Accommodating Immigration Status and Built Environment Effects in a Joint Model of Household Auto Ownership and Residential Neighborhood Type Choice

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***IMMIGRANT ***


Mike Keefe THE DENVER POST 4-24-10
STEP OUT OF THE VEHICLE AND PLACE YOUR HANDS ON YOUR HEAD.
AZ

Presentation Overview

- Land-Use and Travel Demand Relationship
  - Causal vs. Associative Debate
  - Previous Studies
- Problems in Understanding the Relationship between Land-Use and Travel Demand
  - Complex relationship
  - Residential sorting issues
- Current Research
  - How this research addresses the problems
  - Model Formulation and Estimation
  - Data Sources and Variables
  - Results
- Conclusion

Land-Use and Travel Demand

- Assumption:
  - There is an association between land-use development patterns and travel behavior of individuals
  - Relatively little efforts to explain the causal thread generating this association
- Transportation planning focus shift
  - Old: reactive, supply-enhancing, prediction-oriented
  - New: proactive, demand-reducing, policy-oriented
- Need to clearly establish if a causal thread exists before we are able to make policy recommendations

The Relationship between the Built Environment (BE) and Travel Behavior

- The Causal Effect Argument
  - New Urbanism and Smart Growth Theories
  - Car dependence-reducing BE strategies will lead to tangible reductions in motorized vehicle use
  - It will also lead to friendlier, and socially vibrant, neighborhoods

- The Associative Effect Argument
  - Certain types of people choose to live in particular built environments
  - Auto-dependent orientation of the population is due to demographic shifts and lifestyle preferences

Previous Literature: Mixed and Inconclusive

Studies found:

- Significant elasticity effects of BE attributes on travel demand variables
- Significant effects of the BE on one or more dimensions of activity/travel behavior
- No significant effects of the BE on activity/trip frequency and non-motorized mode use

Understanding the Relationship: Two Major Problems

1. The relationship between the built environment and travel behavior can be very complex
   - Multi-dimensional nature
   - Moderating Influence of the Decision-maker characteristics
   - Spatial Scale of Analysis

2. Delineating “true” causal impact from “spurious” association

Multi-Dimensional Nature

- What dimension of the built environment impacts what dimension of travel?
- Some BE measures act as proxies for a suite of other BE measures
  - Makes it difficult to identify which element of the BE is actually responsible for the travel impact
  - This is a problem when using a limited number of BE measures or when using judgmentally pre-defined neighborhoods
- Focusing on the impacts of BE on narrow dimensions of travel does not provide the overall effect on travel

Moderating Influence of Decision-Maker Characteristics

- Characteristics of the Decision-Maker
  - Socio-demographic factors
  - Travel-related and environmental attitudes
  - Perceptions regarding BE attributes

- Two Kinds of Moderating Influences
  1. A direct influence on travel behavior
  2. An indirect influence on travel behavior by modifying the sensitivity to BE characteristics

- Studies need to control for these observed and unobserved influences

Spatial Scale of Analysis

- What shape and scale is considered a “neighborhood”?
- Most studies use predefined spatial units based on census tracts, zip codes, or traffic analysis zones
- Unclear how individuals perceive the “neighborhood” shape and scale
- It is possible that different BE attributes have different spatial extents of influence on travel choices

Residential Sorting/Self-Selection

- Disentangling the “spurious” and “true” causal effects is critical

- Ways to account for residential sorting
  1. Controlling for decision-maker attributes that jointly impact residential and travel choices
  2. Using instrumental variable methods
  3. Using before-after household move data

Reasons for Studying Car Ownership

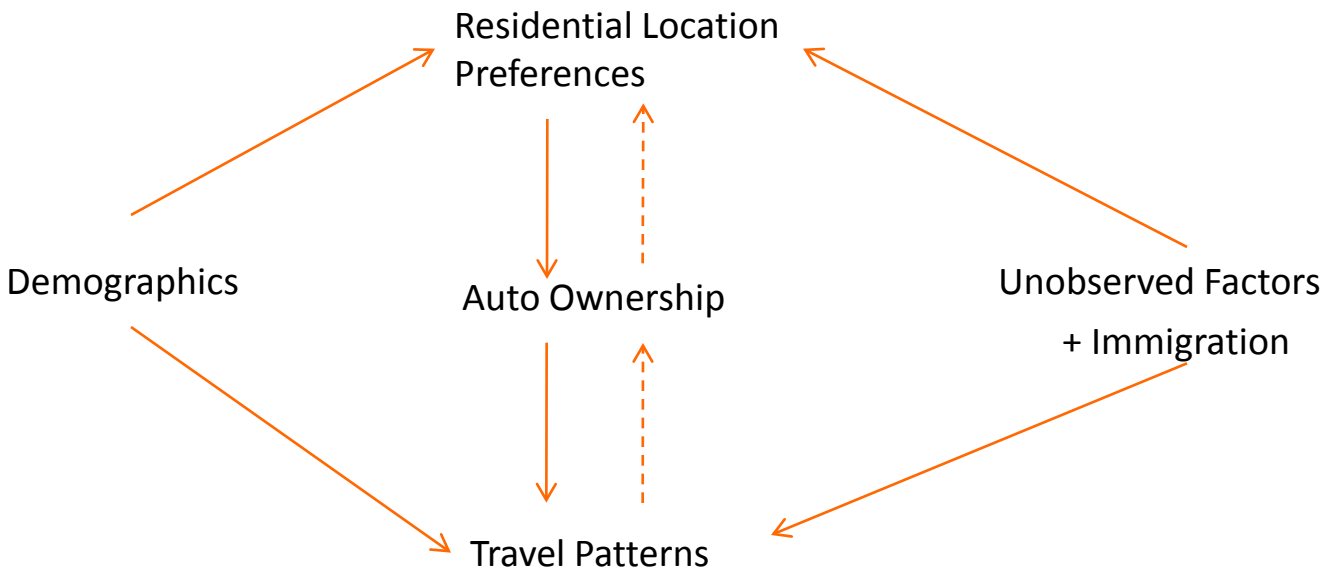
1. Car ownership is an intervening variable in the effect of BE on travel decisions
   - Car ownership and residential choice decisions are medium term decisions
   - Impact of BE measures on car ownership should not be ignored

