Ground access to airports, case study: Port Columbus International Airport

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ABSTRACT

This study examines the ground access mode choices of passengers traveling to Port Columbus International Airport in Columbus, Ohio. The survey was conducted with 642 individuals at the airport in April 2012. The survey included questions about passengers' flights, attitudes toward auto-use, interest in alternative modes of transportation, important factors affecting mode choice, and socio-demographic information. The factors affecting passengers' mode choices constituted the greatest focus of the survey. Binary logit models are estimated to analyze the passengers' interest in taking alternative modes of transportation. The results show that individuals who are on business trips, flying alone (or with fewer people), and already trying to reduce their auto-use in general are more likely to take alternative modes of transportation to the airport. In addition, the most important factors that affect individuals' ground access mode decisions are presented separately for travelers on business trips and non-business trips.

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1. Introduction

There is a growing interest in issues related to planning for airport ground access. As airports are major trip generators in their regions, it is becoming increasingly important to understand how passengers make their travel choices for their trips to and from the airports, whether there is a market for alternative modes of transportation, and the effects of ground access transportation characteristics on airport choice in the case where there are multiple airports in a region. The aim of this study is to identify the factors associated with airport ground access mode choice and to assess the propensity of taking alternative modes across different individuals, such as individuals who are mostly concerned about travel time, those whose main concern is the cost, and those with other concerns such as luggage, flexibility of departure time and time of the current and return flights. This information provides a background for evaluating transportation system improvements (both for public and private modes).

The study focuses on the ground access transportation options, and the potential for alternative modes, at the Port Columbus International Airport (CMH) in Columbus, OH. As reported by Columbus Regional Airport Authority, the current Port Columbus terminal has the potential capacity to serve 8 million to 10 million passengers, and offers more than 140 daily flights to 32 airports. It is estimated that by the end of 2012, the airport would have served 6.3 million passengers (Columbus Regional Airport Authority, 2012). A survey was developed as a tool to collect data about airport passengers' travel preferences and assess the potential demand for alternative modes of transportation to the airport.

Private modes constitute a large majority of trips to CMH. There are several reasons leading to this pattern. First of all, there are no frequent and easily accessible public transportation lines that serve the airport. The only public transit option is a COTA (Central Ohio Transportation Authority) bus line which serves a very limited area. Some hotels provide airport shuttles, which are only available to their own customers. Although some shuttle services exist for individuals within the Columbus area, their prices are similar to taxi cabs, and more often higher. Travel distances being shorter as compared to several other regions, and the easily accessible, well-maintained and relatively cheap parking options, make driving the most popular of all the available modes.

2. Background

There has been a continuous growth in the amount of air passenger traffic, raising ground access related issues and an increase in the levels of congestion around airports (Budd et al., 2011a, 2011b; de Neuville, 2006; Reynolds-Feighan and Button, 1999). A number of studies have investigated how travel time, cost, and socio-demographic characteristics of individuals affect their mode

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choices on their trips to and from the airports (Alhussein, 2011; Cirillo and Xu, 2010; Foote et al., 2007; Gupta et al., 2008; Jou et al., 2011; Monteiro and Hansen, 1996; Pels et al., 2003; Psaraki and Abacoumkin, 2002; Tam et al., 2011; Tsamboulas and Nikoleris, 2008). Several of these studies are based on surveys conducted at the airports, collecting data on travelers and their trip characteristics. For instance, Psaraki and Abacoumkin (2002) examine the existing mode shares at the Athens International Airport to predict markets shares in the future, when the airport is relocated. They first classify passengers into discrete groups based on their residence status, trip destinations and trip purposes, and then analyze the mode choices of these groups separately. Their mode-split forecasts show differences among these passenger groups. For instance, while Athens residents on domestic business trips are more likely to drive and park, passengers on international non-business trips are more likely to be dropped off, or take taxi cabs.

Foote et al. (2007) analyze mode choice and preferences of passengers at two major airports in Chicago, Illinois with a focus on factors affecting the use of rail transit. Cost, time and being close by are reported as the most important factors affecting transit use by actual rail users, while not being close by is cited as the most important deterrent. Based on these findings, the authors state that if convenient access to trip origins and destinations are provided, express transit has the potential to increase its market share.

