UNDERSTANDING THE MULTIPLE DIMENSIONS OF RESIDENTIAL CHOICE

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ABSTRACT

Residential choice may be characterized as a household's simultaneous decisions of location, neighborhood, and dwelling. Traditional models do not account for the latent unmeasured constructs which capture individuals' preferences for and attitudes towards residence and mode choice. This paper employs Bhat's (2014) Generalized Heterogeneous Data Model (GHMD) to accommodate five inter-related residential choice dimensions, including residential location, neighborhood land-use pattern, public transportation availability, housing type, and dwelling ownership. Four latent variables including pro-driving, pro-public transportation, facility availability, and residential spaciousness are constructed to capture individuals' attitudes towards travel modes and preferences for residential features. The inclusion of these latent constructs helps account for self-selection effects in residential choice processes. The determination of relationships among multiple dimensions of residential choice behavior, socio-demographics, and latent attitudes and preferences is critical to integrated land use – transport modeling and the formulation of policies as well as urban residential and neighborhood environments that cater to individual preferences and enhance quality of life.

KEYWORDS

1. INTRODUCTION

Residential land use occupies about two-thirds of all urban land (Guo and Bhat, 2007), indicating its central role in land-use planning. As an anchor point where individuals live with their families and start out-of-home activities (such as working, shopping, and recreation), residential location has an important effect on people's well-being, social status, and access to jobs, schools, and social networks (Mulder, 2007). Due to its multidisciplinary nature, residential choice has been the focus of study for engineers and planners, environmental designers, urban geographers, economists, architects, sociologists, and psychologists. From an activity-travel demand modeling perspective, it is essential for transportation planners to fully capture the decision mechanism underlying residential choice because of its long-standing influence on travel behavior (Srinivasan and Ferreira, 2002). For instance, individuals in a residential location with no public transit accessibility tend to use private vehicles more frequently than those who live in a neighborhood with convenient public transportation service. Given the important role residential location plays in the spatial distribution of people's activities and travel, it is conceivable that changes in travel behavior (towards more sustainable activity-travel patterns and choices) may be brought about through appropriate designs of the built environment and residential landscape. The recognition of the interactions between residential environment and transportation systems is fundamental to the application of integrated land-use and transportation modeling approaches in the metropolitan planning process (Waddell et al., 2007).

The issue with many residential location choice models is that they singularly focus on the choice of spatial unit, i.e., the location expressed as a dwelling unit, parcel, block, tract, or zone. However, it is conceivable that households, when making residential location choices, are choosing a bundle of attributes related to the environment in which they intend to reside. There is considerable evidence in the literature that alludes to the bundled nature of the residential choice phenomenon. Waddell (2001) notes that residential choice is a conglomeration of related dimensions including the location type, dwelling ownership (own or rent), neighborhood land use pattern, and type of housing. Harold and Leonard (1991) suggest that households make a simultaneous determination of the type of housing unit and residential location in the context of residential choice. Studies in the field of microeconomics also emphasize the necessity of simultaneously analyzing residence-related decisions (Barrios García and Rodríguez Hernández, 2008). According to Dieleman and Mulder (2002), residence selection includes both choice of a certain residential environment and type of dwelling. Jansen (2012) pointed out that residential choice involves multiple aspects, including the physical characteristics of available homes (e.g., housing type and number of bedrooms) and the regional or social characteristics of a neighborhood (e.g., proximity to a workplace). Previous studies have contributed to enhancing the conceptual understanding of factors influencing various dimensions of residential choice, and advancing the methodological approaches to residential choice modeling. However, the multi-faceted nature of residential choice processes has been relatively under-developed because of the inherent computational challenges associated with modeling multiple choice dimensions in an integrated simultaneous equations framework. The nested model structure and combinations of feasible alternatives of each choice dimension are the most common approaches used

when two or more residential choice dimensions are considered. An increase in choice dimensions makes it difficult to define the choice set as the structure of the nested model becomes rather complex and the number of combinations of alternatives will be extremely large which may result in a computationally intractable model. This paper aims to make a contribution to the simultaneous modeling of multiple residential choice dimensions using a novel integrated choice modeling approach that offers computational tractability.