2. There is less research on the effect of BE characteristics on car ownership

3. Car ownership impacts almost all aspects of daily activity-travel patterns

Importance of Built Environment Effects: Policy Perspective

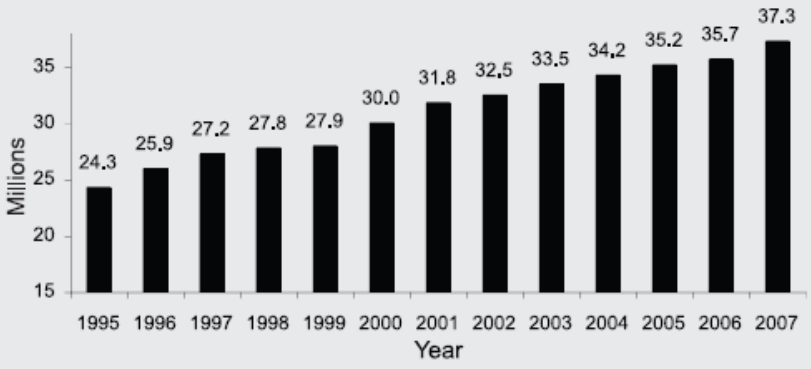
- Vehicle ownership is an important intervening variable in the effect of built environment (BE) attributes on travel decisions.
- Important to evaluate impact of BE measures on vehicle ownership choice to devise land use policies to change travel choices
- Significant fraction of human-generated greenhouse gas (GHG) emissions and fossil fuel-based energy consumption → on-road private vehicle travel
- Interest to Policymakers → explore transportation and land-use strategies to decrease private vehicle ownership


Residential Location Preferences
Demographics
Auto Ownership
Unobserved Factors + Immigration
Travel Patterns

Increasing Immigration in United States

- Total immigrant population → 37.3 million in 2007
- Account for one in eight U.S. residents → highest in 80 years
- Largest increase → California, Florida, Texas, New Jersey, Illinois, Arizona, Virginia, Maryland, Washington, Georgia, North Carolina, and Pennsylvania

Figure 1. Number of Immigrants Living in the U.S., 1995-2007



Source: Center for Immigration Studies analysis of March 1995 through 2007 Current Population Surveys (CPS). The CPS does not include persons in group quarters, such as prisons and nursing homes. Figures for 1995 to 1999 have been re-weighted to reflect the larger number of immigrants revealed in the 2000 Census.

Table 3. States with Statistically Significant Growth in Immigrant Population between 2000 and 2007[1] (thousands)

State	Immigrant Population 2007	Immigrant Population 2000	Growth	Percent Increase
California	9,980	9,053	927	10.2 %
Texas	3,438	2,591	847	32.7 %
New Jersey	1,869	1,281	588	45.9 %
Arizona	891	692	199	28.8 %
Florida	3,453	2,960	493	16.7 %
Illinois	1,702	1,243	459	36.9 %
Maryland	731	479	252	52.6 %
Georgia	953	378	575	152.1 %
Washington	722	457	265	58.0 %
North Carolina	623	373	250	67.0 %
Pennsylvania	581	364	217	59.6 %
Virginia	856	552	304	55.1 %
Indiana	236	151	85	56.3 %
Connecticut	443	306	137	44.8 %
Nevada	457	333	124	37.2 %
Ohio	421	300	121	40.3 %
Minnesota	375	261	114	43.7 %
New Mexico	179	107	72	67.3 %
Utah	239	132	107	81.1 %
Tennessee	286	110	176	160.0 %
Alabama	190	78	112	143.6 %
Rhode Island	140	87	53	60.9 %
D.C.	78	59	19	32.2 %
Nebraska	113	68	45	66.2 %
South Carolina	144	65	79	121.5 %
Delaware	77	38	39	102.6 %
Mississippi	66	29	37	127.6 %
Arkansas	111	54	57	105.6 %
New Hampshire	83	51	32	62.7 %
Alaska	39	28	11	39.3 %
Wyoming	14	5	9	180.0 %
South Dakota	19	10	9	90.0 %
Montana	15	7	8	114.3 %
Nation	**37,280**	**29,985**	**7,295**	**24.3 %**

Source: Center for Immigration Studies analysis of March 2000 and 2007 Current Population Survey.
[1] Assumes a 90 percent confidence interval.

Behavioral Differences Between Immigrants & Natives

- Residential Location (Logan *et al.,* 2002 and U.S. Census Bureau 2003)
  - Cities that are port of entries are the most attractive locations
  - Among recent immigrants (those who entered the U.S. in the 10 years prior), 48 percent lived in central-city neighborhoods, compared to only 28 percent of native-born residents
  - Willing to live in congested locations during the initial phase till economic conditions improve
  - Tend to locate in ethnic neighborhoods which aid them in the assimilation process
- Auto Ownership (Ma and Srinivasan, 2010; Blumenberg, 2008)
  - Average car ownership lower in Immigrant households
  - It takes about 11 years for immigrant single adult households and 30 years for couple households to have same car ownership level as identical US born household
  - Less auto dependent→ More likely to use alternate modes of travel

Assimilation of Immigrants

- With time, immigrants assimilate, assuming the transportation patterns of the native-born population
- Residential location (Yu, 2003)
  - With time immigrants tend to relocate to low density locations
  - *"Discrepancies in residential preferences between U.S.-born and foreign-born residents decrease and immigrants become more dispersed from their initial central-city enclaves"*

- Auto Ownership (Number of vehicles per person) (Tal and Handy, 2005)

Year of arriving to the US	Number	Mean	Std Dev	t-test vs. US born*
US Born	92298	0.81	0.4702	-
Pre 1981	2503	0.79	0.4290	0.0218
1981-1991	1197	0.58	0.3456	<0.0001
1991-1996	722	0.55	0.3514	<0.0001
1996-2001	724	0.45	0.3484	<0.0001

Methodological Contribution

- Two components
  - One MNP model to analyze residential neighborhood type choice
  - Another MNP model to examine vehicle ownership choice

- The two MNP models of residential neighborhood type and vehicle ownership will be tied together in a bivariate system

- Log-likelihood evaluation involves evaluating multi-dimensional integral of the order of sum of number of alternatives in the two choices

- Simulation methods have convergence problems

- Estimated using a Maximum Approximated Composite Marginal Likelihood (MACML) estimation approach

METHODOLOGY

- g → index for the nominal variables (g =1, 2)

- I_g → number of alternatives corresponding to the g^{th} nominal variable and i_g the corresponding index (i_g = 1, 2, 3…… I_g).

