its urban mobility and contribute towards achieving net zero.

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The article has been written by

Mr. Shubham
Research Associate, CTL IIMA

CTL Events- Research Webinars

1. MEL: Pioneering new avenues in Maritime Economics & Logistics research

The Centre for Transportation and Logistics, IIMA hosted a research webinar on '**MEL: Pioneering new avenues in Maritime Economics & Logistics research**' by **Dr. Hercules Haralambides**, Professor of Maritime Economics and Logistics (MEL), on January 11, 2024. The webinar was moderated by **Prof. Debjit Roy**.

Talk Summary

Prof. Haralambides started the webinar with a brief description of his pioneering work in maritime economics and logistics across Asia, Africa and Europe. He discussed topics of topical relevance in MEL like shipping alliances, port integration, port connectivity and centrality, sustainable port development, carrier expectations, port interface, shipping market structures and network among others.

Prof. Haralambides covered the entire gamut of MEL and categorized it into three broad categories of ports, shipping, and network and global logistics. In the ports category, he highlighted the significance of determining hinterlands for container ports in order to determine optimal port size. He argued for integration of closely located ports. He discussed the role of economic factors in shaping the evolution of port systems, using HongKong port as an example. His research showed the importance of port centrality, and not just connectivity in enhancing the attractiveness of hub port. He discussed how trade flows are important in determining port O-D pairs in to ensure sustainable port development. He also touched upon the opportunities and challenges in making seaports a hub for green hydrogen.

In shipping, Prof. Haralambides discussed the forces shaping global shipping alliances. He discussed adaptive and rational expectations in the context of container shipping for carriers. His research revealed that adaptive expectations guide investment decisions in the Atlantic ocean while rational expectations guide decisions for players operating in the Pacific ocean. He also discussed how ship scrapping subsidies by governments may help propel fleet renewal and emergence of the shipbuilding industry in a country. His research revealed that the major hindrances in introduction of Maritime Autonomous Surface Ships is caused by the port design, port interface and navigation rather than the nature of the ship itself. In the networks and global logistics category, Prof. Haralambides discussed his work surrounding port networks in Asia and Africa, port clusters, dual transactions in container terminals and shipping alliances.

Prof. Haralambides left the audience with exciting developments in maritime logistics and interesting research questions for students and scholars to explore and solve.

To watch the webinar, visit: https://youtu.be/vM5hN-5AXuU?feature=shared

2. Maritime Informatics for a High-Performing and Sustainable Transportation and Logistics Industry

The Centre for Transportation and Logistics, IIMA hosted a research webinar on '**Maritime Informatics for a High-Performing and Sustainable Transportation and Logistics Industry**' by **Dr. Mikael Lind**, Professor of Maritime Informatics, Chalmers University and Research Institutes of Sweden (RISE), on March 11, 2024. The webinar was moderated by **Prof. Debjit Roy**.

Talk Summary

Maritime sector carries 90% of the world's trade and emits 2.2% of global emissions. Emphasizing large-scale collaboration for large scale digitization for generation of economic and social value, Prof. Lind explained maritime informatics as the digitalization of sea transport rooted in information systems and relying on eclectic foundations. Maritime ecosystem is unique since it is the oldest and largest sharing economy which is self-organized in nature with no single keystone organization and distributed control. The sector is evolving from fragmented, low-quality information and sub optimized operation sector to one with standardized data exchange and high IT maturity. It encompasses digital innovation, digital collaborations, digital twinning, data driven decision making, smart ports, AI, smart ships, ecosystem innovation and capital productivity. Prof. Lind explained the three focus areas of maritime informatics, which are digital collaboration, digital data sharing and decision making and data analytics. He also advocated for a system-oriented perspective for maritime informatics, which involves systems of engagement, production, framing, record and inquiry, each of which bring attention to different concerns.

Maritime informatics can be applied in bringing information sharing communities together, fostering an appointment and collaborative economy and promoting standardization through smart and sustainable ports, smart ships, intelligent cargo to generate capital productivity gains. Prof. Lind also explained the application of maritime informatics in tackling key global challenges of enhancing predictability of maritime operations, managing supply chain risks and decarbonizing maritime transportation. Collaborative decision making can help enhance predictability of operations through standard data sharing, improved situational awareness and data driven decision making. Shipper driven terminal centric virtual watchtower (VWT) network aims to create a global community for enhanced visibility and supply chain risk management through private and public data driven analytics and collaboration. He emphasized on the need to look at digitalization and collaboration as a powerful duo that generate economic and social value, failing which the maritime ecosystem would get suboptimal results.

