

VMT, Gasoline Price, and Fuel Efficiency

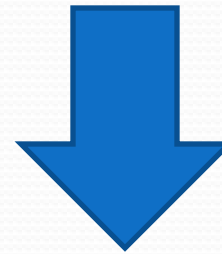
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Motivation

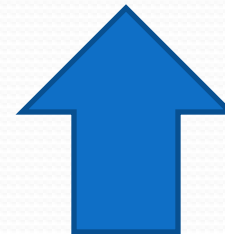
- Greenhouse gas emissions
- Gasoline price
- Electric cars
- Rebound effect
- Congestion

Changes in VMT

Increase in
gasoline
price



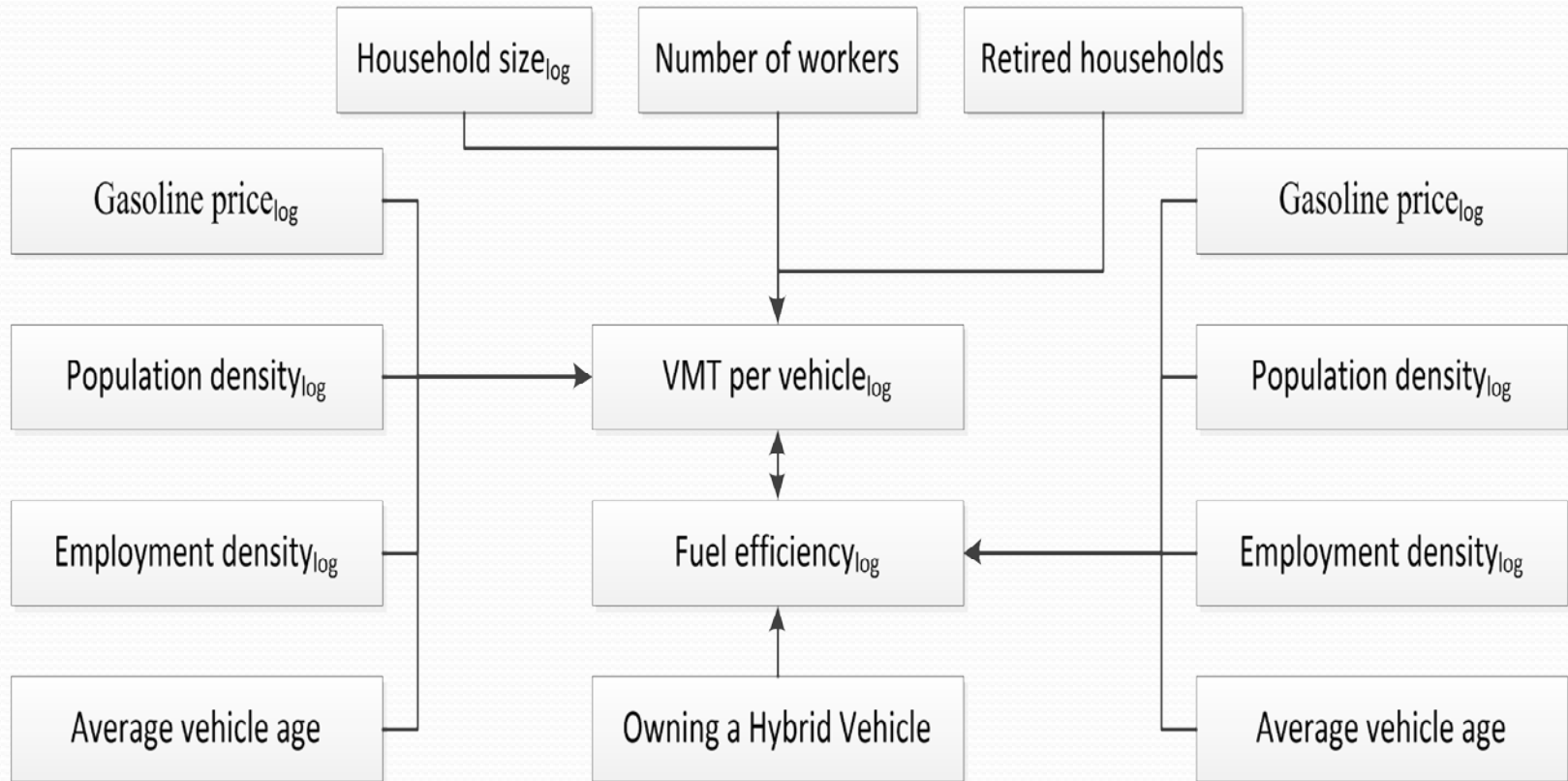
Increase in
fuel
efficiency



Questions

- Do people respond to an increase in gasoline price in the same way as they do to an increase in fuel efficiency?
- Will the price effect be offset by the rebound effect? How does the answer differ by households of different income levels?

The conceptual framework



Specification of VMT and MPG as functions of socio-demographics

| | Household size | No of workers | Average vehicle age | Retired households | Owning a hybrid |
|-----------------|----------------|---------------|---------------------|--------------------|-----------------|