Another important aspect related to residential location choice is that of "self-selection" whereby households and individuals self-select themselves to reside in neighborhoods or environments that are conducive to their preferred lifestyle. Traditional socio-economic characteristics such as income (Lee and Waddell, 2010) and lifecycle stage (Chen et al., 2013) are insufficient to understand residential choice behavior due to the residential self-selection phenomenon (Van Wee, 2009). Aeroe (2001) notes that housing and residential choices are a mechanism through which one attempts to realize lifestyle preferences. Households that intend to drive less and be physically active (Schwanen and Mokhtarian, 2005) are more likely to live in neighborhoods with abundant recreational facilities and sidewalks. The choice of a suburban neighborhood could be attributed to an individual's enjoyment of fast, flexible, and comfortable car travel, or the perception of cars as status symbols (Schwanen and Mokhtarian 2007). Handy and Clifton (2001) found that individuals who prefer walking to stores tend to choose residential neighborhoods with higher accessibility. In other words, the literature provides evidence of the presence of significant self-selection effects whereby attitudes, preferences, and lifestyle desires play a significant role in influencing residential location choice. Yet, virtually all residential location choice models in practice ignore such effects limiting the specifications to observed socio-economic and demographic variables, built environment variables, and network level of service and accessibility variables. By doing so, such models may exaggerate the potential impacts of built environment changes. This paper intends to address this issue through the incorporation of latent constructs that reflect the lifestyle preferences and modal attitudes of households and individuals in residential location choice.

The objective of this study is to simultaneously model the relationships between multi-dimensions of residential choice behavior, observable socio-demographic characteristics and individuals' latent attitudes and preferences. A comprehensive framework built on the multinomial probit (MNP)-kernel Generalized Heterogeneous Data Model (GHMD) proposed by Bhat (2014) is employed to jointly model the five dimensions of residential choice including location, neighborhood land-use pattern, public transportation availability in the neighborhood, housing type, and dwelling ownership. The data set used in this study is derived from the 2013 Housing, Transportation and Community survey conducted in the US.

The following section presents the data and sample used. The third section provides an overview of the modeling framework. The estimation and modeling results are presented in the fourth section. The concluding remarks and future research directions are discussed in the final and fifth section.

2.   DATA

The data for the current study is derived from the 2013 Housing, Transportation and Community Survey, conducted nationwide by the Urban Land Institute (ULI) to obtain information about household preferences and satisfaction related to residential choice. The survey includes a series of questions on respondent level of satisfaction with the current home, neighborhood, and transportation facilities. The survey questions also ask the respondents to specify their future desired features for neighborhoods, homes, and transportation facilities. The survey also collects detailed socio-demographic information.

The present study assumes the respondent's travel attitudes and residential preferences to represent those of the entire household. The residential choice behavior of all respondent types are of interest and hence specific survey questions pertaining to commuters only were excluded from the analysis. The survey sample following extensive data processing included 1300 respondents (households).

The model considers five dimensions of residential choice that are combined to reflect a household's residential choice bundle. In the modeling effort of this paper, the five dimensions of residential choice are jointly considered as dependent variables of interest. The descriptive characteristics of the choice dimensions (dependent variables) are provided in Table 1 and it is to be noted that these statistics represent information about the respondent's current residence and not their stated preference for future residence features. Within the survey sample used for this modeling effort, 21.5% of households (respondents) live in a rural area/small town, 43.5% live in a suburban area, and 35.1% live in an urban area. The majority of the households (63.4%) live in a single-family detached house followed by 24.1% in an apartment/condominium and 12.5% in a single-family attached/townhome. The proportion of households situated in a mixed land-use neighborhood versus a residential neighborhood is somewhat similar, with the former at 44.6% and the latter at 55.4%. The proportion of households that live in a neighborhood with access to public transportation (66.5%) is almost twice that of the proportion not having public transportation access (33.5%). It is found that 63.3% of the households own their home while 36.7% rent their property.

3.   METHODOLOGY

This section provides an overview of modeling process built on Bhat's (2014) Generalized Heterogeneous Data Model (GHMD) approach. This model enables the consideration of multiple ordinal, multiple count, multiple continuous, and multiple nominal variables jointly using a latent variable structural equation model that ties latent constructs to exogenous variables, and a measurement model that links the latent variables and possibly other explanatory variables to a set of different types of outcomes. The approach uses a multinomial probit kernel for the discrete (nominal, binary, and ordinal outcomes) and explains the covariance relationship among a large set of mixed data outcomes through a much smaller number of unobservable latent factors. The adoption of the MNP kernel for the nominal outcomes allows for correlations across error components of the utilities of different alternatives, and also enables the estimation of the model with relative ease using Bhat's (2011) maximum approximate composite marginal likelihood (MACML) inference approach. In particular, in this approach, the dimensionality of integration in the composite marginal likelihood (CML) function that needs to be maximized to obtain a consistent estimator (under standard regularity conditions) for the GHDM parameters is independent of the number of latent factors and easily accommodates general covariance structures for the structural equation and for the utilities of the discrete alternatives for each nominal outcome. Further,

