

# Innovative Approach to Estimating Demand for Intercity Bus Services in a Rural Environment: Executive Summary

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## Abstract

The general objective of this research was to develop an intercity mode choice model that could be incorporated into a statewide travel demand model to estimate demand for rural intercity bus services. Four intercity transportation modes were considered in the study: automobile, bus, rail, and air. A stated preference survey was conducted of individuals across the state of North Dakota, and a mixed logit model was developed to estimate a mode choice model. Results showed the significant impacts of individual, trip, and mode characteristics on choice of mode. Gender, age, income, disability, trip purpose, party size, travel time, travel cost, and access distance were all found to have significant impacts on mode choice, and traveler attitudes were also found to be important. Alternative scenarios were analyzed to show how mode shares would change under different conditions or service characteristics.

## Introduction

Existing models for estimating demand for rural intercity bus services have their limitations. Many models are route-level, corridor-level, or city-pair models. While these models can be useful, they ignore the effects of existing within a larger network, and they rely on aggregate data. Using disaggregate data, or data at the level of the individual or household, are more useful in developing travel demand models.

Ideally, demand for intercity bus services could be estimated within a statewide travel demand model with a mode choice component. Such a model would benefit from the use of disaggregate data, while also accounting for competition between modes. Mode choice models predict the likelihood of an individual choosing a given mode for a given trip based on individual, mode, and trip characteristics. These models are used to estimate mode splits and can be used to predict mode volumes when used with known or estimated total trip volume. Intercity mode choice models have been developed, but there are many variables that could influence mode choice which are often not included in these models.



*Intercity bus stop in Fargo, ND*

The general objective of this research was to develop an intercity mode choice model that could be incorporated into a statewide travel demand model to estimate demand for rural intercity bus services. Four intercity transportation modes were considered in the study: automobile, bus, rail, and air. Specific objectives were to: estimate the impacts of mode, trip, and individual characteristics on mode choice; estimate the impacts of attitudes on mode choice; examine changes in attitudes regarding intercity travel; and conduct scenario analyses to demonstrate how the model could be used to estimate the possible impacts of service changes or changes in other variables.

The model was applied to the state of North Dakota. To obtain the data needed for the mode choice model, a stated preference survey was conducted of individuals across the state. Then, a mixed logit model was used to estimate the mode share model.

## Survey

The survey included four sections: a general demographic information section, a section on transportation experience, a stated preference section, and a section on travel attitudes. The stated preference section of the survey presented a series of hypothetical trips to survey participants. Respondents were asked to identify which mode of transportation they would choose for each trip, given varying levels of price, travel time, access distance, egress distance, and frequency of service for each mode, while also considering trip distance, trip purpose, and whether they were traveling alone or in a group.

The target population for the survey was adults aged 18 or older living in North Dakota. Surveys were distributed to a random sample of 5,000 residents. Half of these residents

received a paper survey in the mail, and the other half received a postcard by mail with a web address for where they could complete the survey online. A total of 541 responses were received. The paper survey had a 17% response rate, while the online-only survey had a 6% response rate, yielding an overall response rate of 11%.

With each survey respondent given nine different stated preference questions to answer, there were a total of 4,724 stated preference responses received. The automobile was the mode of choice in 73% of these responses, while air, rail, and bus accounted for 13%, 10%, and 4% of responses, respectively. The raw data showed differences in mode shares based on gender, age, income, trip distance, trip purpose, party size, travel costs, travel speeds, and access distances, as shown in Table 1.

## Mode Choice Model

A mixed logit model was developed to estimate the impacts of individual, trip, and mode characteristics on choice of mode. Table 2 provides a summary of these impacts. The full report details the magnitude of the effects.

Among the individual characteristics, gender, age, income, and disability were all found to have some effect on mode choice. Men were found to have greater odds of choosing automobile or bus travel. Older adults aged 70 or older were found to be less likely to choose air travel, and younger adults, aged 18-24, were found to be more likely to choose bus travel. As income increased, individuals were more likely to choose automobile and air travel. The impact of having a disability on mode choice was also found to be statistically significant and large in magnitude. People with a disability were much less likely to choose automobile or air travel and, therefore, more likely to choose bus and rail travel, compared to those without a disability.

The results showed that party size and trip purpose have some significant effects on mode choice. Individuals traveling alone were found to be less likely to choose automobile travel, and those traveling for business purposes were more likely to choose air and less likely to choose automobile. Travel time and travel price (consisting of fares and price of gasoline) were found to have negative and statistically significant impacts on mode choice, as did access distances for bus, rail, and air travel. The impacts of egress distance and service frequency, however, were not

**Table 1. Mode Choice Data from the Stated Preference Survey**

Characteristic	Auto (%)	Air (%)	Bus (%)	Rail (%)
Gender				
Male	75	12	4	8
Female	70	14	4	12
Age				
< 25	71	13	6	10
25 - 49	70	16	4	10
50 - 69	77	11	4	9
70+	76	7	6	11
Household income				
<\$25,000	69	11	6	14
\$25,000 - \$49,999	67	14	6	12
\$50,000 - \$74,999	78	10	4	8
\$75,000 - \$99,999	74	14	3	9
\$100,000+	74	14	3	9
Trip distance				
50 miles	89	1	4	6
100 miles	85	2	4	8
250 miles	71	12	4	12
400 miles	45	37	5	14
Trip purpose				
Personal	77	11	3	9
Business	69	15	5	11
Party size				
Alone	71	13	5	11
Group	75	13	3	8