- In the current empirical context, $I_1 = 7$ (7 residential location alternatives) and I_2 = 5 (household auto ownership ranging from 0 to 4 or more)

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

- $\boldsymbol{\Omega}_g$ variance-covariance matrix of the vertically stacked vector of errors ε_g

- If m_g is the chosen alternative, then

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

For one Nominal Variable

$$y^{*}_{gi_g m_g} = U_{gi_g} - U_{gm_g} \; (i_g \neq m_g)$$

$$\boldsymbol{y}^{*}_{\boldsymbol{g}} = \left[\left(y^{*}_{g1m_g}, y^{*}_{g2m_g}, \ldots, y^{*}_{gI_g m_g} \right)' ; i_g \neq m_g \right]$$

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

$$\boldsymbol{B}_{\boldsymbol{g}} \left(\boldsymbol{\beta}_1^{'} \boldsymbol{z}_{g1m_g}, \boldsymbol{\beta}_1^{'} \boldsymbol{z}_{g2m_g}, \ldots . \boldsymbol{\beta}_1^{'} \boldsymbol{z}_{gI_g m_g}\right)',$$

$$\boldsymbol{z}_{\boldsymbol{gi_g m_g}} = \boldsymbol{x}_{\boldsymbol{gi_g}} - \boldsymbol{x}_{\boldsymbol{gm_g}}, i_g = 1,2,\ldots I_g ; i_g \neq m_g$$

$$\boldsymbol{\Sigma}^{*}_{\mathbf{g}} = \boldsymbol{M}_{\boldsymbol{g}} \boldsymbol{\Omega}_{\mathbf{g}} \boldsymbol{M}_{\boldsymbol{g}}^{'}$$

$\boldsymbol{M}_{\boldsymbol{g}}$ is an (I_g-1) x I_g matrix that corresponds to an (I_g-1) identity matrix with an extra column of -1's added as the m_g^{th} column

Extension to Two Nominal Variables

$$\boldsymbol{y}^{*} = \left[\left(\boldsymbol{y}_{\boldsymbol{1}}^{*'}, \boldsymbol{y}_{\boldsymbol{2}}^{*'}\right)'\right]$$

$$\boldsymbol{y}^{*} \sim N(\boldsymbol{B}, \boldsymbol{\Sigma}^{*}),$$

$$\boldsymbol{B} = \left(\boldsymbol{B}_{\boldsymbol{1}}', \boldsymbol{B}_{\boldsymbol{2}}'\right)'$$

$$\boldsymbol{\Sigma}^{*} = \begin{bmatrix} \boldsymbol{\Sigma}_{\boldsymbol{1}}^{*} & \boldsymbol{\Sigma}_{\boldsymbol{12}}^{*} \\ \boldsymbol{\Sigma}_{\boldsymbol{21}}^{*} & \boldsymbol{\Sigma}_{\boldsymbol{2}}^{*} \end{bmatrix}$$

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

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

Ensuring Identification

- Only utility differences matter

- Can estimate
  - Parameters in the covariance matrix $\breve{\Sigma}_g^*$ of utility differences taken with respect to the first alternative for each of the two nominal variables.
  - Covariances between the utility differences taken with respect to the first alternative across the two nominal variables

- $\breve{\Sigma}_g^*$ is different from which Σ_g^* corresponds to the covariance of utility differences taken with respect to the chosen alternative for the individual

- Total parameters estimable $\sum_{g=1}^{2}\left(\frac{I_g * (I_g - 1)}{2} - 1\right) + (I_1 - 1) \times (I_2 - 1)$

Ensuring Identification

- General covariance matrix $\boldsymbol{\Omega}$ for the original -error term vector: $\boldsymbol{\Omega} = \mathbf{D}\breve{\boldsymbol{\Sigma}}^{*}\mathbf{D}'$

$$D = \left[\begin{array}{cccc:cccccc}
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
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0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1
\end{array}\right]_{12*10}$$