the use of the analytic approximation in the MACML approach to evaluate the multivariate cumulative normal distribution (MVNCD) function in the CML function simplifies the estimation procedure even further so that the proposed MACML procedure requires the maximization of a function that has no more than bivariate normal cumulative distribution functions to be evaluated.

Details on the GHMD formulation, sufficiency conditions for identification of model parameters, and the MACML estimation approach for the formulation may be found in Bhat (2014). These details are suppressed here with a focus on the empirical analysis.

3.1   Behavioral Framework

The behavioral framework used in this paper to model the multiple dimensions of residential choice based on the methodology proposed by Ben-Akiva et al. (2002) and Bhat and Dubey (2014) is presented in Figure 1. The solid arrows in the figure represent the structural relationships and the dashed arrows represent the measurement relationships. The framework presented in Figure 1 is merely a graphical representation of the directions of relationships between variables in place of a full path diagram, and for purposes of brevity, does not list specific indicators for latent variables.

Two groups of latent variables are incorporated into the integrated model. The variables *pro-driving* and *pro-public transportation* are associated with household attitudes towards specific transportation modes and *facility accessibility* and *residential spaciousness* represent household desires and preferences for residential features. The *pro-public transportation* attitude reflects an individual's proclivity to use transit modes, while *pro-driving* represents an individual's preference for the use of the private automobile. Households with a higher preference for facility accessibility (such as proximity to shops, parks, and other public services) are expected to prefer a walking-friendly and high-density urban environment.

Following the construction of the latent variables (representing lifestyle preference and attitudes towards modes), the dependent variables are modeled as a bundle of choices. The latent constructs and socio-economic and demographic variables are used as explanatory variables in the discrete choice model set. All five choices are discrete variables with choice alternatives as shown in Table 1.
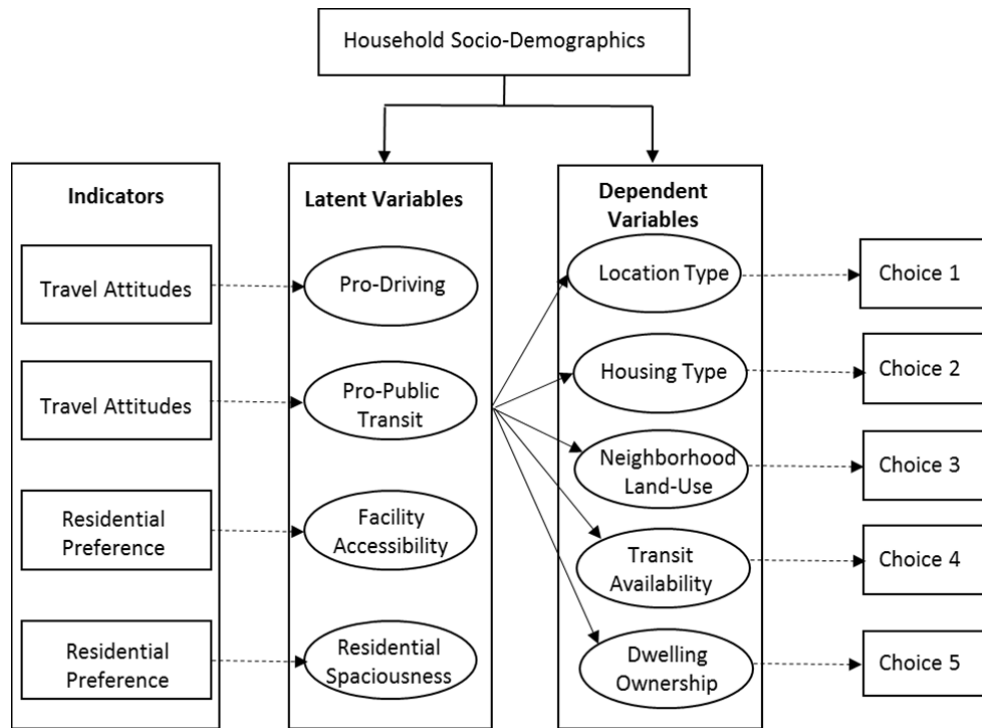
Figure 1. Behavioral Framework of Residential Choice Model

4.   MODEL ESTIMATION RESULTS

Estimation results for different components of the Integrated Choice and Latent Variable (ICLV) model are presented in this section.

