The Impact of Urban Form and Gasoline Prices on Vehicle Usage: Evidence from the 2009 National Household Travel Survey

Harya S. Dillon[1], Jean-Daniel Saphores[2], Marlon Boarnet[3]

[1,2]Institute of Transportation Studies, University of California, Irvine; [3] Sol Price School of Public Policy, University of Southern California

Email: [1]hdillon@uci.edu; [2]saphores@uci.edu; [3]boarnet@usc.edu

Abstract

- We use Structural Equation Modeling (SEM) to tease out the relationship between land use, gasoline prices and travel behavior.
- Data: Southern California subsample of the 2009 National Household Travel Survey (NHTS). N = 3,752
- Quasi-experimental design because large exogenous variations in gasoline prices observed during survey period (March 2008-April 2009).
- Joint models of residential urban form, vehicle efficiency choice, and vehicle use account for residential self-selection and endogeneity of vehicle preferences.

Introduction

Research questions and significance
- How does urban form affect household travel behavior?
- How much do households adjust their travel behavior and vehicle usage in the short-run when gasoline price changes?
- Few studies have analyzed urban form and gas prices together.

Strategy
- Structural Equation Modeling (SEM) to account for endogenous effect of vehicle and residential choices on vehicle usage,
- Model is estimated for **total** household trips, **work** trips and **non-work** trips.
- Residential "urban form" is treated as a latent construct, measured by manifest variables such as population density, land use diversity and distance to employment centers.
- Confirmatory Factor Analysis (CFA) used for measurement sub-model to account for "urban form".
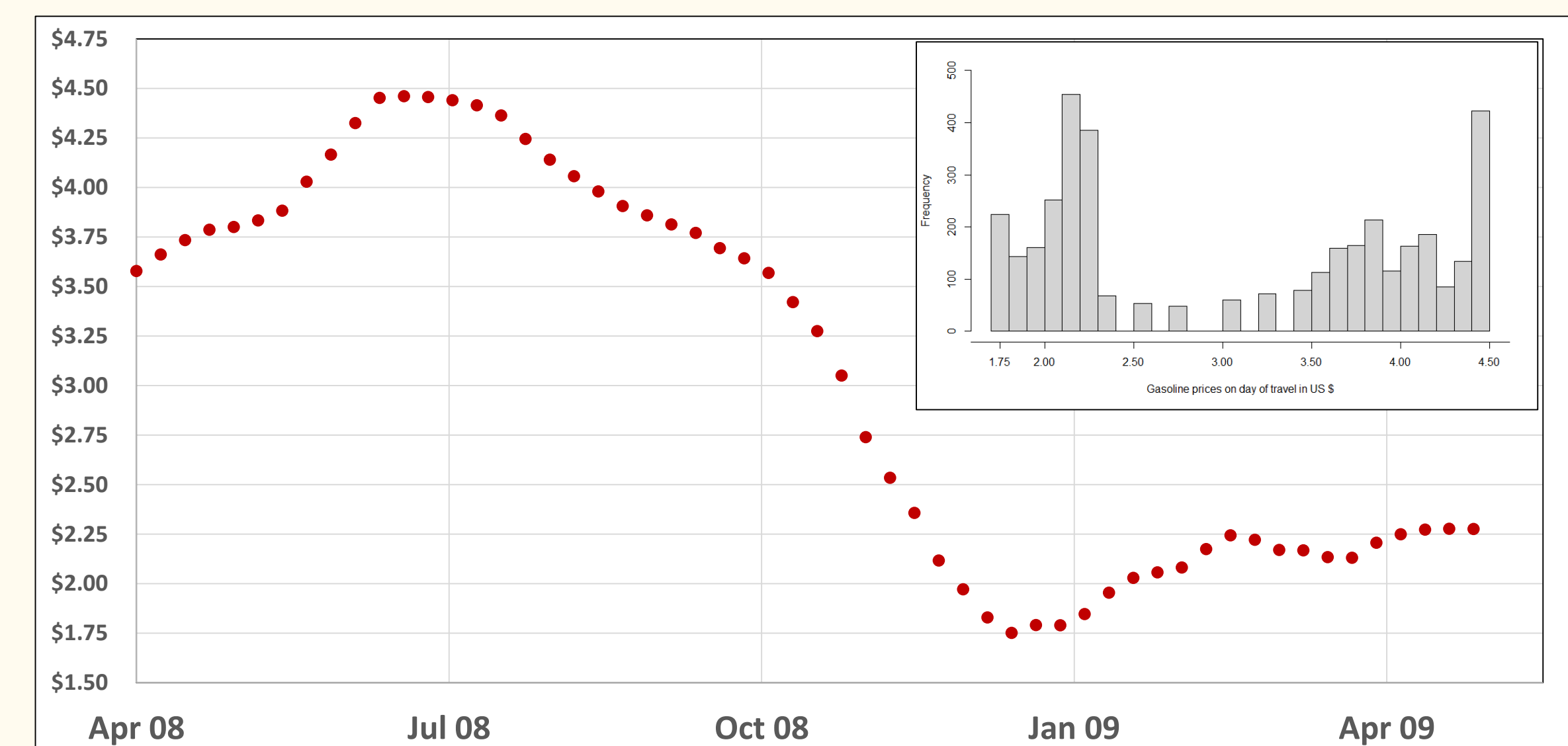
Data

