# A JOINT MODEL OF RESIDENTIAL RELOCATION CHOICE AND UNDERLYING CAUSAL FACTORS


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## ABSTRACT

Residential location choice is a key determinant of activity-travel behavior and yet, little is known about the underlying reasons why people choose to move, or not move, residences. Such understanding is critical to being able to model residential location choices over time, and design built environments that people find appealing. This paper attempts to fill this gap by developing a joint model of the choice to move residence and the primary reason for moving (or not moving). The model is estimated on the Florida subsample of the 2009 National Household Travel Survey. Model results shed considerable light on the socio-economic and demographic variables that impact household decision whether to move residence and the primary reason underlying that decision.

## INTRODUCTION

Residential location choice is a topic of much interest because decisions about where to work, shop, go to school, or pursue recreational activities are all inextricably tied to people's residential location (*1*). Although there is considerable literature devoted to modeling and describing residential location choice behavior, an understanding of the underlying factors that contribute to a household decision to relocate residence (or not) continues to be challenging and in need of further enquiry. To set the context, we first briefly identify the factors that have been identified as determinants of residential relocation in the next section, followed by an overview of the methods used for residential relocation modeling in the subsequent section. Within each of these two sections, we position and highlight the salient aspects of this study.

### Factors Affecting Residential Relocation

Previous research has shown that at least four categories of factors affect residential relocation. The first category corresponds to household demographic and socio-economic factors. Previous research has indicated that relocation is highest among younger adults (*2*) and lowest among older households (*3*). Many research efforts have found that residential relocations are also high among households who have experienced life course changes in household structure, lifecycle stage, and employment, say due to marriage, child birth, divorce, retirement, or an occupation change (*4-6*). Household income and race also impact residential mobility (*7*), with an increase in household income leading to a higher move propensity and Caucasian households being more likely to move than non-Caucasian households.

Besides demographic and socio-economic attributes, a second category of attributes influencing residential relocation are the characteristics/tenure type of the housing unit itself and the housing market conditions, including considerations of housing price (*2*), home size (*8*), and the age of the unit (*9*). In terms of tenure type, previous research suggests that renters are about twice as likely to move as home owners, a reflection of the high transaction costs of getting out of a currently owned home relative to getting out of a rented unit (*10*). The move decision is also closely tied with the state of the housing market (for example, home mortgage rates and demand versus supply of rented units and housing units; see (*11,12*)).

A third category of factors corresponds to neighborhood attributes. As expected, neighborhood safety and crime rates are important considerations (*13*). Significant clustering effects have also been found, with households seeking neighborhoods where the household demographic characteristics match their own (*1,2*). School quality is another major consideration, particularly for households with children (*14*). The measurement of school quality, however, has presented a challenge with various surrogates such as expenditure per pupil or school rankings/ratings serving as proxies of school quality (*15*). Finally, as people become increasingly embedded in the community and form social networks, their likelihood of moving decreases (*16*).

Fourth, and perhaps most relevant in a transportation planning context, are considerations of transportation and accessibility, both for work and non-work activities. Several studies have reported that commute length is a major consideration in home and work location choice (*17,18*). In addition, accessibility to shopping and retail destinations (*18,19*) as well as recreational opportunities, health care facilities, and open space (*20*) has been shown to be significant in residential location choice. Zondag and Pieters (*21*) have shown that households are less likely to move from high accessibility locations.

The literature above has certainly provided a rich body of knowledge regarding factors affecting residential relocation. However, an important issue that has received less attention is the direct introduction of qualitative factors that individuals and households consider important in a home and in a neighborhood (such as importance of neighborhood quality, quality of home, closeness “feel” to work, retail, and recreational outlets, and school system quality). These factors can be very important in relocation decisions, but at the same time are difficult to directly quantify. For instance, the challenge in measuring school quality has already been discussed before, and the same holds for neighborhood quality, home quality, and other qualitative factors. Indeed, this has caused problems in earlier studies of residential location and re-location, in which many studies have found, for example, that measures used for school quality did not to turn out to be statistically significant in residential choices (even for families with small children; see, for example, (*15*)). At the same time, there is a growing body of literature that indicates that the qualitative views and desires (characterized also as lifestyles and attitudes/perceptions) of decision agents are important determinants of choice decisions (see (*22*,*23*) for in-depth social psychology expositions of the theoretical and conceptual reasons for the influence of lifestyle and attitudes/perceptions on observed choice behavior; due to space limitations, we are unable to discuss these issues at length in the current paper). Transportation researchers have also started to recognize the importance of lifestyles and attitudes/perceptions in empirical work on activity-travel behavior (see (*24-26*) for just a few examples), though there has been relatively little research in including such factors in residential mobility decisions. In this paper, we fill this gap by considering a set of qualitative factors (which we will also refer to as the “primary reasons of residential choices”) as explicit determinant variables in household residential relocation decisions.

**Methods Used for Residential Relocation Modeling**

There are, of course, many different approaches to modeling residential relocation, including spatially aggregate models that estimate the fraction of households in a given neighborhood that may be expected to relocate (based on aggregate neighborhood demographic, socioeconomic, and other factors) and micro-level models that operate at the level of individual households. In this brief overview, we will examine only the latter, more behaviorally appealing type of models. In the category of micro-level models, a common method used for modeling residential relocation entails the use of a binary discrete choice model. This is based on cross-sectional data drawn from typical activity-travel surveys that seek information on whether the sampled household moved within the past “x” years or not. These binary models typically link mobility decisions to the types of non-qualitative factors identified in the previous section. The advantage of such models of relocation behavior is that they are estimable from readily available cross-sectional activity-travel surveys (see, for example, (*27,28*)). Once estimated, these micro-level models can be embedded in a straightforward manner within activity/travel demand simulation models. In particular, using current demographic and socio-economic factors, and the current housing unit attributes and the transportation/accessibility environments of households, the micro-level models can be used to forecast whether or not a household will move in a time step of “x” years (usually one year) from the current time, followed by a model to locate the household in a new home for the next time-step conditional on a positive relocation decision. This process is continued until the forecast year is reached. Several comprehensive model systems of urban land-use and activity-travel patterns such as CEMUS (*7*), URBANSIM (*29*), and ILUTE (*30*) use the procedure just discussed or its variants.