4.1   Results of the Latent Variable Measurement Model

The estimation results for the latent variable measurement equation model are presented in Table 2. In the presentation, we do not provide the threshold parameters that govern the mapping of the underlying latent propensity of the ordinal indicators to the actual observed ordinal categories. These thresholds do not have a substantive interpretation, and are available on request from the authors.

Thirteen outcomes/indicators that contribute to the latent attitudes and preferences of the households are included in the model to provide measurement scales for the four latent variables. The results of the measurement equation model are quite intuitive and consistent with expectations. The measured attitudinal indicators that contribute to the pro-driving construct include the importance that individuals attach to expanding highways and maintaining local streets and roads, and willingness to pay for new roads. All of the constants are positive and factor loadings are significant, suggesting that individuals who score high on these variables are clearly auto-centric pro-driving in their attitude. On the other hand, those who are pro-public transportation indicate a greater willingness to pay taxes for expanding public transportation, consider the expansion of public transit important, and are willing to pay taxes to improve existing bus and rail services. The desire for accessibility to facilities is a latent construct that is represented by indicators representative of an individual's preference for a neighborhood that provides easy access to various amenities such shops and restaurants,

parks and playgrounds, places to walk or exercise, and large discount and warehouse stores. Proximity to shops, restaurants, and large discount warehouse stores appear to contribute more strongly to the facility accessibility construct. The residential spaciousness is captured by the importance that an individual attaches to having a large house, the importance of having privacy from neighbors, and the importance of buying as large a house as possible. The measurement equations provide a basis to use measured attitudinal indicators to construct a parsimonious set of latent constructs that may be used as explanatory variables in residential type choice models.

Typical household travel surveys do not collect information about attitudes and latent constructs (lifestyle preferences and perceptions of different modes). It is therefore essential to have a structural equations model system that relates the unmeasured latent constructs to observed and measured explanatory variables typically available in travel surveys. Through such a structural equations model system, the latent constructs can be estimated for each individual as a function of socio-economic and demographic characteristics. The estimated constructs, together with socio-economic variables, built environment attributes, network level of service variables, and accessibility indicators may then be included in residential type choice model specifications thus providing a mechanism to account for latent constructs in residential choice behavior models.

Table 3 presents the results of the latent variable structural equations model. Higher income individuals have a greater propensity to be pro-driving and men tend to have stronger pro-driving attitudes compared to women. These findings are consistent with those reported by Ory and Mokhtarian (2005). Individuals with lower incomes tend to be pro-public transportation possibly due to their lower levels of auto affordability and dependency on transit services. Higher education levels are associated with a pro-public transportation stance, suggesting that individuals with higher levels of education are interested in supporting and using transit if the opportunity presents itself. Older individuals, on the other hand, are less likely to be pro-public transportation. It is likely that older individuals are not as environmentally conscious as younger individuals and are therefore not as pro-public transportation as their younger counterparts.

The latent variable on facility accessibility reflects individual's desire for proximity to various facilities (e.g., shops and parks) within the neighborhoods. Individuals with low income (<\$50,000) exhibit a greater desire for facility accessibility, presumably because of their desire to access opportunities at low transportation costs. Men are less concerned about facility accessibility when compared with women, likely reflecting the activity-travel needs and desires of women who continue to shoulder a greater share of household obligations and responsibilities. Individuals aged between 30 and 49 years show a diminished level of need for facility accessibility, perhaps because they enjoy a high level of mobility and are able to access destinations and opportunities even if they are at a farther distance.

High-income households/individuals and households with children are likely to prefer spacious housing units. These findings are consistent with expectations as one would expect higher income households to be interested in the luxury that larger dwelling units afford and households with children appreciate the space and capacity that larger housing units provide. It is found that men prefer spatial residences more so than women. The elderly, who may not be all that interested in maintaining a large home, and are likely to be retired on a fixed income and have smaller household sizes (with the children having moved out), express a preference for smaller housing units.