Tam et al. (2011) study the effects of travel time reliability on air passengers' ground access mode choices by using passengers' satisfaction level as a latent variable. They find that this latent variable is a positive parameter which indicates that as satisfaction with a certain mode increases, the utility of this mode increases as well. Based on their model estimates and sensitivity analysis, the authors recommend that in order to increase the market share of buses, their travel time reliability should be improved (the customers were least satisfied with this attribute). To increase the market share of airport express services, the cost should be reduced. Based on their forecasts, the expected reduction in revenues due to decreased fares will be offset by the increase in demand.

Some researchers have investigated the potential market shares of new and hypothetical modes. For example, Jou et al. (2011) study the propensity of rail use at Taoyuan Airport (Taiwan). At the time of their study (2010), Taiwan was in the process of constructing a mass rapid transit system connecting the airport and the Taipei train station. Their results show that while in-vehicle and out-of-vehicle travel times are important factors, having no transfers, user-friendliness, punctuality, and safety are also cited as critical factors that affect the propensity of choosing rail. Cirillo and Xu (2010) study the potential demand for cybercar use (automatically controlled vehicles that are shared by several passengers) for ground access at the Baltimore Washington International Airport (BWI). Their results indicate that the cybercar would occupy almost half of the market share at BWI airport. Females are more likely to use the cybercar, whilst individuals with higher incomes are willing to try the cybercar but would still prefer their personal vehicles. Their results also show that people are more sensitive to changes in the cybercar's time and cost than variations in the time and cost of driving a car.

Willingness to pay to save time on trips to the airport is the focus of a study conducted by Tsamboulas and Nikoleris (2008). Based on surveys conducted at the Athens International Airport, they find that a high percentage of passengers would not be willing to pay any amount of money to reduce their travel times to the airport. This is explained by the fact that passengers arrive at the airport very early and have plenty of time available; and that the passengers chose modes that offer high level services, and therefore they were not interested in paying to reduce their travel times.

The research finds that business travelers and car/taxi users are more likely to pay for a reduction in their travel time and willingness to pay increases as the distance from the airport increased.

The joint choice of airport and ground access mode has also been the focus of several studies. For instance, Pels et al. (2003) find that access time has a large influence on the competition between airports in a region. Using data from the Bay Area airports they analyze the effects of ticket prices, flight frequencies, access time and access cost. They find that passengers are sensitive to all these factors, with access time being more important than access cost. Monteiro and Hansen (1996) examine how public transit improvements to one airport may affect the airport market share of a region using data from the Bay Area and its two major airports. Their models include ground access characteristics, daily direct-flight frequency, and average air fare as independent variables. Gupta et al. (2008) develop a joint airport and ground access mode-choice model for the New York City metropolitan region. They find that access time, access cost, individuals' socioeconomic characteristics and travel party size are significant factors affecting the resulting mode choice. They report that the value of time (VOT) estimates for trips to and from the airports are very different (higher) than regular intra-city trips (i.e. commuting or non-work trips), and conclude that trips to airports should be treated as a separate category in regional travel models, and should not be grouped together with any other trip purposes.

Budd et al. (2011b) argue that policies aimed at encouraging public transit use are more likely to succeed when targeted at passengers who are more likely to change their behavior. They state that although there are studies analyzing the needs and choices of different population segments based on socio-demographics, there is room for improvement. They argue including one's needs, preferences and attitudes in segmentation analyses will help airport managers predict how different population segments will change their behavior and make better-informed decisions on different policies and system provisions.

In summary, a number of studies find that travel time, cost, convenient access from origins and destinations, number of transfers, reliability and safety are important factors affecting individuals' decisions regarding their trips to and from the airports. This study adds to the existing literature by presenting a detailed analysis of the survey data collected at the Port Columbus International Airport.

3. Methods

Two main analyses are carried out. First, the factors that affect the individuals' ground access mode choices and their attitudes toward auto-use are analyzed through two separate Principal Component Analyses. This step is undertaken to understand the correlation patterns among these factors and create principal components composed of these factors. These principal components are then introduced as independent variables in the discrete choice models (binary logit), which are estimated to analyze the interest in taking alternative forms of transportation to the airport.

