Understanding Willingness to Support Higher Taxes for Urban Transportation Services: The Case of an American City

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Abstract

This paper examines how a respondent's socioeconomic characteristics influence her willingness to support tax increases for spending on highway transportation infrastructure and four modes of public transportation (i.e., bus, light rail, commuter rail, and streetcar) in a fast growing urban area in the United States. We use and analyze detailed survey data at household level collected from a phone interview survey conducted in the Charlotte, North Carolina, area. We consider two types of response bias in the survey data. One is a systematic response bias which arises from protest zeros and respondents' tendency to under-report their willingness. The other is from the randomized response when a respondent answers survey questions by guessing because she does not have memory or knowledge of the questions and choices. Along with random utility model, these two response bias models are estimated and compared to each other. Empirical results show that an individual's attitudes towards paying higher taxes are affected by the individual's location, home ownership, and the level of educational attainment. It is found that respondents tend to grossly under-report their willingness to support higher taxes for investments on highways, bus, and commuter rail in the survey. Respondents also exhibit positive tendency to choose no increase in taxes in the survey about highway, bus, and commuter rail, although they actually prefer an increase over no increase. They have positive chance of randomly choosing slightly higher taxes for more investment on streetcar whatever her true preference is. We discuss policy implications of the empirical results.

Keywords: Transportation; discrete choice; willingness; taxes; response bias

1 Introduction

This paper examines how a respondent's socioeconomic characteristics influence her willingness to support tax increases for spending on highway transportation infrascture and four modes of public transportation (i.e., bus , light rail, commuter rail, and streetcar) in a fast growing urban area in the United States. We use and analyze detailed survey data at household level collected from a phone interview survey conducted in the Charlotte, North Carolina, area. The participants of the survey choose among "much higher taxes", "slightly higher taxes", and "no tax increase" for spending on highway transportation infrascture and four modes of public transportation.

Surveys of citizens have become a well established approach to crafting urban public policies that reflect the sensitivities of the citizens. Many earlier quantitative studies use surveys to understand the demand for non-market resources, such as environmental amenities (Breffle, et al., 1998), pollution reduction (Dziegielewska and Mendelsohn, 2007), and biodiversity (Treiman and Gartner, 2006), and issues related to transportation (McFadden, 1998; Morikawa et al., 2002). When participants in a stated preference survey are prompted to express a preference for, or act on a specific commodity or environmental good, it is frequently observed that a sizeable proportion of responses are zeros, in contradiction with otherwise reported intents. These so-called "protest zeros" are motivated by the rejection of the principle of economic contingent valuation, strategic posturing on the part of the respondent, or a lack of understanding of the valuation task at hand (Boyle, 2003). They are more likely to happen when tax payments are used as vehicles for payment, especially in the U.S. studies (McConnell and Walls, 2005). One major reason for this bias

would be that the respondent does not actually have to pay for the good in question and therefore more freely overstates their willingness to pay, while an over-reported value may also increase the chance of its provision in the future.

The presence of protest zeros brings obstacles to analyzing survey data and understanding true preferences of the respondents because the valuation data themselves are biased. Also, a respondent may answer survey questions by guessing because she does not have memory or knowledge about the questions and choices. This leads to differences between stated choice and intended choice, too. In this paper, we estimate random utility models and response bias models proposed by Hsiao and Sun (1999). The bias models, respectively, focuse on the situation where the systematic response bias arises from the respondents wanting to under-report their willingness to support higher taxes or in the survey and the response bias from randomized response.

The remainder of the paper is organized as follows. Data description is provided in Section 2. Section 3 describes the econometric models employed in this study with a focus on the response bias model. We report the results of the regression exercises in Section 4. Based on the results, discussions on the aggregation issue and the relationship between residents' attitudes and their socioeconomic status are then provided. We also discuss policy implications of the results of the research. Conclusions are drawn in the final section of the paper.

2 Data Description

Data are collected from the Charlotte-Mecklenburg Annual Survey conducted by the Urban Institute of the University of North Carolina at Charlotte. The sample involved 400 residents in Mecklenburg County, North Carolina interviewed during the fall of 2010.[1]

The county contains Charlotte, the largest city in North Carolina. Respondents were asked about their willingness to pay higher taxes for spending on highway transportation infrastructure and public transportation such as bus, light rail, commuter rail, and streetcar.

