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Developing Vehicle Ownership and Use Models from the 2001 and 2009 NHTS Data for Environmental Policy Analysis

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Background

Travel Survey

- Primary data source in the U.S. for travel behavior analysis and travel demand modeling at all levels

National Household Travel Survey

- Socio-economic, demographic, location, vehicle ownership, and travel information at the household level
- The most comprehensive dataset for travel analysis and monitoring at the national level in the U.S.

Travel Survey Trend

- Cross-sectional → (Rotating) Panel
- Mail/Telephone-based methods → GPS-based methods
- Decisions → Decision-making processes

NHTS Data Processing and Integration

Integration with EPA Nonattainment Data

- Identifying whether or nor an NHTS household resides in a nonattainment area for each criteria pollutant over time.

Integration with Energy/Environmental Data

- Fuel price at the state and county levels;
- Vehicle characteristics such as price, fuel type, pollution emission rates, etc..

Integration with Land Use Data

- Merging NHTS household travel behavior information with trip origin, trip destination, and metropolitan land use characteristics information.

Research Questions

Develop statistical models based on the NHTS data to answer the following environmental and energy policy questions:

- What is the impact of air quality control and EPA nonattainment designation on travel behavior and VMT?
- What is the impact of green transportation financing policies (e.g. green VMT fees, marginal-cost pricing) on Vehicle ownership, VMT, revenue, and equity?
- What is the impact of land use policies (e.g. high density, mixed development, neighborhood design) on travel behavior and VMT?
- How do high gas prices influence travel behavior, and subsequently soak time distributions?

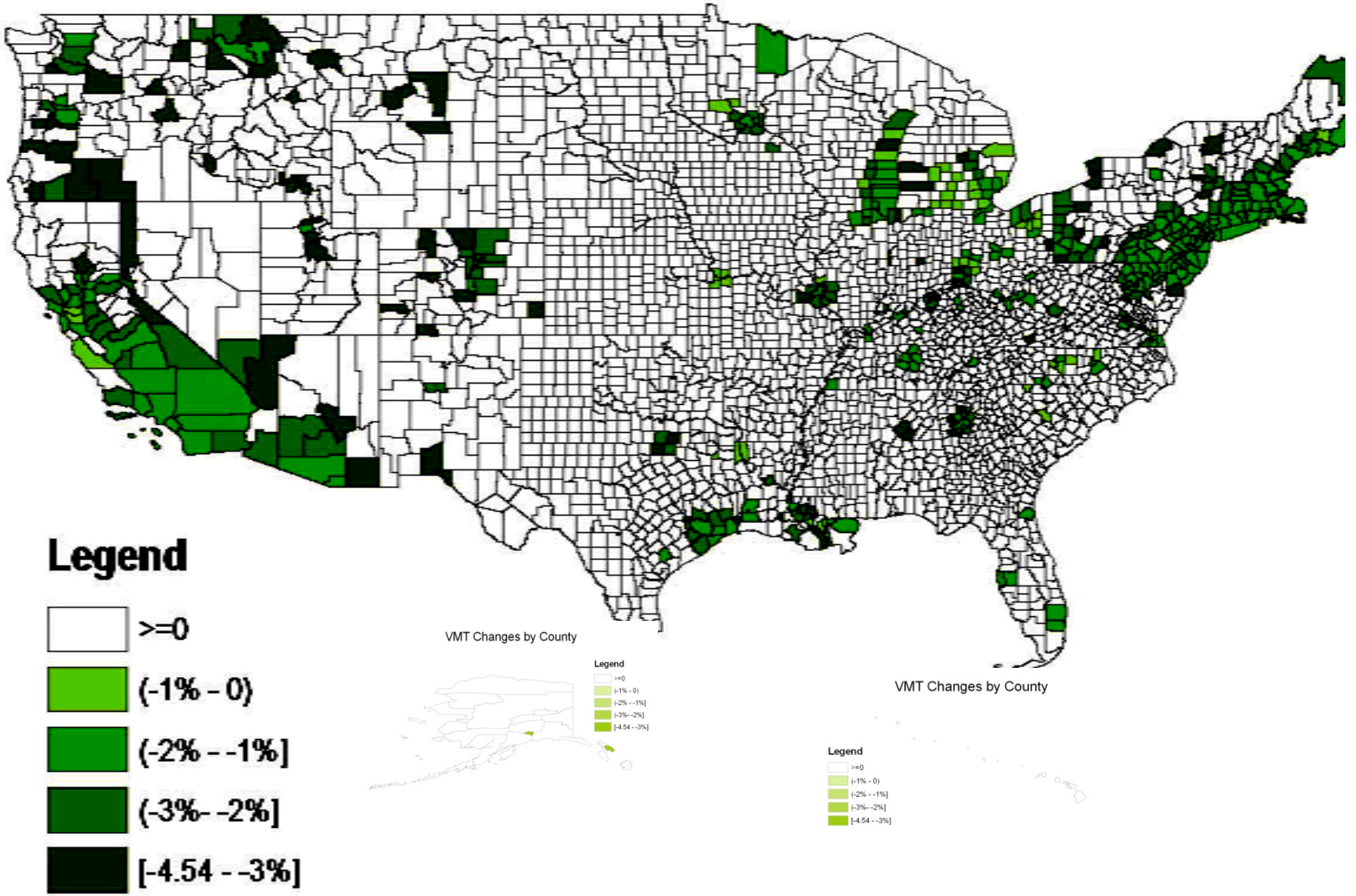
Environmental and Energy Policy Analysis #1

What is the impact of air quality control and EPA nonattainment designation on travel behavior and VMT?

Household-Level Model Results

Dependent Var.: ln (VMT)	Model 1	Model 2
Nonattainment Status: Own County	-0.0165* (0.060)	-0.0465** (0.012)
Nonattainment Status: Adjacent County		0.0349* (0.066)
Large urban area	0.0206* (0.079)	0.0199* (0.089)
Small urban area	-0.0313** (0.004)	-0.0296** (0.007)
Distance to Urban Center	-0.0002** (0.048)	-0.0002** (0.043)
ln(Population density)	-0.0612** (0.000)	-0.0613** (0.000)
Number of transit trips taken	-0.1620** (0.000)	-0.1635** (0.000)
Adjusted R-Square	0.7113	0.7116
Household socio-economic and demographic variables not shown.		