| VMT per vehicle | + | + | - | - | |
| MPG | | | - | | + |

Specification of VMT and MPG as functions of built environment characteristics

| | Population density | Employment density |
|-----------------|--------------------|--------------------|
| VMT per vehicle | - | - |
| MPG | + | + |

VMT, MPG and gasoline price

| | VMT per vehicle | MPG | Gasoline price |
|-----------------|-----------------|-----|----------------|
| VMT per vehicle | | + | - |
| MPG | + | | - |

Empirical dataset

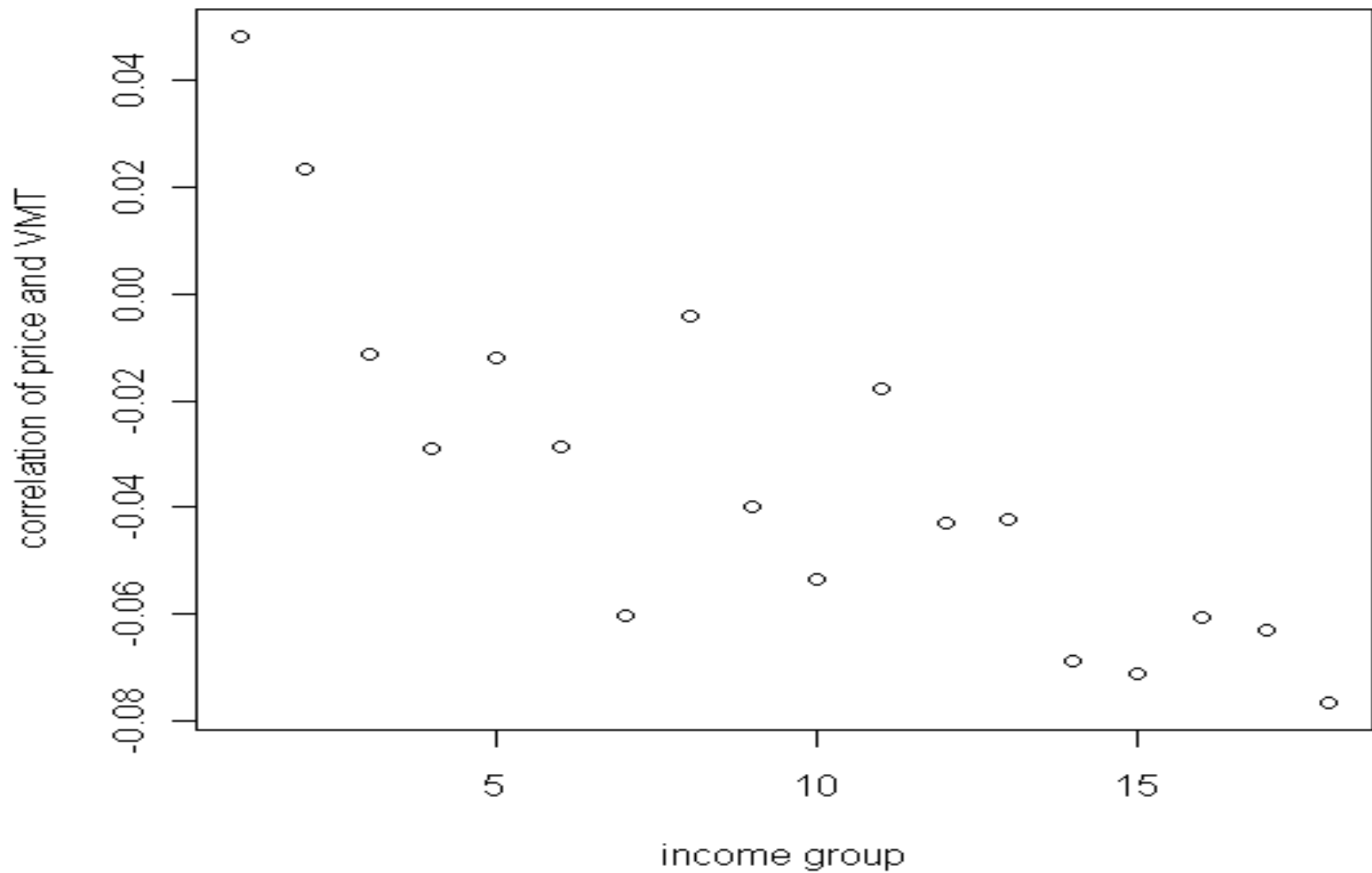
- 2009 National Household Travel Survey (survey conducted bet. March 2008 and May 2009)
 - 150,147 households in the original dataset
 - Our sample of 105,372 households representing 70% of the entire sample
 - Sample selection criteria:
 - Those with commercial vehicles,
 - Those with household income missing
 - Those lacking vehicle age information
 - Those lacking estimates on VMT or MPG
 - Those with extreme values on MPG or no. of vehicles