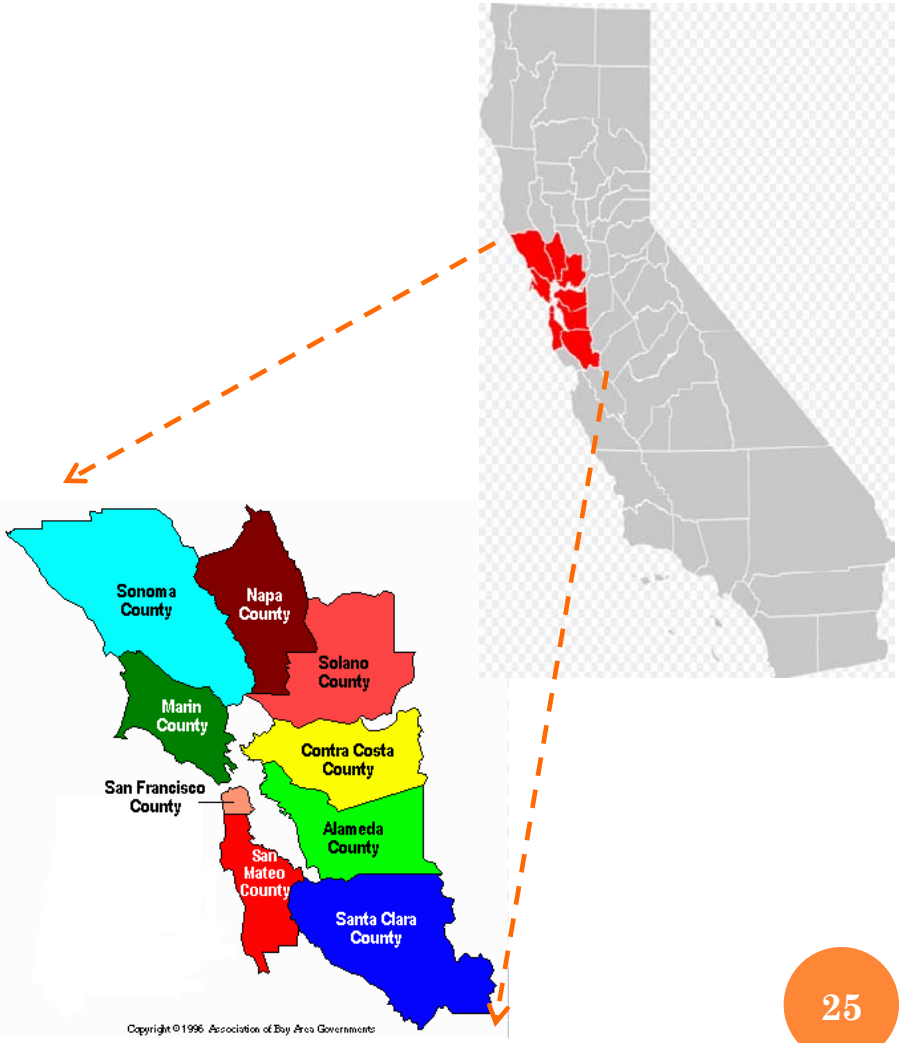
- Covariance matrix $\boldsymbol{\Sigma}^{*}$ that is needed for estimation (and is with respect to each individual's chosen alternative for each nominal variable) can be obtained as $\boldsymbol{\Sigma}^{*} = \mathbf{M}\boldsymbol{\Omega}\mathbf{M}'$

Ensuring Positive Definiteness

- Positive definiteness of $\boldsymbol{\Sigma}^*$ which is constructed multiple times during the optimization routine of the estimation process ←→ Positive definiteness of $\breve{\boldsymbol{\Sigma}}^*$
- Cholesky matrix of $\breve{\boldsymbol{\Sigma}}^*$ as the matrix of parameters to be estimated
- The cholesky elements parameterized appropriately to make sure that the scale of each of the nominal variables is set to one

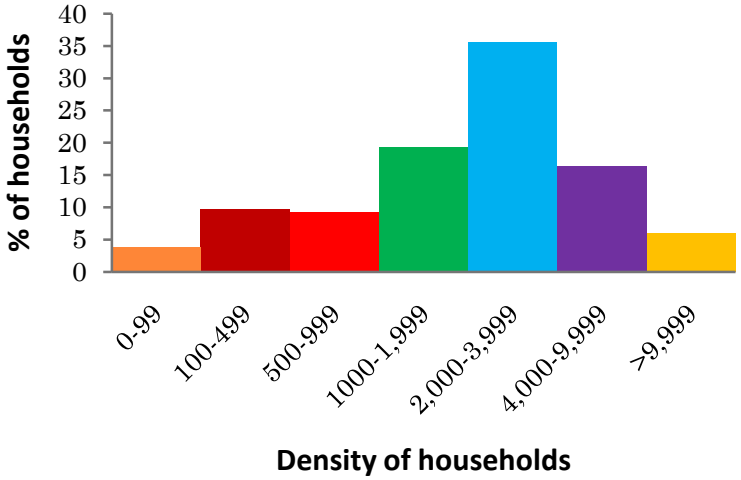
DATA

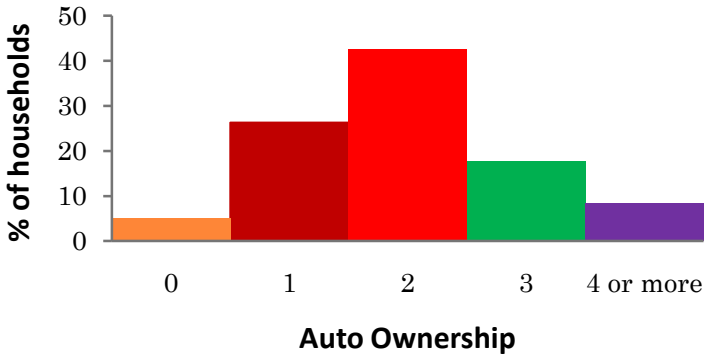
- 2009 NHTS data → ideally suited for the current study
  - Provides information on household vehicle ownership, residential location, and immigration and other socio-demographic information of household members
- Focus specifically on the NHTS sample corresponding to the San Francisco Bay area.
  - Research team already has developed an extensive set of built environment measures for the Bay area
  - California add-on data of the NHTS sample has Census Tract in which each household is located→ used to merge the BE measures
- The Bay area NHTS sample includes 3808 households