Another growing stream of research uses longitudinal data to study residential mobility decision processes in combination with other life course event processes to explicitly recognize the close linkage between the processes. The life course events may include household structure changes (for example, the birth of a child, marriage formation and dissolution, and the death of an individual), employment changes (for example, a new job, movement from unemployed status to employed status, or vice-versa), and changes in mobility tools (for example, change in car ownership level and/or type of cars, and presence of new transportation options). In addition to recognizing the linkage between the many life course processes, a particular advantage of these longitudinal models is that they are able to consider the temporal dynamics (lead and lag time duration effects) of choices, while cross-sectional data methods cannot. A rich set of multiple duration models are now available to capture the temporal dependencies within the same life course process as well the dependencies across life course processes (see (*31*) for a discussion of these methods). The longitudinal data for life course analysis may be obtained either through a long-term panel survey of households or through a retrospective approach that asks households to recall their event histories over an extended period of time. The panel survey approach has the advantage of reliability, though such an approach is expensive, time-consuming, and may suffer from household attrition problems. The retrospective survey approach is relatively easy and convenient, although such surveys covering long periods do raise questions regarding the accuracy of memory recall. In the literature, it is more common to use the retrospective approach to obtain information on the life courses (also, sometimes referred to as biographies) of events (see, for example, (*4,27,31,32*)). These life course models may also be incorporated in comprehensive models of urban land-use, though this is perhaps not as straightforward as for cross-sectional micro-models because of the many intricate linkages and sequentialities that need to be appropriately considered and implemented.

In the current paper, we use the micro-level cross-sectional approach to examine residential relocation decisions rather than the longitudinal approach. While the approach is not as behaviorally rich in accommodating temporal dynamics as earlier life course studies, the current study is behaviorally rich in capturing qualitative factors in ways that previous life course studies (and micro-level studies) do not. In this regard, the current study and life-course studies both have the same general goal of incorporating more behavioral realism in the process leading up to residential relocation decisions (compared to traditional micro-level studies), though the mechanism to add behavioral realism is different. Another common theme between the life course studies and the current study is that both "movers" and "stayers" are considered in all aspects of the analysis, though again in different ways. In the life course studies, both respondents who move and stay during the observed period of time are considered in the duration dynamics (through the use of censoring techniques in event-history models), while in the current paper the effects of qualitative factors are accommodated both for those who move and stay (through the use of a joint discrete choice model for the qualitative factors and the move/no-move decision). Thus, in the current study, the qualitative factors are considered for "mover" households (in terms of the new residence attributes that these households found appealing) and for "stayer" households (in terms of the current residence attributes that these households found appealing) in an examination of the effects of qualitative factors on residential relocation decisions. For instance, households that qualitatively value cost substantially may be less likely to move because they already have found a "good deal" in their current home (as a result of their cost-conscious nature in the first place) and are also sensitive to fixed moving costs (see (*33*)). Such effects can, of course, be examined by including the qualitative factors as determinant variables in a model of "move versus not move". However, in doing so, it is important to control not only for observed factors, but also unobserved household factors that impact the household's primary qualitative reason for residential choice and the relocation decision. For instance, consider the case of a household that is intrinsically mobile (becomes satiated quickly with a particular setting and constantly wants change). This "intrinsic mobility desire" is not observed by the analyst, but can be manifested in the form of the household indicating that "neighborhood quality" (a convenient "catch all" from the household's standpoint if it gets satiated with a particular locational setting) is its primary reason for residential choice. On the other hand, neighborhood quality is intended to be a subjective perception of objective neighborhood issues such as social vibrancy and low crime rates, and not intrinsic household mobility desires. The net result would then be that intrinsic mobility desires (an unobserved variable) can increase the propensity of a household choosing "neighborhood quality" as the primary driver of residential choice as well as increase the household's propensity to move. If such unobserved effects are not considered, it could provide inappropriate effects of the drivers of residential choice on the move/not move decision (in the example provided, a potentially incorrect conclusion that those who value neighborhood quality are more likely to move when they are not). Overall, there are strong reasons to model both the drivers of residential choice as well as move/not move decisions jointly, and use information from both movers as well as non-movers.

### A Summary of the Paper Context and the Paper Structure

In summary, the <u>substantive emphasis</u> of this paper is to unravel the processes at play in households choosing to move, or stay in, their residential locations, with a focus on the qualitative reasons that households choose to move or stay. The use of such data offers insights that other analyses, employing secondary housing and neighborhood data at various spatial scales appended after the fact to household location choice information, cannot offer. The <u>methodological innovation</u> in the paper is the formulation of a bivariate multinomial probit (MNP) choice model system to jointly model the move/stay decision and the primary reasons for residential choice. Such a system treats the qualitative determinants of residential choice (obtained in the form of primary reasons to move or stay) as endogenous to the moving behavior. The model is estimated using Bhat's Maximum Approximate Composite Marginal Likelihood (MACML) procedure. The data sample of households for the analysis is drawn from the Florida add-on of the 2009 National Household Travel Survey. This sample responded to a series of questions regarding the primary reasons for moving, or staying in, their residence over the past five years. The survey did not collect life-cycle events for the respondents, and so is not suitable for the type of life course investigations undertaken by some earlier research efforts, though it offers a unique opportunity to investigate the effects of qualitative factors, as discussed in the previous section.

The remainder of this paper is organized as follows. The next section presents a brief review of the literature. The third section presents the model formulation and estimation methodology. The fourth section provides a description of the data while the fifth section offers model estimation results. Concluding thoughts are made in the sixth and final section.

## MODELING METHODOLOGY

This section presents the modeling methodology employed in this paper.