3.1. Principal Component Analysis (PCA)

PCA is an exploratory analysis that transforms the original variables into new, uncorrelated variables — principal components — based on their interrelationships. The component scores can be calculated for each individual and used as a new variable for further analysis (Afifi and Clark, 1996). Using PCA, the correlation patterns amongst the factors that individuals consider while making their mode choices, and their attitudes toward auto-use, are analyzed in order to group individuals based on the most important factors that

affect their mode choices and attitudes toward auto-use. For example, do people who are concerned about travel time also find the travel cost very important? Do individuals who find the flexibility of departure time important also find the time of their current flight important? The respondents rated the importance of the factors affecting their ground access mode choice (not important through to very important), and their level of agreement with five statements regarding their auto-use (strongly disagree through to strongly agree). As the contexts are different and the responses are recorded on different scales, two separate PCAs are conducted: one for factors affecting airport access mode, and one for attitudes toward auto-use in general.

3.2. Binary logit models

Discrete choice models (binary logit) are estimated to evaluate the effects of traveler characteristics and personal attitudes on the respondents' interest in taking alternative modes to the airport. In this model, the dependent variable (interest in taking alternative modes to the airport) is equal to 1 if the respondent choses at least one alternative mode that he/she may consider taking, and 0 if the respondent indicates that he/she has no interest and will continue driving. Discrete choice models are based on the random utility theory, which assumes that the decision maker's preference for an alternative can be captured by the value of an index, called utility. It is assumed that the decision maker chooses the alternative that yields the highest utility. The probability of any alternative i being selected from a choice set C_n is given by the following:

$$P(i/C_n) = \Pr(U_{in} \geq U_{jn}), \forall j \in C_n, \qquad (1)$$

where, U is the utility of the given alternative. Because the analyst has imperfect information about an individual's utility level, uncertainty is introduced into the utility equation (Ben Akiva and Lerman, 1985). Equation (2) represents the utility (U_{in}) of alternative i in the choice set C_n for decision-maker n.

$$U_{in} = \beta_{in}x_{in} + \varepsilon_{in} \qquad (2)$$

where, x_{ni} are observed variables that relate to the alternative and decision maker, β_{ni} is a vector of coefficients of these variables and ε_{ni} is the random component. The choice set in this study is binary, where the respondent either has interest in taking an alternative mode to the airport or not. The logit model arises from the assumption that the difference of the error terms is logistically distributed (Ben Akiva and Lerman, 1985). Under this assumption the choice probability for alternative i is given by:

$$P(i/C_n) = \Pr(U_{in} \geq U_{jn}), \forall j \in C_n \qquad (3)$$

$$P_n(i) = \frac{e^{V_{in}}}{\sum_{j \in C_n} e^{V_{jn}}} \qquad (4)$$

The variables included in the utility functions can be summarized as:

- A group of personal characteristics:
  - Gender (1, female; 0, male)
  - Employment status (1, employed; 0, not employed)
  - Education (1, has bachelor's degree or higher; 0, otherwise)
  - Local user (1, if CMH is the airport the passenger departs from in general; 0, otherwise)
  - Household income
    - Income group 1 (if income is less than $50,000)
    - Income group 2 ($50 k–$74,999)

- Income group 3 ($75 k–$99,999)
- Income group 4 ($100 k–$150,000)
- Income group 5 (more than $150 k)
  - Individual age
    - Age group 1 (18–22)
    - Age group 2 (23–29)
    - Age group 3 (30–39)
    - Age group 4 (40–49)
    - Age group 5 (50 and over)

- Variables related to respondent's trips
  - Party size (number of people flying with the passenger)
  - Trip purpose (1, business trip; 0, otherwise)
  - Duration between passenger's arrival time at the airport, and flight time
  - Time of the flight (1, if it is an AM flight; 0, otherwise)
- Personal attitudes regarding auto-use and factors affecting mode choice (from the PCA analysis)
  - Principal component 1 (travel time, safety and comfort)
  - Principal component 2 (current and return flight times, and flexibility of departure time)
  - Principal component 3 (amount of luggage and party size)
  - Principal component 4 (parking and gasoline costs)
  - Principal component 5 (auto dependent)
  - Principal component 6 (willing to reduce auto-use)

