Estimating Demand for Intercity Bus Services in a Rural Environment

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Problem Statement

- Need for creating a model to estimate demand for intercity bus service

- Existing models have limitations

  – Route/corridor-level models

  – Mode choice models

  – Statewide travel demand models

Method

- Mode choice model
  - Stated preference survey
  - Mixed logit model
- Incorporated into a statewide travel demand model
- Contribution: Improve upon previous mode choice models and include it in statewide model
- Applications
  - Estimate demand throughout the state
  - Estimate ridership on proposed services
  - Estimate impact of potential service changes, changes in fares or travel time, gasoline prices, etc.

North Dakota Intercity Transportation Survey

Demographic characteristics

General transportation questions

Stated preference survey

Attitudinal questions

Survey Response Rate

	Paper + Online	Online Only	Total
Sample	2,274	2,489	4,763
Responses*	393	148	541
Response Rate	17.3%	5.9%	11.4%

*For the paper+online survey, 341 paper surveys were completed, and 52 were received online

Stated Preference Survey: Mode Alternatives

Air

Automobile

Bus

Train

Attributes

Generic trip attributes

- Trip distance (50 miles, 100 miles, 250 miles, 400 miles)
- Trip type (business or personal)
- Party type (alone or in a group)

Mode-specific attributes

- Price
- Travel time
- Access distance
- Egress distance
- Service frequency

Stated Preference Survey Question

Trip description				
Distance: 100 miles		Type of trip: Business	Traveling with: Alone	
WHICH OPTION WOULD YOU CHOOSE?				
Mode	Automobile	Air	Bus	Train
Price	$3.50 per gallon	$450	$20/person	$15/person
Frequency	-	3 times per week	Once per day	Twice per day
Distance from home to bus/rail station or airport	-	20 miles	2 miles	2 miles
Travel time	1 hour 32 minutes	3 hours	1 hour 33 minutes	2 hours 13 minutes
Distance from bus/rail station or airport to final destination	-	10 miles	10 miles	5 miles
	☐	☐	☐	☐

Attitudinal Questions

- 27 statements about travel with a 1-10 agree-disagree scale

- Focuses on attitudes regarding
  - Environment, time, flexibility, safety, stress, comfort, reliability, privacy, convenience

- Derived from Outwater et al. (2004) and used previously by Mattson et al. (2010)

- Uses
  - Identify what is important to travelers
  - Identify trends or changes in attitudes
  - Estimate impacts of attitudes on mode choice

Response to Opinion Questions

Average Score	Statement
8.4	If my travel options are delayed, I want to know the cause and length of the delay.
8.1	When traveling, I like to keep as close as possible to my departure and arrival schedules.
8.0	It is important to have comfortable seats when I travel.
8.0	I prefer a travel option that has a predictable travel time.
7.8	A clean vehicle is important to me.
7.0	I would like to make productive use of my time when traveling.
6.8	I would change my form of travel if it would save me some time.
6.8	Having a stress-free trip is more important than reaching my destination quickly.
6.2	I would rather do something else with the time that I spend traveling.
5.9	Having privacy is important to me when I travel.
5.7	It's important to be able to change my travel plans at a moment's notice.
5.6	I need to make trips according to a fixed schedule.
5.6	I avoid traveling at certain times because it is too stressful.
5.6	The people who fly are like me.

Response to Opinion Questions

Average Score	Statement
5.5	I prefer to make trips alone, because I like the time to myself.
5.5	When traveling, I like to talk and visit with other people.
5.4	I'm willing to pay more for a ticket if it allows me to re-book my trip later for free.
5.0	I use the most convenient form of transportation regardless of cost.
5.0	I always take the fastest route to my destination even if I have a cheaper alternative.
4.7	I don't mind traveling with strangers.
4.5	The people who use intercity rail service are like me.
4.5	I would switch to a different form of transportation if it would help the environment.
4.4	I worry about getting in an accident when I travel.
4.4	I don't mind long delays as long as I'm comfortable.
4.1	The people who ride intercity bus are like me.
4.1	I would be willing to pay more when I travel if it would help the environment.
2.7	People who travel alone should pay more to help improve the environment.