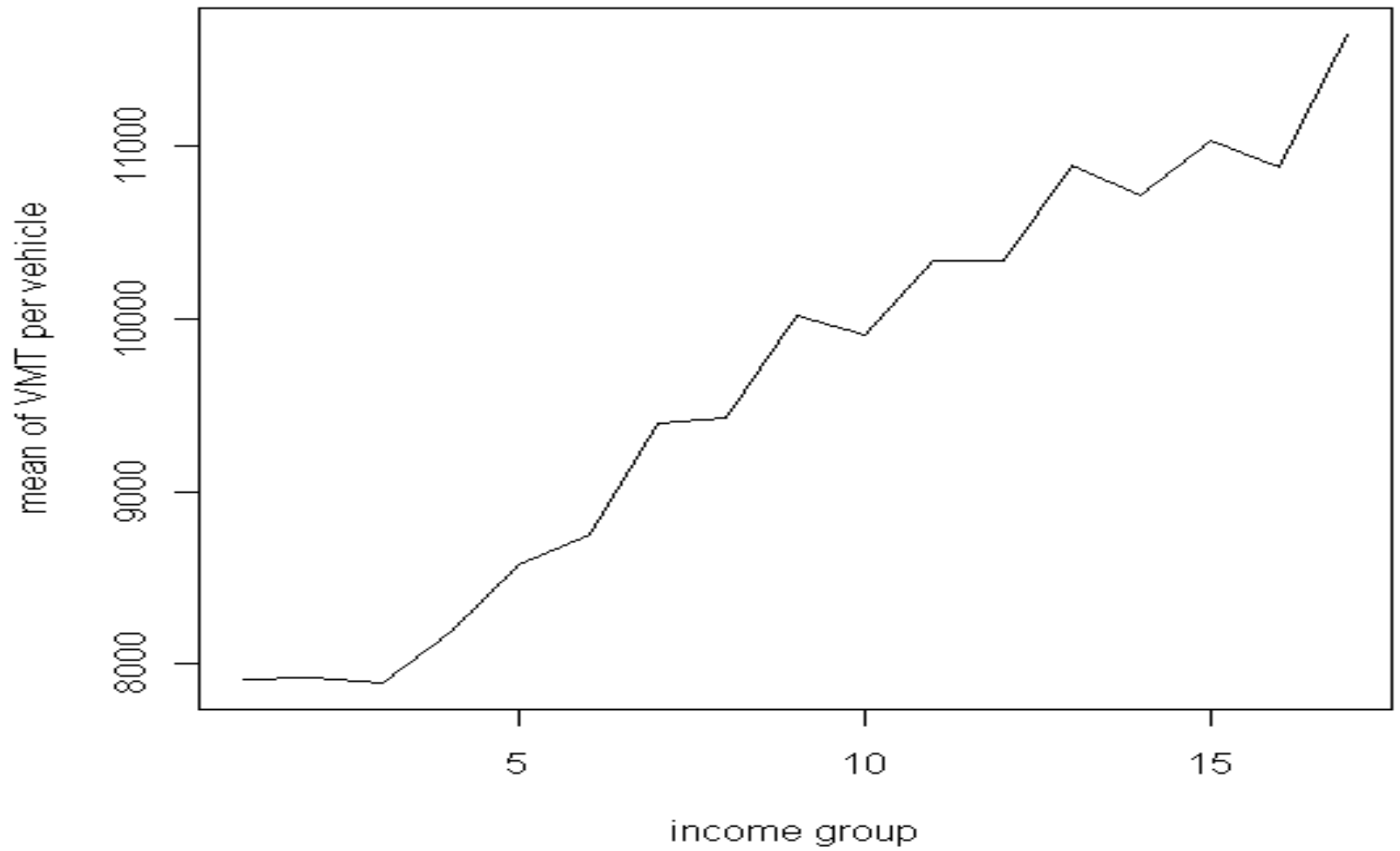
Variable explanations

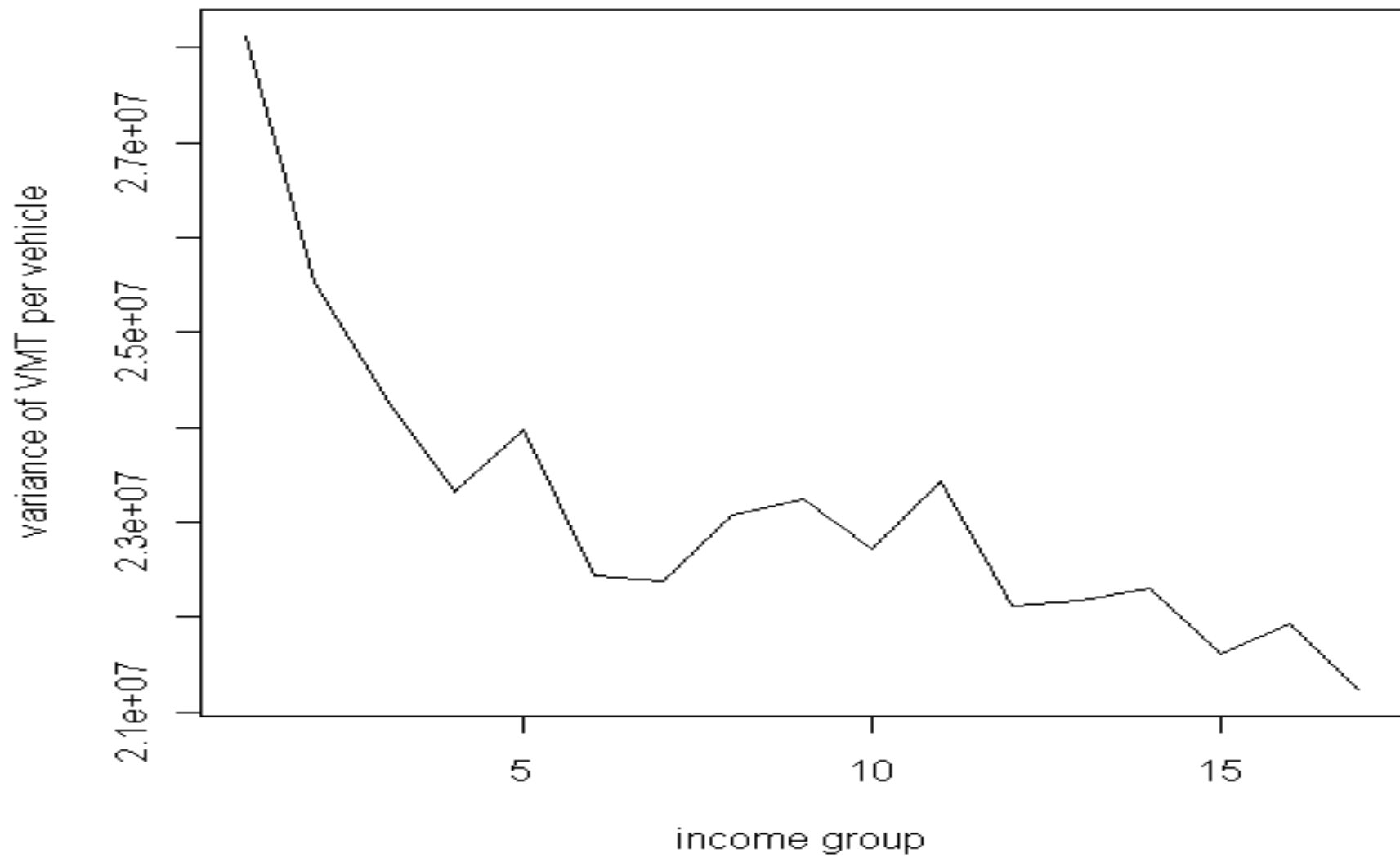
- VMT (annualized)
- Fuel efficiency (MPG): derived by EIA
- Fuel cost (\$/gasoline gallon): derived by EIA

