Oil Product Demand
Where Have We Been and Where Are We Going?

Carol A. Dahl, Professor Emeritus and Senior Fellow, Energy and Mineral Economics Program, Payne Institute of Earth Resources, Colorado School of Mines
More than a century of use
What's driving oil consumption
Elasticities
Refinery slates over the decades
Oil and product price elasticities
Lags in adjustment
Gasoline and diesel demand elasticity
World Consumption of Energy by Fuel
1850-2014

- Wood
- Coal
- Petroleum
- Gas
- Hydro
- Nuclear

mtoe

1850  1875  1900  1925  1950  1975  2000
James Sweeney (1984)

The Response of Energy Demand to Higher Prices: What Have We Learned?

Energy directly or indirectly in almost all economic activity
World and U.S. Primary Energy Consumption 1860-2013
US about 20%
World and U.S. GDP 1880 - 2015
Billion (PPP) USD
Brown, Stephen (forthcoming)
New estimates of the security costs of U. S. oil consumption. Energy Policy

\[ \varepsilon_Y = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta Y}{Y}} \]

Oil demand income elasticity

0.70
(0.55, 0.75)
Long Term Income Growth: Where in the Development Cycle

- GDP/Capita about $4000 in First Year
- U.K. 1851
- U.S. 1870
- Japan 1953
- S Korea 1953
- China 1993
- S Korea 1972

Years from Initial Year

2011 $
Share of World’s Oil (Primary Product)

- United States
- U.S.S.R
- Row

U.S. Share: K, G, F2, F6

- 85% K
- 75% K
- 60% K
- 33% G
- 50% G

1860 1869 1878 1887 1896 1905 1914 1923 1932
U.S. Product Slate
Share of Five Products (Secondary)

>50% G
James Sweeney (1984)

Buyers respond to higher prices
conservation and fuel switching
Brown, Stephen (forthcoming) 
New estimates of the security costs of U. S. oil consumption. Energy Policy

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

Oil demand price elasticity
Short run \hspace{1cm} -0.055
\hspace{1cm} (-0.02, -0.09)
1973 and 2015 shares of refinery output by product

1973
- Fuel oil: 33.8%
- Middle distillates: 26.0%
- Aviation fuels: 4.2%
- Motor gasoline: 21.0%
- LPG/ethane/naphtha: 5.8%
- Other products: 9.2%

Total: 2719 Mt

2015
- Middle distillates: 35.0%
- LPG/ethane/naphtha: 9.2%
- Motor gasoline: 24.2%
- Aviation fuels: 7.2%
- Fuel oil: 11.2%
- Other products: 13.2%

Total: 4033 Mt
Price Elasticities of Oil (O) Products (X)

\[ \varepsilon_O = \frac{\%\Delta O}{\%\Delta P} \]

\[ \varepsilon_X = \frac{\%\Delta X}{\%\Delta P_X} \]

\[ \varepsilon_O = \frac{\%\Delta O}{\%\Delta P} \frac{\%\Delta P_X}{\%\Delta P_O} \]
Composition of a Gallon of Gasoline

Regular Gasoline (April 2015)
Retail Price: $2.47/gallon

- Crude Oil: 51%
- Refining: 23%
- Distribution & Marketing: 8%
- Taxes: 18%
Diesel Prices by Country Frequency (US cents per gallon) 1 gallon is about 4 liters
Gasoline Prices by Country Frequency U.S. Cents per Gallon
Price elasticity for gasoline
  Short Run: -0.2
  Long Run: -0.6 to -1

Brown
  price elasticity of oil
  long run: -0.4
    (-0.55, -0.75)
James Sweeney (1984)

Used with capital some very long lived
Fairly fixed ratio until replaced
Adjustment can continue for many years
Adjustment rates unknown
James Sweeney (1984)

Energy is a derived demand

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

\[ \varepsilon_G = \frac{\% \Delta G}{\% \Delta P} = \frac{\% \Delta M}{\% \Delta P} - \frac{\% \Delta \text{MPG}}{\% \Delta P} \]

