Gasoline Demand Elasticities
2007 EIA Energy Outlook, Modeling and Data Conference
Carol Dahl, Professor and Director
"Find a relationship that survives long enough to be useful." Hendry and Juselius (2001)

1. Study in Context
2. What are Elasticities?
3. Why are They Important?
4. Demand Methodologies
5. Summary of Survey Work to Date
6. Demand for Transportation Fuels

Nasser Al Dossary
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Scope of Study - Critical Review
All Econometric Demand Elasticities

All countries - all products

>1500 studies

Levels of aggregation

E, C, El, O, Ng, Biomass

O – tr & ntr

O – G, K, D, Fo-lt, Fo-hv

Sector r, c, i, e, tr, ii

On line data base
Demand Elasticities
Demand Elasticities – What Are They?

How consumption responds to a variety of variables?

e.g. price elasticity

Consumption response to prices?

\[ \varepsilon_x = \frac{\Delta Q}{\frac{Q}{X}} \]

\[ \frac{\Delta Q}{Q} = \varepsilon_x \frac{\Delta X}{X} \]

\[ \frac{\Delta X}{X} = \varepsilon_x \frac{\Delta Q}{Q} \]
Elasticities – Why Important?

\[
\frac{\Delta Q}{Q} = \varepsilon_x \frac{\Delta P}{P}
\]


- U.S. All Grades All Formulations Retail Gasoline Prices (Cents per Gallon)
How Easily a Market Can Respond to Disruption,

\[
\frac{\Delta P}{P} = \varepsilon_x \frac{\Delta Q}{Q}
\]
Renewable Energy Cost Trends

Levelized cost of energy in constant 2005$\dagger$

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\[
\frac{\Delta Q}{Q} = \varepsilon_p \frac{\Delta P_{\text{sub}}}{P_{\text{sub}}}
\]

Source: NREL Energy Analysis Unit (www.nrel.gov/analysis/docs/cost_curves_2005.ppt)

*These graphs are reflections of historical cost trends NOT precise annual historical data. DRAFT November 2005*
Responses to the Business Cycle

\[ \frac{\Delta Q}{Q} = \varepsilon_x \frac{\Delta Y}{Y} \]
Estimation Issues: $Q_i = \beta_o + \beta_P P_i + \beta_Y Y_i$

Is $P$ exogenous?

Is equation identified?

Is equation correctly specified?

- correct variables, correct functional form
- statistical tests
- recent – cubic splines, nonparametric

Is relationship stable and symmetric?

statistical tests

Aggregation Issues
Measuring Short Run and Long Run

1. Lags
2. Vehicle Stock and Use Choice
3. Data: Cross Sections versus Time Series
Short Run and Long Run Using Lags

\[ Q_t = \alpha + \sum_{i=0}^{J} \beta P_{t-i} + \sum_{i=0}^{K} \delta Y_{t-i} + \sum_{i=1}^{K} \delta Q_{t-i} \]

Time Series Issues

Variables are non-stationary
spurious regression
lose consistency
lagged endogenous
Non-stationarity

Three causes of non-stationarity

\[ y_t = \mu + y_{t-1} + \beta_t + \varepsilon_t \]

- drift
- random walk
- time trend

First difference – make stationary I(1)

run

may lose variation – lower efficiency
Non-stationarity

All integrated of order 1 or same order
linear combination I(0) stationary
cointegrated
OLS consistent (super)
measure long run relationship
error correction model
short run deviations
Endogenous RHS

\[ Q_t = \alpha + \sum_{i=0}^{J} \beta P_{t-i} + \sum_{i=0}^{K} \delta Y_{t-i} + \sum_{i=1}^{K} \delta Q_{t-i} \]

biased and inconsistent
time series – all could be endogenous
system approach – vector autoregression
cointegration may save the day
may be > 1 cointegrating relationships
Stock Changes (LR) Utilization (SR)

Gallons = Miles/(Miles/Gallon)

\[ \log (\text{Gallons}) = \log(\text{Miles}) - \log(\text{Miles/Gallon}) \]

\[ \frac{\partial \log (\text{Gallons})}{\partial \log (\text{Price})} = \frac{\partial \log (\text{Miles})}{\partial \log (\text{Price})} - \frac{\partial \log (\text{Miles/Gallon})}{\partial \log (\text{Price})} \]

Rebound effect (Cafe standards)

MPG ↑ Cost per mile ↓ Miles ↑

cancelling some of efficiency gains

Greening, Greene, and Difiglio (2000) – 10% sr and up to 30% long run
Cross Section (LR) - Time Series (SR)