Sample statistics

| | | Mean | | |
|---------------------------|--------------------|--------|--------------|---------|
| | | <\$10k | \$10k-\$100k | ≥\$100k |
| Income level | | | | |
| Sample size | | 3,557 | 81,898 | 19,917 |
| VMT | miles | 7,919 | 9,905 | 11,650 |
| MPG | miles/gallon | 20.47 | 20.87 | 21.25 |
| Gasoline cost | dollars/gallon | 3.05 | 3.06 | 3.09 |
| Population density | person/square mile | 2,885 | 2884 | 3371 |
| Employment density | person/square mile | 910.2 | 918.7 | 1,038 |
| Vehicle age | years | 12.31 | 8.66 | 6.81 |
| Household size | person | 1.86 | 2.36 | 2.81 |
| Commute time | minute | 20.7 | 22.38 | 26.15 |
| Commute distance | mile | 11.11 | 12.9 | 15.43 |
| No. of workers | person | 0.36 | 0.97 | 1.43 |
| % owing hybrid | % | 0.02 | 0.04 | 0.08 |







VMT and MPG as functions of socio-demographics (direct effect)

| | Household size | No of workers | Average vehicle age | Retired households | Owning a hybrid |
|----------------------|----------------|---------------|---------------------|--------------------|-----------------|
| <i>Low income</i> | | | | | |
| VMT/veh | 0.16 | 0.101 | -0.088 | -0.08 | |
| MPG | | | -0.082 | | - |
| <i>Middle income</i> | | | | | |
| VMT/veh | 0.123 | 0.071 | -0.14 | -0.118 | |
| MPG | | | -0.066 | | 0.137 |
| <i>High income</i> | | | | | |
| VMT/veh | 0.1 | 0.06 | -0.141 | -0.152 | - |
| MPG | | | -0.035 | | 0.24 |

VMT and MPG as functions of built environment characteristics (direct effect)

| | Population density | Employment density |
|----------------------|--------------------|--------------------|
| <i>Low income</i> | | |
| VMT per vehicle | - | - |
| MPG | - | - |
| <i>Middle income</i> | | |
| VMT per vehicle | -0.008 | -0.017 |
| MPG | 0.006 | 0.006 |
| <i>High income</i> | | |
| VMT per vehicle | -0.021 | -0.027 |
| MPG | 0.009 | 0.004 |

VMT, MPG and gasoline price (direct effect)

| | MPG | Gasoline price |
|----------------------|-------|----------------|
| <i>Low income</i> | | |
| VMT per vehicle | 0.467 | |
| <i>Middle income</i> | | |
| VMT per vehicle | 0.127 | -0.273 |
| <i>High income</i> | | |
| VMT per vehicle | | -0.3 |