To watch the webinar, visit: https://www.youtube.com/watch?v=MLM98ODIsjE
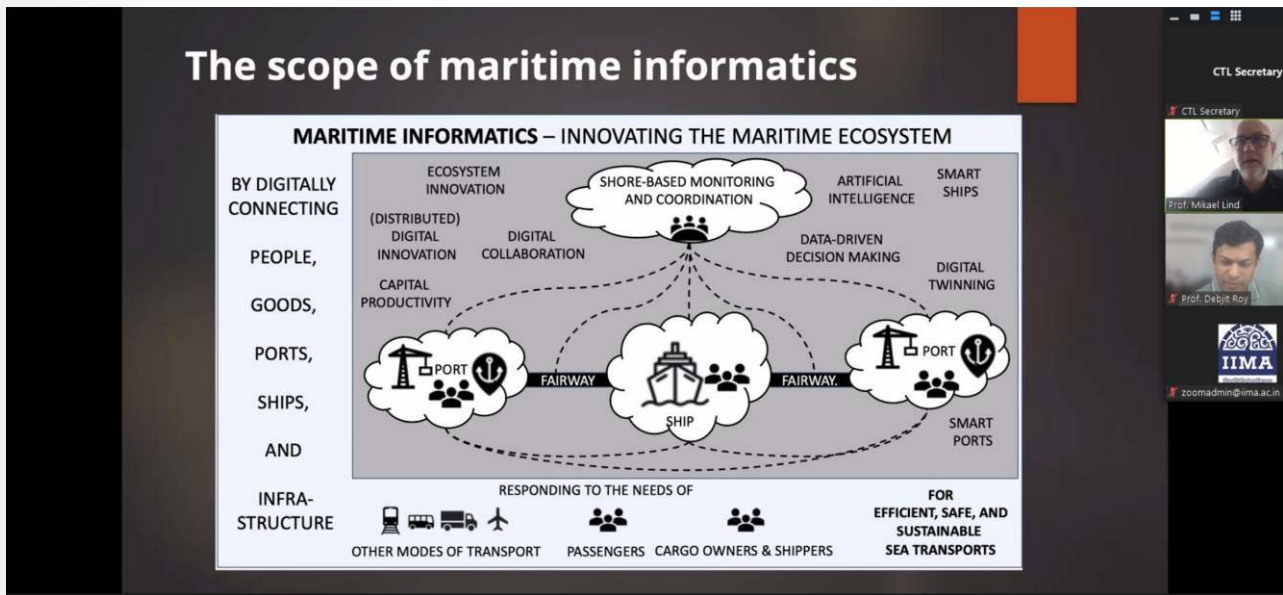
CTL Events-Panel Discussion

1. Online Panel Discussion on 'Digitizing Logistics Services'

The Centre for Transportation and Logistics, IIMA hosted an online panel discussion on '**Digitizing Logistics Services**', on March 26, 2024.

Panelists:

Mr. Tim T Edmunds
Partner,
Sustainable Value Chain
Strategy & Transformation
PwC

Mr. Manuj Bansal
Senior Director,
Supply Chain Network Design,
Flipkart

Moderated by: Dr. Debjit Roy
Discussion Theme: Freight transportation and logistics

What does it mean to have a connected supply chain?

1. Supply chain partners – such as suppliers, logistics service providers, customers and innovation partners – will all be integrated, effectively creating a transparent, connected ecosystem that can self-adjust or orchestrate as needed

2. Companies can gather more fluid data on consumer demand from a range of tech touchpoints and use this information to feed the supply chain - and use it to make decisions

3. Consumers will dictate what's happening in the supply chain on a near real-time basis - and supply chains will be able to react to this

4. Companies will have the ability to take "smart" decisions related to procurement, production, warehousing, logistics

Discussion Summary

The cost of logistics is a major concern for many low and middle income countries like India, China and Vietnam. Recent times have seen many disruptions in the supply chain, like, Covid-19 pandemic, Suez canal crisis and Russia-Ukraine war which has forced supply chain managers to look at ways to make supply chain resilient, one of which is digitization. The boom in e-commerce and rising customer expectations of same day zero cost delivery has put further pressure on businesses. In light of these circumstances, certain questions emerge like - How to digitize and who should initiate that? What should be the focus of such digitization?

