Consumer Choice Between Gasoline and Sugarcane Ethanol

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January 2011, Transportation Center @ NU
(joint with Cristian Huse, Stockholm)

“100%”

&

“33%”
Motivation

• Central policy aim: wean economies off fossil fuels (particularly oil derivatives)
  • Diversify energy sources
  • Curb emissions
  • Sustain growth

• Private road transport: large and growing sector
  • Gasoline-powered engine set to lose share
  • Alternative energy sources: electricity, biofuels

• How will motorists substitute away from century-old gasoline??
  • Price incentives required at pump or plug?
  • Research is scarce: RP studies cannot be conducted
  • Except Brazil: Gasoline × Alternative (Sugarcane Ethanol)
Alternative hypotheses & Preview

An example (lab measurements)
Fiat Palio ELX (Flex), 2 doors, 1.0 – 8V, manual transm., AC, hydraulic steering, city driving cycle:
Ethanol (E100): $e = 6.9 \text{ km/liter}$
Gasoline (E22): $g = 9.9 \text{ km/liter}$

Null: Perfect substitutes
$/\text{km Ethanol} = \$/\text{km Gasoline}$

Ethanol preference e.g., “green” types, “home bias”
State dependence e.g., short-run habit, inattentive, unwilling or unable to compare prices

Ethanol aversion e.g., “conventional” types, “range anxiety”

FIND: Observed + unobserved consumer heterogeneity:
+20% E v. G in $/\text{km} \rightarrow 20\% \text{ E}$
+20% G v. E in $/\text{km} \rightarrow 20\% \text{ G}$
Outline of talk

• A natural experiment
• Our opportune survey
• Brief descriptive stats
  • Empirical demand
• Demand estimates
  • Probits, Multinomial probits
  • Price sensitivity of “median” motorist
  • Elasticity matrices for subgroups: aged +65y
  • WTP for “greenness” and to relieve “range anxiety”
• A counterfactual
  • Planning the energy mix
World prices × local prices, 2000-2010

**World prices***

WTI R$/bbl, & ISA R$ cents/lb

2003, 2006 and...2010: The pump price of Ethanol peaks when the world price of Sugar peaks

**Prices at the pump in the city of São Paulo***

R$/liter

* Constant prices in Brazilian Real (R$), base Mar/10. Sources: EIA, ISO, IBGE (IPCA), Bacen
World/local sugar/ethanol markets: Arbitrage
Demand responds: Market-level data

**Fuel shipments to stations, Total Brazil***

m³ / month

Early 2010:
- Fuel mix shifts
- Ethanol → Gasoline → Ethanol

**Fuel shipments to stations, State of São Paulo***

m³ / month

Market-level study:
- Consumer heterogeneity?
- Poor data (e.g., FFV fleet size and usage)

* Source: ANP
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Variation in relative per-liter prices, $p_e/p_g$

Evolution of the relative price of ethanol in the weeks about the week of January 25 2010
Percentiles of the distribution across stations surveyed by the regulator in each city

<table>
<thead>
<tr>
<th>City</th>
<th>Graph of $p_e/p_g$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belo Horizonte</td>
<td><img src="image1.png" alt="Graph" /></td>
</tr>
<tr>
<td>Curitiba</td>
<td><img src="image2.png" alt="Graph" /></td>
</tr>
<tr>
<td>Porto Alegre</td>
<td><img src="image3.png" alt="Graph" /></td>
</tr>
<tr>
<td>Recife</td>
<td><img src="image4.png" alt="Graph" /></td>
</tr>
<tr>
<td>Rio de Janeiro</td>
<td><img src="image5.png" alt="Graph" /></td>
</tr>
<tr>
<td>Sao Paulo</td>
<td><img src="image6.png" alt="Graph" /></td>
</tr>
</tbody>
</table>

Number of weeks prior to (negative) or after (positive) week of January 25 2010

- $p_{e\_rel\_pg\_p5}$
- $p_{e\_rel\_pg\_p25}$
- $p_{e\_rel\_pg\_p75}$
- $p_{e\_rel\_pg\_p95}$

5th, 25th, 75th, 95th percentiles of distribution of Ethanol-to-regular-Gasoline price ratio over 1st Qtr 2010 in 6 main cities (source: ANP)

