

Research Statement

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In recent years, the rise of digital platforms and the gig economy has reshaped labor markets, offering workers greater autonomy and flexibility over when and how long they work. This shift presents new challenges for service providers that rely on variable or uncertain labor supplies, such as ride-sharing and delivery services, to meet demand. Understanding the factors that drive workers' decisions to participate on these platforms—such as work characteristics, scheduling preferences, compensation structures, and behavioral tendencies—is crucial for capacity planning and efficient operations. As service providers adapt to this dynamic landscape, important questions arise about how these labor decisions and behaviors affect traditional operating models, their economic implications, and the development of optimal service strategies that are sustainable for both providers and workers.

In my dissertation, I investigate these critical issues within the context of the long-haul trucking industry, which shares key characteristics with gig work—even prior to the advent of the internet and digital platforms—due to its unstructured and fragmented market, as well as the autonomy drivers have in job selection. I employ a mix of empirical methods and analytical modeling to first identify the factors affecting supply reliability and then examine their implications for service system design. In my first paper, I analyze data from a large platform-based trucking company to identify the impact of job characteristics on subsequent worker activity. I then apply the tandem queues framework to study how such supply behavior impacts optimal network choices, staffing strategies, and cost implications for service providers. In my second project, I propose a data-driven, large-scale mixed-integer model to design an optimal relay network that is resilient to supply variability. Lastly, in the third study, I examine the satisficing vs. maximizing tendencies of gig workers through surveys and experiments, providing insights that can guide optimal staffing policies in workforce management with flexible workers.

In my first paper, titled **“Adapting to Gig Economy Dynamics: Network and Staffing Strategies for Long-Haul Trucking Platforms”** (co-authored with Milind Sohoni and Achal Bassamboo, Under Revision), I leverage three years of data from a large platform-based trucking company in India to explore the effects of trip characteristics on drivers' subsequent participation and reliability. Using panel data with two-way fixed effects models, we demonstrate that longer trip duty lengths increase the likelihood of driver no-shows in subsequent periods and reduce overall active hours on the platform. Traditional point-to-point (P2P) networks are known to result in longer trips for drivers, leading to extended periods away from home. In contrast, the relay network model allows

drivers to hand off shipments at relay points near their home base, offering more regular and shorter schedules. While this model has the potential to improve driver reliability, it introduces higher costs for service providers due to the fixed costs associated with establishing and operating a relay network. Our data insights reveal a trade-off between the P2P model’s lower operational costs and the relay network’s improved driver reliability. Since supply is sensitive to trip lengths, the P2P network tends to result in less reliable supply, which leads to higher staffing and congestion costs. We analyze a stylized single-dimension tandem queue network under flexible worker conditions to model the flow of trucks. In this scenario, where supply behavior depends on the trip characteristics offered, we identify a threshold on cost parameters: above this threshold, the relay network becomes optimal, while below it, the P2P network is more cost-effective, challenging the perception that relay networks are always more expensive. Moreover, when demand rates are uncertain, shifting from a traditional fixed staffing policy to a dynamic staffing policy not only improves cost efficiency but also makes the relay network more cost-optimal than the P2P network, creating a win-win situation for both drivers and service providers. These findings highlight that while the gig economy introduces challenges in labor supply prediction and operational planning, it also opens up opportunities for operational flexibility. Service providers currently operating with fixed staffing mechanisms can adapt to this evolving landscape, leading to sustainable operations for both providers and workers.

In the second paper, **“A Modified Benders Decomposition Algorithm for Relay Network Design Problem Resilient to Supply Shocks”** (co-authored with Milind Sohoni and Achal Bassamboo, Draft under preparation), we investigate the design of relay networks that are resilient to variability in driver supply. We propose a single-stage chance-constrained stochastic programming formulation to determine the optimal location of relay points for any road network. Using Google Maps APIs to simulate the road network in India, we identify optimal relay locations. We formulate deterministic equivalents of the problem for homogeneous supply distributions, including binomial, normal, and uniform distributions. The model optimizes relay point locations, routing, and the assignment of non-relay points to relay locations. To efficiently solve large instances, we propose a modified Benders decomposition algorithm enhanced with predetermined connectivity cuts. Through computational experiments using real-world data from a trucking platform, we demonstrate the effectiveness of this algorithm compared to a static expected value approach. Additionally, we show that relay networks are more resilient to supply uncertainty than point-to-point models by leveraging capacity from adjacent nodes in labor shock simulations. These findings contribute to the design of robust transportation networks in environments with variable labor supply, offering valuable insights for logistics planning and operations.

In my third project, which is a work in progress, we explore worker choices regarding scheduling preferences, flexibility, and compensation policies, specifically in the context of the Indian trucking industry. From preliminary interviews, we observed that drivers tend to prefer daily trips over week-long or month-long journeys, even if it means potential wage reductions. This reveals a tension between personal preferences and compensation, a challenge central to many gig economy jobs. Understanding such phenomenon is crucial to efficiently design incentive structures. We examine these trade-offs using a combination of survey studies, qualitative interviews, discrete choice experiments, and experiments involving random assignment of trip types. By understanding the complex trade-offs between flexibility, work-life balance, and compensation, this research seeks to inform policy and management practices in the evolving landscape of workforce management with flexible workers.

Future Plans

Looking ahead, I aim to continue pursuing data-driven research that explores the dynamic landscape of service systems and evolving work cultures. My passion for uncovering narratives from data, cultivated through both my professional and academic experiences, will continue to guide my work at the intersection of empirical and analytical modeling. By leveraging this interdisciplinary approach, I aim to develop and evaluate innovative operational strategies that address the challenges of rapidly changing work environments. Collaborating with the tech industry will be central to my efforts, enabling me to dig deeper into the factors that influence worker choices, productivity, and behavior. This will also allow me to test theoretical models in real-world settings and assess their impact in practice. I've had the privilege of engaging in dynamic discussions with my peers from IIT Bombay, bringing invaluable real-world perspectives to my academic pursuits. I look forward to partnering with my esteemed alumni network, who now hold significant positions across various industries and entrepreneurial ventures. These collaborations will provide a multi-faceted perspective, enriching my research with insights from diverse sectors and ensuring its broader relevance.