Stated Preference Response

- 4,724 responses received from 541 respondents

- Mode choice responses:

Mode	Percentage
Automobile	73%
Air	13%
Rail	10%
Bus	4%
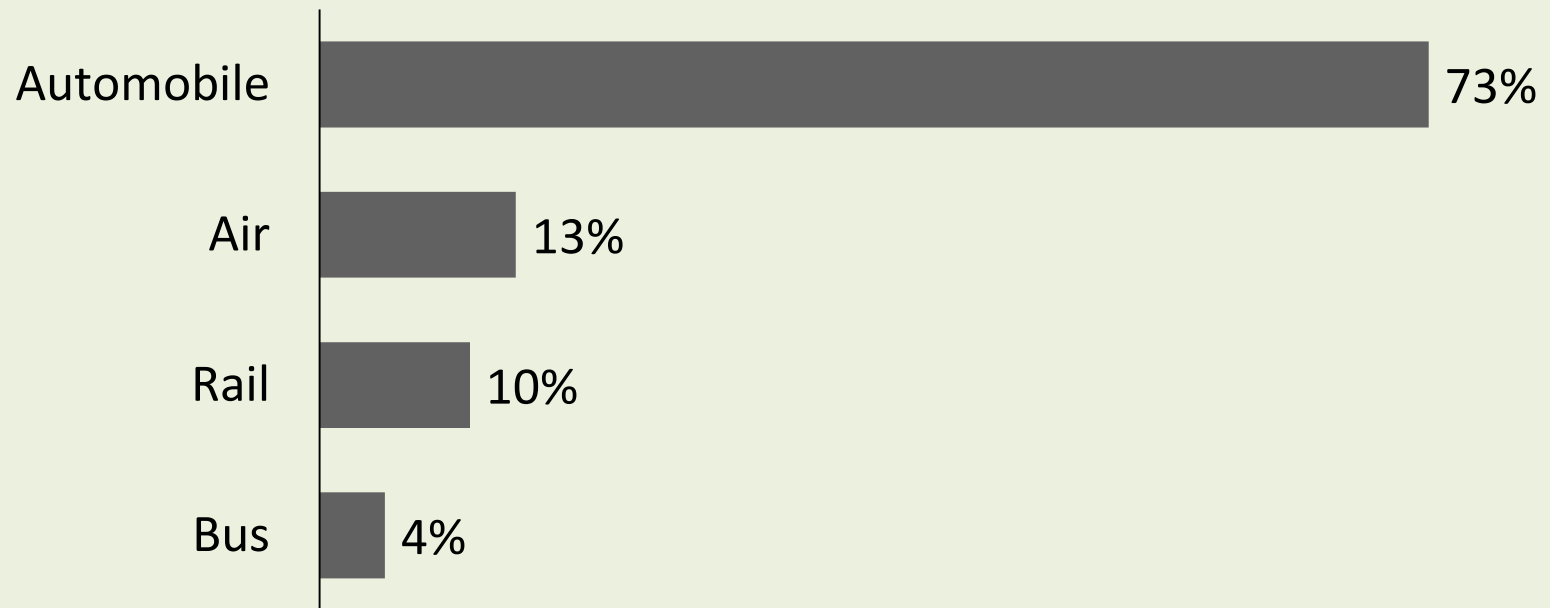
Mode Choice by Individual Characteristics