Approximate parity ratio, $p_e/p_g = 70\%$

Week of 11 Jan 2010

Week of 25 Jan

Week of 29 Mar 2010

Vertical lines: 9 city-weeks in our survey
Survey design

- 6 cities: SP, CTB, REC, RJ, BH, POA
- 9 city-weeks (3 weeks) in Jan and Mar 2010
- 2160 FFV motorists in 180 retail fueling stations
  - 12 motorists/station: pass filter & agree to interview
  - Private use (exclude cab and corporate use)
  - Week days + Saturday, rush hours + off-peak
  - Branded stations (29% BR, 27% Shell, 19% Ipiranga...)
- Instructed field representative to:
  - (Quietly) observe motorist’s choice (revealed preference)
  - E × G regular (plus, if available: G midgrade, G premium)
  - (Only then) approach motorist for short interview (“stated” preference)
    - E.g.: Main reason(s) behind fuel choice (“spontaneous” response); Car usage (km/week); Schooling
Fueling stations visited

- São Paulo
- Curitiba
- Rio de Janeiro
- Porto Alegre
- Belo Horizonte
- Recife
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- A counterfactual
  - Planning the energy mix
# Station-level data (selected)

<table>
<thead>
<tr>
<th>Variable</th>
<th>January visits Mean (N, Std.Dev.)</th>
<th>March visits Mean (N, Std.Dev.)</th>
<th>Total visits Mean (N, Std.Dev.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol price, $p_e$ (R$/liter)</td>
<td>SP1 1.89 (20, .12) SP2 1.88 (20, .14) CTB 1.91 (20, .06) REC 1.89 (20, .04) RJ 2.18 (20, .15) BH 2.06 (20, .11) POA 2.32 (20, .10)</td>
<td>SP 1.46 (20, .14) CTB 1.33 (20, .06)</td>
<td></td>
</tr>
<tr>
<td>Per-liter ethanol-to-regular-gasoline price ratio, $p_e/p_g$ (%)</td>
<td>SP1 74% (20, 3%) SP2 75% (20, 3%) CTB 75% (20, 2%) REC 75% (20, 2%) RJ 81% (20, 4%) BH 85% (20, 3%) POA 90% (20, 4%)</td>
<td>SP 59% (20, 4%) CTB 58% (20, 2%)</td>
<td>Price variation: Opportunity</td>
</tr>
<tr>
<td>Midgrade gasoline markup over regular (%)</td>
<td>104% (164, 3%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of nozzles</td>
<td>13 (180, 6) E:4, G:5, midgr:3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of station visit (hours)</td>
<td>2.5 (180, 1.0)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Motorist-level data (selected)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>dv_male</td>
<td>2160</td>
<td>.658</td>
<td>.475</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>dv_age_25to40y</td>
<td>2160</td>
<td>.463</td>
<td>.499</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>dv_age_40to65y</td>
<td>2160</td>
<td>.395</td>
<td>.489</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>dv_school_secondary_complete</td>
<td>2160</td>
<td>.281</td>
<td>.151</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>dv_school_college_incomplete</td>
<td>2160</td>
<td>.121</td>
<td>.326</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>dv_school_college_complctc</td>
<td>2160</td>
<td>.497</td>
<td>.500</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Value of fuel purchased</td>
<td>2160</td>
<td>46.973</td>
<td>29.601</td>
<td>10</td>
<td>158</td>
</tr>
<tr>
<td>Car usage</td>
<td>1835</td>
<td>296.094</td>
<td>319.930</td>
<td>5</td>
<td>3500</td>
</tr>
<tr>
<td>dv_reason_1_price_characteristic</td>
<td>2160</td>
<td>.683</td>
<td>.465</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>dv_reason_2_range_or_price</td>
<td>2160</td>
<td>.263</td>
<td>.440</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>dv_reason_3_environment</td>
<td>2160</td>
<td>.056</td>
<td>.230</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>dv_reason_4_engine_performance</td>
<td>2160</td>
<td>.017</td>
<td>.211</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>dv_reason_5_engine_startup</td>
<td>2160</td>
<td>.083</td>
<td>.276</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Last two occasions chose this station 2X</td>
<td>2160</td>
<td>.513</td>
<td>.500</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Last two occasions chose this station 1X</td>
<td>2160</td>
<td>.219</td>
<td>.413</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
Fuel choices aggregated to station level