4. Data

This study uses the data collected at the Port Columbus International Airport on April 2012. The research team was given permission to conduct paper based surveys with passengers waiting at the gate areas for one day only. A total of 642 individuals participated in the survey, with 458 of these providing complete responses. The core questions of the survey included respondents' travel mode to the airport; factors that affect their mode choice to airport; the most important factors that they would consider if they were to take another form of transportation other than driving; socio-demographic information; and attitudes toward auto-use in general.

4.1. Descriptive statistics

4.1.1. Survey sample & trip characteristics

Table 1 provides an overview of the survey respondents. A little over half of the survey respondents were male (55.7%). Almost all survey respondents had driver's licenses (98.6%) and owned cars (95.2%). Over 75% of the respondents were employed full time, and over 65% of the survey respondents reported a household income of $75,000 or over. Approximately half of the respondents (54%) were local users (CMH is the airport they use most often).

Table 2 presents the characteristics pertaining to the individuals' trips. The survey results reveal that a great majority of survey respondents either drove or were dropped-off at the airport (86.9%). Public bus has the lowest percentage. This is an expected result given the infrequent and limited service area of the COTA buses serving the airport. The modal split does not change much when trip purpose (business versus non-business), and gender of the trip maker is considered; driving continues to be the top choice.

The results show that there was roughly an even number of passengers who drive themselves to the airport or get a ride to the airport. The survey also inquired about the ownership of the vehicles that passengers drove to the airport. The majority of respondents arrived by a privately-owned vehicle (64.45%), followed by rental vehicles (28.1%) and company owned vehicles (7.5%). Over

Table 1
Descriptive statistics.

	N	%		N	%
Gender			Household income		
Male	348	55.7	Less than $25 k	30	5.11
Female	277	44.3	$25 k–$49,999	79	13.46
Age			$50 k–$74,999	93	15.84
18—22	36	5.77	$75 k–$99,999	93	15.84
23—29	114	18.27	$100 k–$150,000	135	23.00
30—39	145	23.24	More than $150 k	157	26.75
40—49	137	21.96	Has driver's license		
50—59	110	17.63	Yes	617	98.56
60+	82	13.14	No	9	1.44
Employment status			Own a car		
Employed full-time	483	77.3	Yes	594	95.19
Employed part-time	39	6.24	Share it with other people	17	2.72
Student	31	4.96	No	13	2.08
Homemaker	15	2.4	Education		
Retired	51	8.16	Less than high school	5	0.8
Searching for jobs	6	0.96	High school graduate	55	8.8
Local airport user			Technical/some college	108	17.3
Yes	344	53.92	Bachelor's degree	243	38.9
No	294	46.08	Graduate degree	214	34.2

half of the survey respondents started their trip to the airport from their homes (59%) followed by hotels (24%) and their offices (11.6%). A little over half of the respondents (53.3%) indicated that they were on a business trip. There was about an even split between local and non-local users (53.8% and 46.2%, respectively). The survey asked respondents to report how many times they have flown out of Port Columbus International Airport in the past 12 months including the flight they were to take on the day of the survey. The average number was 6.1 trips per year. The majority of respondents (68.45%) flew out of CMH less than five times per year. The majority of the respondents reported that they were flying by themselves (55.9%). The next largest group of people (23.4%) had 1 other person flying with them.

4.1.2. Attitudes toward auto usage

Participants were asked to record their attitudes about a series of statements related to their auto-use in general. The scale for this question ranged from 'strongly agree' to 'strongly disagree'. The results, as reported in Table 3, reveal that around 90% of the

Table 2
Trip characteristics.