Impact of Air Quality Control on VMT



Findings from Household-Level Analysis

Average Impact of Nonattainment Designation

- 1.64% reduction in vehicle miles traveled
- 1.76% reduction in VMT based on HPMS 1968~2008

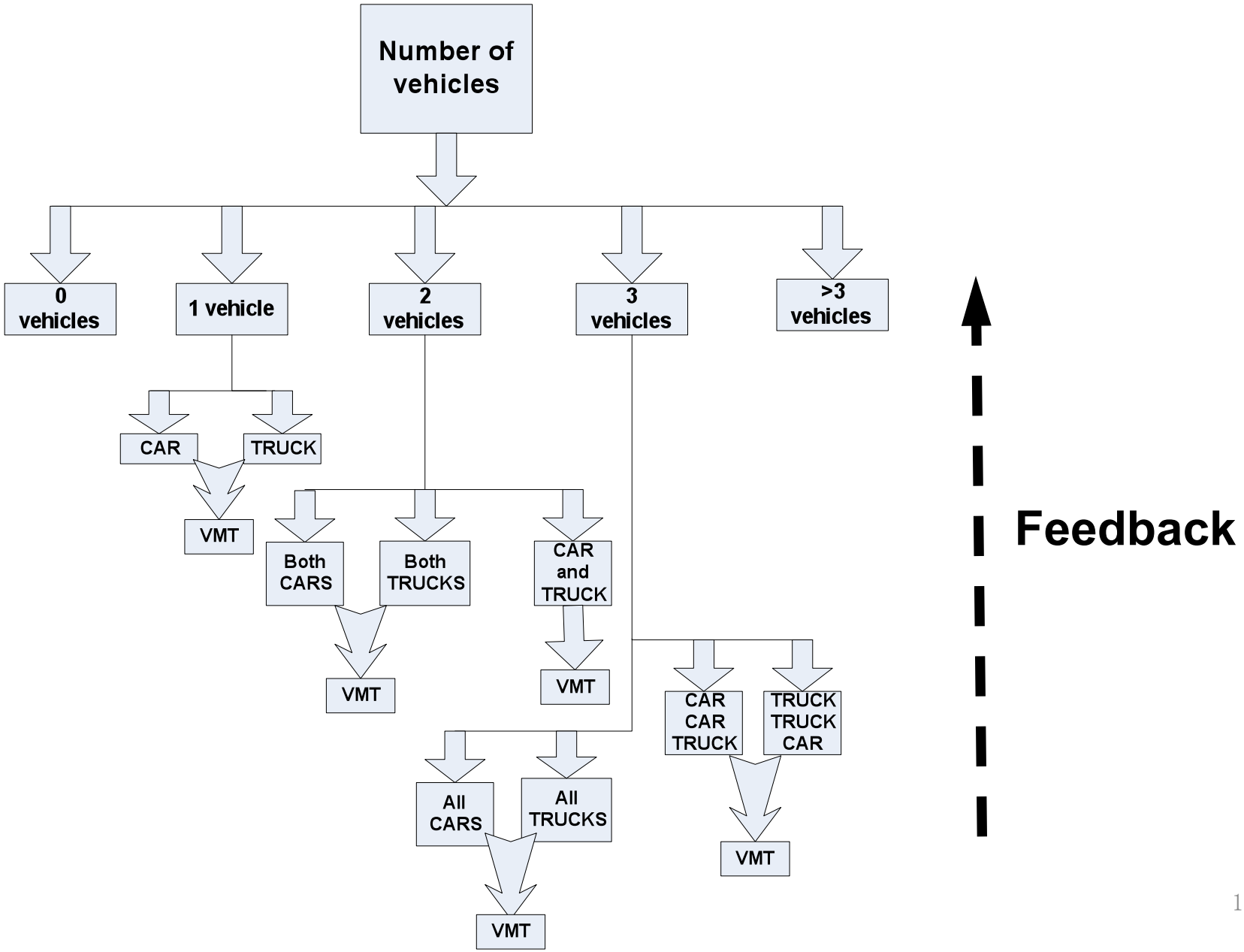
Spatial Variation of the Impact

- 4.54% VMT reduction in counties that only have *attainment* surrounding counties
- 1.15% VMT reduction in counties that only have *nonattainment* surrounding counties

Environmental and Energy Policy Analysis #2

What is the impact of green transportation financing policies (e.g. green VMT fees, congestion pricing, emission taxes) on vehicle ownership, VMT, revenue, and equity at the national and state levels?

Discrete-Continuous Mixed Logit Model



Vehicle Number Choice

	One Vehicle	Two Vehicle	Three Vehicle	Four Vehicle
Variable	Coefficient	Coefficient	Coefficient	Coefficient
Constant	-3.040**	-8.990**	-14.300**	-18.800**
Driver Count	2.860**	5.560**	7.300**	8.240**
Resp_Age16~34	-0.215**	0.488**	0.717**	1.110**
Resp_Age35~64	0.021	0.627**	1.140**	1.570**
Children Count/Household Size	0.052	0.504**	-0.137	-0.944**
Driving Cost/Mile	0.260*	0.048	-0.307	-0.545*
Income (100,000$)	2.120**	3.740**	4.360**	4.680**
MSA>1 million with Rail	0.063	-0.155	-0.434**	-0.670**
MSA>1 million without Rail	0.321**	0.169**	-0.194**	-0.522**
MSA<1 million	0.206**	0.089	-0.213**	-0.576**
Resp_American of Afrian	-0.971**	-1.300**	-1.160**	-1.450**
Resp_Asian	0.017	-0.210	-0.168	-1.000**
Resp_Other Race	-0.526**	-0.603**	-0.508**	-0.541**
Male Respondent	-0.287**	0.155**	0.184**	0.320**
Own House	1.260**	2.430**	2.990**	3.580**
Residential Density	-0.104**	-0.193**	-0.257**	-0.329**

Vehicle Type Choice

	Small Car	Large Car	Small SUV	Large SUV	Small Truck	Large Truck	Minivan
Variables	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Driving Cost/Mile	-0.46100**						
Vehicle Price	-0.00015**						
Price*Income	0.00032**						
Interior Room	0.00991**						
Horse Power	0.00952**						
-Towing	0.000	0.000	0.00011	0.00071**	0.0001	0.00014**	0.00038
Income (100,000$)	0.259*	-1.730**	0.908**	-2.420**	0.347	-2.110**	0.0000
Household Size	-0.948**	-0.559**	-0.655**	0.151**	-0.697**	0.022	0.0000
MSA>1 million with Rail	2.270**	0.176	1.030**	-1.550**	-0.701**	-3.080**	0.0000
MSA>1 million without Rail	0.947**	0.124	0.310**	-0.672**	-0.699**	-1.290**	0.0000
MSA<1 million	0.577**	0.105	0.191	-0.627**	-0.520**	-1.220**	0.0000
Constant	1.060	1.770	0.416	4.490*	1.240	1.440	0.0000

Vehicle Miles Traveled

Dependent Var.: ln (VMT)	Coefficients	P-Value
ln(driving cost/mile)	-2.6628	0.000
ln(income)	-0.1526	0.042
ln(driving cost/mile)* ln(income)	0.1777	0.000
ln(driving cost/mile)* (vehicle substitute)	0.0102	0.002
Ln(vehicle count)	0.8089	0.000
Vehicle Substitute	-0.0307	0.000
Household socio-demographic variables not shown.		