A positive correlation (0.425) was estimated between the latent variables *pro-driving* and *residential spaciousness*. This is behaviorally intuitive as large houses with considerable privacy from neighbors are usually built in lower density suburban areas where the transportation system attributes are auto-centric and favor driving. In other words those who

favor large houses are also likely to be pro-driving in nature. An urban area with a mixed land use pattern is typically more easily served by public transportation, and this seems to be a plausible explanation for the positive correlation (0.149) between the latent variables *facility availability* and *pro-public transportation*. In other words, those who consider access to facilities important are likely to favor neighborhoods that are dense, have mixed land use, and are well served by transit.

4.2   Results of Discrete Choice Models

The estimation results of the discrete choice models with five dependent variables (including two nominal and three binary) are displayed in Table 4. The "Rural Area" is selected as the base alternative for the residential location choice models. The positive and negative constants for suburban and urban alternatives indicate there is a baseline preference for residing in a suburban neighborhood characterized by larger homes, auto-centric transportation systems, and low-medium density of land use. Individuals aged between 30 and 49 years and those with higher education levels (Bachelors or Post Graduation) have a higher propensity to live in suburban areas. Single individuals have a greater inclination to reside in urban areas, probably due to the accessibility to a number of activity opportunities that such locations offer, a finding that is also reported by Bagley and Mokhtarian (1999). Employed individuals opt for urban areas, presumably to keep commute durations low and access a variety of employment opportunities (Schwanen and Mokhtarian, 2007), while retired people tend to prefer suburban and rural areas over urban areas possibly seeking a quieter lifestyle. As expected, the latent variables significantly influence choice of residential location. Those who are pro-driving prefer suburban areas, those who are pro-public transportation prefer urban areas and are less likely to reside in rural areas, and those favoring residential spaciousness are likely to seek the space they desire in rural areas. All of these findings are intuitive and consistent with expectations, and more importantly, statistically significant clearly indicating that models that omit such latent constructs suffer from omitted variable bias.

For the housing type model, single-family detached house is the chosen base alternative. The negative constants for both apartment and single-family attached house alternatives indicate that the baseline preference is in favor of the choice of a detached single-family dwelling. As expected, single and separated individuals are more likely to reside in apartments presumably because of the smaller sample sizes and lower incomes of these household types. Relative to households in the highest income category, households in the lower income category are more likely to live in apartments, possibly due to cost considerations. Individuals with higher levels of education are less likely to reside in single family attached housing units while those with just a high school diploma are more likely to reside in such units. Married individuals are also less likely to reside in single family attached housing units. Blacks and Asians are more likely to reside in apartments. All of these findings are consistent with expectations and residential patterns of choice observed in the real world and reflect the role played by ethnic, income, lifecycle stage, and educational attributes on housing choice. Once again, latent variables play a significant and important role. Pro-driving individuals favor single-family detached housing and single-family attached housing (over apartments), suggesting that these individuals seek the lower density environments with this type of housing. Those who are pro-public transportation prefer apartments, which are likely to be located in higher density areas served by transit. Those seeking residential spaciousness prefer to reside in single-family detached and single-family attached housing units over apartments, a finding that is consistent with expectations.

The neighborhood land-use pattern is a binary choice of residential (base) or mixed

land-use. Minority groups including African-American, Hispanic, and Asian individuals show a preference for mixed land-use neighborhoods, presumably due to cultural differences and income considerations. Individuals who are married or have children are less likely to choose neighborhoods with mixed land-use; these households are more likely to choose suburban housing enclaves that are more homogeneous in nature. Employed individuals prefer mixed land use environments, presumably to take advantage of the opportunities that such locations offer. On the other hand, retired individuals who may not have the same need for diverse employment and destination opportunities prefer to reside in housing-only neighborhoods. Recent movers are found to prefer mixed land use environments, possibly because they want to have easy access to various opportunities in a new and unfamiliar location. Those who are pro-public transportation prefer mixed land use environments while those who crave residential spaciousness are likely to choose housing-only enclaves (likely located in suburban areas that offer larger housing options).

In terms of public transportation availability, it is found that minority groups prefer neighborhoods with good transit service, once again reflecting cultural differences (a greater propensity and willingness to use transit) and income considerations. The absence of public transportation is chosen the base alternative in the model. Similarly, those who are single or separated prefer neighborhoods with public transportation. Married households, on the other hand, are likely to favor areas not well served by transit (suburban areas, for example). Also, individuals who moved in the past three years prefer to reside in neighborhoods with access to public transportation, a finding that reinforces the result reported previously where recent movers prefer to reside in areas with mixed land use. As expected, the latent construct depicting a pro-public transportation attitude is found to significantly favor the choice of a neighborhood that is well served by transit.