Rebound effect (Cafe standards)

\[ \text{MPG} \uparrow \text{Cost per mile} \downarrow \text{Miles} \uparrow \]

cancelling some of efficiency gains

Greening, Greene, and Difiglio (2000)

10% sr and up to 30% long run
Government policy can reduce price & economic activity 80-90% of adjustment
# Gasoline Price Elasticities

<table>
<thead>
<tr>
<th>GDP</th>
<th>Price 2014 Dollars per Gallon</th>
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<th>GDP</th>
<th>Price 2014 Dollars per Gallon</th>
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<tbody>
<tr>
<td>per</td>
<td>&lt;$11740</td>
<td>-0.15</td>
<td>$1.174-$2.935</td>
<td>-0.22</td>
<td>&gt;$2.67</td>
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<td>per</td>
<td>$11740-$23480</td>
<td>-0.11</td>
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<td>-0.22</td>
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<td>Capita</td>
<td>&gt;$23480</td>
<td>-0.22</td>
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<td>-0.22</td>
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Notes: 1 gallon = 3.785 liters

Source: Dahl (2012). Price and GDP per capita converted from 2006 to 2014 $ using the U.S. CPI of 1.174 from World Development Indicators. GDP per capita measured in purchasing power parities.
Diesel Price Elasticities

<table>
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<tr>
<th>GDP per Capita</th>
<th>Price 2014 Dollars per Gallon</th>
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<tr>
<td>&lt;$17610</td>
<td>&lt;$2.935: -0.22, &gt;$2.935: -0.38</td>
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<tr>
<td>&gt;$17610</td>
<td>&lt;$2.935: -0.13, &gt;$2.935: -0.27</td>
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Notes: 1 gallon = 3.785 liters

Source: Dahl (2012). Price and GDP per capita converted from 2006 to 2014 $ using the U.S. CPI of 1.174 from World Development Indicators. GDP per capita measured in purchasing power parities.
Short and Long Run Price and Income Elasticities
Time Path
Gasoline Income Elasticity

\[ \varepsilon_{gy} = 1.27 \]

\[ \varepsilon_{gy} = 0.66 \]
Diesel Income Elasticities

![Graph showing the relationship between diesel income elasticity and income per capita. The graph illustrates a negative correlation, with points scattered above and below the linear trend line, indicating diminishing responsiveness as income per capita increases.]
<table>
<thead>
<tr>
<th>Region</th>
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<th>Elasticity by Frequency</th>
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<td>0.71, 1.07</td>
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<td>1.07, 1.42</td>
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<td></td>
<td>1.42, 1.78</td>
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<td></td>
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<td>&gt; 1.78</td>
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# of elasticities
87     27     42     51     104     165     307

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# of elasticities
111    46     55     108    148    194    358

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# of elasticities
83     26     41     63     143    174    230

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# of elasticities
63     119    95     8    69     44    55    58

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# of elasticities
86     96    135    151     8     46    30    71

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# of elasticities
30     54    72     53     35     19     43
Sweeney

Demand oil, natural gas, and coal price elasticities in industrial uncertain
No fuel substitution non-rail transportation
Energy densities of chemical fuels and the best commercial battery

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Mj/kg</th>
<th>Mj/liter</th>
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</thead>
<tbody>
<tr>
<td>Body Fat</td>
<td>38</td>
<td>35</td>
</tr>
<tr>
<td>Kerosene, jet fuel</td>
<td>43</td>
<td>32</td>
</tr>
<tr>
<td>Lithium ion battery</td>
<td>0.54</td>
<td>0.9</td>
</tr>
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Global Energy Supply By Source

2015

- Coal: 28.1%
- Oil: 31.7%
- Natural gas: 21.6%
- Nuclear: 4.9%
- Hydro: 2.5%
- Other: 1.5%
- Biofuels and waste: 9.7%

Total: 13,647 Mtoe
Elasticity Data Base

Dahl Energy Demand Data Base

DEDD

http://dahl.mines.edu/courses/dahl/dedd