Mr Tim Edmunds started the discussion with his views on connected supply chains. He underlined the key challenges faced by the industry which include high market volatility, regulatory pressure towards sustainable and socially responsible supply chains, challenging economic conditions and increasing customer expectations. Underlying the importance of improving visibility as the core goal of digitalization, he emphasized on a need to look at supply chains from linear to circular ecosystems where technology is implemented holistically to enable end-to-end connectivity. The four key components of a connected supply chain include integrated supply chain partners, data driven decision making, responsive to customer needs and ability to take smart decisions. He further explained how digital leaders are driving digital transformation in supply chains and presented a five step starting approach towards building a connected supply chain. He also showcased two cases where digitization helped achieve cost optimization.

Mr. Manuj Bansal started by explaining the difference between digitization, digitalization and digital transformation. Digital transformation aims to improve efficiency and effectiveness through data availability, elimination of subjectivity and data driven decision making. The three major barriers in digital transformation are organizational culture, resistance to change and legacy infrastructure. He further explained the process of digital transformation through the digital transformation journey at eKart which enabled significant savings.

The ensuing discussion yielded many important takeaways, some of which are-

1. The increased pressure on topline and bottomline along with increased customer expectations has forced businesses to optimize cost and digital transformation is an enabler of such optimization.

2. Logistics industry needs to understand the needs of other businesses and design their supply chains accordingly.

3. There is a clear two stage approach towards understanding the digitization needs. The first stage involves value stream mapping through internal consultations to identify the pain points in existing systems and processes. The second stage involves finding solutions to such pain points, which in some cases may not even need digitization.

4. Digital transformation makes sense for business uses for all players, irrespective of scale. Scale can drive the magnitude of digitization.

5. Digitizing the supply chain should start from a process, followed by people and then technologies.

6. Digitizing should be looked at as an enabler for humans, and not displacement. It helps improve the quality of work and add to the skills of the people.

7. Digitization should be done in a manner that creates value for all players of the supply chain to facilitate information sharing.

8. The biggest benefit of digitization lies in its potential in optimizing cost.

CTL Snippet

CTL Snippets E6: Understanding Indian food security program: design, interventions and innovations
Interaction with: Prof. Maya Ganesh, IIM Ahmedabad

Prof. Maya Ganesh
Assistant Professor of Operations and Decision Sciences
Indian Institute of Management Ahmedabad

Prof. Ganesh discusses her work on the Indian food security program. She talks about the design of the Indian public distribution system (PDS) and related inefficiencies. Prof. Ganesh answers some questions related to the introduction of Portability (agent choice), a demand side intervention, in the PDS. Her work studies the impact of this intervention using differences in differences approach on sub district level data from the states of Andhra Pradesh and Telangana. Further, the work looks at how absence of complementary supply side modifications to address demand variability can prevent the realisation of the intervention's full benefits. She advocates the use of micro level data and predictive analytics to improve demand management for food supply chains to reduce wastage and other inefficiencies. Similarly, availability of dynamic weather and traffic data can be used to make real time vehicle routing decisions. Use of IoT sensors that determine the freshness/shelf life of produce can also help retailers make dynamic pricing decisions.

To watch, visit: https://www.youtube.com/watch?v=gMBBiGgIDk8

1. A dynamic pricing strategy model for Indian Railways

Prof. Sundaravalli Narayanaswami, along with IIMA students Karthikeya Singh and Pushkaraj Dhake, authored a research paper titled **"A dynamic pricing strategy model for Indian Railways"**.

Abstract

The Indian Railways has adopted a dynamic pricing mechanism for its premium trains like Shatabdi, Rajdhani, and Duronto. This led to an increase in its revenue but also a fall in passenger traffic. In this paper, we have analyzed the existing dynamic pricing model. A major flaw in the existing system is that the present system is only a fare hike system rather than a dynamic pricing system as there is no provision for a decrease in prices when the demand is low. Considering this, we have developed a new model that incorporates both inter-temporal pricing and demand-based pricing to come up with the dynamic fares along with the provision of having a downside in case of low demand. We developed a route selection criteria based on the key parameters identified by us where dynamic pricing would yield good results. The model was then tested on these routes using real-time data to determine the feasibility of the dynamic pricing system.

To read the complete research paper, visit: https://doi.org/10.1057/s41272-023-00450-w

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A dynamic pricing strategy model for Indian Railways

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Kartikeya Singh, Pushkaraj Dhake & Sundaravalli Narayanaswami ✉

2. Integrated inventory replenishment and online demand allocation decisions for an omnichannel retailer with ship-from-store strategy

Prof. Debjit Roy and **Prof. Prahalad Venkateshan**, published a research paper along with Prof. Vishal Bansal and Prof. Arnab Bisi, titled **"Integrated inventory replenishment and online demand allocation decisions for an omnichannel retailer with ship-from-store strategy"**.