Dependent Variables

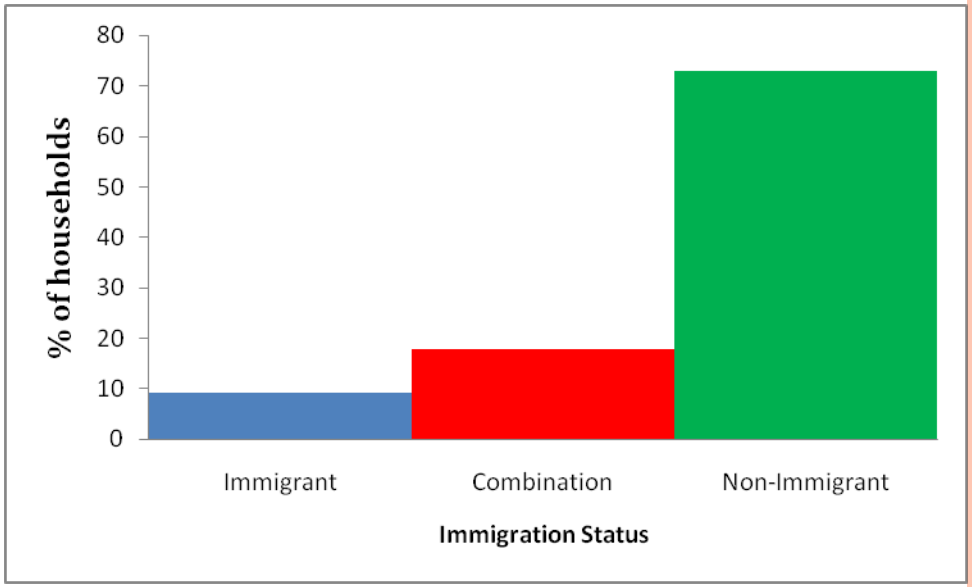
- Five auto ownership alternatives→ 0, 1, 2, 3, 4 or more
- Total seven residential location alternatives →a) 0-99, b) 100-499, c) 500-999, d) 1,000-1,999, e) 2,000-3,999, f) 4,000-9,999, and g) >9,999
- We used residential household location variable defined based on the number of households per square mile of the Census Block in which the household is located



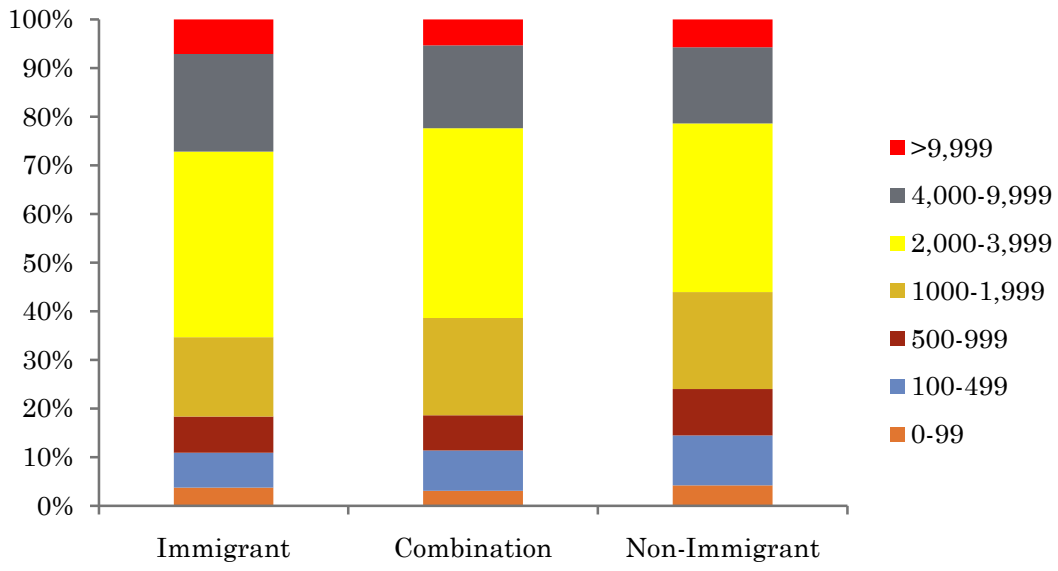


Immigration Status

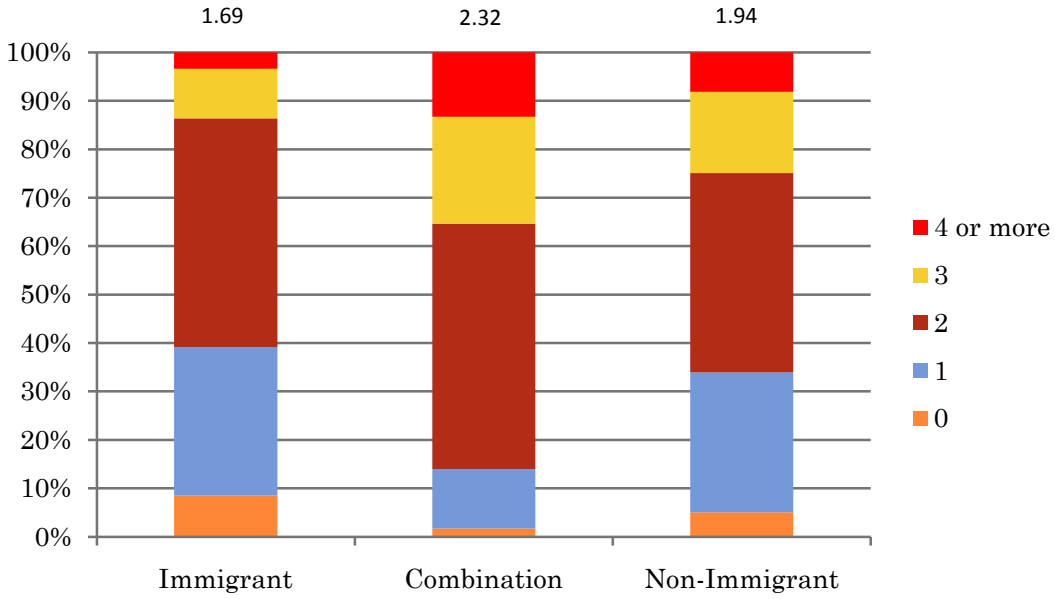
- Immigration status collected at individual level → whether an individual was born in the US or not
- Three types of households → *Non-immigrant* households with no immigrants, *Combination* households with both immigrants and non-immigrants, *Immigrant* households
- Combination households mainly represent immigrant parents with domestic-born children