**Model Framework**

Let $g$ be the index for the nominal dependent variables ($g$ = 1, 2, 3, …, G). Also, let $I_g$ be the number of alternatives corresponding to the $g^{th}$ nominal variable ($I_g \geq 2$) and $i_g$ be the corresponding index ($i_g$ = 1, 2, 3, …, $I_g$). In the current empirical context, there are two nominal variables (G = 2). The first is a binary choice of whether a household has moved or not in the past five years, and the second is a multinomial choice of the primary reason for the household choosing their residential home/location. In the model estimated for this paper, $I_1 = 2$ (two alternatives- whether the household moves or not) and $I_2$ = 9 (nine alternatives which together constitute the choice set for the primary reason for choosing a specific residential home/location). In the rest of this section, the model formulation is presented for the case where G = 2 nominal variables.

Consider the following equation system:

$$U_{11} = \varepsilon_{11},\, U_{12} = \boldsymbol{\delta}'\boldsymbol{w}_{12} + \boldsymbol{\gamma}'\boldsymbol{A}_2 + \varepsilon_{12}$$
$$U_{2i_2} = \boldsymbol{\beta}_2 \boldsymbol{x}_{2i_2} + \varepsilon_{2i_2}, \tag{1}$$

where $U_{11}$ and $U_{12}$ represent the utility of not moving and moving, respectively, and $U_{2i_2}$ $(i_2 = 1, 2, ..., 9)$ represents the underlying latent variable for the $i_2^{\,th}$ qualitative reason (home cost, home quality, and home size, for example) driving residential choice decisions (note that residential choice, as used here, includes both the choice of home as well as location). The vectors $\boldsymbol{w}_{12}$ and $\boldsymbol{x}_{2i_2}$ are columns of exogenous attributes with corresponding coefficient vectors $\boldsymbol{\delta}$ and $\boldsymbol{\beta}_2$, while $\boldsymbol{A}_2$ is a (9×1)-column vector of binary (0/1) indicator variables for the stated primary qualitative reason driving the household's residential choice decisions. Thus, if the household indicates that alternative $m_2 \in (1, 2, ..., 9)$ is the primary reason driving residential choice, then the vector $\boldsymbol{A}_2$ will have a '1' entry in its $m_2^{\,th}$ row and 0 elsewhere. Also, $\boldsymbol{\gamma}$ is a coefficient vector to be estimated. One of the nine possible qualitative reasons forms the base category in the relocation equation. Assume, without any loss in generality, that this is the first qualitative reason and set $[\boldsymbol{\gamma}]_1 = 0$, where ($[\boldsymbol{\gamma}]_{m_2}$ denotes the $m_2^{\,th}$ element of $\boldsymbol{\gamma}$ ).

The intent of including the qualitative vector $\boldsymbol{A}_2$ driving residential choice decisions in the move/no-move equation is to examine if individuals with certain kinds of residential choice preferences are more likely to move or not. Thus, for example, it may be the case that households who are particularly cost-sensitive are less likely to move (as discussed earlier), while those who place a premium on school quality are more likely to move (since they are perhaps constantly on the look-out for locations with better school quality). Thus, the structural interpretation of the first equation in (1) is that, if a household were randomly observed (without any information on whether it had moved recently or not) to pick alternative $m_2$ as the primary reason driving its residential choice, then the probability of a move would be $P[\boldsymbol{\delta}'\boldsymbol{w}_{12} + [\boldsymbol{\gamma}]_{m_2} + \varepsilon_{12} > \varepsilon_{11}]$, which is a simple univariate cumulative normal distribution function assuming $\varepsilon_{11}$ *and* $\varepsilon_{12}$ are normally distributed.

However, the observations of the primary reasons of residential choice in the sample are not random; rather, these primary reasons are obtained from a sample of households that moved and from a sample of households that did not move. For the reasons mentioned in the first section, there are likely to be observed and unobserved factors that impact the primary reason for choosing residential locations as well as mobility choices. While the observed effects can be captured by having common variables in the $\boldsymbol{w}_{12}$ and $\boldsymbol{x}_{2i_2}$ vectors, the common unobserved effects can lead to correlations between the $\varepsilon_{12}$ and the $\varepsilon_{2i_2}$ $(i_2 = 1, 2, ..., 9)$ terms, which implies that the equation system (1) should be estimated jointly due to sample selection effects (in the context of the discussion in Section 1, ignoring the jointness in the two equations in (1) can, and in general will, corrupt the elements of the $\boldsymbol{\gamma}$ vector). Of course, another reason for modeling the system jointly is that the $\boldsymbol{A}_2$ primary driver indicators are not available for forecasting. However, as we will discuss later, we can make use of the second equation that relates the $\boldsymbol{x}_{2i_2}$ vector to $U_{2i_2}$ $(i_2 = 1, 2, ..., 9)$ and "uncondition" out the $\boldsymbol{A}_2$ indicators for forecasting, using information only on the $\boldsymbol{w}_{12}$ and $\boldsymbol{x}_{2i_2}$ vectors in future years.

To proceed further in a compact representation, let $\boldsymbol{x}_{12} = (\boldsymbol{w}'_{12}, \boldsymbol{A}'_2)'$ , let $x_{11}$ be a vector of the same size as $x_{12}$ but with all its elements taking a value of zero, and let $\boldsymbol{\beta}_1 = (\boldsymbol{\delta}', \boldsymbol{\gamma}')'$. Then, in general notation, the utility that a household associates with alternative $i_g$ of the $g^{th}$ nominal variable ($g$=1,2) can be written as:

$$U_{gi_g} = \boldsymbol{\beta}'_g \boldsymbol{x}_{gi_g} + \varepsilon_{gi_g}, \tag{2}$$