Abstract

Retailing has changed dramatically from single-channel brick-and-mortar stores to multi-channel and omnichannel retailers over the last few decades. Omnichannel retailers employ different strategies to integrate online and offline sales channels as well as order fulfillment processes. Among these strategies, the ship-from-store is the most popular and widely accepted among retailers. It enables retailers to use inventory from store locations to fulfill online demand. An omnichannel retailer with a distribution center and a retail store has to make important, interlinked decisions — (1) how much inventory to keep at the retail store, and (2) where to fulfill the online demand from and how much. In this work, we model the integrated inventory replenishment and online demand allocation decisions for an omnichannel retailer employing the ship-from-store strategy. We analyze this problem for both single-period and multi-period settings. We extend the analytical framework of the single-period problem by providing a finite-horizon Markov decision process (MDP) formulation for the multi-period problem. Our findings suggest that for a single-period setting, decentralized inventory replenishment and demand allocation system maximizes the profit of the omnichannel retailer for low values of the incentive for fulfilling the online demand through store inventory, while for sufficiently high values of the incentive, a pooled system provides the optimal profit. An increment in the discount factor has the same effect on the optimal decisions in a multi-period setting as that of salvage value in a single-period setting for a given value of the incentive for the ship-from-store strategy. We also provide several extensions (such as cross selling, endogenous and correlated demand streams) of our analytical framework for the multi-period problem.

Read here: https://doi.org/10.1016/j.ejor.2024.02.027

Innovative applications of O.R.

Integrated inventory replenishment and online demand allocation decisions for an omnichannel retailer with ship-from-store strategy

Vishal Bansal [a] 👤 ✉ , Arnab Bisi [b], Debjit Roy [c], Prahalad Venkateshan [c]

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3. The capacitated r-hub interdiction problem with congestion: Models and solution approaches

Prof. Sachin Jayaswal published a research article with Prof. Sneha Dhyani Bhatt & Prof. Ankur Sinha titled **"The capacitated r-hub interdiction problem with congestion: Models and solution approaches"**.

Abstract

We study the r-hub interdiction problem under the case of possible congestion. Hub interdiction problems are modeled as attacker-defender problems to identify a set of r critical hubs from a set of p hubs, which when attacked, causes maximum damage to network restoration activities of the defender. In this work we consider that in addition to the routing cost, the defender also aims to minimize the congestion cost. Incorporating the congestion cost in the problem introduces non-linearity in the objective function of the interdiction problem, which makes the problem challenging to solve. To address this, we propose two alternate exact solution approaches. The first approach is an inner-approximation-based approach (IBA), which overestimates the convex non-linear objective function and provides an upper bound. A lower bound is obtained from solving the lower-level problem exactly corresponding to the upper bound solution. The upper bound is tightened using improved approximation with new points generated in successive iterations. In the second approach (referred to as SBA), the problem is reformulated as a second-order conic program, which can be solved using an off-the-shelf solver. From our computational experiments on benchmark datasets (CAB and AP), we demonstrate the efficacy of both the proposed methods. However, IBA consistently outperforms SBA by a significant margin.

To read the complete research paper, visit: https://doi.org/10.1016/j.tre.2024.103482

The capacitated r-hub interdiction problem with congestion: Models and solution approaches

Sneha Dhyani Bhatt [a] , Ankur Sinha [b] , Sachin Jayaswal [b]

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4. Stochastic modeling of integrated order fulfillment processes with delivery time promise: Order picking, batching, and last-mile delivery

Prof. Debjit Roy published a research paper with Dr. Gyanesh Raj, Prof. René de Koster and Prof. Vishal Bansal, titled **"Stochastic modeling of integrated order fulfillment processes with delivery time promise: Order picking, batching, and last-mile delivery"**.