	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

Mode Choice by Trip Characteristics

	Auto	Air	Bus	Rail
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

Mode Choice by Mode Characteristics

	Auto	Air	Bus	Rail
Price of gasoline				
$2.00/gallon	79	12	3	6
$3.50/gallon	75	14	3	8
$5.00/gallon	65	14	6	15
Own-price				
Low	79	16	5	13
Medium	75	13	5	9
High	65	10	3	8
Speed				
Slow	-	10	4	7
Medium	-	-	4	11
Fast	-	16	5	11
Access distance				
2 miles	-	12	5	11
10 miles	-	13	4	10
20 miles	-	13	4	8
Egress distance				
1 mile	-	13	5	11
5 miles	-	12	5	9
10 miles	-	14	3	10
Frequency				
Three times per week	-	14	4	10
Once per day	-	12	5	10
Twice per day	-	13	5	9

Mixed Logit Model

- Probability of choosing a given mode is a function of

  - Mode characteristics

  - Individual characteristics

  - Trip characteristics

Results from Mixed Logit Model: Mode Characteristics

Parameter	Estimate	t value	Odds Ratio
Mode characteristics			
Auto dummy	1.1581	5.87***	3.18
Air dummy	0.9613	2.95***	2.62
Bus dummy	-0.8797	-2.9***	0.41
Travel time mean	-0.2706	-6.21***	0.76
Travel time st. dev.	-0.6322	-10.16***	0.53
Price mean	-5.4204	-11.04***	0.00
Price st. dev.	-2.4231	-8.49***	0.09
Access distance	-0.0189	-3.57***	0.98
Egress distance	-0.005461	-0.53	
Frequency level 1	-0.0149	-0.16	
Frequency level 3	0.0197	0.22	

*,**,*** denote significance at the 10%, 5%, and 1% levels, respectively

Results from Mixed Logit Model: Individual Characteristics

Parameter	Estimate	t value	Odds Ratio
Individual characteristics			
Male x Auto	0.4425	3.98***	1.56
Male x Air	0.0871	0.46	
Male x Bus	0.508	2.76***	1.66
Age 18-24 x Auto	0.1778	0.97	
Age 18-24 x Air	0.123	0.39	
Age 18-24 x Bus	0.4762	1.68*	1.61
Age 70+ x Auto	0.135	0.73	
Age 70+ x Air	-0.7658	-2.29**	0.46
Age 70+ x Bus	0.0712	0.25	
Income x Auto	0.096	2.22**	1.10
Income x Air	0.1905	2.63***	1.21
Income x Bus	-0.1167	-1.57	
Disability x Auto	-0.8052	-4.3***	0.45
Disability x Air	-1.4034	-3.16***	0.25
Disability x Bus	0.2571	0.91	

*,**,*** denote significance at the 10%, 5%, and 1% levels, respectively

Results from Mixed Logit Model: Trip Characteristics

Parameter	Estimate	t value	Odds Ratio
Trip characteristics			
Travel alone x Auto	-0.3531	-3.28***	0.70
Travel alone x Air	-0.2013	-1.11	
Travel alone x Bus	0.1236	0.69	
Personal trip x Auto	0.3108	2.88***	1.36
Personal trip x Air	-0.4977	-2.67***	0.61
Personal trip x Bus	-0.1997	-1.1	