Vertical axis: $p_e/p_g$ (per-liter prices)

Horizontal axis: “Unweighted” Ethanol share:

$$s^e_j = \frac{1}{12} \sum_{i \in O_j} \chi \left[ qei \frac{k^\text{city}_e}{k^\text{city}_g} i > \sum_{f \in \{g, \bar{g}, \bar{\bar{g}}\}} q_{fi} \right]$$

Horizontal axis: “Weighted” Ethanol share:

$$s^w_e j = \frac{\left( \sum_{i \in O_j} qei \frac{k^\text{city}_e}{k^\text{city}_g} i \right)}{\sum_{i \in O_j} \left( qei \frac{k^\text{city}_e}{k^\text{city}_g} i + \sum_{f \in \{g, \bar{g}, \bar{\bar{g}}\}} q_{fi} \right)}$$
Controlling for “parity” differences across models

Vertical axis: 1 ppt bins:
\[ \frac{p_{ei}}{p_{gi}} - \frac{k_{ei}}{k_{gi}} \]

E.g.: Motorist in Belo Horizonte in January, drove a VW Gol 1.0: 88.2% — 69.9% ≈ 18% → Enters the 18 ppt bin

(Equivalently:
\[ \frac{p_{ei}}{k_{ei}} \approx 0.28 \text{ R$/km} \]
\[ \frac{p_{gi}}{k_{gi}} \approx 0.22 \text{ R$/km} \]
0.06 R$/km, or 21%, discount represents 624 R$ per year)

Horizontal axis: Proportion of motorists in bin who chose ethanol as their dominant source of kilometers

Choosing Ethanol when Gasoline is cheaper per km (i.e., where \( \frac{p_{ei}}{k_{ei}} > \frac{p_{gi}}{k_{gi}} \))

Choosing Gasoline when Ethanol is cheaper per km (i.e., where \( \frac{p_{ei}}{k_{ei}} < \frac{p_{gi}}{k_{gi}} \))
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Discrete choice specifications

- **Binary choice models:**

\[
\begin{aligned}
X \left[ \sum_{f \in \{g, e, \bar{g}\}} q_{fi} \right] &> q_{ei} / \frac{k_{e}^{\text{city}}}{k_{g}^{\text{city}}} \\
1 &\text{ if } \delta_{i} + \varepsilon_{i} > \frac{p_{ei}}{p_{qi}} - \frac{k_{e}^{\text{city}}}{k_{g}^{\text{city}}} \\
0 &\text{ otherwise}
\end{aligned}
\]

- **Probit:** \( \varepsilon_{i} \sim iid \ N(0, \sigma^2) \)
- **Logit:** \( \varepsilon_{i} \sim iid \logit \)

- **Multinomial response models (multinomial probits):**

- **Motorist** \( i \) chooses fuel with maximal utility

\[
U_{fi} - x_{i}'\delta_{f} - \alpha p_{fi}/k_{f} + \varepsilon_{fi}, \quad f \in \{g, e, \bar{g}\}, \quad (\varepsilon_{a}, \varepsilon_{e}, \varepsilon_{\bar{g}}) \sim MVN(0, \Omega)
\]

and thus (to state one choice probability):

\[
\Pr (i \text{ chooses } e) = \Pr (U_{gi} - U_{ei} \leq 0 \cap U_{gi} - U_{ei} \leq 0) = \Phi \left(- \left((x_{i}'\delta_{f} - \alpha p_{fi}/k_{f}) - (x_{i}'\delta_{e} - \alpha p_{ei}/k_{e})\right), \Omega_{-e}\right), \quad f = g, \bar{g}
\]

**Note 1:** Standard errors clustered at the station visit level

**Note 2:** Relying on the moderate (within-route) price dispersion and consumers’ professed station loyalty, we ignore any substitution across stations
## Multinomial probit marginal effects (other results omitted)