Abstract

To guarantee high customer service and short and accurate lead times, many e-commerce retailers have started to home deliver their customer orders within a few hours or even minutes, also known as quick-commerce order fulfillment. Quick-commerce order fulfillment consists of three main processes: order picking in the warehouse, order batching for delivery, and last-mile delivery. The ultimate delivery performance depends on managing all three processes, which are highly stochastic, and interdependent. We capture this stochasticity and interdependency in an integrated analytical framework and derive approximate analytical expressions for the mean and variance of the total order fulfillment time. We validate the analytical expressions with both in-house detailed process simulations and external-party output measures. We then analyze the delivery cost-service quality trade-offs using an optimization model that minimizes the expected order fulfillment cost with a delivery probability (DP) constraint, focusing on meeting delivery time deadlines. The optimization model determines the number of pickers, the optimal delivery batch size, and the number of vehicles required to deliver the customer orders. Achieving a high delivery reliability comes at a cost. In comparison to the model with DP constraints, we observe that the expected order fulfillment cost averaged over all data parameter settings obtained from the model without DP constraints is 8.9% lower; however, the mean and standard deviation of order fulfillment time increase by 44.1% and 18.6%, respectively, which results in low delivery reliability. We further demonstrate that an integrated analysis of the order fulfillment process is essential to set reliable fulfillment due times.

Read here: https://doi.org/10.1016/j.ejor.2024.03.003

Innovative Applications of O.R.

Stochastic modeling of integrated order fulfillment processes with delivery time promise: Order picking, batching, and last-mile delivery

G. Raj [a] ⌨ , D. Roy [b], R. de Koster [c], V. Bansal [d]

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5. Bilevel Optimization: Applications, Models and Solution Approaches

'Bilevel Optimization: Applications, Models and Solution Approaches', a research paper co-authored by **Prof. Sachin Jayaswal** and Prof. Ankur Sinha, has been featured in a book titled 'Optimization Essentials: Theory, Tools, and Applications', which is a part of the book series 'International Series in Operations Research & Management Science'.

Abstract

Bilevel optimization is a difficult class of optimization problems, which contain an inner optimization problem as a constraint to an outer optimization problem. Such optimization problems are commonly referred to as Stackelberg games in the area of game theory, where a hierarchical interaction between a leader and a follower is modeled. This chapter presents several examples of bilevel optimization problems arising in various contexts, e.g., the product line selection problem and the shortest path interdiction problem. Depending on the context of the problem, the leader and the follower may have the same objective function but with conflicting objectives (max-min in the shortest path interdiction), or may have different objective functions (as in the product line selection problem). Under this hierarchical setting, the leader tries to optimize its own decision by taking into account the rational response of the follower. A bilevel optimization problem is NP-hard even in the simplest case in which the problems of the leader and the follower are both simple linear programs. This chapter discusses classical solution approaches that are based on the reformulation of the bilevel problem into a single level. It also discusses several alternate single-level reformulations for the application problems considered in this chapter.

To know more, visit: https://link.springer.com/book/9789819954902

CTL Faculty Engagements

1. International Convention on 'Digital Transformation of Indian Railways: Track to Train & Operations to Maintenance' by IRSE

Prof. Sundaravalli Narayanaswami was a distinguished Guest of honor and keynote speaker at the International Convention organized by the IRSE on the subject of "Digital Transformation of Indian Railways: Track to Train & Operations to Maintenance" held at Manekshaw Convention Center, Dhaula Kuan from December 11-13, 2023.

Prof. Sundaravalli Narayanaswami alongside other esteemed guests of the International Convention by IRSE

2. Workshop on 'Modelling Resource Synchronization Delays'

An online workshop on 'Modelling Resource Synchronization Delays' led by **Prof. Debjit Roy** was organised by IIMA on January 05, 2024.

Key Highlights:
- The workshop focused on three key areas- Understanding of constructs for modelling resource synchronization, identifying application areas, and learning solution methods with potential research opportunities.
- The discussions further delved into the concept of Semi-open queuing networks (SOQNs) were introduced and several stochastic models for manufacturing, logistics, and service systems were discussed in depth.

Prof. Debjit Roy led an online workshop on 'Modelling Resource Synchronization Delays' at IIMA

3. Webinar on 'Emerging Technologies for Operational & Strategic Interventions in Supply Chain'

A webinar on "Emerging Technologies for Operational & Strategic Interventions in Supply Chain" was conducted by **Prof. Debjit Roy** on January 08, 2024, at IIM Kashipur.

Prof. Debjit Roy delivered a Research Webinar on 'Emerging Technologies for Operational & Strategic Interventions in Supply Chain' at IIM Kashipur

4. Autonomous Drone Logistics Systems to Automate Last-Mile Healthcare Supply Chains

Prof. Maya Ganesh along with Prof. Namrata Chindarkar (JSW School of Public Policy) have initiated a collaborative project with Redwing Labs, a company that designs and operates autonomous drone logistics systems to automate last-mile healthcare supply chains. Redwing recently established drone hubs in the Kandhamal and Rayagada districts of Odisha to support delivery of emergency medicines, vaccines, and diagnostic services. The objective of this project is to evaluate the impact of Redwing's intervention on various health indicators in these districts.

