DISCLAIMER

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Household Transportation Energy Burden depends on the annual vehicle miles, fuel price, and vehicle efficiency.

Household energy costs are an important component of household budgets.

Household Transportation Energy Burden = \frac{\text{Cost}}{\text{Income}} = \frac{\text{Annual Vehicle Miles} \times \text{Fuel Price}}{\text{gallon}} \times \frac{\text{Vehicle Efficiency}}{\text{mile}} \times \frac{\text{household}}{\text{gallon} \times \text{year} \times \text{household}}

Household Income by Census tract

Key research question

Household expenditure categories

Household energy costs
WE USE HIGH RESOLUTION DEMOGRAPHIC CHARACTERISTICS OF EACH TRACT TO PROJECT HOUSEHOLD ANNUAL TRAVEL

Research framework

- Project household annual vehicle travel
- Estimate stock-weighted vehicle efficiency
- Collect fuel price by fuel type (e.g. gasoline)
- Quantify the transportation energy burden

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% of household by # vehicles, # workers and income group for a representative census tract
(Tract ID: 17031770602)

VMT

- Project household annual vehicle travel

MPG

- Estimate stock-weighted vehicle efficiency

Fuel Price

- Collect fuel price by fuel type (e.g. gasoline)

Burden

- Quantify the transportation energy burden

* Each census tract has 220 groups
HOUSEHOLD ANNUAL MILES VEHICLE TRAVEL (VMT) DEPENDS ON THEIR SOCIOECONOMIC FACTORS

Applied Machine Learning techniques to predict household annual vehicle miles traveled (VMT)

- Used National Household Travel Survey (NHTS) samples to develop models to project household annual VMT
- Identified 5 important socioeconomic factors contributing to household VMT (in order of feature importance)
  - # of vehicles
  - # of workers
  - household income
  - housing units density (Urban/Suburb/Rural)
  - Lifecycle factors (# of children or senior people)
- Developed 18 different VMT projection models considering the heterogeneity among census regions and urban/rural areas

6 Census Regions * 3 Urbanity (Urban/Suburb/Rural)
WIDE VARIATION IN AVERAGE HOUSEHOLD VMT ACROSS THE U.S.

The national average annual household VMT is 18,515

- Household annual VMT varies by housing unit density and by region: 2,507 to 40,985, by county
- Suburban and rural households have higher annual VMT than the urban households
- Households in the Pacific and Mountain regions tend to have lower annual VMT

Results are available for each census tract

National average 18,515
ANNUAL VMT INCREASES AS THE HOUSEHOLD AVERAGE INCOME INCREASES: FROM 11,000 TO 30,000 MILES

Higher-income groups have the widest distributions of annual VMT

Household annual VMT by average tract income
(each dot represents a tract)
ON-ROAD VEHICLE MPG VARIES FROM 15.6 TO 23.3 BY COUNTY ACROSS THE U.S.

Adoption of newer vehicles or energy efficient vehicles increases the on-road vehicle efficiency

Efficiency of On-road Vehicles
(Stock-weighted MPG by County, 2018 Registration)

Results are available for each census tract
LOCAL VARIABILITY IN FUEL PRICES UNDERSCORES THE NEED FOR HIGH GEOGRAPHIC FIDELITY

Estimate typical household fuel costs at the tract level

- Gasoline prices vary over time and by place
- Multiplied the on-road MPG by the cost of fuel (in $/GGE) for each fuel type to find the cost per mile of operating each vehicle

\[
\text{Cost} \left( \frac{\$}{\text{mile}} \right) = \text{MPGGE} \times \frac{\$}{\text{GGE}}
\]

MPGGE: miles per gallon of gasoline-equivalent
AVERAGE HOUSEHOLD TRANSPORTATION ENERGY BURDEN RANGES FROM 1.4% TO 4.0% BY STATE

Household transportation energy burden depends on household VMT, MPG, and fuel price.
HOWEVER, THE BURDEN BY CENSUS TRACT VARIES BETWEEN 0.09% AND 23.3%

Rural households have higher transportation energy burden than suburban and urban households for all regions (households with at least 1 vehicle)

% of household income spent on vehicle fuel by county/tract

Illinois: 0.6% to 12.7% by tract

Results are available for each census tract
THIS VARIATION IN TRANSPORTATION ENERGY BURDEN CAN BE LARGELY EXPLAINED BY VEHICLE FUEL EFFICIENCY

Besides income, energy burden highly correlates with vehicle efficiency

Adoption of more fuel-efficient vehicles, especially among low-income households, could have the biggest impact on improving household transportation energy burden.

<table>
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<tr>
<th>Factor Correlations</th>
<th>Burden</th>
<th>Fuel Consumption</th>
<th>Income</th>
<th>VMT</th>
<th>Fuel Price</th>
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<td>VMT</td>
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<td>-0.32</td>
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Blue: Positive Correlation
Orange: Negative Correlation

Household Transportation Energy Burden = \( \frac{\text{Cost}}{\text{Income}} \times \left( \frac{\text{gallon}}{\text{mile}} \times \frac{\$}{\text{gallon}} \times \frac{\text{VMT}}{\text{household}} \right) \times \frac{\$}{\text{year} \times \text{household}} \)
3% IMPROVEMENT IN STOCK-WEIGHTED MPG SAVED
AMERICAN HOUSEHOLD $8.2 BILLION


Largely due to improvement of ICE fuel economy for new vehicles and increasing PEV adoption

Other benefits such as GHG emission reductions could also be quantified

Calculations keep gasoline price and household VMT unchanged to focus on fuel economy improvements
THIS STUDY DEVELOPS A FRAMEWORK TO IDENTIFY THE REGIONAL AFFORDABILITY LEVEL AND QUANTIFY OVERBURDENED FRACTION OF HOUSEHOLDS

- A baseline to show % of households spending above a given affordability threshold on household vehicle fuel
- Help to identify underserved communities and rural populations for future investment
- Help to identify the communities that could benefit from energy efficient technologies
COMMUNITIES WITH HIGH TRANSPORTATION ENERGY BURDEN ALSO FACE HIGH ENVIRONMENTAL BURDEN

Identify the communities that could benefit from energy efficient technologies

% of HH income spent on vehicle fuel

Burden of Environmental Exposures & Population Vulnerability

Source: NRDC
THE FULL DATASET IS AVAILABLE TO VISUALIZE, DOWNLOAD AND EXPLORE

https://openei.org/wiki/Transportation_Energy_Affordability
## SUMMARY

### Method
- Estimate household transportation energy burden, based on annual VMT, on-road vehicle efficiency and fuel price

### Conclusions
- Variation in transportation energy burden can be largely explained by vehicle fuel efficiency

### Equity
- Currently, wealthier census tracts have better fuel economy on average

### Applications
- Identify the communities that could benefit from energy efficient technologies

### Future work
- Include other vehicle ownership costs into the framework
THANK YOU!

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