	N	%		N	%
Travel mode			Travel party size (including the traveler)		
Auto	557	87.30	1	359	55.92
COTA bus	1	0.16	2	150	23.36
Taxi	32	5.02	3	58	9.03
Shuttle	36	5.64	4	19	2.96
Charter bus	12	1.88	5 or more	56	8.72
Trip origin			Number of bags		
Home	384	62.24	0	43	6.73
Hotel	148	23.99	1	211	33.02
School	10	1.62	2	222	34.74
Office	75	12.16	3	59	9.23
Trip purpose			4 or more	104	16.28
Business	341	53.28			
Non-business	299	46.72			
Durations				Mean	Std. dev
Duration between flight time and departure time from origin (min)				149.50	60.20
Duration between flight time and arrival at the airport (min)				108.43	45.92
Duration between arrival time and departure time from origin (min)				45.67	35.31

respondents agreed with the statement 'my lifestyle is dependent on having a car'; however, over 35% indicate that they are actively trying to use their cars less. Only about 40% of the respondents stated that they have no interest in reducing their car use. It is observed that although more people (40%) strongly disagreed/disagreed with the statement 'I have no interest in reducing my car use', fewer people (35%) reported that they are actively trying to reduce their car use. This may be because several individuals with an interest of reducing auto-use may not be able to do so because of lack of alternatives.

4.1.3. Important factors in mode choice, other than automobile

The survey respondents were asked to rate several factors in terms of their importance if they were to take alternative modes of transportation other than autos. The results are tabulated in Table 4. Since several previous studies stress the importance of trip purpose in explaining behavioral differences, particularly in sensitivity to time and cost (Gupta et al., 2008; Psaraki and Abacoumkin, 2002; Tsamboulas and Nikoleris, 2008), Table 4 reports these factors separately for business and non-business travelers.

All six factors (cost, travel time, luggage storage capacity, service frequency, reliability and flexibility of departure time) were found to be important; the most important one was reliability, followed by travel time to the airport, and flexibility of departure time for both business and non-business travelers. These findings are generally consistent with the existing literature. Tam et al. (2011) report that travel time reliability is an important factor, and a significant portion of passengers would switch to buses if their travel time reliability were improved. In this study, the sum of respondents who cite reliability as being 'very important' and 'important' is over 90% for both groups (business and non-business), supporting the argument for the importance of travel time reliability. Non-business travelers cited having a lower cost relative to driving as a more important factor. A total of 75% of non-business travelers cited lower cost as being 'important' and 'very important', whereas this percentage is 63% for business travelers. This is an expected result and was pointed out by earlier studies. For instance, Tsamboulas and Nikoleris (2008) report a higher willingness to pay for airport ground access time savings for business travelers. Studies by Tam et al. (2011), Cirillo and Xu (2010) and Gupta et al. (2008) refer to luggage related issues. These studies state that the amount of luggage amount, storage capacity, convenience of storage and retrieval affect individuals' ground access mode choices.

4.1.4. Hypothetical mode choice

The respondents were asked to pick their top two choices if they were to consider taking alternative modes to the airport. The options that were only hypothetically available were included in the question (rail service from downtown, bus service from downtown and bus service close to trip origin), as well as the shuttle options. The question also included an option for those who would not consider alternative modes (None, I will continue driving). Several respondents indicated that they would continue driving (36.7%), followed by a shuttle option (with 4—6 people that would pick the respondent up from their origin) at 22.7%. The third most chosen option was a rail system from downtown Columbus at 19.2%. The bus option (either from origin or downtown) was among the least likely chosen alternatives, which may indicate that there may not be a market for bus transportation to CMH. The results are tabulated in Table 5.

4.1.5. Important factors affecting airport ground access mode choice

The respondents were asked to consider their journey to the airport on the day the survey was conducted, and rate a series of

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Table 3
Attitudes toward auto use.

	Strongly agree %	Agree %	Disagree %	Strongly disagree %	N/A %	Total N
I have no other option but to drive.	39.19	33.5	17.24	6.34	3.74	615
My lifestyle is dependent on having an auto.	55.19	35.39	4.55	2.27	2.6	616
I am actively trying to reduce my auto use.	6.07	30.66	39.67	17.21	6.39	610
I have no interest in reducing my auto use.	17.11	23.03	36.02	18.26	5.59	608
I don't have an auto or don't use one.	2.84	2.01	9.03	37.46	48.66	598

Table 4
Factors to consider in alternative modes.