- Travel diary: Southern California geocoded sub-sample of 2009 National Household Travel Survey (NHTS)
- Large gas price variation during survey period: March 2008-April 2009
- Parcel level land use data from the Southern California Association of Governments (SCAG) used to calculate land use diversity.
- Location of employment centers & transit stops location and service level

Spatial distribution of surveyed households shows spatial randomness during survey period. Study area boundary shown in red.

April 2008 / July 2008 / Oct 2008 / Jan 2009
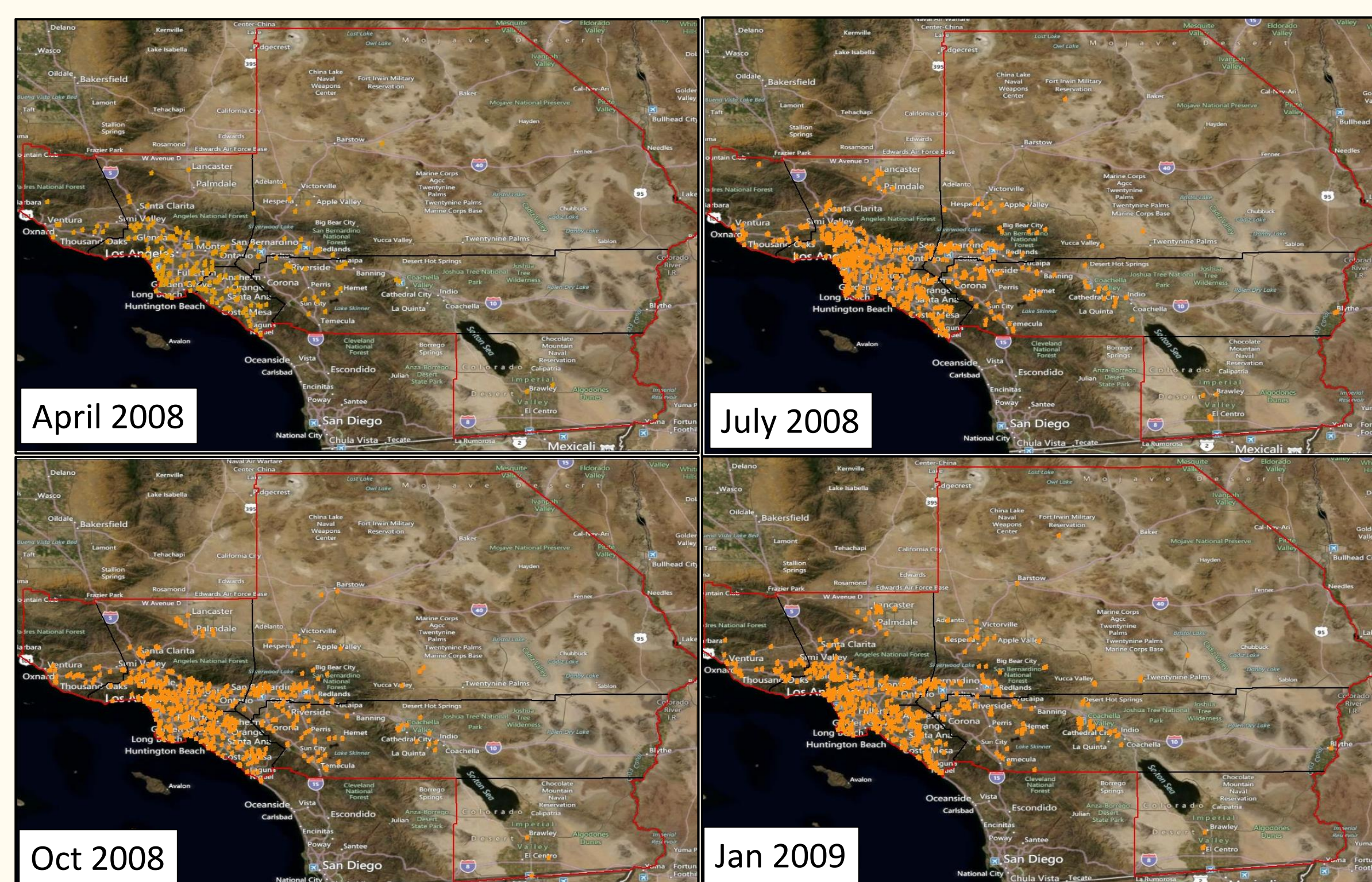
©Harya S Dillon [hdillon@uci.edu], 2015