In the dwelling ownership model, it is found that older individuals tend to own a home when compared with younger counterparts possibly due to household size and income effects. Those with a lower level of education are less likely to own their home. Minority groups are less likely to own a home, reflecting income disparities that may be contributing to differential levels of home ownership. These results are consistent with those reported by Harold and Leonard (1991). Married individuals, and employed and retired individuals (as opposed to homemakers, students, and unemployed individuals) are more likely to own a home. Recent movers are more likely to rent, a finding consistent with expectations as individuals may choose to explore an area for a while before purchasing a home. Pro-driving individuals are likely to own a home (possibly in an auto-centric suburban area), while pro-transit individuals and individuals who desire facility accessibility are likely to rent (likely in transit-friendly mixed land use areas). These findings point to the important and significant role played by latent constructs in home ownership and residential choice.

Based on the above results, it can be concluded that the bundle of residential choices, corresponding to location, neighborhood land use pattern, availability of public transportation, housing unit type, and dwelling ownership status, and the latent variables corresponding to household preferences and attitudes are closely related.

5.   CONCLUSIONS

Modeling of residential location choice has been an important facet of travel demand forecasting due to the important role that residential location attributes play in shaping daily activity-travel patterns. Residential location models have hitherto focused largely on predicting the spatial unit (such as a traffic analysis zone) chosen by households for their residence. However, there is a growing recognition that residential choice involves a bundle of multiple dimensions that are interrelated. In order to more comprehensively model residential choice processes of households, this paper employs the Generalized

Heterogeneous Data Model framework proposed by Bhat (2014) to jointly model five residential choice dimensions including location type, neighborhood land-use pattern, public transportation availability in the neighborhood, housing type, and dwelling ownership. Four latent variables that describe individual/household travel attitudes and residential preferences are considered to help account for self-selection effects in explaining and modeling household residential location decisions.

The current study utilizes data from the 2013 Housing, Transportation and Community Survey conducted nationwide by the Urban Land Institute (ULI). The study offers several important findings. The latent constructs depicting individual attitudes towards travel modes and lifestyle preferences were found to play an important role in the multiple dimensions of residential choice. In general, individuals (or households) making residential choice decisions seek the residence that best satisfies their array of lifestyle and modal preferences. This is an important consideration in the context of implementing policies that aim to modify travel behavior through changes in the built environment and land use, as the effects of such policies cannot be accurately estimated without considering the self-selection effects that derive from attitudes and preferences. As expected, individual and household socio-demographic characteristics are found to be strongly associated with residential choice. For example, retirees have a greater propensity to own their homes, and are less likely to live in urban neighborhoods with mixed land-use patterns. Education, race, employment status, marital status, and age are other socio-economic variables that play a significant role in shaping residential choices.

The results confirm the key role played by latent attitudinal and lifestyle variables in shaping the multiple dimensions of residential choice. Specifically, residential location, neighborhood types (including land-use pattern and public transportation availability), housing type, and dwelling ownership are all endogenous variables depicting residential choice, emphasizing the need for multidimensional modeling of residential attributes. The construction of a latent variable structural equations model offers the ability to estimate latent attitudinal and lifestyle constructs as a function of observed socio-economic and demographic variables, and include such constructs in models of residential choice. Thus the model system presented in this paper overcomes the challenge associated with including attitudinal and lifestyle variables that are not typically observed in travel surveys, in residential choice model specifications. The model system presented in this paper should be extended to include built environment and level of service variables, along with additional choice dimensions such as housing cost and housing unit configuration (square feet, number of rooms, year of construction) to develop a comprehensive model system of residential choice.

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Table 1 Descriptive Statistics of Dependent Variables

Choice dimension	Alternatives	Proportion (%)
Location	Rural	21.46
	Suburban	43.46
	Urban	35.08
Housing type	Single-family detached house	63.38
	Apartment/Condominium	24.08
	Single-family attached house	12.54
Neighborhood land-use pattern	Residential	55.38
	Mixed land-use	44.62
Public transportation availability	No	33.46
	Yes	66.54
Dwelling ownership	Rent	36.69
	Own	63.31