where $\boldsymbol{x}_{gi_g}$ is a ($K_g$×1)-column vector of exogenous attributes, $\boldsymbol{\beta}_g$ is a column vector of corresponding coefficients, and $\varepsilon_{gi_g}$ is a normal error term. Let the variance-covariance matrix of the vertically stacked vector of errors $\varepsilon_g \left[= \left(\varepsilon_{g1}, \varepsilon_{g2}, .....\varepsilon_{gI_g}\right)'\right]$ be $\boldsymbol{\Omega}_g$ (this corresponds to the covariance matrix for the $g^{th}$ nominal variable). Assume that the household chooses the alternative $m_g$. Then, for the $g^{th}$ nominal variable, the utility differences with respect to this chosen alternative $m_g$ must be less than zero:

$$U_{gi_g} - U_{gm_g} < 0 \,\forall\, i_g \neq m_g \tag{3}$$

Let $y^*_{gi_gm_g} = U_{gi_g} - U_{gm_g}$ $(i_g \neq m_g)$, and let $\boldsymbol{y}^*_{\boldsymbol{g}}$ be the stacked vector of the latent utility differentials $\boldsymbol{y}^*_{\boldsymbol{g}} = \left[\left(y^*_{g1m_g}, y^*_{g2m_g}, ..., y^*_{gI_gm_g}\right)'; i_g \neq m_g\right]$. $\boldsymbol{y}^*_{\boldsymbol{g}}$ has a mean vector of $\boldsymbol{B}_{\boldsymbol{g}}\,(\boldsymbol{\beta}'_{\boldsymbol{1}}\boldsymbol{z}_{\boldsymbol{g1m_g}}, \boldsymbol{\beta}'_{\boldsymbol{1}}\boldsymbol{z}_{\boldsymbol{g2m_g}}, ....\boldsymbol{\beta}'_{\boldsymbol{1}}\boldsymbol{z}_{\boldsymbol{gI_gm_g}})'$, where $\boldsymbol{z}_{\boldsymbol{gi_gm_g}} = \boldsymbol{x}_{\boldsymbol{gi_g}} - \boldsymbol{x}_{\boldsymbol{gm_g}}, i_g = 1, 2, ..., I_g; i_g \neq m_g$ and a covariance matrix given by $\boldsymbol{\Sigma}^*_{\mathbf{g}} = \boldsymbol{M}_{\boldsymbol{g}}\boldsymbol{\Omega}_{\mathbf{g}}\boldsymbol{M}'_{\boldsymbol{g}}$, where $\boldsymbol{M}_{\mathbf{g}}$ is an ($I_g$–1) × $I_g$ matrix that corresponds to an ($I_g$–1) identity matrix with an extra column of –1's added as the $m^{th}_g$ column. Thus,

$$\boldsymbol{y}^*_{\boldsymbol{g}} \sim N\left(\boldsymbol{B}_{\boldsymbol{g}}, \boldsymbol{\Sigma}^*_{\mathbf{g}}\right), \tag{4}$$

Now consider the stacked $\tilde{G} = (I_1 + I_2 - 2)$ vector $\boldsymbol{y}^* = \left[\left(\boldsymbol{y}^{*\prime}_{\boldsymbol{1}}, \boldsymbol{y}^{*\prime}_{\boldsymbol{2}}\right)'\right]$, each of whose element vectors is formed by differencing utilities of alternatives from the chosen alternative $m_g$ for the

$g^{th}$ nominal variable. Then, $\boldsymbol{y}^* \sim N(\boldsymbol{B}, \boldsymbol{\Sigma}^*)$, where $\boldsymbol{B} = \left(\boldsymbol{B}_1', \boldsymbol{B}_2'\right)'$ and $\boldsymbol{\Sigma}^*$ is a $\tilde{G} * \tilde{G}$ matrix as follows:

$$\boldsymbol{\Sigma}^* = \begin{bmatrix} \boldsymbol{\Sigma}_1^* & \boldsymbol{\Sigma}_{12}^* \\ \boldsymbol{\Sigma}_{21}^* & \boldsymbol{\Sigma}_2^* \end{bmatrix} \tag{5}$$

The off-diagonal elements in $\boldsymbol{\Sigma}^*$ capture the dependencies across the utility differentials of the two nominal variables, the differential being taken with respect to the chosen alternative for each nominal variable. Let $\boldsymbol{\theta}$ be the collection of parameters to be estimated: $\boldsymbol{\theta} = [\boldsymbol{\beta}_1, \boldsymbol{\beta}_2; \text{Vech}(\boldsymbol{\Sigma}^*)]$, where Vech($\boldsymbol{\Sigma}$) represents the vector of upper triangular elements of $\boldsymbol{\Sigma}$. Then the likelihood function for the household may be written as:

$$L(\boldsymbol{\theta}) = F_{\tilde{G}}\left[-\tilde{\boldsymbol{B}}\ , \boldsymbol{\Sigma}^*\right] , \tag{6}$$

where $F_{\tilde{G}}(.,.)$ is the $\tilde{G} = (I_1 + I_2 - 2)$ -dimensional normal cumulative distribution function.

The above likelihood function involves the evaluation of a $\tilde{G} = (I_1 + I_2 - 2)$ -dimensional integral for each household, which can be very computationally expensive if each nominal variable can take a large number of values (in the current empirical context, a nine-dimensional integral would have to be evaluated). For this reason, the Maximum Approximate Composite Marginal Likelihood (MACML) approach of Bhat (*34*) is applied.

Once the system is estimated, forecasting whether a household will move or not requires information only on the $\boldsymbol{w}_{12}$ and $\boldsymbol{x}_{2i_2}$ vectors. Specifically, using the same approach as above to develop the likelihood function, it is straightforward to develop the joint probability of each household choosing to move and choosing a specific primary reason for moving (the only change from the estimation case is that the utility differences in Equation (3) are taken with respect to each primary reason to get an expression that is equivalent to Equation (6) for that primary reason, which provides the required joint probability; note also that, when computing this joint probability, it is for a specific primary reason for moving, say reason $m_2$ and so the component of $\boldsymbol{\gamma}'\boldsymbol{A}_2$ that will appear in the joint probability computation (from the relocation equation) will be $[\boldsymbol{\gamma}]_{m_2}$. The joint probabilities can be used in important ways in forecasting and/or policy analysis, as discussed in the final section of this paper. Further, once the joint probabilities are obtained, the overall probability of a move of a household, given the $\boldsymbol{w}_{12}$ and $\boldsymbol{x}_{2i_2}$ vectors, is simply the sum of the joint probabilities across all the possible drivers of residential choice.