Gas price fluctuation and distribution during survey period

### Land Use Entropy calculation

$$Entropy = \frac{-1}{\ln(k)} \sum_{j=1}^{k} p_j \cdot \ln(p_j)$$

Where p_j is the area's proportion of land use of type j in the block group. SCAG's land use database stores parcel level land use based on 150 categories, which we condensed into k = 15 major types of land uses

Methodology

Measurement Model
- Residential urban form (Urban Form), represented as an endogenous latent construct, estimated using Confirmatory Factor Analysis (CFA)

Path Diagram
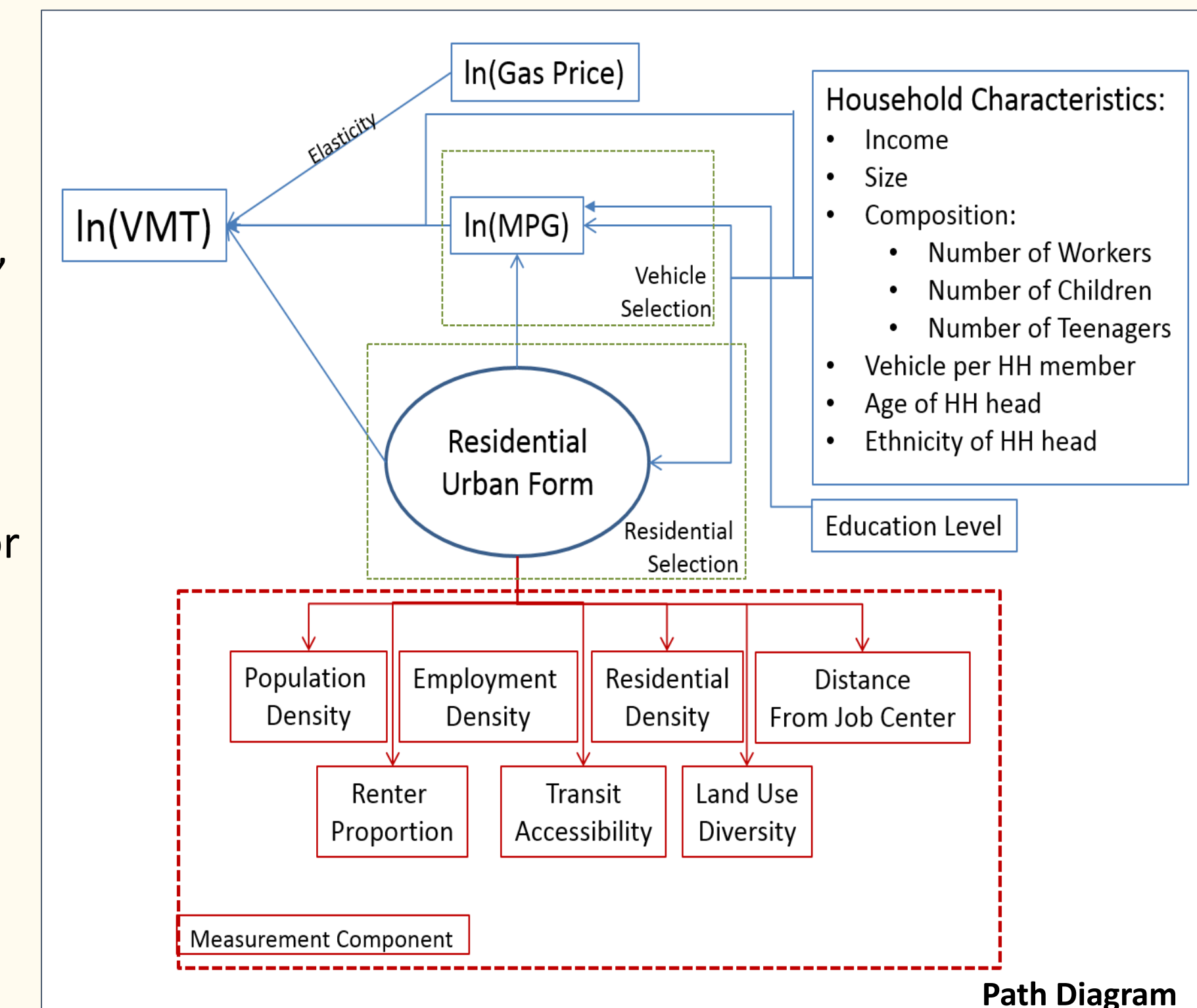
Structural Model
- Recursive, 3 simultaneous equations to estimate gas price elasticity of driving, vehicle selection and residential selection.
- Model estimated for total household trips, work trips and non-work trips.
- Identification guaranteed by recursivity (Bollen, 1989; Kline, 2005).
- Model fit is adequate (CFI = 0.93, RMSEA = 0.025) (Bollen, 1989; Kline, 2005).