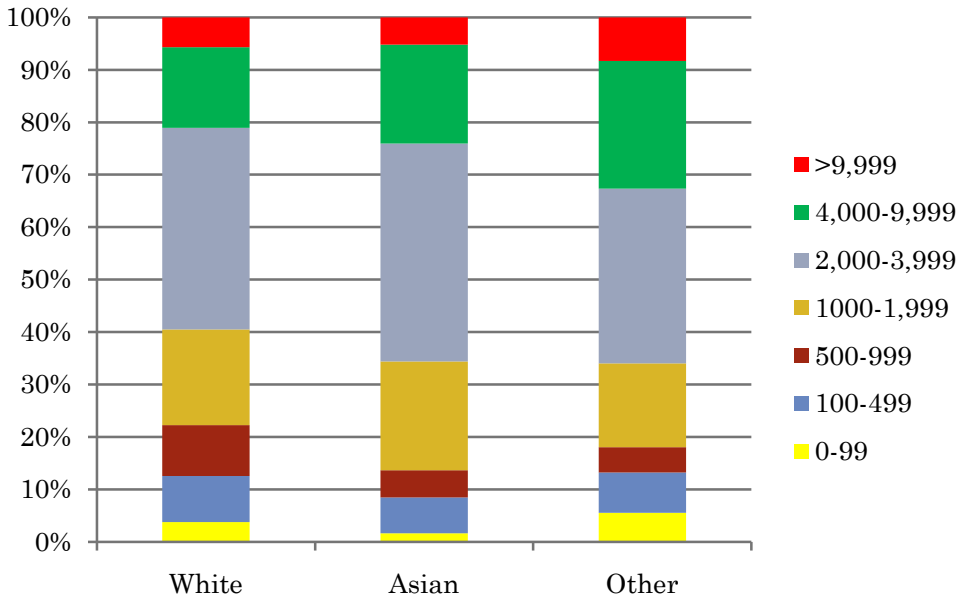
Residential Location & Immigration Status



Auto Ownership and Immigration Status



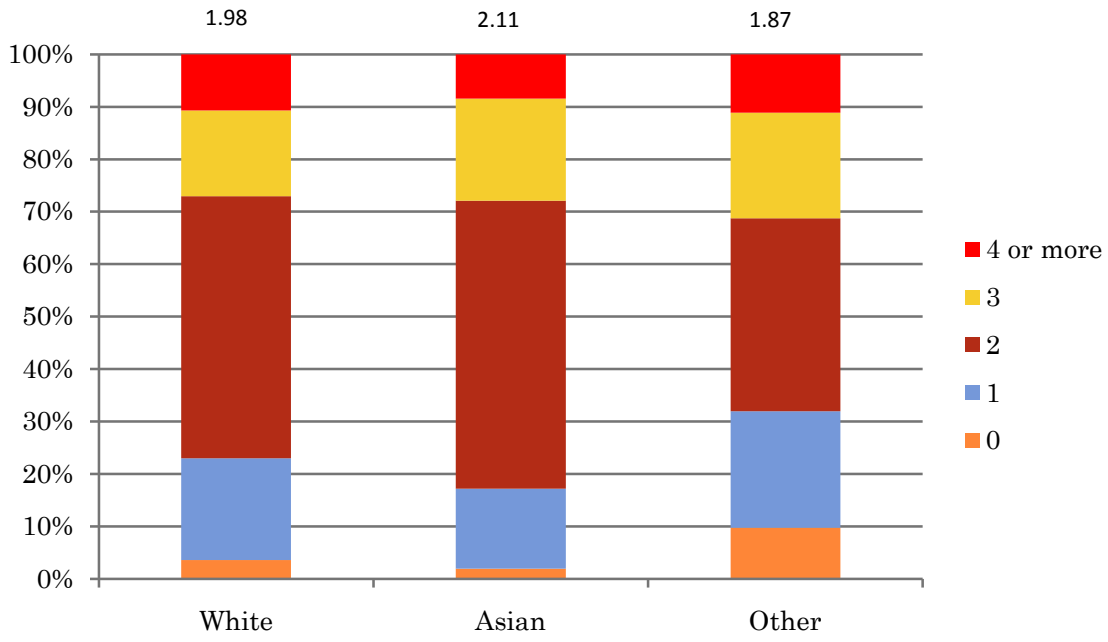
Residential Location: Ethnicity + Immigration Status



Only among immigrants

White → Mostly Hispanic origin

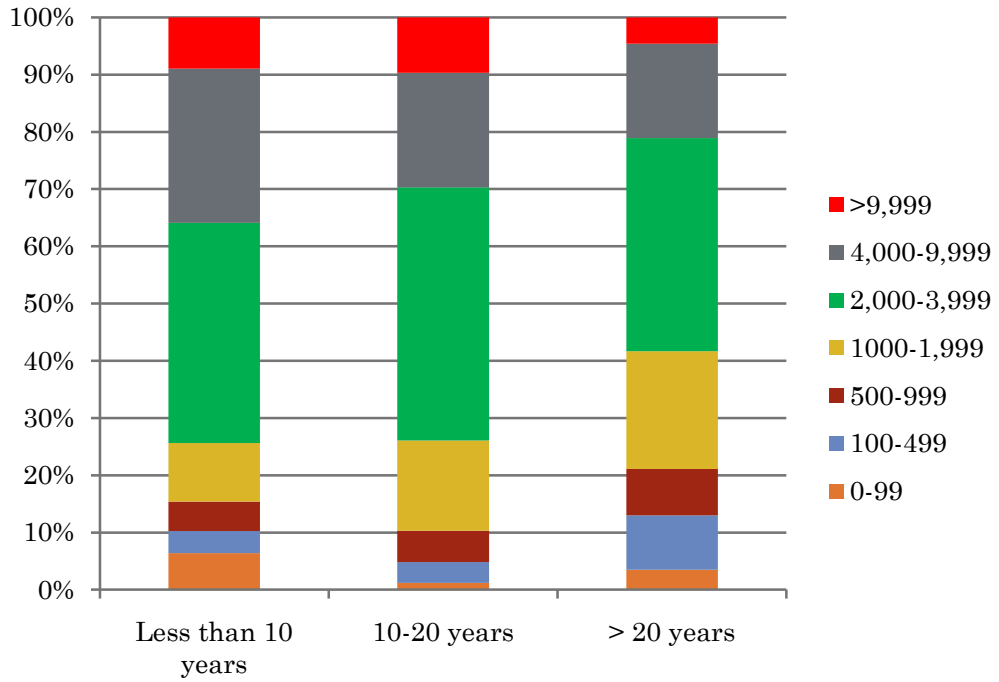
Auto Ownership: Ethnicity + Immigration Status