**Table 2. Summary of Estimated Impacts from Mode Choice Model**

Factor	Impact on Mode Choice
<i>Individual characteristics</i>	
Gender	Men are more likely to choose the automobile or bus, compared to women.
Age	Young adults aged 18-24 are more likely than others to choose the bus. Older adults aged 70 or older are less likely than others to choose air travel.
Income	As income decreases, individuals are more likely to choose the bus or train.
Disability	People with a disability are less likely to choose the automobile or air travel and more likely to choose bus or rail.
<i>Trip characteristics</i>	
Party size	People are more likely to choose air, bus, or rail if they are traveling alone rather than in a group. Conversely, they are more likely to choose the automobile if they are traveling in a group.
Trip purpose	If someone is traveling for business purposes, he or she is more likely to choose air and less likely to choose the automobile, compared to traveling for personal reasons.
<i>Mode characteristics</i>	
Travel time	As travel time for a mode increases, individuals are less likely to choose that mode.
Cost	As travel cost for a mode increases, individuals are less likely to choose that mode.
Access distance	If individuals need to travel longer distances to access an intercity bus station, rail station, or airport, they are less likely to use that mode of travel.
Frequency	The frequency of service for intercity bus, rail, and air service was not found to have a significant impact on mode choice.
General preference	Everything else equal, individuals were most likely to choose automobile travel and least likely to choose intercity bus.

found to be statistically significant. Finally, all other variables equal, respondents were significantly more likely to choose automobile travel (in comparison to all other modes) and air travel (in comparison to bus and rail), and they were least likely to choose bus.

### Traveler Attitudes

Comparing responses to the survey's attitudinal questions to those from a similar survey conducted in 2009 showed

little change in traveler attitudes. Survey responses showed a demand for predictability, comfort, and cleanliness. Modeling the impacts of traveler attitudes on mode choice revealed that attitudes play a role (see Table 3). For example, individuals more likely to choose bus than the automobile included those who do not mind traveling with strangers, those more concerned about getting into an accident, those more concerned about having a stress-free trip than reaching their destination quickly, those more sensitive to cost, and those who feel that people who use intercity bus are like them. On the other hand, people who value a more predictable travel time or who place a higher value on cleanliness were more likely to choose the automobile.

### Implications

The study demonstrated how the model could be used to estimate mode shares between origin-destination pairs after calculating in-vehicle travel times for each mode and access distances to intercity bus and rail stations. When combined with travel volume estimates from a statewide travel demand model, this model would provide estimates for travel volume by intercity bus or rail.

The model could be used to estimate changes in mode shares and travel volume by each mode under different scenarios, including changes in service characteristics, demographic characteristics, or costs of competing modes. The model could be used to estimate demand for a new route, and the feasibility of the route could be analyzed by comparing the estimated ridership and fare revenue with the expected costs, allowing for a cost-benefit analysis.

Similarly, the model could be used to estimate the impact of adding a new stop along an existing route. The new stop would provide access to more potential users, but it would also increase travel time along the route. On the other hand, a low-usage stop could be removed to decrease travel time along a route. This model could be used to evaluate the tradeoff between providing access to more potential users or decreasing travel time. Two of the scenarios analyzed in this study evaluated such a tradeoff.

The model also takes into account how individual routes fit into a larger network. Ridership on an individual route can affect or be affected by ridership on another route. The model would be able to determine the overall net effect on

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ridership from the addition of the route, and its feasibility could be assessed. Policy makers would be able to use the tool to determine if the additional ridership could justify public investment.

In addition to changes in service characteristics, the model could be used to analyze impacts of demographic changes or changes in the characteristics of competing modes.

Notably, the price of gasoline can have a significant impact on the demand for intercity bus service. One of the scenarios in this study analyzed the impact of higher gasoline prices. Bus mode shares roughly doubled when the price of gasoline increased from \$2.00 per gallon to \$5.00 per gallon, although this scenario did not consider a corresponding increase in bus fares.

With an aging population in North Dakota and across the county, consideration of demographics is important. The results showed that adults aged 70 or older are much less likely to travel by air, and given that driving rates tend to decrease for older adults, demand for intercity bus could increase as the elderly population continues to increase. The results did not specifically show that older adults are more likely to choose intercity bus, compared to those who are younger, but it did show that people with disabilities are much more likely to choose bus or rail. Given that disability rates increase significantly with age, an aging population

**Table 3. Analysis of Attitudes and Mode Choice**

Statement	Mode Choice
Would rather do something else with the time I spend traveling	Less likely to choose automobile
Prefer predictable travel time	More likely to choose automobile
Want to know the cause and length of delay	Less likely to choose air
Would change form of travel if it would save some time	More likely to choose air
Don't mind traveling with strangers	More likely to choose bus or rail
Worry about getting into an accident	Less likely to choose automobile
Stress-free trip is more important than getting there quickly	More likely to choose bus and less likely to choose air
Clean vehicle is important	More likely to choose automobile
Use the most convenient form of travel regardless of cost	More likely to choose auto or air, less likely to choose bus or rail
People who ride a given mode are like me	More likely to use that given mode

would lead to increased demand for intercity bus or rail services.

The analysis of attitudes and mode choice provides some insight into how intercity bus services are perceived by the public and how they could be marketed. Bus services tend to be perceived as less stressful than automobile or air services and safer than the automobile. Intercity bus companies could market their services to those more concerned about having a safe and stress-free trip, those who want to make a more productive use of their time when traveling, or those who like to visit with others when traveling. Results also suggest intercity bus service is perceived as less predictable and less clean than traveling by automobile, whether warranted or not, and that individuals would be more likely to travel by bus if they were made to feel like they are similar to other bus users.