**Specification** (multinomial probit):

<table>
<thead>
<tr>
<th>Variable</th>
<th>I: m.e.</th>
<th>II: m.e.</th>
<th>III: m.e.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price of ( e ) per km (mean = .268)</td>
<td>-3.961***</td>
<td>-3.933***</td>
<td>-6.345***</td>
</tr>
<tr>
<td>Price of ( g ) per km (mean = .246)</td>
<td>3.463***</td>
<td>3.424***</td>
<td>4.804***</td>
</tr>
<tr>
<td>Price of ( \bar{g} ) per km (mean = .257)</td>
<td>0.499**</td>
<td>0.509**</td>
<td>1.541***</td>
</tr>
<tr>
<td>( dv_{female} ) (mean = .342)</td>
<td>-0.009</td>
<td>-0.009</td>
<td>-0.010</td>
</tr>
<tr>
<td>( dv_{age_25to40y} ) (mean = .463)</td>
<td>-0.057</td>
<td>-0.056</td>
<td>-0.064</td>
</tr>
<tr>
<td>( dv_{age_40to65y} ) (mean = .395)</td>
<td>-0.054</td>
<td>-0.053</td>
<td>-0.075*</td>
</tr>
<tr>
<td>( dv_{age_morethan65y} ) (mean = .037)</td>
<td>-0.255***</td>
<td>-0.254***</td>
<td>-0.276***</td>
</tr>
<tr>
<td>( dv_{school_some_secondary} ) (mean=.310)</td>
<td>0.060</td>
<td>0.060</td>
<td>0.059</td>
</tr>
<tr>
<td>( dv_{school_some_college} ) (mean = .618)</td>
<td>0.042</td>
<td>0.042</td>
<td>0.040</td>
</tr>
<tr>
<td>( dv_{heavy_car_user} ) (mean = .229)</td>
<td>-0.086***</td>
<td>-0.086***</td>
<td>-0.092***</td>
</tr>
<tr>
<td>( dv_{pricey_car_model} ) (mean = .262)</td>
<td>-0.049*</td>
<td>-0.050*</td>
<td>-0.046*</td>
</tr>
<tr>
<td>( dv_{reason_environment} ) (mean = .056)</td>
<td>0.435***</td>
<td>0.436***</td>
<td>0.432***</td>
</tr>
<tr>
<td>( dv_{reason_engine} ) (mean = .122)</td>
<td>-0.261***</td>
<td>-0.261***</td>
<td>-0.259***</td>
</tr>
<tr>
<td>( dv_{reason_range_75%tank} ) (mean= .035)</td>
<td>-0.245***</td>
<td>-0.246***</td>
<td>-0.242***</td>
</tr>
<tr>
<td>( dv_{sao_paulo} ) (Producer, mean = .333)</td>
<td>0.182**</td>
<td>0.169*</td>
<td>0.276***</td>
</tr>
<tr>
<td>( dv_{curitiba} ) (Producer, mean = .222)</td>
<td>0.288***</td>
<td>0.163*</td>
<td>0.085</td>
</tr>
<tr>
<td>( dv_{recife} ) (Producer, mean = .111)</td>
<td>0.173**</td>
<td>0.163*</td>
<td>0.094</td>
</tr>
<tr>
<td>( dv_{rio_de_janeiro} ) (Importer, mean= .111)</td>
<td>0.086</td>
<td>0.073</td>
<td>0.097</td>
</tr>
<tr>
<td>( dv_{belo_horizonte} ) (Importer, mean= .111)</td>
<td>-0.022</td>
<td>-0.038</td>
<td>-0.155</td>
</tr>
<tr>
<td>( dv_{porto_alegre} ) (Importer, mean = .111)</td>
<td>-0.133</td>
<td>-0.038</td>
<td>-0.155</td>
</tr>
</tbody>
</table>

- **Age > 65y** → \( dv_{age\_morethan65y} \) (mean = .037)
- **Heavy user** → \( dv_{heavy\_car\_user} \) (mean = .229)
- **Pricey car** → \( dv_{pricey\_car\_model} \) (mean = .262)
- **Environmental.”** → \( dv_{reason\_environment} \) (mean = .056)
- **Invoke engine** → \( dv_{reason\_engine} \) (mean = .122)
- **“Range anxiety”** → \( dv_{reason\_range\_75\%tank} \) (mean= .035)
- **“Home bias”** → \( dv_{sao\_paulo} \) (Producer, mean = .333)

- Number of nozzles of \( e \) (mean = 3.900)
- Number of nozzles of \( g \) (mean = 5.044)
- Number of nozzles of \( \bar{g} \) (mean = 3.677)
Considerable “unobserved” consumer heterogeneity.