TABLE 2 Latent Variable Measurement Equation Model

Latent variables	Indicators	Scale	Constant (t-stat)	Factor loading (t-stat)
Pro-driving	Importance of "Expanding highways"	5	1.443 (44.13)	0.394 (11.42)
	Importance of "Maintaining local streets and roads"	5	2.173 (72.92)	0.11 (4.7)
	Willing to pay taxes for "New roads"	3	0.188 (8.91)	0.32 (8.31)
Pro-public transportation	Importance of "Expanding local bus services"	5	1.19 (21.79)	0.783 (8.23)
	Willing to pay taxes for "Expansion of public transportation, like bus or rail"	3	-	3.372 (1.04)
	Willing to pay taxes for "Better quality and service from existing public transportation, like bus or rail"	3	-	2.394 (1.94)
Facility accessibility	Attitudes: "Shops or restaurants within an easy walk of your house"	3	1.54 (3.86)	0.691 (1.26)
	Attitudes: "Parks and playgrounds"	3	1.944 (1.86)	-
	Attitudes: "Places to walk or exercise for fun"	3	2.342 (1.23)	-
	Attitudes: "Large discount or warehouse stores"	3	1.23 (5.67)	0.568 (1.41)
Residential spaciousness	Importance of "Having a large house"	5	1.386 (1.43)	2.208 (1.17)
	Importance of "Privacy from neighbors"	5	1.87 (38.09)	0.398 (5.36)
	Importance of "Being able to buy as large a house as you can"	5	1.082 (2.41)	1.716 (1.75)

TABLE 3 Latent Variable Structural Equation Model

Variable	Coefficient (t-stat)
Pro-Driving	
Household Income (base is more than $100,000)	
Less than $25,000 (Yes=1, No=0)	-1.262 (-29.01)
$25,000–$50,000 (Yes=1, No=0)	-0.652 (-28.10)
$50,001–$75,000 (Yes=1, No=0)	-0.230 (-16.08)
$75,001–$100,000 (Yes=1, No=0)	-0.020 (-1.38)
Gender (Male=1, Female=0)	0.114 (11.18)
Pro-Public Transportation	
Household Income (base is more than $100,000)	
Less than $25,000 (Yes=1, No=0)	0.168 (16.8)
$25,000–$50,000 (Yes=1, No=0)	0.044 (6.88)
Education Status (base is some college)	
Bachelor degree (Yes=1, No=0)	0.187 (30.66)
Post-graduate degree (Yes=1, No=0)	0.203 (24.17)
Age (base is 18–29 years old)	
50–64 years old (Yes=1, No=0)	-0.283 (-37.73)
Older than 64 years old (Yes=1, No=0)	-0.453 (-37.75)
Facility Availability	
Household Income (base is more than $100,000)	
Less than $25,000 (Yes=1, No=0)	0.173 (1.95)
$25,000–$50,000 (Yes=1, No=0)	0.066 (1.82)
Gender (Male=1, Female=0)	-0.200 (-2.04)
Age (base is 18–29 years old)	
30–49 years old	*-0.039 (-1.75)*
Residential Spaciousness	
Presence of children in the household (Yes=1, No=0)	0.497 (7.41)
Household Income (base is more than $100,000)	
$50,001–$75,000	0.082 (5.19)
$75,001–$100,000	0.138 (6.00)
Gender (Male=1, Female=0)	0.135 (6.49)
Age (base is 18–29 years old)	
Older than 64 years old (Yes=1, No=0)	-0.553 (-7.48)