Table 1 provides summary statistics for the respondents' attitudes and their socioeconomic characteristics. Independent variables for the empirical analyses include those collected in the interviews such as respondents' educational attainment, home ownership, marital status, their distances to central business district, and a congestion index for their residenece location. Household location is measured at the zip code level. We dropped the observations that have missing values on the independent variables from the sample. Doing this reduces the sample from 400 observations to 382. The "do not know/refused" responses and refusal to vote are treated as "no tax increase" votes instead of dropping them from the sample when estimating our models.[2] Income variable is not chosen as a explanatory variable because of high refusal rate on income questions which is typical of public opinion surveys.[3]

Table 1: Summary statistics

Variable	Categories	Percentage
Education	0-11 years	5.24
	12 years	16.49
	13-15 years	25.92
	16 years	30.63
	17+ years	21.73
Home Ownership	own	90.05
Employment status	employed	50.52
Marital status	married	73.82
"Would you be willing to pay higher taxes, slightly higher taxes or no higher taxes for …"		
highway transportation infrastructure	much higher	2.09
	slightly higher	47.12
	no increase	48.95
	do not know/refused	1.83
Bus	much higher	2.62
	slightly higher	33.77
	no increase	63.61
	do not know/refused	0
light rail	much higher	9.69
	slightly higher	42.15
	no increase	46.60
	do not know/refused	1.57
commuter rail	much higher	7.85
	slightly higher	37.70
	no increase	51.83
	do not know/refused	2.62
streetcar	much higher	3.40
	slightly higher	15.97
	no increase	79.58
	do not know/refused	1.05
Any transit mode	much higher	4.19
	slightly higher	39.53
	no increase	54.19
	do not know/refused	2.09

	MIN	MAX	MEAN	STD
Distance to CBD	0	20.65	9.8238	4.0934
Congestion index	1.2212	2.0374	1.6148	0.2234
number of respondents:	382			

3 Estimation Models

We start with a conventional random utility model (McFadden, 1974). Let the set $\{0,1,...,M\}$ denote the set of mutually exclusive and collectively exhausitive choice alternatives faced by individuals participating in the survey. In this paper, the choice set contains the three different hypothesized levels of future taxation that were presented to the respondents during the phone interview.

Let n indexes respondents and y_n^* denote a respondent's intended response taking on values $\{0,1,2\}$ and $y_n^* = 0$ be the lowest level of tax increase, $y_n^* = 1$ slightly higher and $y_n^* = 2$ much higher. The ordered logit model for the intended response can be described by each response probability:

$$prob(y_n^* = 0) = \frac{1}{1 + e^{(x_n\alpha + \alpha_0)}} \equiv F_{0n},$$

$$prob(y_n^* = 1) = \frac{1}{1 + e^{(x_n\alpha + \alpha_0 - \alpha_1)}} - \frac{1}{1 + e^{(x_n\alpha + \alpha_0)}} \equiv F_{1n},$$

and

$$prob(y_n^* = 2) = 1 - F_{0n} - F_{1n} \equiv F_{2n}. \quad (1)$$

where x_n is the vector of independent variables [4] measuring socioeconomic characteristics of respondent n. Given the possible incidence of respondents' protest vote, a distinction needs to be made between the stated and intended choice of each respondent. The intended choice is motivated by the true motivations and preferences of the respondent.

Note that a respondent's intended choice can be systematically different from her stated choice in our data sample, in that the latter may be affected by various reasons. Let

y_n denote the respondent's actual choice as stated during the survey interview. If the respondents state their intended choice in the survey, we have the conventional random utility model since

$$prob(y_n = j) = prob(y_n^* = j), \quad j = 0,1,2. \tag{2}$$

One reason for the differences between stated choice and intended choice is that respondents tend to under-report their willingnesses to support higher taxes. Following Hsiao and Sun (1999) who model positive response bias in a product marketing research, we assume that there is a one-side negative respond bias in the data collected from the survey. Respondents whose intended choice is a specific level of taxation for open space tend to declare a preference for a lower level of taxation and thus present a negative response bias. To model such bias, we introduce an indicator w_{jn} with probability $\pi_{jn} \in [0,1]$ that $w_{jn} = 1$ and probability $1-\pi_{jn}$ that $w_{jn} = 0$. The alternatives are indexed so that larger j denotes a higher level of tax increases. Because of the tendency to under-report her willingness to support higher taxes, a respondent will choose the level j only in the following two cases: First, her intended choice is level j and she does not report a lower level than that in the phone interview (i.e., $y_{jn}^* = 1$ and $w_{j'n} = 0$ for all $j' \le j$). Second, her intended choice is a level of taxation higher than j, but she reports j in the interview (i.e., $w_{jn} = 1$ and $y_{j'n}^* = 1$ for all $j' > j$). Formally, the probability of each response in this study can be written as,