Effectiveness for Revenue Generation

Gas Tax

Increase federal tax by 10 cents/gallon to 28.4 cents/gallon

Vehicle Miles Traveled Tax (VMT)

To achieve the same level of revenue increase, the fixed VMT charge needs to be 1.5 cents/mile

Green VMT

Charge vehicles with > 20 mpg fuel efficiency 1 cent/mile
Charge vehicle with < 20 mpg fuel efficiency 2.1 cents/mile

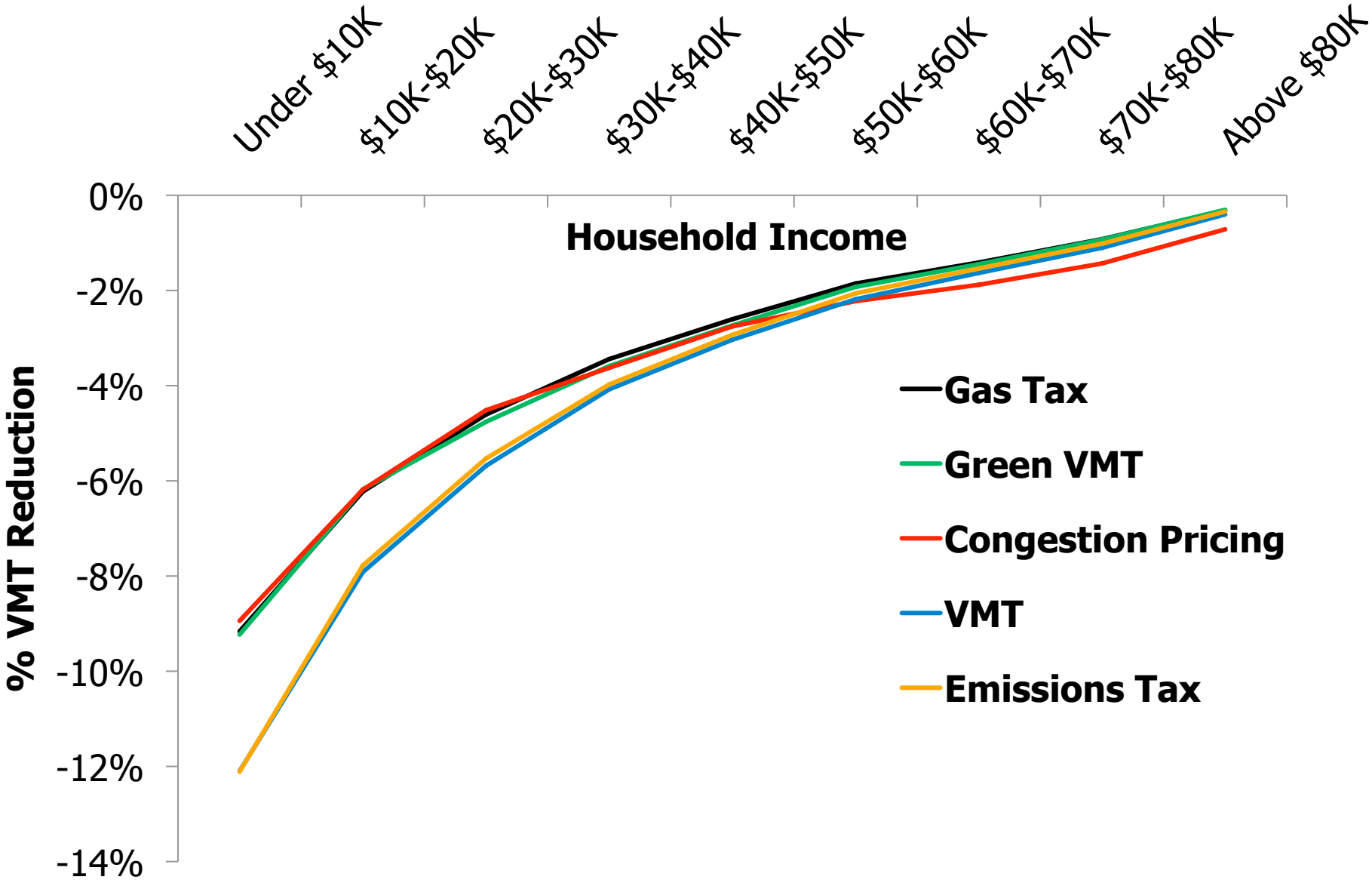
Congestion Pricing

Charge road users a per-mile fee that ranges from 1 to 3.4 cents/mile based on level of MSA congestion