- The “median” motorist’s price responsiveness
  - Male, 25-40y, some college, neither uses car heavily nor drives a pricey model, invokes neither the environment, the engine nor range
  - Varying the ethanol price holding gasoline prices constant
- Baseline specification excluding city fixed effects (to conservatively reduce price range for switching)

### Fuel choice probabilities for median motorist in specification without city fixed effects

Energy-adjusted gasoline prices held constant at 0.246 R$/km regular and 0.256 R$/km midgrade

<table>
<thead>
<tr>
<th>Parity: $p_e/p_g$</th>
<th>Simulated choice probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>50%</td>
<td>0.246</td>
</tr>
<tr>
<td>60%</td>
<td>0.196</td>
</tr>
<tr>
<td>70%</td>
<td>0.146</td>
</tr>
<tr>
<td>80%</td>
<td>0.096</td>
</tr>
<tr>
<td>90%</td>
<td>0.046</td>
</tr>
</tbody>
</table>

### Effect on the probability of choosing ethanol from raising the ethanol price by 0.01 R$/km

Energy-adjusted gasoline prices held constant at 0.246 R$/km regular and 0.256 R$/km midgrade

<table>
<thead>
<tr>
<th>Energy-adjusted ethanol price in R$/km</th>
<th>Estimated marginal effect on ethanol and 95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.146</td>
<td>-0.06 -0.04</td>
</tr>
<tr>
<td>0.196</td>
<td>0.02 -0.04</td>
</tr>
<tr>
<td>0.246</td>
<td>0.06 -0.04</td>
</tr>
<tr>
<td>0.296</td>
<td>0.146 -0.196</td>
</tr>
<tr>
<td>0.346</td>
<td>0.246 -0.296</td>
</tr>
</tbody>
</table>
“Observed” heterogeneity: Hypothetical extremes

- “Ethanol fan”: Younger (<25y), some college, resides in Curitiba (capital of ethanol-producing state), spontaneously invokes the environment
- “Gasoline fan”: Older (>65y), no more than primary, resides in Porto Alegre (ethanol importer), heavy commuter, drives expensive model, invokes engine
- Baseline specification (hereafter)

<table>
<thead>
<tr>
<th>Energy-adjusted ethanol price in R$/km</th>
<th>Ethanol</th>
<th>Regular gasoline</th>
<th>Midgrade gasoline</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.146</td>
<td>0.196</td>
<td>0.246</td>
<td>0.296</td>
</tr>
<tr>
<td>0.196</td>
<td>0.246</td>
<td>0.296</td>
<td>0.346</td>
</tr>
<tr>
<td>0.246</td>
<td>0.296</td>
<td>0.346</td>
<td></td>
</tr>
<tr>
<td>0.296</td>
<td>0.346</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.346</td>
<td>0.396</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Simulated choice probabilities:
- \( p_e/p_g \approx 50\% \)
- \( p_e/p_g \approx 60\% \)
- \( p_e/p_g \approx 70\% \)
- \( p_e/p_g \approx 80\% \)
- \( p_e/p_g \approx 90\% \)

Parity:
- \( p_e/p_g \approx 60\% \)
- \( p_e/p_g \approx 70\% \)
- \( p_e/p_g \approx 80\% \)
- \( p_e/p_g \approx 90\% \)
Price elasticity matrices: Effect of age

- Evaluated at the median of regressors:

<table>
<thead>
<tr>
<th>São Paulo, January, Age ≤ 65y</th>
<th>São Paulo, January, Age &gt; 65y</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Increase in price</strong></td>
<td><strong>Change in choice probability</strong></td>
</tr>
<tr>
<td>e</td>
<td>g</td>
</tr>
<tr>
<td>e</td>
<td>$-1.77^{***}$</td>
</tr>
<tr>
<td>g</td>
<td>$1.49^{***}$</td>
</tr>
<tr>
<td>ŝ</td>
<td>$0.16^*$</td>
</tr>
</tbody>
</table>