Abstract

Rural areas continue to face challenges in accessing good quality healthcare services. Many parts of rural India still lack timely access to medical services such as diagnostics and vaccines. The absence of efficient and agile supply-chains at the last mile poses a significant problem, resulting in the unavailability of essential medicines, increased out-of-pocket expenses for patients, and loss of lives. Drone-based autonomous systems have shown great promise and success in addressing last-mile delivery challenges in healthcare systems worldwide. Although drones hold the potential to overcome this challenge, there is a need for evidence to understand and quantify their impact. The Government of India has been actively encouraging public and private stakeholders to utilize drones to enhance healthcare access and equity. Considering that a substantial section of the rural population must travel more than 100 kilometers to access basic healthcare, drones offer immense potential in improving access to quality healthcare. An academic lens will enable policymakers to understand the cost-effectiveness, replicability, and scalability of this intervention.

5. Keynote on 'Customer Driven Warehouse Automation'

Prof. Debjit Roy delivered a keynote on the topic "Customer Driven Warehouse Automation" to the global leaders at FM Logistic.

6. CTL at Vibrant Gujarat Global Trade Show 2024 at Gandhinagar, Gujarat

The Centre for Transportation and Logistics, IIM Ahmedabad participated in the Vibrant Gujarat Global Trade Show 2024 as part of the IIMA booth, which was held in Gandhinagar from January 11 to 13, 2024. The Centre showcased its research projects, products, activities, and events to the audience which included thought leaders, industry experts, startup founders, research scholars and students among others.

The Centre was represented by team members **Mr. Subodh Patrikar** and **Mr. Shubham**. They held insightful discussions, exchanged ideas, and explored collaborative opportunities with stakeholders from various transportation & logistics sectors like e-mobility, warehousing and industrial real estate, industry 4.0, port logistics, last mile connectivity and autonomous vehicles among others.

CTL Team Members, alongside other representatives from IIMA, at the Vibrant Gujarat Global Trade Show 2024

7. Workshop on 'Freight Emission Index developed for the Walled City of Ahmedabad'

Prof. Debjit Roy was one of the esteemed panelists for the knowledge dissemination workshop on the "Freight Emission Index developed for the Walled City of Ahmedabad" that addressed challenges and opportunities in implementing emission reduction strategies. The workshop was held at the Ahmedabad Management Association on February 24, 2024. CTL Research Associate, Mr. Shubham, also participated in the workshop.

Key Highlights:
- Dr. Debjit Roy provided insights on the role of the market in optimizing the supply chain and promoting an aggregated freight movement through government mandates.
- Further, he also discussed capacity building of private freight operators as driver behaviour plays a key role in vehicle emissions.

Prof. Debjit Roy alongside other esteemed guests and attendees of the workshop

8. Research Talk at International Conference on Computations and Data Science, IIT Roorkee

Prof. Sachin Jayaswal was invited to deliver a research talk on 'Old polytopes, new valid inequalities for cutting-plane methods' at the International Conference on Computations and Data Science organised by the Indian Institute of Technology Roorkee on March 08, 2024.

Prof. Sachin Jayaswal presenting his research talk at the International Conference on Computations and Data Science held at IIT Roorkee

9. Conference Presentation at International Network Optimization Conference (INOC)

Prof. Sachin Jayaswal participated in the International Network Optimization Conference (INOC), presenting his work 'A cutting-plane-based method for solving fixed-charge transportation problems using new valid inequalities for single-node flow polytope'. The conference was held at University College Dublin, Ireland, from March 11-13, 2024

News Watch

1. MHI Scheme to Promote Manufacturing of Electric Passenger Cars In India

Image courtesy ~ Michael Marais on Unsplash

The Ministry Of Heavy Industries introduced 'Scheme to Promote Manufacturing of Electric Passenger Cars In India' on March 15, 2024 with the aim of advancing the EV manufacturing ecosystem in India by making India an attractive destination for foreign manufacturers of EVs. The scheme incentivises foreign manufacturers of e-4 wheelers to set up their manufacturing base in India by offering a steep import duty cut in the first five years for import of completely built units (CBU).

Find out more at: https://www.linkedin.com/feed/update/urn:li:activity:7178714901383712769/

The write-up was prepared by
Mr. Shubham
Research Associate, CTL IIMA

Centre for Transportation and Logistics

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