	Very important %	Important %	Somewhat important %	Not important %	N/A %	N
Travelers on business trips						
Lower cost relative to driving	33.1	29.7	18.4	13.1	5.6	320
Travel time to the airport	57.6	29.7	5.6	3.4	3.7	323
Luggage storage capacity	25.0	30.6	26.6	14.1	3.8	320
Frequency of service	45.6	36.6	9.4	3.1	5.3	320
Reliability (on time service)	72.1	19.2	2.2	1.5	5.0	323
Flexibility of departure time	51.4	31.2	9.0	3.1	5.3	321
Travelers on non-business trips						
Lower cost relative to driving	42.0	33.0	10.1	12.8	2.1	288
Travel time to the airport	58.0	33.3	3.8	3.5	1.4	288
Luggage storage capacity	25.7	36.8	24.3	11.4	1.8	280
Frequency of service	52.6	31.2	9.8	4.9	1.4	285
Reliability (on time service)	78.1	17.7	1.0	1.7	1.4	288
Flexibility of departure time	52.8	33.9	8.7	2.1	2.4	286

factors in terms of their importance on their travel decisions. The results are presented in Table 6 segmented by trip purpose (business and non-business).

Over 60% of the respondents in both groups indicated that the time of their current flight, flexibility of departure time and travel time were important factors when it comes to their travel choices to the airport. Cost was not chosen as an important factor by some of the survey respondents. This may be due to the fact that the trip distances to CMH are relatively shorter when compared to other regions (thus less driving costs), and some of the parking lots are quite affordable with prices starting from $4 per day.

Consistent with Table 4, considering the responses 'very important' and 'important', cost of travel (both parking and gasoline) was found to be more important for non-business travelers. In addition, a higher percentage of non-business travelers cited the amount of luggage, the number of people in the travel party and safety concerns as being 'important' and 'more important'. This may be due to the fact that in general business travelers tend to travel alone or with fewer people, and with less luggage. These differences are statistically significant at the 95% level. Although both groups cited travel time and time of current flight as important factors, a higher percentage of business travelers cited these two factors as being 'very important' as compared to non-business travelers. This is consistent with Tam et al. (2011)'s argument about business travelers being more sensitive to travel time.

Table 5
Interest in alternative modes.

Mode	N	%
Bus from Downtown Columbus	19	2.35
Other	39	4.82
Shuttle with 4–6 people from Downtown Columbus	45	5.56
Bus that passes close to the origin of my trip	70	8.65
Rail system from Downtown Columbus	155	19.16
Shuttle with 4–6 People which would pick me from my origin	184	22.74
None, I will continue driving	297	36.71

5. Results

5.1. Principal Components Analysis (PCA)

Table 7 shows the results of the PCA for mode choice factors and attitudes toward auto-use. This table presents the number of underlying components, the percentage of variance explained by each component and the loadings for each variable on that particular component. Loadings which are larger than +0.40 or smaller than −0.40 are considered to be the most dominant variables in a given component and are presented in bold in Table 7. The reported results are with varimax factor rotation.

The first component on Table 7 is characterized by a high concern for safety, comfort and travel time. People who choose timing of their current and return flights as well as their departure time flexibility as important factors score high with the second component. The third component is characterized by the people who find the amount of luggage and travel party as important determinants of their mode choices. Respondents who find parking and gasoline costs important score high with the fourth component. In terms of the attitudes regarding auto-use in general, there are two resulting components. Respondents who score high with the first component indicate that they their lifestyles are dependent on driving and they have no interest in reducing their car use. Individuals who try to reduce their auto-use score high with the second component. These components are used in explaining the individuals' interest in taking alternative modes of transportation in the next section.

5.2. Interest in alternative modes

Table 8 presents the results of the binary choice model for interest in alternative modes for trips to the airport. The first model is the full model with all the hypothesized variables included, and the second model includes only the variables which are significant at least at the 90% level. In terms of personal characteristics, the model results indicate that gender, employment, education and being a

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Table 6
Factors affecting travel mode to the airport.