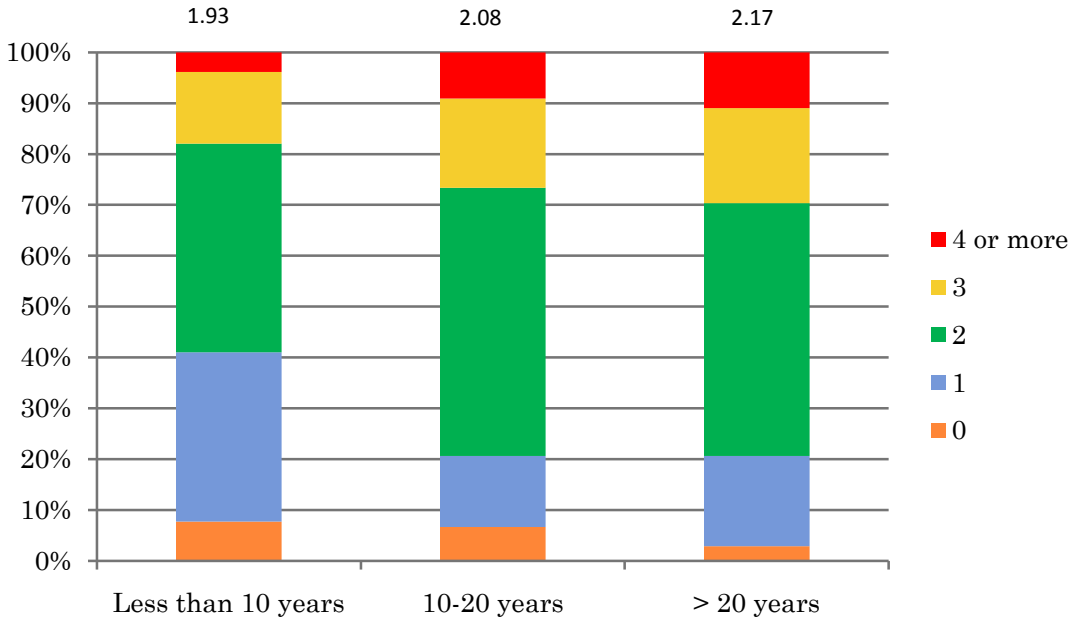
Only among immigrants

White → Mostly Hispanic origin

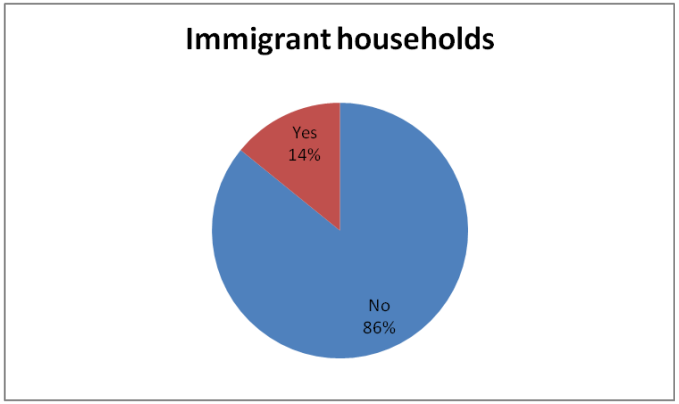
Residential Location: Number of years in US

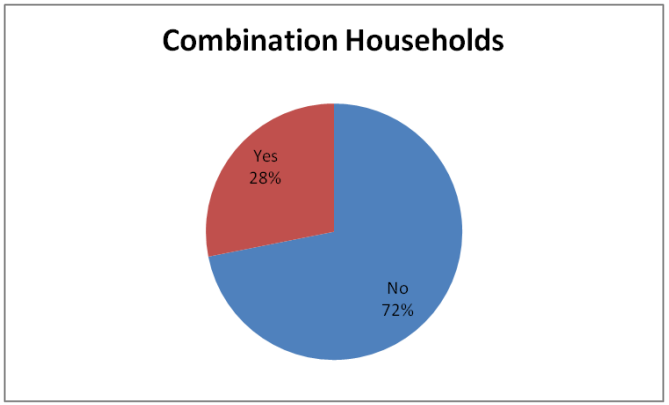


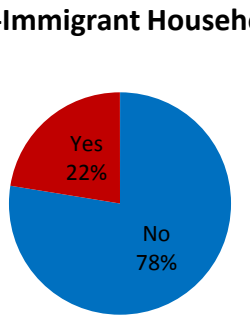
Auto Ownership: Number of years in US



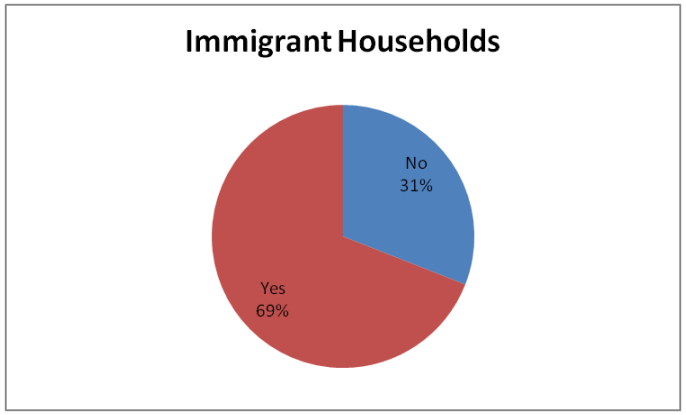
Demographics Differences: Presence of children