*,**,*** denote significance at the 10%, 5%, and 1% levels, respectively

Applying the Results

North Dakota Statewide Passenger Travel Demand Model
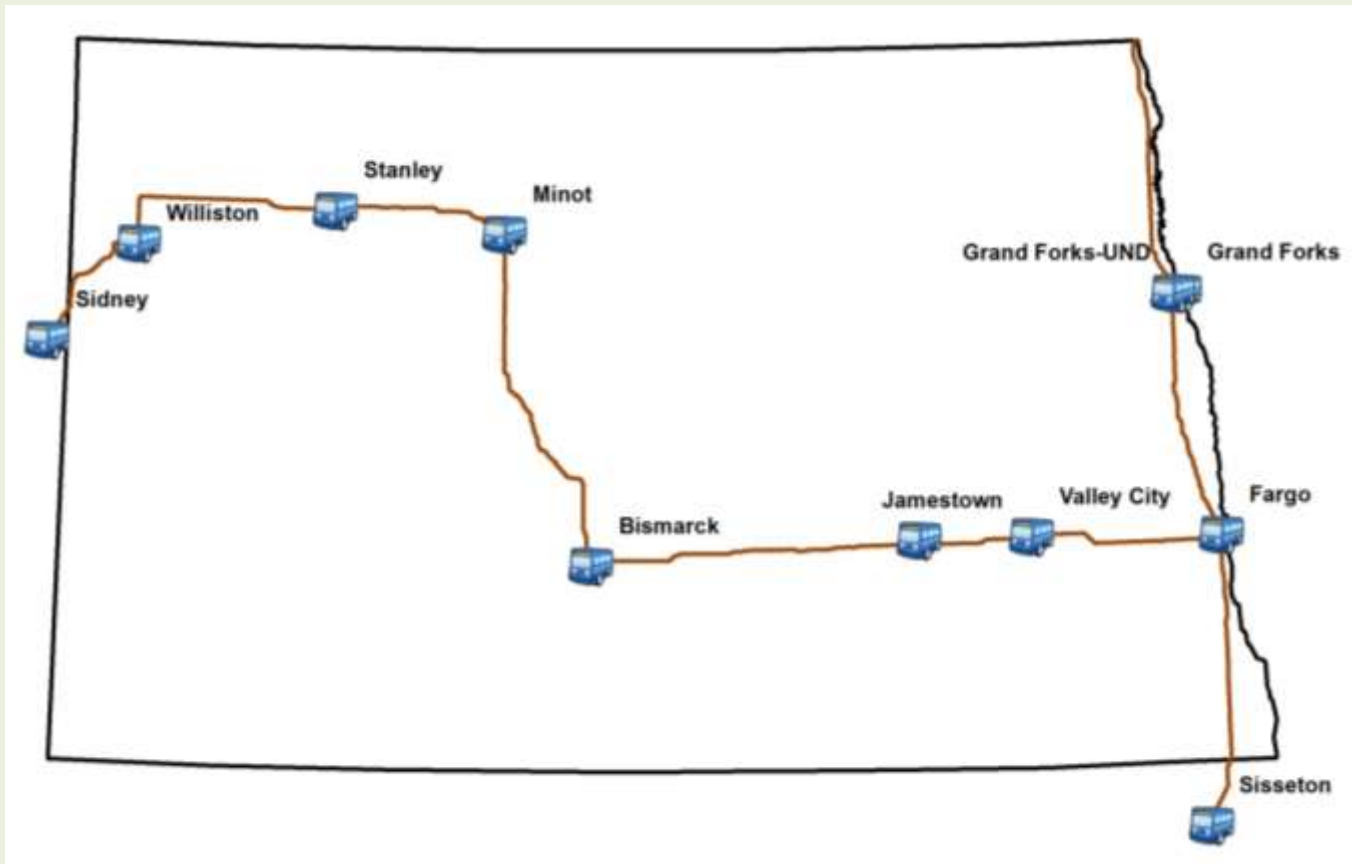
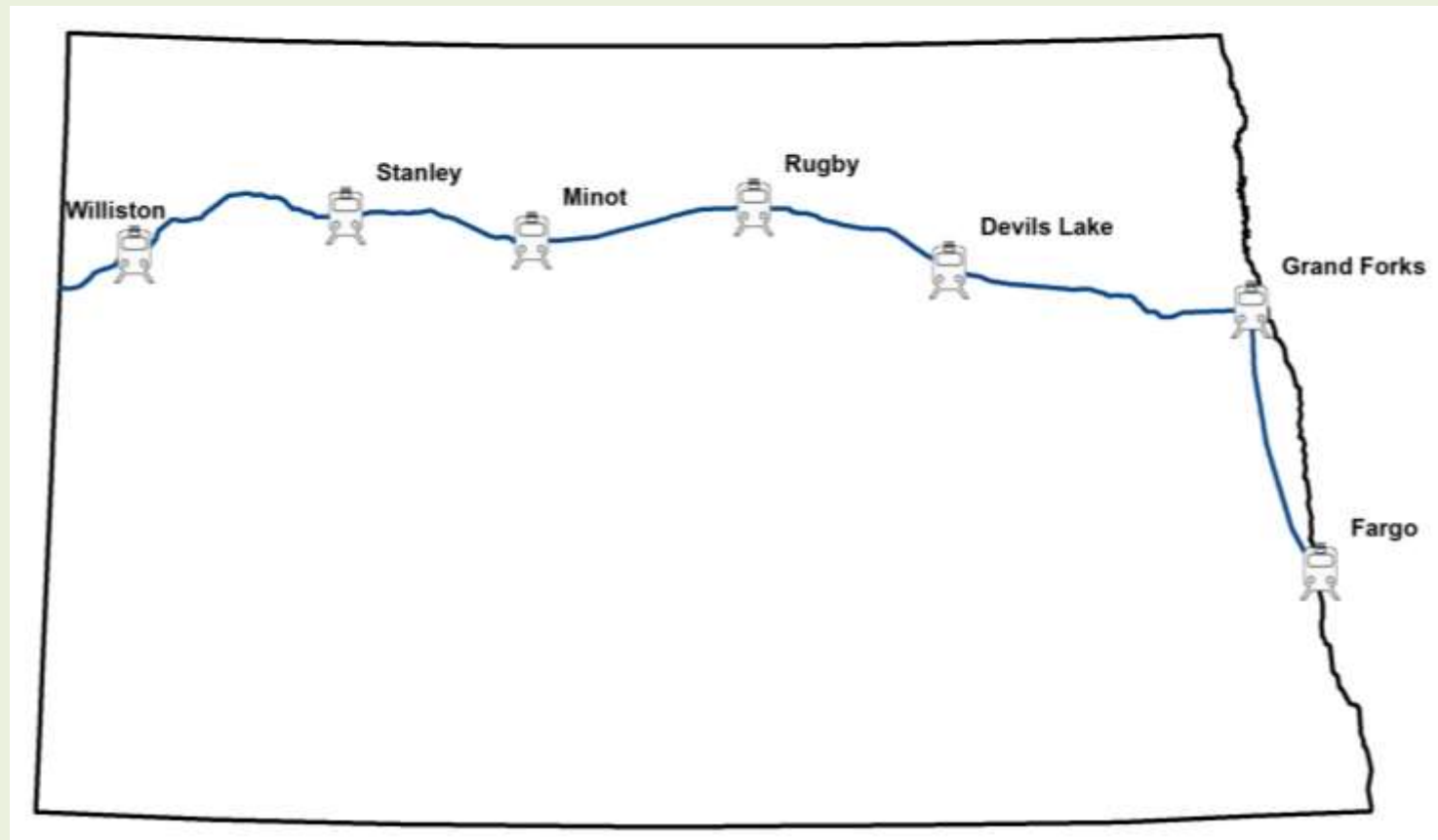Estimating Mode Shares

