The time-of-day travel demand elasticity paradox

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Motivation

- Energy efficiency programs used to correct market failures
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- Direct rebound effect elasticity usually 0.1-0.4
  - Heterogeneity in rebound can have large implications
Rebound Effect Heterogeneity

**Recent Research**—estimates of rebound effect may vary across products, consumers, and regions (Barla et al., 2015; Gillingham and Munk-Nielsen, 2019; Knittel and Sandler, 2018; Nehiba, 2019; Spiller et al., 2017)
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Research Question—Does the rebound effect from fuel economy standards vary by the time of day? Mechanisms?
This paper

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  - Some evidence for public transit availability and lumpiness in commute decisions
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- Policy implications for fuel economy standards and gasoline taxes
  - CAFE standards are welfare reducing
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- Trip-level data from National Household Travel Survey with confidential county identifiers
Estimating Travel Demand Elasticities

▶ OLS estimates of effect of fuel prices on travel demand biased towards zero

▶ Gasoline content regulations as an IV for fuel prices

IV Assumptions

▶ Seasonal pollution controls to combat ground-level ozone

▶ Within county seasonal regulatory variation

Estimation Map

▶ Estimate a model for each county and hour-of-day (339*24 estimates)

Estimating Equations
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Regulation Map

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  - Gasoline content regulations as an IV for fuel prices
    - Seasonal pollution controls to combat ground-level ozone
    - Within county seasonal regulatory variation
  - Estimate a model for each county and hour-of-day (339*24 estimates)
Main Result

T-stats

Graph showing the elasticity estimate over the hour of the day.
Weekday and weekend estimation
Urban-rural divide

![Graph showing elasticity estimates by hour-of-day for different metro areas.](image)
## Policy Implications

### Panel A: Baseline Simulation Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak congestion costs per mile</td>
<td>$0.05</td>
</tr>
<tr>
<td>Off-peak congestion costs per mile</td>
<td>$0.00</td>
</tr>
<tr>
<td>Pollution costs per gallon</td>
<td>$0.34</td>
</tr>
</tbody>
</table>

### Panel B: CAFE Results (Increase Avg. MPG By 1)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\Delta) Gallons (millions)</td>
<td>-3,059</td>
</tr>
<tr>
<td>(\Delta) VMT (millions)</td>
<td>+ 56,942</td>
</tr>
<tr>
<td>(\Delta) Welfare from (\Delta) VMT (millions)</td>
<td>+$112.6</td>
</tr>
<tr>
<td>Pollution Benefit (millions)</td>
<td>+$1,041</td>
</tr>
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<td>-$2,024</td>
</tr>
<tr>
<td><strong>Net (\Delta) Welfare (millions)</strong></td>
<td>-$870.4</td>
</tr>
</tbody>
</table>

### Panel C: Gas Tax Results (Increase Per Gallon Gas Tax by $0.1682)

<table>
<thead>
<tr>
<th>Parameter</th>
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</tr>
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<tbody>
<tr>
<td>(\Delta) Gallons (millions)</td>
<td>-3,059</td>
</tr>
<tr>
<td>(\Delta) VMT (millions)</td>
<td>-73,736</td>
</tr>
<tr>
<td>(\Delta) Welfare from (\Delta) VMT (millions)</td>
<td>-$108.6</td>
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<td>Pollution Benefit (millions)</td>
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- Analysis of energy efficiency programs has ignored important temporal variation in rebound effects
- Examined heterogeneity of fuel price elasticity of travel demand across hour of day
  - Results present a paradox—drivers are more responsive to fuel prices during rush hour
  - Explored mechanisms—some evidence transit availability drives results
- Policy simulation suggests CAFE standards reduce welfare
Thank you
Cody Nehiba
cnehiba@lsu.edu
T-stats

8 am

T-statistic distribution

11 pm

T-statistic distribution
Gasoline Content Regulation Instrument Validity

- Instrument Relevance

  Increase refining costs and segment fuel markets (Auffhammer and Kellogg, 2011; Brown et al. 2008; Chakravorty et al., 2008; Muehlegger, 2006)

- Instrument Exogeneity

  Entire U.S. has a gasoline content regulation

  Regulation stringency determined by:
  - Weather–ozone formation requires warm sunny weather, so warmer regions received more stringent regulations
  - Past travel demand–not contemporaneous travel demand

  Very little change in regulations over the sample period (2013-2016)

  Instruments plausibly exogenous conditional on weather controls and location fixed effects
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Gasoline Content Regulations

Notes: The figure illustrates gasoline content regulations across the U.S. as of December 2016.
Elasticity Estimating Equations

Estimate a model for each county and hour-of-day (339*24 estimates)
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**First stage**
\[
\ln(P_{it}) = \tau + \delta \cdot R_{it} + \phi \cdot X_{it} + \mu_i + \rho_t + \nu_{it}
\]

**Second Stage**
\[
\ln(V_{it}) = \omega + \eta \cdot \ln(\hat{P}_{it}) + \psi \cdot X_{it} + \mu_i + \rho_t + \epsilon_{it}
\]

- \(i=\)traffic sensor, \(t=\)day-of-sample
- \(P=\)gas price, \(R=\)gasoline content regulations, \(V=\)vehicle counts, \(X=\)weather, \(\mu=\)sensor fixed effect, and \(\rho=\)day-of-week, and month-of-year fixed effects
- \(\eta=\)travel demand elasticity