A final note. During estimation, it is important to ensure that the final model is identified, but also to make sure that the covariance matrices of utility differences that are constructed during the estimation process are all positive definite. These two important issues are discussed in a supplementary note (see http://www.caee.utexas.edu/prof/bhat/ABSTRACTS/ResidentialRelocation/SuppNote.pdf).

## DATA

The data used in this study comes from the 2009 National Household Travel Survey of the United States. Here the Florida-based sample is used because Florida respondents were asked a series of questions about residential relocation decisions that were not asked of households elsewhere. Additional information collected for the Florida sample included data on the respondent's length of residence in their current home, the number of months each year spent residing in the home, and the most important reason for choosing the current home location. More specifically, respondents who had lived in their current home for less than five years were asked "What is the most important reason you chose your current home?". Respondents who had lived in their home for five years or more were asked "What is the most important reason for you to have stayed in your current home?".

An extensive data assembly process was undertaken to form the analysis sample in this paper. The final sample includes 2,691 households who moved within the past five years and provided a primary reason for choosing the current home location to which they had moved, and 7,779 households who chose to stay in their current home for five years or more and provided the most important reason for their choice to stay. The total sample includes 10,470 households. A descriptive examination of the relocation and the "primary reason for residential choice" variable distributions provides initial insights into how the primary reasons affect relocation decisions, though these insights are first-order naïve effects because they do not control for observed and unobserved factors at play (which is the reason for the joint multivariate model of this paper). The descriptive statistics indicate that nearly 75 percent of households did not move within the past five years, while about one-quarter did move. About one-quarter of respondent households in the sample (both in total and also across each of the mover and non-mover segments) indicated that neighborhood quality is the primary reason for choosing their residence. The second and third most common reasons provided for residential choice correspond to home cost (21% of all households, 16% of mover households, and 23% of non-mover households) and quality of the home (14.5% of all households, 5.5% of mover households and 18% of non-mover households). The results here suggest that those sensitive to cost and who value home quality are more likely to be non-movers than movers. Both these groups are likely to have explored their options very carefully before selecting their homes in the first place, which may account for their lower propensity to move. Also, cost-sensitive households are likely to be well cognizant of the fixed costs of moving. Other commonly selected considerations for residential choice include proximity to work (11% of all households, 16% of mover households, and 9% of non-mover households) and proximity to friends/family (10% of all households, 16% of mover households, and 8.5% of non-mover households). These results indicate a higher move propensity for households that consider proximity to work and social connections as important residential choice factors. Interestingly, each of closeness to retail establishments, size of the home, and school quality is the primary reason for a rather small percentage of households (in total, and also within each of the move and non-move segments). Even within the sub-sample of households with children, school quality came out only to be the sixth most important driver of residential choice decisions based on the simple descriptive statistics.

## MODEL ESTIMATION RESULTS

The joint model system was estimated following a comprehensive exploratory analysis of the data to understand trends and possible relationships between the endogenous variables and the demographic and socio-economic attributes of households. Model estimation results for the decision to move (or not) are presented in Table 1, while those for the primary reason to choose a certain residence (defined by home and location) are furnished in Table 2.

Table 1 presents the results for the effects of variables on the move utility (with the non-move or stay utility serving as the base alternative). The model has a negative significant constant, implying that households have a baseline preference to stay in the current residential location. Considering scenery as the base dummy variable, a series of dummy variables representing reasons for choosing a residential location were entered into the model, along with a few interaction terms where the reasons were interacted with demographic attributes. As expected, concerns about cost or home affordability resulted in a lower likelihood of moving, and this effect was more pronounced for Caucasians. Similarly, as the quality of the current residential location increased, the lower was the probability of seeking to move to another residence. Those who sought to move tended to be immigrants desiring to upgrade to a larger home (home size interacted with immigrant household) and households looking for neighborhoods with good schools. The latter effect was especially pronounced for households with very young children. Those considering closer proximity to work or family and friends as primary reasons for choosing a residential location were more likely to move than others. On the other hand, those considering the quality of the neighborhood as very important were less likely to move, unless they had children in which case they were more likely to move – possibly because they seek to find nicer and safer neighborhoods for their families.

Those with higher education levels have a higher disposition to move than others, possibly because they have a greater array of opportunities to do so. Low income households are less likely to move than middle income households, but more likely to move than the high income households (>75,000 per year). Rising income levels contribute to a greater propensity to move, although that tendency starts decreasing beyond the $60,000 annual income level. It appears that those in the $45,000 to $60,000 middle income range are most likely to move as they seek to upgrade to nicer homes and neighborhoods as their incomes rise and lifecycle stages change. Those in the highest income brackets are probably already happy with their homes and neighborhoods, making them the least likely to move (as also observed by (*35*)). The presence of adults, and in particular, senior adults, reduces the likelihood of moving – suggesting that mature households tend to be more "settled in place". Those households with many self-employed individuals perhaps already have things set up in their homes for work and have an established local practice, making them unlikely candidates to want to move (see (*36*) for a similar result). Households with children and with individuals with a prolonged medical condition have a higher inclination to move. The former finding is consistent with the notion that households with children are at a lifecycle stage where they are actively seeking desirable housing and neighborhoods. The latter finding perhaps indicates active searching to find a home and neighborhood that can provide better support and accommodations for their situation. Finally, immigrant households have a higher inclination to move, an indication of searching for more desirable housing and neighborhoods; however, as immigrants assimilate into the U.S. (spend more years in the country), their likelihood of moving reduces.