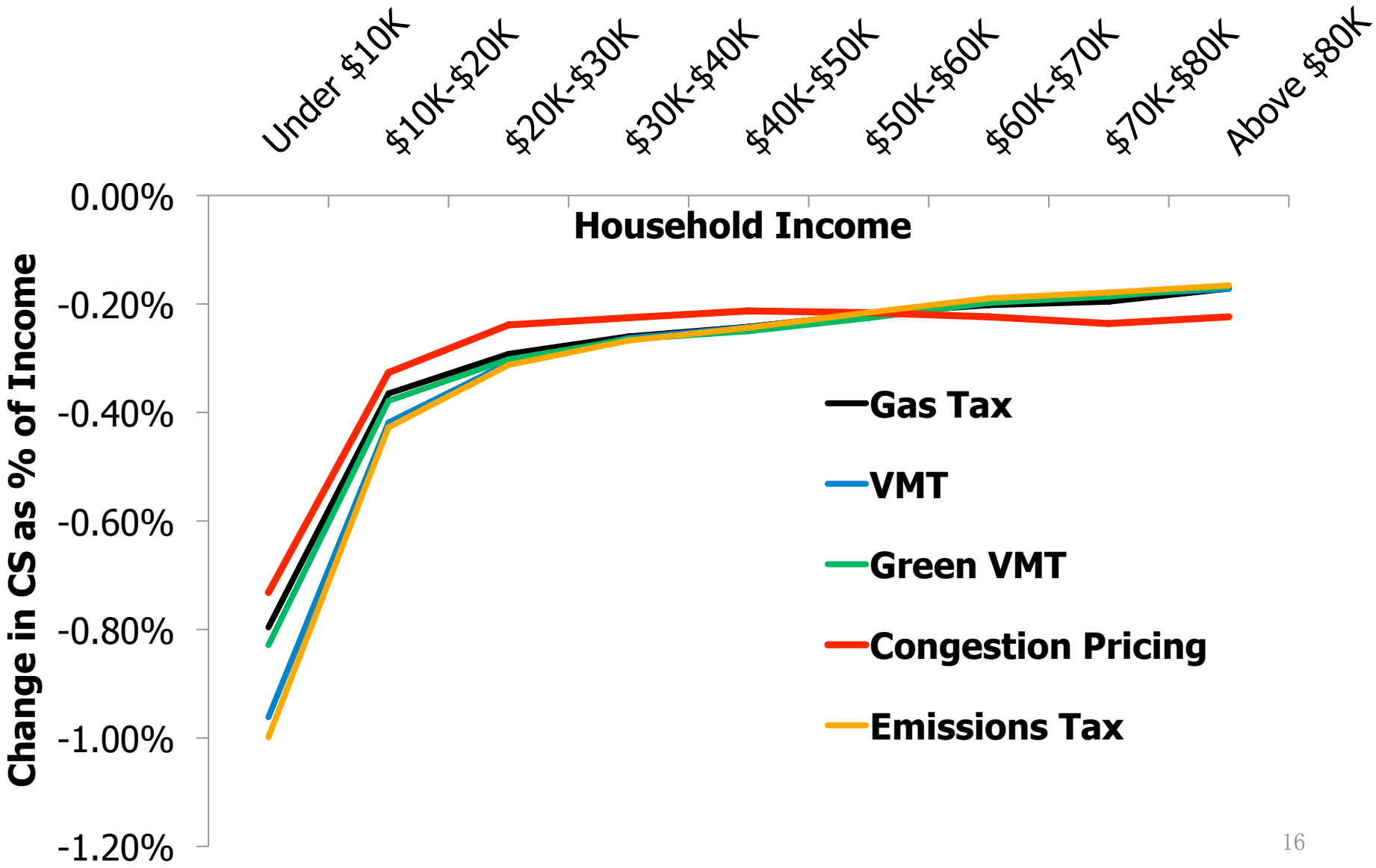
Emission Tax

Charge road users a per-mile fee that ranges from 1 to 2.3 cents/mile based on their EPA vehicle emission