	Very important %	Important %	Somewhat important %	Not important %	N/A %	N
Travelers on business trips						
Cost of gasoline	12.0	16.1	16.5	40.8	14.6	316
Cost of parking	13.3	17.5	13.3	30.2	25.7	315
Time of my current flight	40.1	29.5	9.7	11.0	9.7	319
Time of my return flight	25.2	25.6	11.1	17.0	21.0	305
Flexibility in departure time	30.1	33.0	10.3	13.8	12.8	312
Weather conditions	13.2	20.6	19.3	32.5	14.5	311
Travel time	33.1	31.5	12.7	13.1	9.6	314
Concern for environment	9.8	15.6	28.3	35.2	11.1	307
Safety or security concerns	19.9	20.9	21.2	27.3	10.6	311
Comfort	20.2	34.3	24.0	12.2	9.3	312
Luggage (amount)	12.4	23.2	29.3	24.5	10.5	314
Number of people	10.0	20.0	19.0	34.8	16.1	310
Parking considerations	12.9	18.8	17.2	28.2	23.0	309
Travelers on non-business trips						
Cost of gasoline	16.1	22.9	19.3	36.4	5.4	280
Cost of parking	21.6	27.6	21.2	17.7	12.0	283
Time of my current flight	32.0	40.8	12.0	12.3	2.8	284
Time of my return flight	22.6	35.5	15.1	20.4	6.5	279
Flexibility in departure time	27.3	38.5	15.1	14.7	4.3	278
Weather conditions	13.5	24.2	22.8	33.8	5.7	281
Travel time	27.3	39.0	17.0	13.5	3.2	282
Concern for environment	9.4	21.7	30.3	32.5	6.1	277
Safety or security concerns	21.9	29.1	22.3	22.3	4.3	278
Comfort	23.6	36.6	26.4	10.6	2.8	284
Luggage (amount)	14.4	31.7	26.8	21.8	5.3	284
Number of people	14.5	23.0	22.0	31.9	8.5	282
Parking considerations	16.9	33.5	20.5	17.3	11.9	278

local user does not have significant effects on the interest in taking alternative modes to the airport. Households with higher incomes are less likely to be interested in alternative modes as compared to the lowest income group (household income less than $50,000). Surprisingly, age groups 3 and 4 (ages 30–49) are more likely to be interested in alternative modes as compared to younger and older individuals. This finding contradicts earlier studies by Gupta et al. (2008) and Tam et al. (2011) which report that younger individuals are more likely to choose lower cost alternatives. The reason for this may be that younger individuals in this sample were

mostly passengers who did not own their vehicles and were dropped off, or traveled with others, and so they did not bear the full cost of the access trip.

The effects of component scores calculated through the principal component analyses are tested in the binary logit models. For

Table 7
Principal Component Analysis.

Components based on important factors affecting mode choice	Components			
	1	2	3	4
Eigenvalues	2.41	1.91	1.78	1.63
Proportion	0.24	0.19	0.18	0.16
Factor loadings				
Cost of gasoline	0.083	−0.024	0.026	**0.644**
Cost of parking	−0.034	0.046	−0.033	**0.728**
Time of current flight	0.110	**0.599**	−0.043	−0.075
Time of return flight	−0.179	**0.645**	0.100	0.138
Flexibility of departure time	0.269	**0.434**	−0.050	−0.101
Travel time	**0.629**	0.067	−0.208	−0.004
Safety and security	**0.522**	−0.169	0.107	0.124
Comfort	**0.419**	−0.039	0.256	−0.070
Luggage amount	0.144	0.011	**0.551**	−0.013
Travel party	−0.106	0.028	**0.748**	−0.005

Components based on attitudes toward auto use	Components	
	5	6
Eigenvalues	1.61	1.16
Proportion	0.40	0.29
Factor loadings		
I have no other option but to drive.	**0.614**	0.132
My lifestyle is dependent on having an auto.	**0.673**	−0.034
I am actively trying to reduce my auto use.	0.233	**0.727**
I have no interest in reducing my auto use.	**0.339**	**−0.673**

Table 8
Interest in alternative modes.