The multinomial choice model of the primary reason to choose a residential location is presented in Table 2. The constants do not have any substantive interpretations because of the inclusion of ordinal explanatory variables in the model; they simply serve as adjustor terms to fit the data after the effects of other variables are accounted for. Those with the highest level of education are less likely to be sensitive to cost, possibly because they have greater earnings potential; those with the lowest level of education are more likely to consider friends and family to be important in their choice of residence, perhaps because these individuals desire a stronger support system. Interesting differences are found with respect to ethnicity and race. There may be cultural differences at play in the finding that Hispanic households consider school and neighborhood quality to be important considerations, while Caucasian households consider these two reasons to be less important than others.

As income increases, the sensitivity to cost decreases, as hypothesized in Section 1. All income groups above the lowest income category consider proximity to work as being important relative to the lowest income category, suggesting time constraints at play. Lower to middle income groups are more likely to consider home quality to be a primary reason for choosing a residence, suggesting a desire to upgrade to a nicer home when possible. These income groups are also more sensitive to neighborhood quality and retail accessibility.

The results for the number of adults, presence of senior adults, and the other work-related variables in the next panel of the table need to be considered altogether. As the number of adults increases, households tend to be more sensitive to home size and less sensitive to retail proximity and friends and family. The coefficient on the "Number of adults" variable must be considered in conjunction with other variables in this group for the other reasons for residential choice. For instance, as expected, households with several non-workers will have a lower sensitivity to proximity to work (as reflected by the negative coefficient on the "Number of adults" variable in the "Close to work" column). This effect becomes even more pronounced in the case of households with one or more non-working senior adults in the household (see the negative sign on the "Presence of senior adult" variable for the "Close to work" column). For non-working senior households, school proximity is also a non-issue, while closeness to retail is important. Another important result in this group of variables is the importance of the proximity to work and school among households with many workers (except for households with self-employed individuals). The importance ascribed to proximity to work is particularly high for households with many multiple job workers.

As expected, the presence of children in the household heightens the level of importance attributed to home cost, school quality, and neighborhood quality. These are probably three of the most important considerations for families with children when choosing a home, a finding consistent with the literature reviewed earlier in the paper. Similarly, those with a medical condition seek to be close to work (if employed) and to friends and family. Immigrants choose to locate in homes close to the work place, as evidenced by the positive coefficients for immigrants on the closeness to work utility. As the number of years that the immigrants lived in the U.S. increases, they appear to consider home quality and cost as increasingly important, though proximity to work still dominates their residential choice decisions at all stages of their lifecycle.

There are no statistically significant elements in the off-diagonal part of $\breve{\boldsymbol{\Sigma}}^*_{22}$. However, several diagonal elements of $\breve{\boldsymbol{\Sigma}}^*_{22}$ came out significantly different from one. Specifically, the variance of all utility differences (with respect to scenic locations), except for the one corresponding to home "quality", turned out to be significantly greater than one (note that the variance of the cost attribute is normalized to one for identification). That is, there is substantial variance in the unobserved portions of these utility differences than in those associated with "cost" and "quality." It is likely that there are greater idiosyncratic unobserved differences across households in their outlook towards qualitative residential and neighborhood attributes (such as proximity and accessibility, neighborhood quality, home size, and school quality) to "cost" and "quality."

Only one of the elements of $\breve{\boldsymbol{\Sigma}}^*_{12}$ came out to be statistically significant. The covariance between the move-or-not decision and the utility difference of "neighborhood" quality (relative to "scenery") was found to be equal to 0.23. This reinforces the hypothesis presented earlier in Section 1 that people who are extremely sensitive to their surroundings are likely to be constantly seeking nicer neighborhoods in which to locate. The unobserved factor, *i.e.*, extremely sensitive to surroundings, simultaneously contributes to both neighborhood being the most important reason to move and also the likelihood of moving itself.

In order to compare the statistical performance of the joint model estimation, another simpler naïve model system was estimated. The naïve model: (1) ignores the direct effect of all household attitudinal variables (indicator variable for the primary reason for choosing residential location and its interaction with different household attributes) on the decision to move or not, (2) ignores possible self-selection effects in the decision to move and primary reason decision, and (3) assumes that the utilities in the primary reason model are independently and identically distributed across all alternatives. This restricted model can be compared to the final joint model using the standard log-likelihood ratio (LR) test. The log-likelihood of the final model came out to be –25063.9 whereas that of the restricted model is –25414.77. The likelihood-ratio test statistic comparing these two models is equal to 701.7, which is much higher than the critical $\chi^2$ value of 27.59 at 17 degrees of freedom. This indicates that the joint model offers superior goodness-of-fit in explaining residential location choice factors than the restricted model system that, among other things, ignores the jointness in these processes.[1]

Lastly, we used the parameter estimates to compute the "pseudo-elasticity" effects of variables on the move/stay decision (we label these as "pseudo-elasticity effects" because all the explanatory variables are either dummy variables or ordinal variables; for dummy variables, we compute the effect of a change in the variable from 0 to 1, and for ordinal variables, we compute the effect of an increase in the value of the variable by 1 unit; see (*37*) for details). However, due to space constraints, we do not discuss all of these in detail, except for the effects of the "primary reason for choosing residential location" variables. Households which cite "quality of home" as the primary reason for choosing residential location are the least likely to move, followed by households that cite "neighborhood quality" and "cost of home." Furthermore, households that cite "school quality" as the primary reason for choosing a residential location are the most likely to move, followed by households that cite "friends and family" and "close to work" as the primary reasons for choosing residential location.

