Joint Transportation Research Program

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Forecasting Shifts in Hoosiers' Travel Demand and Behavior

Introduction

The main goal of this project was to develop long-term future forecasts of transportation demand conditions for people and freight—both conventional and micro-freight (e.g., individual meal or small package delivery). To achieve this goal, this project focused on three objectives. The first objective was forecasting travel demand to determine which locations in Indiana will experience long-term increases in traffic flows. This was achieved using high-resolution, individual trip-level data derived from the GPS geolocation data of mobile phones. The use of GPS data provided some key advantages over travel surveys, including scalability and temporal variance (longitudinal data), which are important factors in trip generation modeling. The primary outcome of this objective was the generation of origin-destination matrices representing travel patterns for a typical weekday and weekend in three future years—2025, 2035, and 2045.

The second objective involved forecasting and quantifying the travel demand impact of e-commerce on Indiana residents by considering different future adoption scenarios. Using Indianapolis as a case study region, we first conducted a market segmentation analysis for Hoosier's heterogenous shopping behaviors (e.g., frequency) based on the 2017 National Household Travel Survey (NHTS) data and consumer panel data. Subsequently, travel demand changes resulting from e-commerce service (i.e., substitute in-store shopping trips) were integrated into a travel demand simulation model to estimate the net vehicle miles traveled (VMT) impacts. The model accounted for personal travel flow, mode choice, and goods delivery. Different scenarios representing the forward trend of e-commerce service were also analyzed to forecast future travel demand impacts.

The third objective focused on forecasting the growth in freight and passenger traffic at the county level, incorporating macroeconomic and demographic data, such as Gross Domestic Product (GDP) and population, using a scenario-based approach. A regression analysis was employed, using data obtained from several government sources. Additionally, an optimization model was developed to identify the road infrastructure upgrades needed to support the projected growth in traffic while enhancing connectivity and commute. The optimization model used *opensolver* engine, which allowed users to change the input variables and make the model more dynamic.

Findings

This study forecasts a nearly constant overall trip count growth rate over the coming decades, but with spatial variations in this growth pattern. Urban areas, particularly the Indianapolis Metropolitan Statistical Area (MSA) outside of Marion County, are predicted to experience the highest growth. Furthermore, most of the trip flow growth is expected to originate from major urban centers across the state.

The analysis of e-commerce patterns in Indianapolis

revealed that different shopper categories correlate with household size, internet access, and education level. Promoting the adoption of e-commerce is expected to yield benefits to the transportation system by reducing personal travel demand, as well as encouraging Hoosiers to choose more sustainable travel modes. Additionally, centralizing delivery services can improve system efficiency by enabling route optimization.

The freight and passenger traffic forecasts at the county level are influenced by county population and industry GDP, and Freight Analysis Framework (FAF) domestic regions, respectively, as revealed through regression analysis. The study identified five industries—manufacturing, construction, retail trade, wholesale trade, and transportation and warehousing—which contribute significantly to freight traffic based on the North American Industry Classification System (NAICS) codes. Specific counties were identified for these five industries using industry attractiveness criteria, such as current industry giants, workforce availability, industry growth potential, and highway proximity. Optimization models were developed for these counties to determine the bottlenecks in road infrastructure that could arise from future traffic growth led by economic activities.

Implementation

This study leveraged a diverse set of data sets and modeling techniques. The overall origin-destination matrices were developed using multiple linear regression-based trip generation and gravity-based trip distribution models. These models were trained on trips extracted from mobile phone geolocation data.

The development of an e-commerce for urban transportation sustainability emphasizes transitioning from in-store to online shopping. Key strategies include building accessible and affordable digital infrastructure to reach traditional shoppers and prioritizing cyber security. The reduction of private car use and the development of green delivery services, including the use of low-emission vehicles, can minimize traffic congestion and emissions. Insights from an agent-based travel demand simulation model can guide infrastructure investment and long-range transportation planning. This approach aims to reduce urban traffic burdens and enhance environmental sustainability through digital innovation and shared green delivery systems.

Based on the regression analysis, freight, and passenger traffic forecasts for up to 2050 across various Shared Socioeconomic Pathway (SSP) scenarios provide key information for INDOT's capacity planning. Identifying counties that are attractive for specific industries enables INDOT to plan for the growth of those industries in said counties and further allows road infrastructure projects to align with the expected growth in industry and the associated freight and passenger traffic. The optimization model uses the traffic forecasts and the industry-attractive counties to determine whether existing capacity is enough to support future growth.

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