Median $p_{fi}/k_{fi}^{city}$:
- **0.262**
- **0.243**
- **0.253**

Choice probab.:
- **0.58**
- **0.38**
- **0.04**

Median $p_{fi}/k_{fi}^{city}$:
- **0.262**
- **0.243**
- **0.253**

Choice probab.:
- **0.30**
- **0.58**
- **0.12**

Notes: Standard errors in parentheses. * p<.1, ** p<.05, *** p<.01. $p_{fi}/k_{fi}^{city}$ in R$/km$

Recall per-liter $p_e/p_g$:
- 74%
- 74%
WTP for “greenness” and to relieve “range anxiety”

- Median motorist in each of 3 cities with varying home bias
- Horizontal shifts provide natural measures for:
  - “Greenness”: Switch environ.-invoking reason on/off: .12 R$/km (.10 $/mi)
  - Relieve “range anxiety: Switch range-reason on/off: .07 R$/km (.06 $/mi)

![Diagram showing ethanol and gasoline choice probabilities](image)

Energy-adjusted gasoline prices held constant at 0.246 R$/km regular and 0.256 R$/km midgrade

Ethanol choice probabilities for median motorists with and without environmental concerns

Energy-adjusted ethanol price in R$/km

Energy-adjusted gasoline prices held constant at 0.246 R$/km regular and 0.256 R$/km midgrade

Gasoline choice probabilities for median motorists with and without range concerns

Energy-adjusted ethanol price in R$/km

Parity: $p_e/p_g$ ≈ 70%
A counterfactual: Planning the energy mix

- A planner in the Amazonian state of Pará (pop 7.6m, 2/3 urban)
- Nation’s highest state sales tax on ethanol: 28% ICMS (v. 12% SP)
- Consider a plan to wean PA motorists (FFVs 45%) off gasoline
- Different scenarios, common message: Uptake of ethanol would remain limited
  - Qualifier: Ignores long run changes (preferences, behavior, information)

<table>
<thead>
<tr>
<th>State of Pará scenario: May 2010 “Current”</th>
<th>Counterfactual 1 Pricing parity</th>
<th>Counterfactual 2 12% ICMS tax (SP)</th>
<th>Counterfactual 3 0% ICMS tax</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p_g$, R$/liter</td>
<td>2.695</td>
<td>2.695</td>
<td>2.695</td>
</tr>
<tr>
<td>$p_e$, R$/liter</td>
<td>2.075</td>
<td>1.887</td>
<td>1.743</td>
</tr>
<tr>
<td>(Ratio) $p_e/p_g$</td>
<td>77%</td>
<td>70%</td>
<td>65%</td>
</tr>
<tr>
<td>ICMS in $p_e$, R$/l</td>
<td>0.581</td>
<td>0.393</td>
<td>0.249</td>
</tr>
<tr>
<td>$p_g$, R$/l (91% avail.)</td>
<td>2.799</td>
<td>2.799</td>
<td>2.799</td>
</tr>
</tbody>
</table>

Predicted ethanol share of ethanol-plus-gasoline “energy units” consumed:

| FFVs only, PA                            | 15%                            | 21%                               | 27%                         | 38%                         |

Notes: Pump prices are inclusive of ICMS sales tax
Takeaways

• Direct & transparent empirical strategy uncovers substantial consumer heterogeneity in the choice among century-old gasoline and a less-established alternative motor fuel
• Likely to generalize to other markets---and perhaps even in a magnified way
  • This setting: G & E similarly distributed, comparably priced and billed, almost identically consumed
  • Gasoline v. Alternative: Comparison can be less transparent!
• Observed heterogeneity
  • E.g., “Green” consumers do exist (not Prius status-seekers), Consumer’s age, Confusion about engine aspects
• Unobserved heterogeneity
  • Salience-raising policy considerations
Salience-raising example (among others)

- Mail cost conversion tables to households (or mandate per-liter price ratio to be displayed at the pump)