TABLE 4 Estimation Results of the Discrete Choice Models

Variable	Coef	t-stat	Coef	t-stat	Coef	t-stat
Residential location (base: rural area)	**Rural**		**Suburban**		**Urban**	
Constant			0.502	15.79	-0.826	-10.35
Socio-demographic attributes						
Age (base is 18–29 years old)						
30–49 years old (Yes=1, No=0)			0.043	4.22		
Education Status (base is some college)						
High school degree (Yes=1, No=0)			-0.183	-17.10		
Bachelor degree (Yes=1, No=0)			0.086	7.75		
Post-graduate degree (Yes=1, No=0)			0.143	9.17		
Race (base is white)						
Black (Yes=1, No=0)					0.863	13.99
Asian (Yes=1, No=0)					0.652	13.15
Marriage status (base is unmarried and living with partners)						
Married (Yes=1, No=0)			-0.220	-19.47		
Single (Yes=1, No=0)					0.520	14.02
Employment status (base is others, including students, homemakers, and unemployed)						
Employed (Yes=1, No=0)					0.426	14.01
Retired (Yes=1, No=0)					-0.394	-11.55
Moving in the last three years (Yes=1, No=0)					0.588	13.71
Latent variables						
Pro-driving			0.539	16.23		
Pro-public transportation	-0.459	-9.72			0.282	6.18
Facility availability						
Residential spaciousness	0.098	5.36				
House type (base is single-family detached house)	**Single-family detached house**		**Apartment**		**Single-family attached house**	
Constant			-1.850	-27.17	-1.679	-2.38
Socio-demographic attributes						
Education Status (base is some college)						
High school degree (Yes=1, No=0)					0.057	2.01
Bachelor degree (Yes=1, No=0)					-0.208	-2.37
Post-graduate degree (Yes=1, No=0)					-0.482	-2.37
Household Income (base is more than $100,000)						
$50,001–$75,000 (Yes=1, No=0)			0.036	1.67		
$75,001–$100,000 (Yes=1, No=0)			-0.004	-0.15		
Race (base is white)						
Black (Yes=1, No=0)			0.330	16.34		
Asian (Yes=1, No=0)			0.555	15.72		
Marriage status (base is unmarried and living with partners)						
Married (Yes=1, No=0)					-0.222	-2.36
Single (Yes=1, No=0)			0.323	18.56		
Separated (Yes=1, No=0)			0.514	20.16		

Moving in the last three years (Yes=1, No=0)			0.755	24.59		
Latent variables						
Pro-driving	0.776	13.59			0.405	3.04
Pro-public transportation			0.647	13.12		
Facility availability						
Residential spaciousness	0.197	6.06			0.350	4.26

Neighborhood land-use pattern (base is only houses)	**Only houses**		**Mixed land-use**	
Constant			-0.302	-29.90
Socio-demographic attributes				
Race (base is white)				
Black (Yes=1, No=0)			0.292	27.29
Hispanic (Yes=1, No=0)			0.247	25.73
Asian (Yes=1, No=0)			0.222	14.32
Marriage status (base is unmarried and living with partners)				
Married (Yes=1, No=0)			-0.014	-1.77
Employment status (base is others, including students, homemakers, and unemployed)				
Employed (Yes=1, No=0)			0.205	23.56
Retired (Yes=1, No=0)			-0.030	-2.50
Presence of children (Yes=1, No=0)			-0.133	-9.05
Moving in the last three years (Yes=1, No=0)			0.210	26.58
Latent variables				
Pro-driving				
Pro-public transportation			0.595	18.89
Facility availability				
Residential spaciousness	0.067	2.89		

Public transportation availability in the neighborhood （base is no）	**No**		**Yes**	
Constant			0.171	13.05
Socio-demographic attributes				
Race (base is white)				
Black (Yes=1, No=0)			0.253	25.56
Hispanic (Yes=1, No=0)			0.495	53.80
Asian (Yes=1, No=0)			0.684	41.45
Marriage status (base is unmarried and living with partners)				
Married (Yes=1, No=0)			-0.210	-18.10
Single (Yes=1, No=0)			0.118	9.37
Separated (Yes=1, No=0)			0.191	14.04
Employment status (base is others, including students, homemakers, and unemployed)				
Employed (Yes=1, No=0)			0.301	43.62
Moving in the last three years (Yes=1, No=0)			0.224	30.27
Latent variables				
Pro-driving				
Pro-public transportation			0.331	16.39
Facility availability				

Residential spaciousness				
Dwelling ownership (base is renting)	**Renting**		**Owning**	
Constant			1.872	8.59
Socio-demographic attributes				
Age (base is 18–29 years old)				
30–49 years old (Yes=1, No=0)			-0.351	-8.34
50–64 years old (Yes=1, No=0)			0.445	8.32
Education Status (base is some college)				
High school degree (Yes=1, No=0)			-0.519	-8.58
Race (base is white)				
Black (Yes=1, No=0)			-0.867	-8.61
Hispanic (Yes=1, No=0)			-0.544	-8.51
Asian (Yes=1, No=0)			-0.428	-6.90
Marriage status (base is unmarried and living with partners)				
Married (Yes=1, No=0)			0.919	8.93
Employment status (base is others, including students, homemakers, and unemployed)				
Employed (Yes=1, No=0)			0.166	6.86
Retired (Yes=1, No=0)			0.647	8.80
Moving in the last three years (Yes=1, No=0)			-1.844	-8.89
Latent variables				
Pro-driving			1.739	6.77
Pro-public transportation	0.535	6.14		
Facility availability	0.189	1.94		
Residential spaciousness				