Scenario Analysis

Statewide Travel Demand Model

- North Dakota passenger travel demand model under development

- Census block groups used as TAZs

- O-D matrix of trips across the state

- Number of bus trips for each O-D pair can be estimated using results from mode choice model

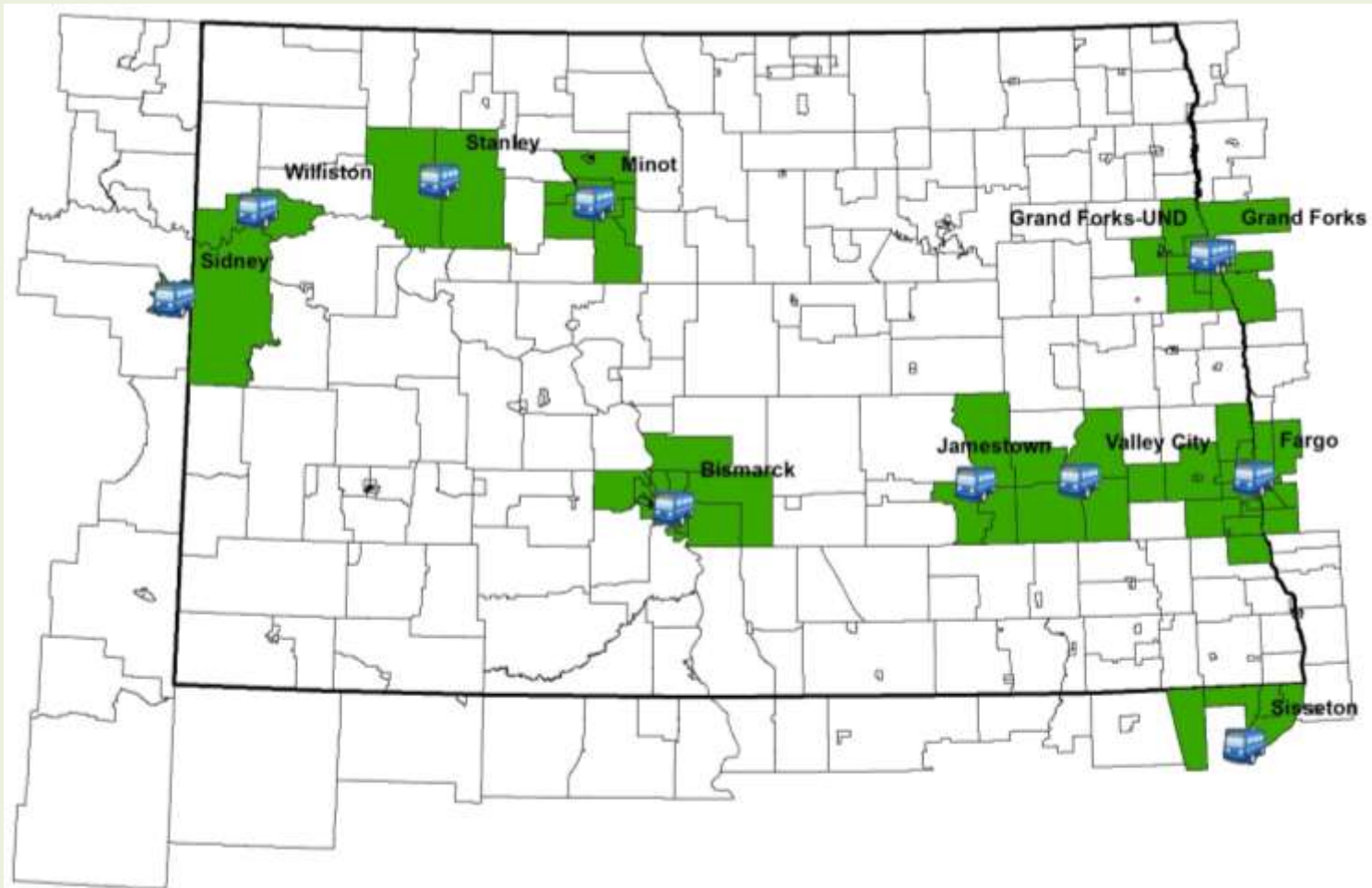- To account for demographics, TAZ data for age and income is used

