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Examining Transit Service Improvements with Internet-of-Things (IoT): A Disparity Analysis

Project 2330
June 2024

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Introduction

The literature highlights that unreliable transit services lead to uncertain waiting times and reduced popularity, with poor infrastructure and lack of timely information exacerbating the issue. Low-income commuters, heavily reliant on public transit, are most affected by these shortcomings. In Southern California, LA Metro's light rail lines serve primarily low-income populations but face declining ridership due to these service reliability issues. The introduction of Internet-of-Things (IoT) technology promises to enhance service reliability by providing accurate, real-time information on arrivals and departures, potentially improving ridership. IoT enables interconnected transportation systems, improving service reliability, connectivity, and accessibility, crucial for attracting ridership and addressing equity goals. However, the effectiveness of IoT in reducing service inequality remains a challenge, necessitating further research to develop new measures for connectivity and accessibility that consider IoT's impact. This research aims to assess IoT's potential to improve equity in public transit, using LA Metro as a case study and proposing a methodology that incorporates socioeconomic data and station-level analysis to guide policy and investment decisions.

Study Methods

This study introduces a novel approach to evaluate rail system performance by integrating conventional connectivity and accessibility metrics into an inequality framework. Utilizing centrality for connectivity and a new formula for accessibility, both metrics are adapted to be time-sensitive, reflecting the impact of train schedules on station connectivity and accessibility. The connectivity measure is based on the degree centrality of a station within the network, indicating its importance based on the number of direct connections to neighboring stations. Accessibility is quantified by considering the low-income population around stations and the impedance to travel between stations, adjusted for scenarios with and without Internet of Things (IoT) deployment. A generalized index combines both metrics, allowing for a comprehensive assessment of a station's connectivity and accessibility. Inequality among transit lines is measured using a modified Theil T index, incorporating the generalized connectivity-accessibility index to identify disparities. Performance persistence analysis (PPA) is employed to classify rail lines as winners or losers based on changes in inequality with and without IoT, guiding investment decisions towards achieving regional and social equity in public transport. This methodology offers a unique perspective on evaluating and improving public transit systems by addressing connectivity, accessibility, and inequality.

Findings

The findings reveal that IoT enhances accessibility across all lines, with significant improvements noted in certain years, such as LA Metro Rail Line A's accessibility jumping three times from the 'without' to 'with' IoT scenarios for the same year 2015. However, the impact on reducing service inequality is mixed. For instance, Rail Line B's accessibility fluctuates, and Rail Line C's inequality persists despite IoT enhancements, suggesting that technological integration does not uniformly translate to equitable service improvements. The analysis, underpinned by data on schedule/travel times, low-income employment, and GIS data, indicates that while IoT could boost service performance, its effectiveness in addressing inequality varies. This variability points to the need for a planned approach to technology deployment in public transit, considering factors such as infrastructure state and integration effectiveness. The study underscores IoT's potential in improving public transit accessibility but highlights the complexities in achieving consistent service equity improvements.

Policy Recommendations

The findings underscore the potential of IoT technologies to improve public transit by making it more accessible and efficient. Yet, the uneven benefits observed across different rail lines highlight the complexities involved in technology deployment in public infrastructure. The persistence of inequality in service levels, even with IoT adoption, calls for a planned approach to implementing technological solutions. The disparity in the impact of IoT suggests that technology alone may not suffice to address systemic issues within public transit systems. Factors such as infrastructure readiness, socioeconomic conditions of the transit system's users, and the strategic integration of technology must be considered to achieve more equitable outcomes. Further research should explore the conditions under which IoT technologies can most effectively contribute to reducing service inequality. Longitudinal studies could provide deeper insights into the sustainability of improvements in accessibility and service quality over time. Comparative studies across different transit systems could highlight best practices for IoT integration in public transit. Understanding the role of infrastructure, user engagement, and policy frameworks in mediating the benefits of technology could guide more effective implementations. There is a need for developing inclusive strategies that consider the diverse needs of all transit users, particularly marginalized communities, to ensure equitable access to improved services. This involves not only technological upgrades but also infrastructural improvements, policy interventions, and community engagement efforts to address broader issues of inequality in urban mobility.

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To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2330

MTI is a University Transportation Center sponsored by the U.S. Department of Transportation's Office of the Assistant Secretary for Research and Technology and by Caltrans. The Institute is located within San José State University's Lucas Graduate School of Business.