Direct, indirect, and total effects for low-income households

| | number owning a of hybrid workers vehicle | retired hhlds | hhld size | average vehicle age | Emp. density | Pop. density | Gas price | MPG | VMT |
|------------|-------------------------------------------------|------------------|---------------|---------------------------|-----------------|-----------------|--------------|-------------|------------------|
| MPG direct | - | | | -0.082 | - | - | 0.406 | | - |
| indirect | - | - | - | - | - | | - | 0.02 | 0.00 |
| total | - | - | - | -0.088 | - | - | 0.427 | 0.02 | - |
| VMT direct | 0.101 | | -0.08 | 0.16 | -0.088 | - | - | - | 0.46 |
| indirect | 0.002 | - | -0.002 | 0.004 | -0.041 | - | - | - | 0.01 0.02 |
| total | 0.103 | - | -0.082 | 0.163 | -0.129 | - | - | - | 0.47 0.02 |

Direct, indirect, and total effects for middle-income households

| | number of workers | owning a hybrid vehicle | retired hhlds | hhld size | average vehicle age | Emp. density | Pop. density | Gas price | MPG | VMT |
|------------|-------------------|-------------------------|---------------|-----------|---------------------|--------------|--------------|-----------|------|------|
| MPG direct | | - | | | -0.066 | 0.006 | 0.006 | 0.48 | | 0.07 |
| indirect | 0.005 | 0.001 | -0.009 | 0.009 | -0.011 | -0.001 | -0.001 | -0.01 | 0.01 | 0.00 |
| total | 0.005 | 0.139 | -0.009 | 0.009 | -0.078 | 0.005 | 0.005 | 0.47 | 0.01 | 0.07 |
| VMT direct | 0.071 | | - | 0.123 | -0.14 | -0.017 | -0.008 | -0.27 | 0.12 | |
| indirect | 0.001 | 0.018 | -0.001 | 0.001 | -0.01 | 0.001 | 0.001 | 0.06 | 0.00 | 0.01 |
| total | 0.071 | 0.018 | -0.119 | 0.124 | -0.15 | -0.016 | -0.008 | -0.21 | 0.12 | 0.01 |

Direct, indirect, and total effects for high-income households

| | number of workers | owning a hybrid vehicle | retired hhlds | hhld size | average vehicle age | Emp. density | Pop. density | Gas price | MPG | VMT |
|------------|-------------------|-------------------------|---------------|--------------|---------------------|---------------|---------------|-------------|-----|------------|
| MPG direct | | 0.24 | | | -0.035 | 0.004 | 0.009 | 0.45 | | 0.1 |
| indirect | 0.006 | - | -0.015 | 0.01 | -0.014 | -0.003 | -0.002 | -0.0 | - | |
| total | 0.006 | 0.239 | -0.015 | 0.01 | -0.049 | - | 0.007 | 0.42 | - | 0.1 |
| VMT direct | 0.06 | | -0.152 | 0.101 | -0.141 | -0.027 | -0.021 | -0.3 | - | |
| indirect | | - | | | - | | | - | | - |
| total | 0.06 | - | -0.151 | 0.1 | -0.139 | -0.027 | -0.021 | -0.3 | - | - |

Total effects of gasoline price and MPG on VMT

| | Gasoline price | MPG (rebound) | |
|-----|----------------|---------------|---------------|
| VMT | - | 0.47 | Low income |
| | -0.21 | 0.12 | Middle income |
| | -0.3 | - | High income |

Total effects of gasoline price and VMT on MPG

| | Gasoline price | VMT | |
|-----|----------------|------|---------------|
| MPG | 0.41 | - | Low income |
| | 0.47 | 0.07 | Middle income |
| | 0.42 | 0.1 | High income |

Policy implications

- From the VMT perspective, promoting fuel efficiency will not result in a large rebound effect
- Increasing gasoline price mostly decreases VMT and promotes fuel efficiency
- Increasing gasoline price may affect the low-income people more due to that they may be already traveling at a minimum

Unfinished work

- Separating work and non-work VMT to verify and understand the insignificant price effect and large rebound effect associated with low-income households and the reverse trend with the higher-income groups