## CONCLUSIONS

In an era of microsimulation modeling, it is increasingly of interest to be able to evolve households over time with respect to their demographic and location attributes (home, work, and school locations, in particular) and forecast activity-travel demand for any horizon year. As households evolve over time (with changes in household structure, age composition, lifecycle stage, working status, and vehicle ownership), they move for various reasons. Household migration (whether moving locally or long distance) changes socio-economic composition of

[1] One can also compute an adjusted rho-bar squared value for the joint model and the restricted model. The adjusted rho-bar squared value for a model, $\overline{\rho}_c^2$, is computed as $\overline{\rho}_c^{\,2} = 1 - [(L(\hat{\beta}) - H)/L(C)]$, where $L(\hat{\beta})$ is the log-likelihood of the model at convergence, $H$ is the number of parameters in the model excluding all the constants, and $L(C)$ is the log-likelihood of the "constants only" model. The "constants only" model corresponds to the model with only a constant in the binary move/stay model and only constants in the "primary reason for residential location choice", and that assumes independence between the move/stay and primary reason choices (this model assigns a probability for each alternative that is equal to the sample share of that alternative). In our estimations, $L(C)$ = –26,826.9, and $H$ = 96 for the joint model and $H$ = 79 for the restricted model. The $\overline{\rho}_c^2$ value for the joint model is 0.062 and for the restricted model is 0.049.

regional geographies and is therefore a phenomenon of much interest in the integrated land use – transport modeling domain.

In this paper, two choice phenomena are modeled jointly with a view to more comprehensively capture the inter-dependencies at play in residential (re)location behavior. First, the joint model includes a binary choice of whether a household chooses to move or not. Second, the joint model includes a multinomial choice of the primary reason for the household choosing to locate in a certain residence. The model system is estimated on the Florida sample of the 2009 US National Household Travel Survey, for which information about residential moves and the primary reasons driving residential location choice was available. Model estimation results showed that a host of demographic and socio-economic attributes significantly affected the primary reason that a household would choose a certain residential location. In turn, socio-economic and demographic attributes, combined with the primary reason(s) for moving, influenced the decision of whether to move or not. In other words, the reason(s) for moving are themselves endogenous to the system, calling for the adoption of a joint model such as that estimated for and presented in this paper. Model results showed significant unobserved heterogeneity in household considerations/priorities with regard to choosing a residential location, and the presence of correlated unobserved factors simultaneously affecting the decision to move and the importance attached to residential housing/location attributes.

The work reported in this paper has key implications for land use – transport planning. In the modeling domain, a joint model system such as that presented in this paper can be deployed in operational demographic model systems to better capture residential location and move processes that characterize the population of interest. The model in this paper can be used to predict the likelihood that a reason for moving would be chosen. The probability of a household moving or staying in a particular year can be simulated as such, and/or jointly with the reason for which a household may desire to move, as a function of the demographic and work attributes of the household and the current residential tenure. In short, the model presented in this paper could be integrated in a larger household evolution and migration model system. Depending on the predicted primary reason to move, one could also identify the probable locations to which the household would move. For example, a household with children – concerned about school quality – would likely relocate to a neighborhood within a strong school district.

Second, from a policy standpoint, public agencies can implement policies and urban revitalization strategies that may enhance quality of life. People develop a sense of community when they stay in place. However, if households are not satisfied with neighborhood quality, school quality, proximity to job and retail opportunities, and the housing stock, then they will seek to move to more desirable locations. Public entities should strive to target neighborhoods that experience higher levels of residential turnover with specific programs that enhance school quality, neighborhood appeal, and access to jobs and opportunities. By doing so, quality of life can be enhanced, property values and tax bases can be increased, and community well-being can be improved as households choose to stay in place longer and get invested in the neighborhood. Information campaigns can be developed for different demographic groups with a view to appealing to specific priorities of households when it comes to residential location choice.

Further research is undoubtedly warranted in the residential location choice arena. More research is needed on how people perceive space, quality of schools and neighborhoods, and accessibility to destinations. It would be useful for future household travel surveys to include questions about residential moves and the underlying motivations for those moves, which can in turn provide valuable information for modeling migration patterns over time. In addition, future research should include life-cycle event variables in the analysis, as these events have been found to be of significance in previous behavioral research. Finally, it would be helpful in the future to move beyond gaining an understanding of the factors that affect residential mobility to focusing attention on the forecasting ability and validation of residential mobility models.

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## LIST OF TABLES

**TABLE 1 Estimation Results for Model of Decision to Move**

| Variable | Coef | t-stat |
|---|---|---|
| Constant | -0.3914 | -4.65 |
| *Primary Reason for choosing Residential Location (Base is Scenic/Close to Retail)* | | |
| Cost of Home | -0.1797 | -1.73 |
| Caucasian * Cost of Home | -0.1757 | -1.69 |
| Quality of Home | -0.7007 | -11.31 |
| Home or Lot Size * Immigrant Household | 0.2362 | 1.51 |
| Close to School or Quality of school | 0.2685 | 2.35 |
| Presence of Children 0 to 5 years * Close to School or Quality of School | 0.1765 | 1.24 |
| Close to Work | 0.0927 | 1.54 |
| Close to Friends and Family | 0.2783 | 4.76 |
| Neighborhood Quality | -0.4728 | -2.77 |
| Presence of Children * Neighborhood Quality | 0.0814 | 1.10 |
| *Highest Education Attainment in Household (Base is High School or less)* | | |
| College | 0.1079 | 2.67 |
| Bachelor Degree | 0.1105 | 2.50 |
| Post Graduate Degree | 0.1464 | 3.09 |
| *Race* | | |
| Caucasian | -0.1047 | -2.01 |
| *Household Income (Base is >75K)* | | |
| Less than $20K | 0.0748 | 1.57 |
| Between $20K-$45K | 0.1024 | 1.84 |
| Between $45K-$60K | 0.1216 | 1.93 |
| Between $60K-$75K | 0.0877 | 1.60 |
| *Number of Adults(>15 years)* | -0.0769 | -3.26 |
| *Presence of Senior Adults (≥65 years)* | -0.2720 | -7.82 |
| *Number of Self employed Individuals* | -0.0772 | -2.27 |
| *Presence of Children* | | |
| 0-5 years | 0.0943 | 1.69 |
| *Presence of Individuals with Prolonged Medical Condition* | 1.7380 | 22.93 |
| *Immigration Status* | | |
| Mixed Immigrant Household | 0.5331 | 6.39 |
| Pure Immigrant Household | 0.5484 | 7.30 |
| Maximum Number of Years in US | -0.0168 | -8.44 |