$$prob(y_n = 2) = [1 - \pi_{1n} - \pi_{0n}]F_{2n},$$

$$prob(y_n = 1) = [1 - \pi_{0n}]F_{1n} + \pi_{1n}F_{2n},$$

and

$$prob(y_n = 0) = 1 - \sum_{j=1}^{2} prob(y_n = j). \quad (3)$$

In this model, only the respondents whose intended choice is alternative j' could have positive chances to choose alternative j for $j \le j'$ in the interview. There is no chance that a respondent with intended choice j will choose any higher level j'' ($j'' > j$). It follows from (3) that $prob(y_{0n} = 1) > prob(y_{0n}^* = 1)$, which denotes a protest zero bias in our response bias model. This suggests that the probability of observing that a respondent reports no tax increase is greater than the probability that her intended choice is no increase. The model setup also indicates that $prob(y_n = 2) < prob(y_n^* = 2)$. However, the sign of the difference between $prob(y_n = j)$ and $prob(y_n^* = j)$ for $M > j > 0$ could be nonpositive or nonnegative.

The second reason for the possible differences between stated choice and intended choice is that a respondent does not have memory or knowledge about the questions and choices. She may answer the question by guessing. To model such randomized response, we assume that there is a probability $\rho_{jn} \in [0,1]$ that respondent n will choose alternative j, irrespective her intended choice. Then the probability of each response in this study can be written as,

$$prob(y_n = 2) = \rho_{2n} + [1 - \rho_{2n} - \rho_{1n} - \rho_{0n}]F_{2n},$$

$$prob(y_n = 1) = \rho_{1n} + [1 - \rho_{2n} - \rho_{1n} - \rho_{0n}]F_{1n},$$

and

$$prob(y_n = 0) = 1 - \sum_{j=1}^{2} prob(y_n = j). \quad (4)$$

This model is labeled as randomized response model.

The models can be estimated by maximizing the following log-likelihood function

$$logL = \sum_{n=1}^{N}\sum_{j=0}^{M} y_n \log[prob(y_n = j)], \tag{5}$$

where $prob(y_n = j)$ is defined by (2) in the random utility model and by (3) in the one-sided response bias model and by (4) in the randomized response model. The models are also referred to as model 1, model 2 and model 3, respectively. Sun (1995) shows that the MLE estimator for model 2 and model 3 is consistent and asymptotically normally distributed with the asymptotic covariance matrix equal to the inverse of the negative of the information matrix. We use estimated results and statistics to determine whether there are response bias in our data and which model is the appropriate one.

To get a more flexible version of the response bias model, one can further let $\pi_{jn} = G_j(\eta_j' x_n)$ where $G_j(\cdot)$ is a probability function in model 2. For more information on this setup, see Hsiao and Sun (1999). This extended setup may allow one to link the characteristics of a respondent with her chance of underreporting. The links are described by the coefficients η_j's. To estimate, a format for distribution function $G_j(\cdot)$ should be assumed. Given that survey respondents are very likely to under-report their willingness to support tax increases, we estimate the response bias model with the assumption that $\pi_{jn} = \pi_j$ for any n and $j = 1,2$. The same holds true for ρ_{jn} in model 3.

4 Empirical Results

This section reports empirical results of applying the above-mentioned models to the survey data. All models take logit specifications. The results on response bias are

reported first, followed by those on the socioeconomic factors that affect respondents' willingness to support higher taxes. The individual behavior is also aggregated to obtain a regional level of willingness to support higher taxes.

4.1 Estimation and model selection

We estimate three models discussed in the previous section for each transportation infrastructure/mode in the the survey. Akaike Information Criterion (Akaike, 1973) is used as to determine the appropriate model for each transportation infrastructure/mode. The results for the best models are reported in Table 2. It is found that model 2 (i.e., one-side response bias model) is the best one for the survey data on highway, bus, and commuter rail. The conventional random utility model is the best for light rail, and model 3 (randomized response model) is for streetcar.