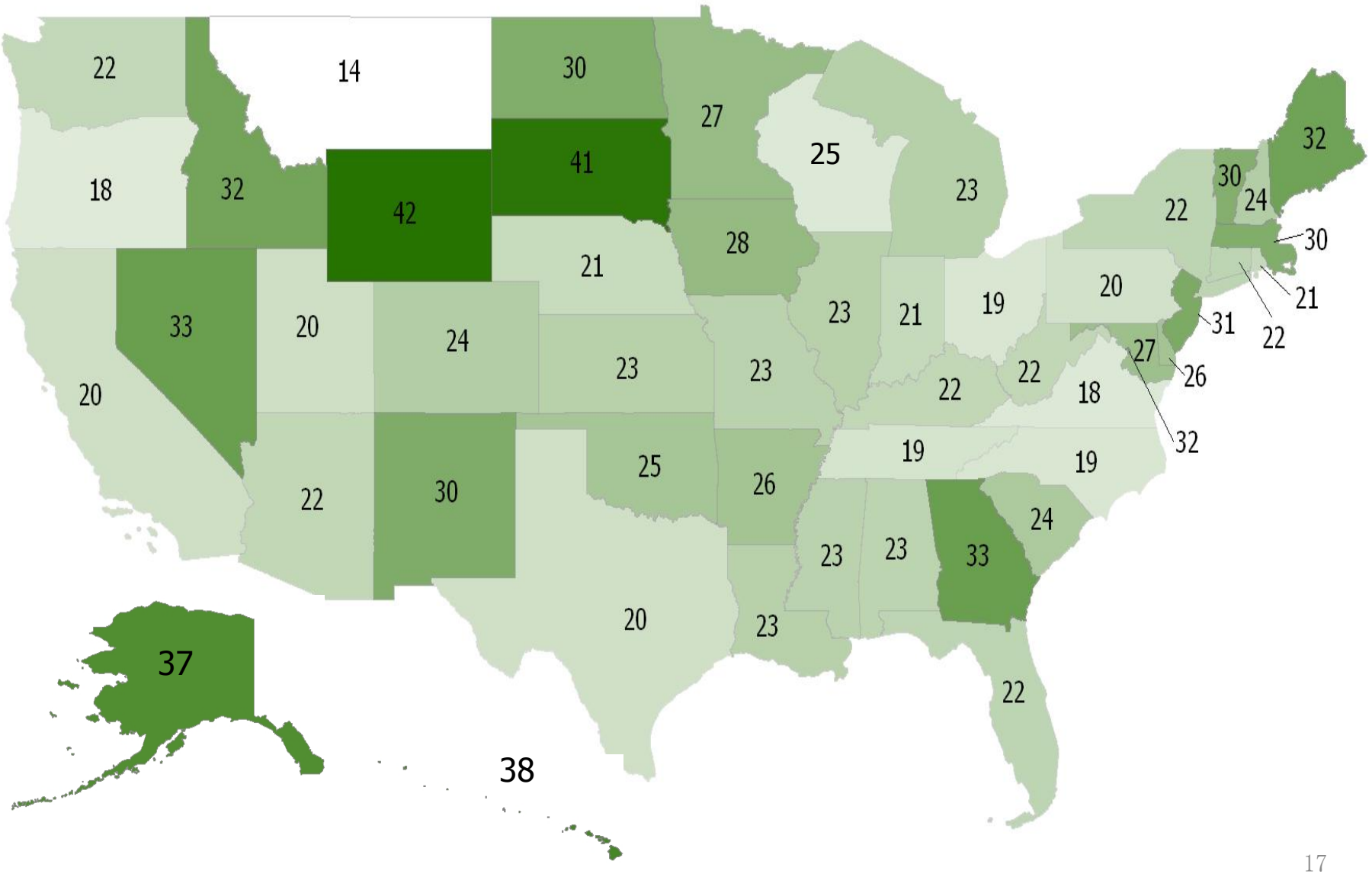
VMT Reduction by Household Income



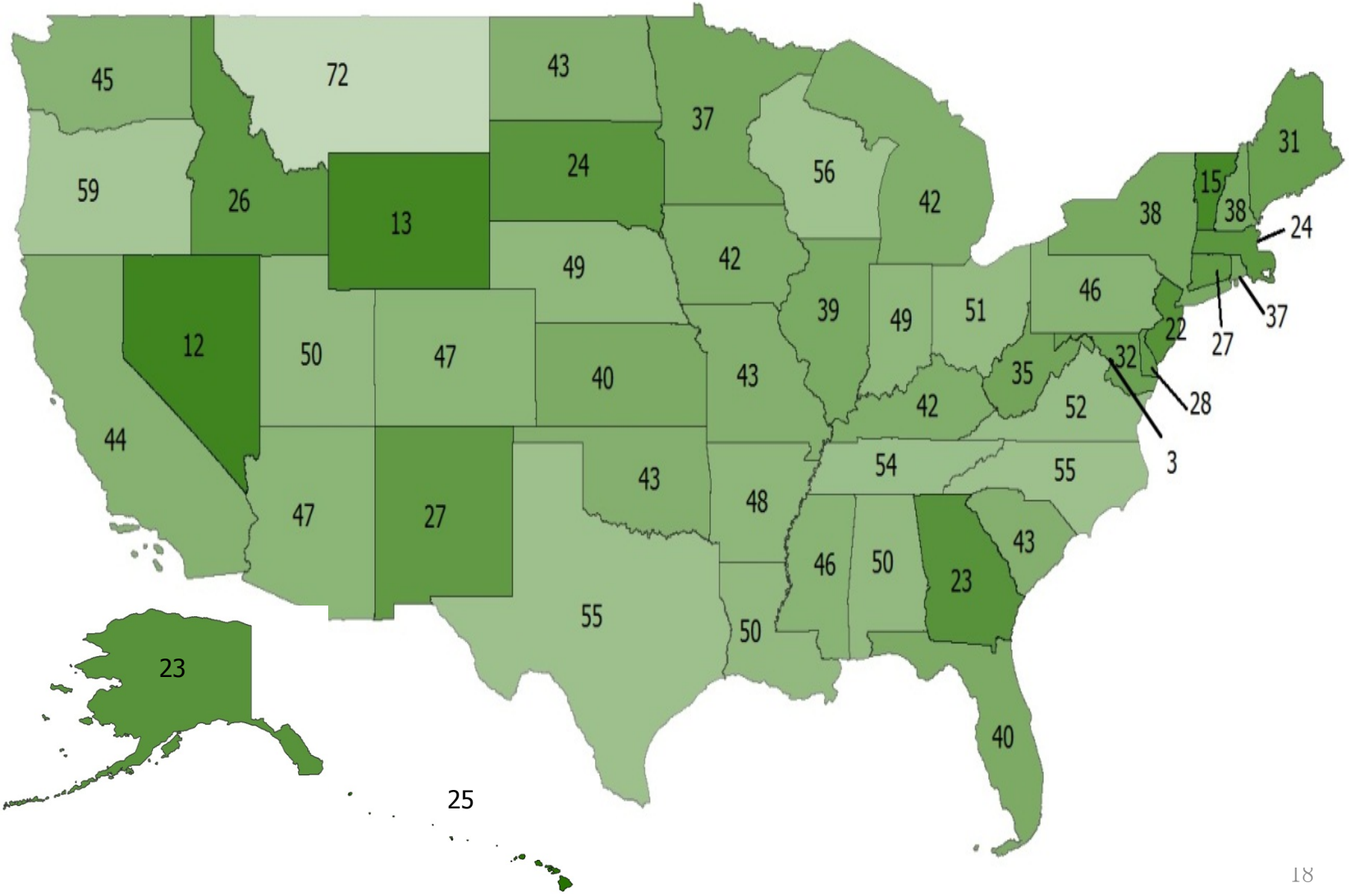
Changes in Consumer Surplus: By Income Group