**TABLE 2 Estimation Results for Model of Primary Reason for Residential Location**

| | Home Cost | | Home Quality | | Home Size | | School | |
|---|---|---|---|---|---|---|---|---|
| Variables | Coef | t-stat | Coef | t-stat | Coef | t-stat | Coef | t-stat |
| Constant | 0.9517 | 17.06 | 0.2223 | 7.39 | -2.7011 | -2.92 | -1.8908 | -2.63 |
| *Highest Education Attainment in Household* | | | | | | | | |
| *(Base is High School or Less)* | | | | | | | | |
| Some College | | | | | | | | |
| Bachelor Degree | | | | | | | | |
| Post Graduate Degree | -0.1010 | -2.71 | | | | | | |
| *Hispanic Status* | | | | | | | | |
| Hispanic Household | 0.1295 | 2.38 | | | | | 0.5308 | 3.07 |
| *Race* | | | | | | | | |
| Caucasian | | | | | | | -0.3795 | -2.45 |
| *Household Income* | | | | | | | | |
| Less than $20K | | | 0.1884 | 4.63 | | | | |
| Between $20K-$45K | -0.1622 | -3.82 | 0.1884 | 4.63 | | | | |
| Between $45K-$60K | -0.3311 | -5.73 | 0.1502 | 2.78 | | | | |
| Between $60K-$75K | -0.5504 | -8.61 | | | | | | |
| Greater than $75K | -0.7156 | -12.82 | | | -0.1435 | -1.31 | | |
| *Number of Adults(>15 years)* | -0.1072 | -4.23 | | | 0.1912 | 2.20 | -0.2003 | -1.97 |
| *Presence of Senior Adults (≥65 years)* | -0.1485 | -4.33 | | | | | -0.8801 | -3.36 |
| *Number of Workers* | 0.1224 | 3.35 | | | | | 0.2255 | 2.62 |
| *Number of People with Option to Work from Home* | -0.1399 | -2.76 | | | | | | |
| *Number of Self-employed Individuals* | -0.1464 | -3.70 | | | | | -0.2137 | -1.96 |
| *Number of Full-time Workers* | 0.1153 | 3.06 | | | | | | |
| *Number of People with Multiple Jobs* | | | 0.0794 | 1.54 | 0.2569 | 1.59 | | |
| *Presence of Children* | | | | | | | | |
| 0-5 years | 0.2205 | 3.90 | | | | | 1.0330 | 4.07 |
| 6-10 years | | | | | | | 0.9785 | 4.21 |
| 11-15 years | | | | | | | 1.1011 | 4.12 |
| *Presence of Individuals with Prolonged Medical Condition* | | | -0.2617 | -2.95 | | | | |
| *Immigration Status* | | | | | | | | |
| Mixed Immigrant Household | | | | | | | 0.3147 | 1.72 |
| Pure Immigrant Household | | | | | | | | |
| Maximum number of years in US | | | 0.0022 | 1.90 | | | | |

**TABLE 2 (continued) Estimation Results for Model of Primary Reason for Residential Location**

| | Neighborhood Quality | | Close to Work | | Close to Retail | | Friends & Family | |
|---|---|---|---|---|---|---|---|---|
| Variables | Coef | t-stat | Coef | t-stat | Coef | t-stat | Coef | t-stat |
| Constant | 0.4687 | 6.19 | -1.8210 | -2.41 | -2.5628 | -2.90 | -1.0158 | -1.81 |
| *Highest Education Attainment in Household* | | | | | | | | |
| *(Base is High School or Less)* | | | | | | | | |
| Some College | | | | | | | -0.2422 | -2.36 |
| Bachelor Degree | | | | | | | -0.2422 | -2.36 |
| Post Graduate Degree | | | | | | | -0.2422 | -2.36 |
| *Hispanic Status* | | | | | | | | |
| Hispanic Household | 0.1475 | 2.19 | 0.1586 | 1.05 | | | | |
| *Race* | | | | | | | | |
| Caucasian | -0.1541 | -2.93 | | | | | | |
| *Household Income* | | | | | | | | |
| Less than $20K | | | | | | | | |
| Between $20K-$45K | 0.1390 | 3.20 | 0.6608 | 2.85 | 0.5242 | 3.33 | | |
| Between $45K-$60K | 0.1246 | 2.23 | 0.6608 | 2.85 | 0.5682 | 3.74 | | |
| Between $60K-$75K | | | 0.6608 | 2.85 | | | -0.2648 | -1.94 |
| Greater than $75K | | | 0.6608 | 2.85 | | | -0.5674 | -4.32 |
| *Number of Adults (>15 years)* | | | -0.4583 | -3.86 | -0.1973 | -2.04 | -0.1306 | -2.05 |
| *Presence of Senior Adults (≥65 years)* | | | -1.0231 | -3.94 | 0.7755 | 3.39 | 0.1726 | 1.63 |
| *Number of Workers* | 0.0574 | 2.43 | 0.5239 | 3.64 | | | | |
| *Number of People with Option to Work from Home* | | | | | | | -0.1665 | -1.20 |
| *Number of Self-employed Individuals* | -0.0533 | -1.20 | -0.4445 | -3.45 | -0.2208 | -1.59 | -0.1148 | -1.15 |
| *Number of Full-time Workers* | | | | | | | | |
| *Number of People with Multiple Jobs* | | | 0.3795 | 2.86 | | | | |
| *Presence of Children* | | | | | | | | |
| 0-5 years | | | | | | | | |
| 6-10 years | 0.1349 | 2.21 | | | | | | |
| 11-15 years | | | | | | | 0.2501 | 1.65 |
| *Presence of Individuals with Prolonged Medical Condition* | | | 0.5312 | 2.22 | | | 0.7705 | 3.13 |
| *Immigration Status* | | | | | | | | |
| Mixed Immigrant Household | | | 0.4518 | 2.58 | | | | |
| Pure Immigrant Household | | | 0.5194 | 2.88 | | | | |
| Maximum Number of Years in US | 0.0024 | 1.77 | | | | | | |