Cross section
adjusted to large differences
price and income

Time series
how much adjustment in periodicity of data
<table>
<thead>
<tr>
<th>Author and Year</th>
<th># Studies</th>
<th>Study Years</th>
<th>Psr</th>
<th>Plr</th>
<th>Ysr</th>
<th>Ylr</th>
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</thead>
<tbody>
<tr>
<td>Taylor (1977)</td>
<td>7</td>
<td>70-76</td>
<td>(0.10,-0.50)</td>
<td>(-0.25,-1.00)</td>
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<td>Bohi (1981)</td>
<td>11</td>
<td>74-78</td>
<td>-0.20</td>
<td>-0.70</td>
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<td>Kouris (1983) CSTS</td>
<td>7</td>
<td>75-83</td>
<td>(-0.10,-0.20)</td>
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<td>near 1</td>
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<tr>
<td>Kouris (1983) US TS</td>
<td>7</td>
<td>72-83</td>
<td>(-.20,-.40)</td>
<td>-0.70</td>
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<td>Bohi and Zimmerman (1984)</td>
<td>10</td>
<td>79-82</td>
<td>-0.20</td>
<td>inelastic</td>
<td>0.40</td>
<td>elastic</td>
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<tr>
<td>Dahl (1986)</td>
<td>69</td>
<td>69-84</td>
<td>-0.12 (m,q)</td>
<td>0.31 (m,q)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>-0.29 (a)</td>
<td>-1.02</td>
<td>0.47 (a)</td>
<td>1.38</td>
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<td>Dahl and Sterner (1991a, 1991b)</td>
<td>~100</td>
<td>66-88</td>
<td>-0.26</td>
<td>-0.86</td>
<td>0.48</td>
<td>1.21</td>
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<td>Goodwin (1992)</td>
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<td>-0.27</td>
<td>(-0.71,-0.84)</td>
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<tr>
<td>Dahl (1995)</td>
<td>14</td>
<td>89-93</td>
<td>-0.20</td>
<td>-0.60</td>
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<td>&lt;1</td>
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<td>Espey (1996) U.S.</td>
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<td>69-90</td>
<td>-0.65</td>
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<td>0.91</td>
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<td>Espey (1998)</td>
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<td>66-97</td>
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<td>-0.81</td>
<td>0.32</td>
<td>0.90</td>
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<td>Graham and Glaister (2002)</td>
<td>113</td>
<td>66-00</td>
<td>(-0.20,-0.30)</td>
<td>(-0.60,-0.80)</td>
<td>(0.30,0.50)</td>
<td>(0.50,1.50)</td>
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<td>Hanly, Dargay, Goodwin (2002)</td>
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<td>72-01</td>
<td>-0.25</td>
<td>&lt;-0.60</td>
<td>0.40</td>
<td>&gt;1.00</td>
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<td>Dahl (2006)</td>
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Notes: Numbers in parenthesis indicate authors range of estimates (a) = annual, (m,q) = monthly and quarterly, CSTS = cross section time series data, TS = time series data, <-0.60 means more elastic
Espy 96’ Meta-analysis on Gasoline Elasticities

Determine effects on gasoline demand elasticities by
  Functional form
  Lag structure
  Estimation technique
  Other study differences

Analysis on US studies without household panel data
Price Elasticity Results of Espy 96’

Explains 1/3 to 1/2 variation in long run elasticities

No significant from non-price & income variables

Static & dynamic no significantly difference long run estimates

Per capita or per household demand less elastic than total demand or demand per vehicle
Price Elasticity Results of Espy 96’

No difference in LR estimates for monthly, quarterly, or annual data

No difference in linear or log linear models

No difference national or state cross section time series

Cross section time series of non-US find 50% more elastic price response
Price Elasticity Results of Espy 96’

Random coefficient techniques < elastic price response

Demand was more price elastic prior to 1974

Other

Hughes, Knittel, and Sperling (2006 – monthly, static

<table>
<thead>
<tr>
<th></th>
<th>Price</th>
<th>Income</th>
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<tr>
<td>1/75-1/80</td>
<td>-0.30</td>
<td>0.47</td>
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<tr>
<td>3/01-3/06</td>
<td>-0.04</td>
<td>0.53</td>
</tr>
</tbody>
</table>
Income Elasticity Results Espy 96

Vehicle ownership lowers the elasticity

Non-price and income variables do not lower elasticity

Linear models are not different than non-linear

Monthly and quarterly data find a smaller long run income response
Higher income elasticity (10% significance level)
- Per capita
- Per household
- Per vehicle

Income elasticity less elastic before 1974 (10%)

No difference national and cross section time series of states

Random coefficient find more elastic income response
Global Demand for Transportation Fuels
Nasser Aldossary (PhD Candidate)

Scope: Estimate elasticities (price, income) for 45 countries.

Methodology: Building an econometrics model for each country.

Fuels of focus: Gasoline and Diesel.

Sample years: 1978-2004

Total consumption of selected countries:
Gasoline 88% and 85% Diesel of world’s consumption
Numerous Surveys

conventional wisdom

little or no price response

all surveys conclude there is

most come to numerical conclusion

income near 1

not so inconsistent with surveys

my best guesses

\( \varepsilon_p(\text{annual } -0.2) \ varepsilon_p(\text{lr } -0.6 \text{ to } -0.8) \)

\( \varepsilon_p(\text{annual } 0.3 \text{ to } 0.5) \ varepsilon_p(\text{lr } <1) \)