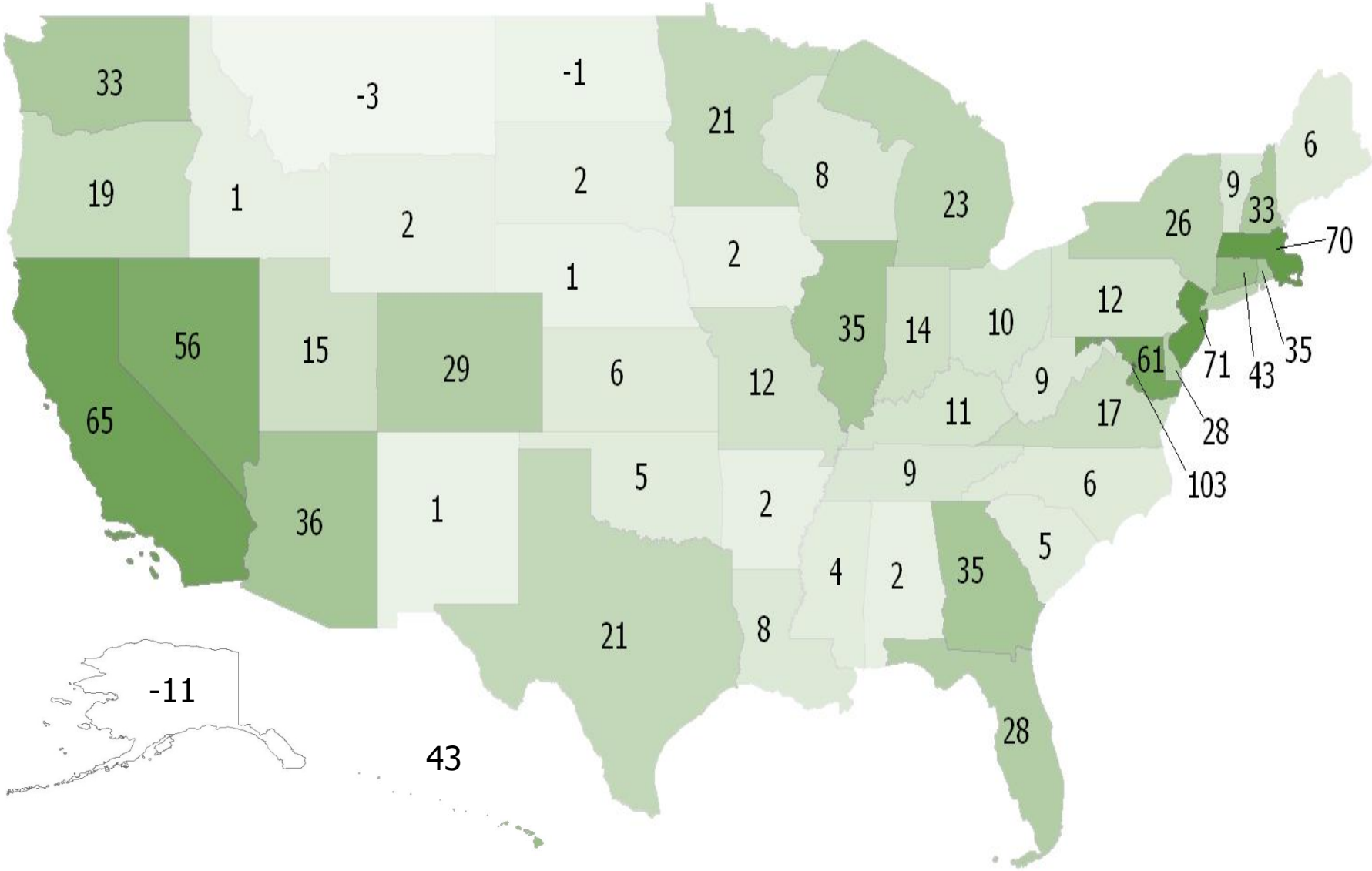
Percentage Change in State Revenue Green VMT Fee



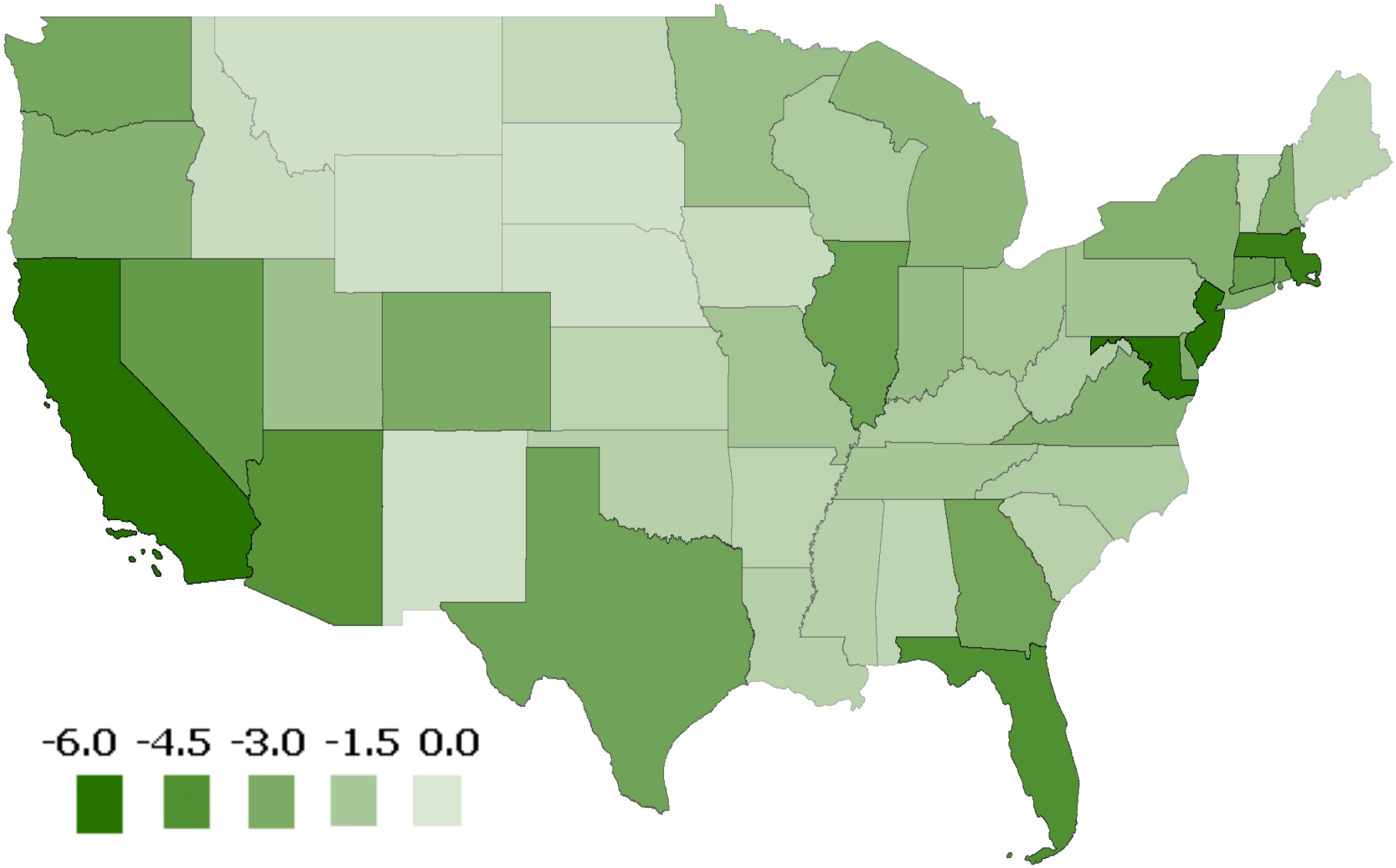
Percentage Change in State Revenue: Emission Tax