Table 2 suggests that there are statistically significant response bias in our data sample when the respondents face three options with respect to raising taxes for spending on highway, bus and commuter rail. We find that respondents tend to under-report their willingness to support higher taxes and that they are inclined to declare a preference for no tax increase. The respondents who actually prefer slightly or much higher taxes for highway have about a 31.75% chance to select no tax increases during the phone interview. The chance is 33.58% for the case of commuter rail. A respondent will have 54.97% chance of choosing no tax increases while her intended choice is much higher taxes or slightly higher taxes for bus. She will also have 30.55% chance of choosing slightly higher taxes if her true preference is much higher taxes.

We find that respondents have about 9.24% chance of randomly choosing slightly higher taxes for more investment on streetcar whatever her true preference is. We do not

find any response bias in the data on light rail.

Table 2: Estimates of the willingness to support higher taxes: ordered logit models

Variable	Descriptions	Transportation infrastructure/mode				
		Highway	Bus	Commuter rail	Streetcar	Light rail
		(model 2)	(model2)	(model2)	(model 3)	(model 1)
Intercept1		-0.55	7.29*	1.91	-0.18	-1.27
		(1.62)	(3.97)	(1.45)	(1.67)	(0.92)
Education	13-15 years	1.21**	0.03	0.89*	-0.04	0.38
		(0.54)	(0.70)	(0.48)	(0.83)	(0.33)
	16 years	1.92***	3.45	2.06***	0.80	1.49***
		(0.69)	(2.36)	(0.59)	(0.74)	(0.34)
	17+ years	1.30**	5.17**	2.67***	1.38*	1.26***
		(0.60)	(2.60)	(0.64)	(0.77)	(0.36)
Marital status	=1 if married	0.57	1.40*	1.56***	0.66	0.67**
		(0.44)	(0.73)	(0.44)	(0.57)	(0.27)
Employment	=1 if employed	0.76*	0.00	-0.09	-0.33	0.13
		(0.45)	(0.59)	(0.33)	(0.45)	(0.22)
House ownership	=1 if own	-2.25***	-6.00**	-1.85***	-0.96	-1.25***
		(0.77)	(2.89)	(0.59)	(0.69)	(0.38)
Distance to CBD		0.06	-0.17**	-0.07*	-0.24***	-0.03
		(0.05)	(0.08)	(0.04)	(0.07)	(0.03)
Congestion index		0.67	-0.26	-0.68	0.02	0.85*
		(0.89)	(1.42)	(0.75)	(0.94)	(0.49)
Intercept 2		5.06***	6.00**	3.45***	1.31***	2.55***
		(0.79)	(2.45)	(0.51)	(0.41)	(0.19)
Response bias	probability of respondents choosing no tax increase	0.3175*** (0.0837)	0.5497*** (0.0380)	0.3358*** (0.0672)		
	probability of respondents choosing slightly higher taxes		0.3055*** (0.1042)		0.0924*** (0.0323)	
$-logL$		281.53	268.88	319.94	207.81	331.44
correct prediction		61.78%	63.61%	56.02%	80.63%	57.59%

Notes: Number of observations is 382. Standared errors are in parentheses; ***, ** and * indicate significance at 1%, 5% and 10%, respectively.

We note that there are no specific boundaries assigned for "much higher taxes" or "slightly higher taxes" in the phone survey instrument. Respondents may have their own

interpretations of these two alternatives, which could possibly make our discrimination between the two choice alternatives inappropriate. Accordingly, to evaluate this possibility, we recode the response variable by collapsing the options of "much higher taxes" and "slightly higher taxes" into one single category--"higher taxes". Estimation results for the reclassified response variable of higher taxes are reported in Table A1 of the Appendix. The patterns of the estimated coefficients are similar as those from the models with three categories. Response bias are found for the cases of highway, bus, and streetcar.

To provide further information on the perfoemance of our models, we present Table 3 which is a detailed prediction success table. Each column corresponds to a predicted alternative and each row corresponds to an actual choice. For example, the number 2 in the first row of the table is the number of persons who actually chose "much higher taxes" and are predicted to choose "slightly higher taxes". We report the percentage of correct prediction for each category. For the "slightly higher taxes" alternative for highway, 70.56% of our predictions are correct. The figures suggest that it is easier to predict slightly higher taxes than to predict much higher taxes in the models.