North Dakota Intercity Bus Network

North Dakota Intercity Rail Network

TAZs within 25 Miles of Intercity Bus Stop

Estimated Bus Mode Shares for Personal Trips

Destination → / Origin	Fargo	Bismarck	Grand Forks	Minot	Williston	Dickinson	Jamestown	Wahpeton	Devils Lake	Valley City	Grafton	Watford City	Beulah	Rugby	Casselton	Hazen	Stanley
Fargo	-	3.2	4.1	3.0	2.2	0.0	3.5	0.0	0.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0	2.4
Bismarck	3.4	-	0.0	4.2	2.9	0.0	4.0	0.0	0.0	3.9	0.0	0.0	0.0	0.0	3.2	0.0	3.3
Grand Forks	4.6	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	0.0	0.0
Minot	2.9	4.4	0.0	-	3.9	0.0	2.6	0.0	0.0	2.8	0.0	0.0	0.0	0.0	2.7	0.0	4.1
Williston	1.8	2.0	0.0	3.7	-	0.0	1.7	0.0	0.0	1.9	0.0	0.0	0.0	0.0	1.7	0.0	4.0
Dickinson	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jamestown	4.0	4.2	0.0	3.5	2.6	0.0	-	0.0	0.0	4.5	0.0	0.0	0.0	0.0	3.8	0.0	2.7
Wahpeton	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Devils Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Valley City	4.2	3.7	0.0	3.1	2.3	0.0	4.1	0.0	0.0	-	0.0	0.0	0.0	0.0	3.9	0.0	2.5
Grafton	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0
Watford City	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0
Beulah	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0
Rugby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0
Casselton	0.0	2.2	2.9	2.0	1.4	0.0	2.4	0.0	0.0	2.8	0.0	0.0	0.0	0.0	-	0.0	1.5
Hazen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0
Stanley	2.0	2.3	0.0	4.0	4.1	0.0	1.8	0.0	0.0	2.0	0.0	0.0	0.0	0.0	1.8	0.0	-

Estimated Bus Mode Shares for Business Trips

Destination → / Origin	Fargo	Bismarck	Grand Forks	Minot	Williston	Dickinson	Jamestown	Wahpeton	Devils Lake	Valley City	Grafton	Watford City	Beulah	Rugby	Casselton	Hazen	Stanley
Fargo	-	5.1	6.9	5.2	3.8	0.0	5.4	0.0	0.0	7.3	0.0	0.0	0.0	0.0	0.0	0.0	4.1
Bismarck	5.8	-	0.0	7.0	5.0	0.0	6.7	0.0	0.0	6.5	0.0	0.0	0.0	0.0	5.5	0.0	5.6
Grand Forks	7.7	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.9	0.0	0.0
Minot	4.9	7.5	0.0	-	6.5	0.0	3.9	0.0	0.0	4.4	0.0	0.0	0.0	0.0	4.7	0.0	6.9
Williston	3.1	3.0	0.0	6.2	-	0.0	2.6	0.0	0.0	3.0	0.0	0.0	0.0	0.0	2.9	0.0	6.7
Dickinson	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jamestown	6.8	7.1	0.0	5.9	4.4	0.0	-	0.0	0.0	7.6	0.0	0.0	0.0	0.0	6.4	0.0	4.7
Wahpeton	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Devils Lake	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Valley City	7.1	6.3	0.0	5.3	4.0	0.0	7.0	0.0	0.0	-	0.0	0.0	0.0	0.0	6.7	0.0	4.2
Grafton	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0
Watford City	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0
Beulah	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0
Rugby	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0
Casselton	0.0	3.5	4.9	3.4	2.5	0.0	3.8	0.0	0.0	4.8	0.0	0.0	0.0	0.0	-	0.0	2.7
Hazen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0
Stanley	3.4	3.3	0.0	6.9	7.0	0.0	2.8	0.0	0.0	3.1	0.0	0.0	0.0	0.0	3.2	0.0	-

Applications of Model

- Estimate impacts of changes in:

    – The intercity bus network

    – Service characteristics of intercity bus

    – Attributes of competing modes

    – Demographics

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

Conclusions

- Intercity mode choice model estimated incorporating individual, trip, and mode characteristics

- Results show effects of travel time, cost, access distance, age, income, disability, trip purpose, and party size on mode share

- Results incorporated into statewide travel demand model

- Application: Estimate effects of changes in service characteristics, competing modes, demographic shifts

Thank you!

Questions?

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