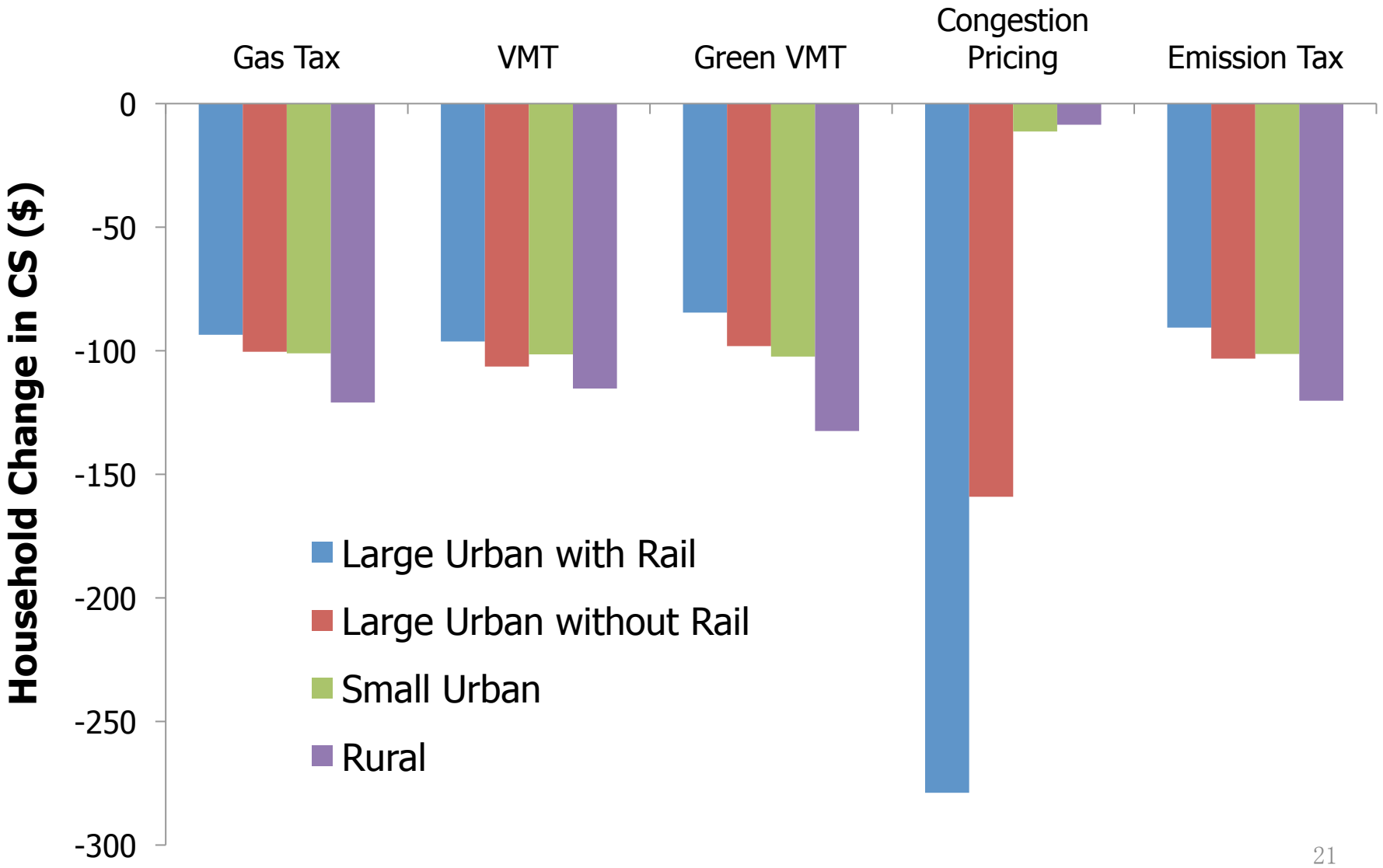
Percentage Change in State Revenue: Congestion Pricing



Percentage Change in VMT by State: Congestion Pricing



Changes in Consumer Surplus: By Level of Urbanization



Environmental and Energy Policy Analysis #3

What is the impact of land use policies (e.g. high density, mixed development, neighborhood design) on travel behavior and VMT?

Defining Land Use Policy Variables

Density

- Residential density (building sqft/area)
- Commercial density (building sqft/area)
- Industrial density (building sqft/area)
- Office density (building sqft/area)

Mixed Use

$$Entropy = -\sum_j \frac{P_j * \ln(P_j)}{\ln(J)}$$

- Six (J=6) land use types are considered: residential, commercial, industrial, office, government and others.

Average Block Size

Distance to CBD

Etc.

Methodological Issues and Research Design

Methodological Issues

- Causality (self-selection)
- Spatial auto-correlation
- Inter-trip dependency (tour)
- Geographic scale

Research Design

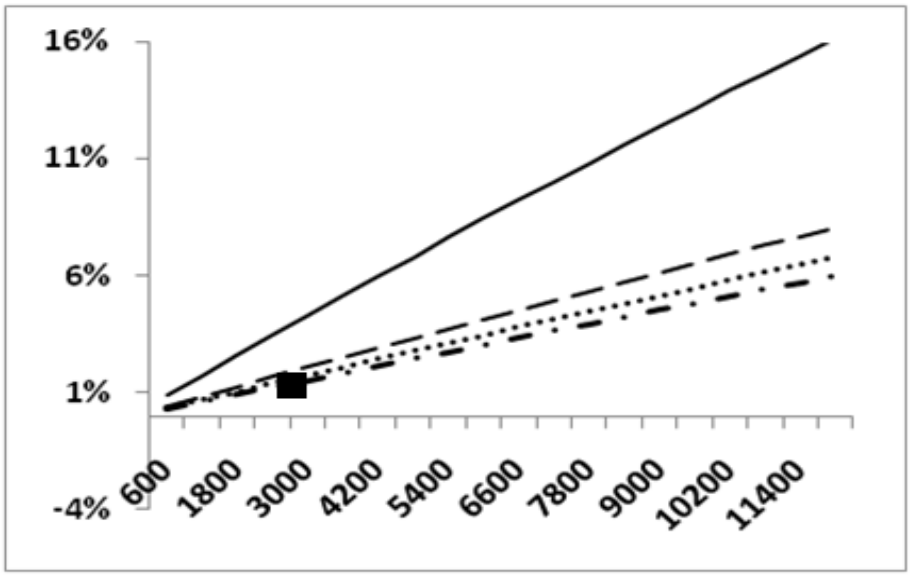
- Address these issues with careful control for travel attitude in modeling, and multilevel/structural equation modeling methods.
- Compare metropolitan areas that have different land use characteristics and policies, using the same analytical approach