Table 3: Prediction Success Table

Transportation Mode	Actual Alternatives	Predicted Alternatives: Much higher	Slightly higher	No increase	Observed total	Percent correct (%)
Highway	Much higher taxes	0	6	2	8	0
	Slightly higher taxes	0	127	53	180	70.56
	No increase	0	85	109	194	56.19
Bus	Much higher taxes	0	0	10	10	0
	Slightly higher taxes	0	0	129	129	0
	No increase	0	0	243	243	100
Commuter	Much higher taxes	1	18	11	30	3.33
	Slightly higher taxes	1	73	70	144	50.69
	No increase	2	66	140	208	67.31
Streetcar	Much higher taxes	0	0	13	13	0
	Slightly higher taxes	0	1	60	61	1.64
	No increase	0	1	307	308	99.68
Light rail	Much higher taxes	0	29	8	37	0
	Slightly higher taxes	0	100	61	161	62.11
	No increase	0	64	120	184	65.22

4.2 Socioeconomic influences on individual's willingness

We explain how an individual's socioeconomic characteristics influence her true willingness to support higher taxes for the express purpose of investments on transportation infrastructure and different modes of public transportation. Though the empirical models present varying estimated coefficients, some general observations can be made.

Estimated coefficients for some of the education variables are found to be statistically significant in Table 2. Respondent with educational attainment of some college or higher are more likely to actually want to support higher taxes than those with lower level of education attainment. This result holds in most cases that are reported in Tables 2 and Table A1, and it may reflect a preference for more highway and public tansportation by the educated people and/or reflect the correlation between income (which correlated positively to education) and the demand for open space. The two possible sources cannot

be quantified because no income variable is included in the analysis. Homeowners are more reluctant to support such policies, perhaps reflecting a greater tax burden for homewoners.

The location of a household and the degree of congestion also have effects on her attitudes. Locations of the respondents are identified through their residential zip codes revealed by themselves in the interview. Each zip code area's distance to the central business district (CBD) of the city of Charlotte is measured at road miles. The estimated coefficient for the distance to the CBD takes statistically significantly negative sign in three cases—bus, commuter, and streetcar. It is insignificant in the regressions for highway and lightrail. More congestion around one's residential area makes her more willing to support higher taxes for light rail. The estimated coefficient for cogestion index is not statistically different from zero in the other four cases.

4.3 The regional level of willingness

The discrete choice models described above mainly focus on individual behavior of the respondents, while policy makers are more interested in aggregate behavior. We calculate a regional level of willingness to support higher taxes by aggregating the disaggregated model. The aggregate proportion of choosing the j^{th} option can be calculated by

$$P(j) = \int prob(y^* = j \mid x) f(x) dx, \tag{5}$$

where $f(x)$ is the population density of x. The sample being randomly drawn, $P(j)$ can be approximated by

$$\hat{P}(j) = \frac{1}{N} \sum_{n=1}^{N} prob(y^* = j \mid x_n). \tag{6}$$

Table 4 presents the estimated results of the willingness to support tax increases at the regional level. For comparison purposes, the reported level of willingness is also presented. If the data is well representative of the whole population of the County, the models find that the regional willingness to support much higher taxes for highway, bus and commuter rail are much greater than the percentage of support in the survey. It gives 68.94% of regional willingness to support slightly higher taxes for highways which is much greater than the level suggested directly from the survey. The source for those differences is the large chance of systematically negative response bias. Interestingly, there are much higher level of support for investment on bus. Our model indicates that only 19.19% respondents are not willing to see tax increases for it.