Results & Interpretation

Structural Model Coefficients

Direct Effects	Gasoline price elasticity			Vehicle Selection	Residential Selection
	All Trips	**Non-Work**	**Work trips**	**All Trips**	
Exogenous ↓ | Endogenous →	Log(total VMT)	Log(non-work VMT)	Log(work VMT)	Log-MPG	Res. Urban Form
Residential Urban Form	-0.127***	-0.127***	-0.058**	0.006*	- -
Log-Vehicle efficiency	0.133	0.217*	0.008	- -	- -
Log-price of gasoline	-0.209**	-0.251***	-0.030	- -	- -
Household characteristics					
Midpoint of annual HH income	0.011***	0.010***	0.004***	0.000	-0.006***
Annual Income is more than $100,000	-0.247***	-0.208**	-0.018	0.008	-0.031
Household size	0.003	0.101***	-0.047	0.002	-0.173***
Number of workers	0.531***	0.254***	1.227***	- -	- -
Number of children under 16	0.068	0.056	0.067	- -	-0.017
Number of person between 16 and 24	0.186***	0.337***	-0.028	- -	- -
Vehicles per licensed driver	0.114**	0.115*	-0.056	- -	-0.408***
Respondent characteristics					
Age 16 to 29	-0.143	-0.068	-0.186	0.050**	0.626***
Age 30 to 44	-0.016	-0.219**	0.045	0.002	0.397***
Age 65 and up	0.006	0.262***	-0.394***	0.014	-0.346***
Hispanic	-0.204***	-0.421***	0.210**	0.013	0.491***
Black	-0.092	-0.227	0.079	-0.015	0.788***
Asian	0.103	-0.068	0.275**	0.062***	0.147
Other ethnicity	0.079	0.273	-0.256	-0.006	0.118
Education: High School degree	- -	- -	- -	0.011	- -
Education: some college	- -	- -	- -	0.003	- -
Education: Bachelor's degree	- -	- -	- -	0.044**	- -
Graduate or professional degree	- -	- -	- -	0.102***	- -

Note: * p≤0.1, ** p≤0.05, *** p≤0.01

Elasticities of driving
- Gas price elasticities vary by trip purpose
  - Work trips: inelastic
  - Non-work trips: - 0.25 (p-value<0.01)
  - Total: - 0.21 (p-value<0.01)
- Elasticity of driving w.r.t population density:
  - Work trips: -0.07 (p-value<0.05)
  - Non-work trips: -0.16 (p-value<0.01)
  - Total: -0.16 (p-value<0.01)

Vehicle selection
- The effect of higher education on vehicle choices begin after attainment of a bachelor's degree
- Asian households own a vehicle with 6.4% higher fuel-efficiency (p-value<0.01) compared to White households.

Residential Selection
- Households in low density neighborhoods are more likely to have a higher household income, to be older than 45 and White.
- These households tend to own more vehicles per driver

Conclusions
- Driving elasticities vary by trip-purpose. Driving for discretionary trips are more responsive to gasoline prices in the short run.
- Effect of urban form on driving is pretty sizeable to gasoline prices, even after accounting for self-selection. However, changes in urban form may take longer to manifest.
- Direct effects dominate total effects: endogeneity exist, but the effect is mild.
- Future studies should investigate the broader context of urban form and prices on travel behavior