Impact of Land Use on per-capita VMT

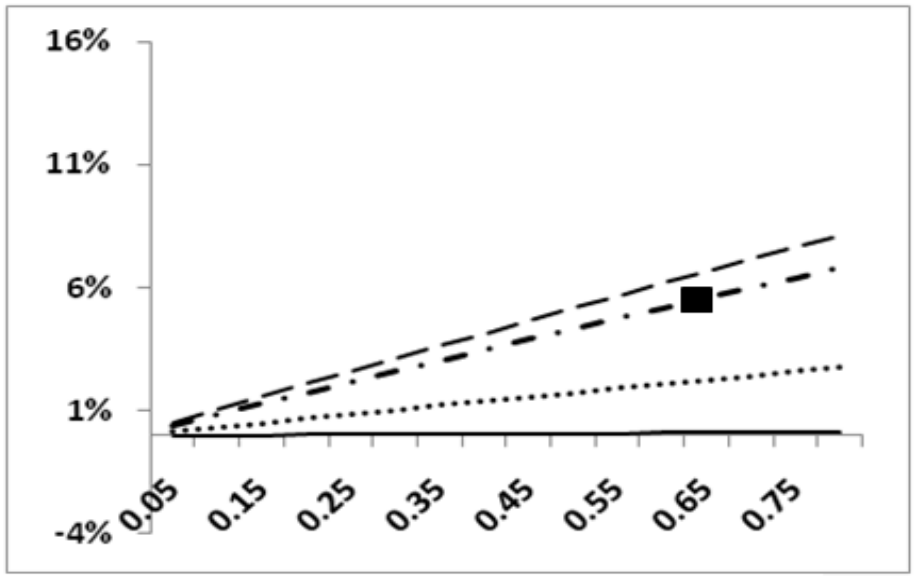
Land Use Variables	Seattle	Baltimore	DC	Virginia
Residential density	-0.308	-0.344	-0.444	-0.262
Employment density	-0.071	-0.085	-0.010	0.034
Mixed Development	-0.149	-0.074	-0.195	-0.003
Average block size	0.153	0.089	0.021	0.220
Distance from CBD	0.331	0.264	0.456	-0.043
Distance to bus stop	0.036	---	---	---

Household socio-demographic variables not shown.

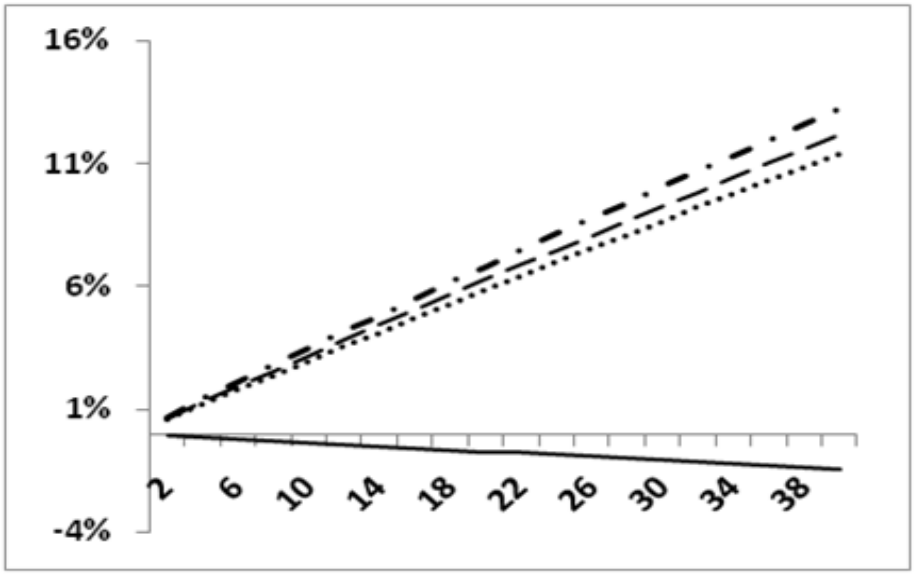
Policy Analysis Applications



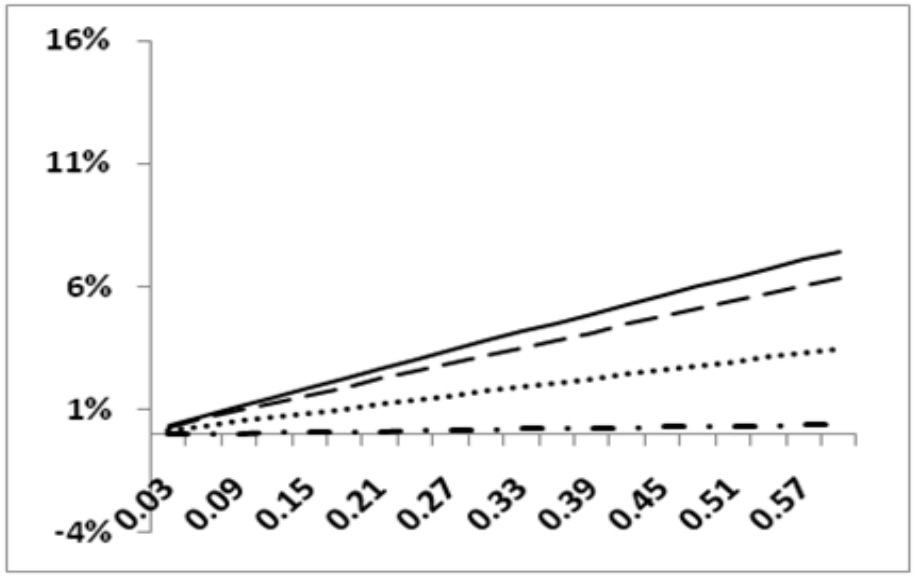
a. Residential Density (persons/sqm)



b. Mixed Development: Entropy (no unit)



c. Compact Development: Distance to CBD (mile)



d. Neighborhood Design: Block Size (mile)

Conclusions

- Air quality control and EPA's nonattainment designation have a statistically significant negative correlation with vehicle miles traveled.
- Green transportation financing policies will result in significant reduction in VMT, fuel consumption, and pollution/GHG emissions. While the lowest-income (< $25K/year) households are hurt the most, the regressivity of green transportation financing policies is similar to that of policies increasing fuel taxes.
- Land use policies can effectively influence travel behavior and VMT, but the actual impact depend on existing local and metropolitan land use characteristics.
- NHTS provides important and often necessary information for critical environmental and energy policy analysis; and its value is even higher in add-on states.

Thank you!

Additional Questions and Comments

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