Table 4: Estimated regional willingness to support higher taxes (%)

Transportation Infrastructure/Mode		Reported level	Estimation models
Highway	much higher taxes	2.09	3.12
	slightly higher taxes	47.12	68.94
	no tax increases	50.79	27.94
Bus	much higher taxes	2.62	17.30
	slightly higher taxes	33.77	63.51
	no tax increases	63.61	19.19
Commuter rail	much higher taxes	7.85	12.07
	slightly higher taxes	37.70	56.35
	no tax increases	54.45	31.58
Street car	much higher taxes	3.40	3.76
	slightly higher taxes	15.97	7.49
	no tax increases	80.63	88.75
Light rail	much higher taxes	9.69	9.66
	slightly higher taxes	42.15	42.19
	no tax increases	48.17	48.16

5 Conclusions

This paper examines how an individual's socioeconomic characteristics affect her willingness to support tax increases for spending on transportation infrascture and public transportation in a fast expanding urban area. We control and estimate potential response bias in the data sample obtained from a survey conducted in the Charlotte, North Carolina, area. Individual decisions are also aggregated across the region to get a measure of the regional level of willingness to support.

Empirical results show that an individual's attitudes towards paying higher taxes are affected by the individual's location, home ownership, and the level of educational attainment. It is found that respondents tend to grossly under-report their willingness to support higher taxes for transportation investments on highways, bus, and commuter rail in the survey. Respondents exhibit positive tendency to choose no increase in taxes in the survey about highway, bus, and commuter rail, although they actually prefer an increase over no increase. They have positive chance of randomly choosing slightly higher taxes for more investment on streetcar whatever her true preference is.

Because the estimation framework used in the paper allows for protest zero bias and negative response bias, we established that support for more investment in the urban region of Charlotte, North Carolina is much more widespread than raw survey results could suggest.

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Appendix

Table A1: Estimates of the willingness to support higher taxes: Results for the re-categoried responses

Variable	Descriptions	Transportation infrastructure/mode				
		Highway	Bus	Commuter rail	Streetcar	Light rail
		(model 2)	(model2)	(model2)	(model 3)	(model 1)
Intercept1		0.53	11.14	3.35	-0.26	-1.46
		(2.97)	(102.18)	(2.62)	(2.75)	(0.98)
Education	13-15 years	1.67*	0.07	0.85	-0.10	0.32
		(1.00)	(0.65)	(0.60)	(0.43)	(0.34)
	16 years	2.11**	1.97	3.04**	0.28	1.54***
		(0.93)	(1.72)	(1.23)	(0.45)	(0.35)
	17+ years	1.54*	1.71	2.86**	0.53	1.00***
		(0.83)	(1.39)	(1.23)	(0.53)	(0.37)
Marital status	=1 if married	0.99	0.76	2.21***	0.55	0.72**
		(0.62)	(0.73)	(0.76)	(0.44)	(0.28)
Employment	=1 if employed	1.58	0.43	0.03	-0.39	0.14
		(0.99)	(0.59)	(0.56)	(0.34)	(0.23)
House ownership	=1 if own	-3.29	-9.99	-2.47**	-0.49	-1.18***
		(2.08)	(102.08)	(1.03)	(0.52)	(0.41)
Distance to CBD		-.14	-0.15	-0.16*	-0.14*	-0.04
		(0.10)	(0.10)	(0.08)	(0.08)	(0.03)
Congestion index		-0.01	-0.26	-0.84	0.09	0.99*
		(0.06)	(1.65)	(1.21)	(0.62)	(0.53)
Response bias	probability of respondents choosing no tax increase	0.3778*** (0.0599)	0.5001*** (0.0862)	0.3376*** (0.0572)	0.0000 (1.44)	
$-logL$		248.80	239.19	319.94	207.81	237.65
correct prediction		62.57%	63.61%	64.14%	80.63%	64.14%

Notes: Number of observations is 382. Standared errors are in parentheses; ***, ** and * indicate significance at 1%, 5% and 10%, respectively. Models 2 and 3 are the same when there are only two alternatives (i.e. "higher taxes" and "no tax increase") in the response variable.

[1] To conduct the survey, a random digit dial sample of residential telephone numbers was purchased from a private survey sampling firm. The random sample ensures that each household telephone in the county has an equal possibility of being called. Within each household, one adult (18 years or older) was designated by a random procedure to be respondent for the survey. This random selection procedure was designed to ensure that respondents of all ages and both genders were included in the survey process.

[2] We also estimated the models by dropping them from the data sample. The results from this other analysis

are almost the same and are available from the authors.

[3]In the empirical analyses reported in Section 4, the income variable is approximated by home ownership dummy and the dummies on the levels of educational attainment.

[4]There are no choice-specific independent variables in our data sample. The discrete choice models presented in this paper can be extended to consider such variables.