	Model 1		Model 2	
	Coef.	z	Coef.	z
Trip characteristics				
AM flight	0.040	0.18		
Party size	−0.162	−2.02	−0.202	−2.36
Duration between arrival time & flight time	0.005	2.21	0.004	2.20
Business trip	0.447	1.99	0.596	2.75
Personal characteristics				
Female	−0.174	−0.79		
Employed	0.231	0.71		
Has bachelor's degree	0.191	0.75		
Local user	−0.103	−0.39		
Income group 3	−0.813	−2.19	−0.811	−2.21
Income group 4	−0.751	−1.99	−0.708	−1.91
Income group 5	−0.327	−1.91	−0.269	−1.76
Income group 6	−0.696	−1.87	−0.608	−1.69
Age group 1	0.759	1.53	0.646	1.33
Age group 2	0.219	0.63	0.322	0.96
Age group 3	0.583	1.99	0.632	2.21
Age group 4	0.368	1.90	0.418	1.99
Component 1	0.203	1.95	0.169	2.20
Component 2	0.039	0.38		
Component 3	−0.116	−1.03		
Component 4	0.171	1.71	0.140	1.88
Auto patron	−0.341	−3.49	−0.344	−3.63
Captive user	0.363	3.63	0.367	3.72
Constant	−0.767	−1.29	−0.606	−1.45
Number of observations	458		458	
Log likelihood	−280.2		−282.8	
Pseudo R-squared	0.116		0.114	

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instance, *Component 1* is associated with people who are concerned about their travel times, safety and comfort. The positive and significant coefficient for this component indicates that individuals who are concerned about their travel times, safety and comfort with their trips have the propensity of taking alternative modes to the airport, and this shift can be possible if alternative modes offer travel time reliability (so they do not need to be concerned about arrival time), safety and comfort. People who cite the cost of gasoline and parking as important factors score high with the *Component 4*, and this component is also associated with a propensity of taking alternative modes to the airport. Consequently offering lower cost alternatives, or increases in parking or fuel costs may make these individuals favor alternative modes. As expected, people who score high with Component 5 (auto patrons) are less likely to take alternative modes, whereas passengers who indicate that they already try to use their cars less often (captive drivers, *Component 6*) are likely to have an interest in taking other forms of transportation rather than driving.

6. Conclusions

The survey showed that the majority of respondents arrived to CMH by automobile, while the least amount arrived by the public bus system. Most of the results about feelings toward auto-use indicated a proclivity toward automobiles. Therefore, while the mode share to CMH is dominated by the automobile, there does appear to be a demand for alternate modes of transportation to the airport. Respondents were asked to identify modes of transportation they would take to the airport, which included hypothetical modes. The top two modes that people would be interested in taking to CMH, other than driving, were a shuttle with 4–6 people that would pick passengers up from their origins and a rail line from downtown Columbus.

In terms of important factors influencing transportation other than the automobile, the top five, in descending importance, were reliability (on-time service), travel time to the airport, flexibility of departure time, frequency of service, lower cost relative to driving, and luggage storage capacity. The top five most important factors for respondents that affected the mode choice they took on the survey day, in descending importance, were time of current flight, travel time, flexibility in departure time, comfort, and time of return flight. The findings are generally consistent with the existing literature and while some vary across business and non-business travelers, some are found to be very important for both groups. These indicate that to be able to compete with autos, alternative modes should offer reliability, shorter travel times, flexibility in departure time (which could be offered through frequent service times) and comfort for more people to consider taking them. Deciding on which alternative mode (or modes) to offer will require a comprehensive study on the feasibility of each alternative mode; opportunities and constraints, as well as financial considerations.

Several studies find travel time, cost, convenient access from origins and destinations, number of transfers, reliability and safety as important factors affecting individuals' decisions regarding their trips to and from the airports. This study adds to the existing literature by developing choice models for individuals' interest in taking alternative modes to the airport incorporating the individual preferences and attitudes in the analysis. While the transferability of these results brings some challenges, the information gathered through this study can be used to help inform planning efforts at other airports.

Acknowledgments

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