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

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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.

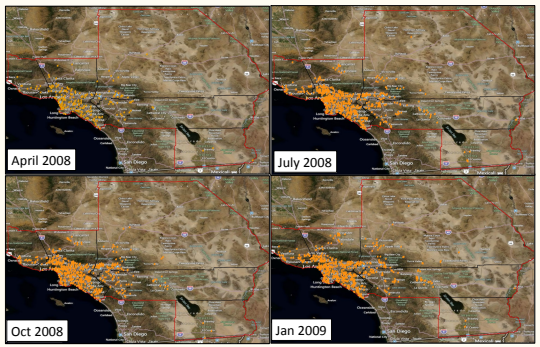
Strategy

- 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".

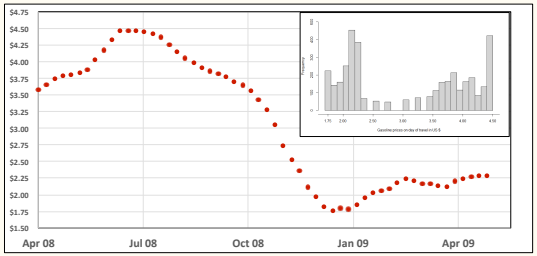
Data

- 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.



Gas price fluctuation and distribution during survey period



Land Use Entropy calculation

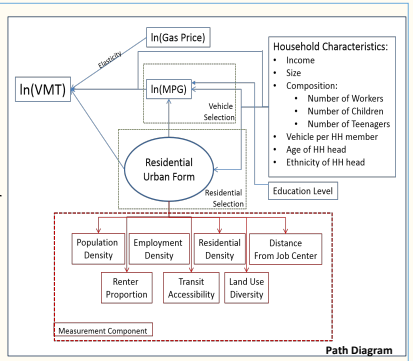
$$Entropy = \frac{-1}{\ln(k)} \sum_{j=1}^{k} p_j . \ln(p_j)$$

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