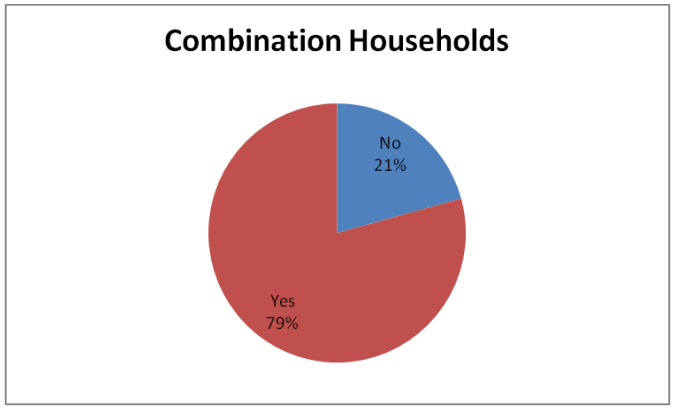


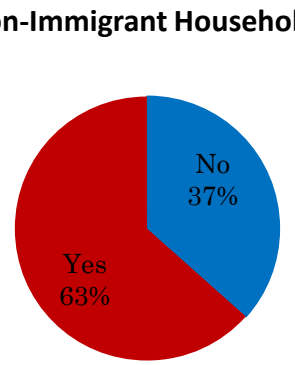




Demographics Differences: Presence of Worker







KEY RESULTS: Self Selection

- Even after controlling for various BE measures and individual + household socio-demographic variables we found significant residential self selection effects
- Residential neighborhood choice is endogenous to auto ownership decision
- Households in high density locations are less likely to obtain more vehicles
- Households might be deliberately choosing to live in neighborhoods that have land use configurations and transport infrastructure elements conducive to less auto dependence because of some intrinsic lifestyle preferences

Key Results: Household Residential Location

- Immigration Status
  - *Both Immigrant and combination households are more likely to locate in neighborhoods with higher household density compared to non-immigrant households*
  - *As the number of years that the immigrant household has been living in US increase, the utility associated with high density location alternatives decrease → Assimilation*

- Built Environment Effects
  - *Land use mix measures*
    - Among neighborhoods with the same fraction of multi-family dwelling units, high density (4,000 -9,999 and >9,999) locations are preferred over neighborhoods with lower densities
    - High density neighborhoods (>500) are preferred over locations with lower densities with the same fraction of residential land use
    - *Fraction of residential land use in the zone less important to combination and more so for immigration households*
  - *Demographic Mix Measures*
    - High density neighborhoods (>1000) with higher average zonal household income have lower utility compared to low density neighborhoods
    - As the fraction of Asian population in the neighborhood increase, utility associated with high density alternatives (>3,999) increase relative to other location alternatives
    - *Zones with high fraction of Asian population most likely neighborhood for Asian Immigrants*

KEY RESULTS: HOUSEHOLD RESIDENTIAL LOCATION

- *Employment Density Measures*
  - As the total employment density increases, utility associated with location alternatives with household density> 100 increase
- *Activity Intensity Measures*
  - Presence of school in the zone significantly increases the utility associated with high density (>3,999) alternatives
  - *Presence of school in the zone is not as important as it for non-immigrant households*
- *Local Street Network Measures*
  - As miles of highways increases in the zone, utility associated with high density alternatives (>1,000) decreases → reflection of congestion concerns
  - As the miles of bikeways increase, utility of high density alternatives (> 1,000) increase compared to low density alternatives
  - Presence of transit service also positively impacts the utility associated with all the location alternatives relative to the base alternative (<100)
- *Network level accessibility measures*
  - Accessibility to retail opportunities and number of zones accessible by bike or walk within 5 minutes have a positive effect on the utility associated with high density alternatives
  - *Number of zones accessible by bike or walk within 5 minutes is very important for combination and immigrant households. But, as the number of years in US increase it becomes less important*
  - *It is even more important for Asian immigrant households*

KEY RESULTS: AUTO OWNERSHIP

- Immigration Status
  - *Immigrant households are less likely to own cars compared to non-immigrant and combination households*
  - *As the number of years that the immigrant household lived in US increase, utility associated with non-zero auto (1,2,3 and 4 or more) ownership alternatives increase → Assimilation*

- Built Environment Measures
  - *Land use mix measures*
    - As the fraction of multi-family dwelling units in the home TAZ increase, the utility associated with non-zero auto ownership alternatives decrease
    - *Fraction of multi-family dwelling units has the same directional but much greater impact on utilities of non-zero auto-ownership alternatives for immigrant households*
    - Households located in TAZ with high residential land use are more likely to own 4 or more vehicles
    - *Immigrant households in TAZs with higher commercial land use are less likely to own 3 or more vehicles*

- *Demographic Mix Measures*
    - Households in TAZs with higher average household income are more likely to own more vehicles
    - Households located in TAZs with high Hispanic population are less likely to own any vehicles whereas *immigrant households in TAZs with high Asian population are very less likely to own 4 or more vehicles*

Key Results: Auto Ownership

- *Employment Density Measures*
  - Households located in TAZs with high retail and service employment densities are more likely to own vehicles
- *Activity Intensity Measures*
  - As the density of out-of-home recreational centers at the home TAZ increase, utility of 4 or more vehicles alternative increase significantly → probably because of more chances of joint recreation activities with other household members
  - Households located in TAZs with high density of retail and maintenance centers are less likely to own more than 2 vehicles
  - Presence of school in home TAZ brings down the utility associated with higher auto ownership alternatives
- *Local Street Network Measures*
  - Households located in TAZs with higher miles of street blocks are less likely to own more than 3 vehicles
  - *Asian immigrant households located in zones with high miles of street blocks are even less likely to own more vehicles*
- *Network level accessibility measures*
  - *Higher the number of zones accessible by walk, bike or transit within 5 minutes from home zone, less likely is the immigrant and combination households to own more vehicles*

Conclusion

- Impact of immigration status and duration of stay in US on vehicle ownership
- Found significant impact of immigration status on residential location as well as auto ownership even after controlling for various demographic factors
- Evaluated the impact of comprehensive set of BE measures accounting for the selection effects
- Found differential sensitivities of immigrant and non-immigrant households to BE measures
- Future efforts: Compare the implications of the joint model with those obtained using model ignoring immigration status for different land use policies

Thank You