Location, Location, and Gasoline: Do Gasoline Prices Affect Residential Property Values?

- Adele C. Morris, Brookings Institution
  - is a fellow and the policy director for the Climate and Energy Economics Project
  - Brookings Mountain West Scholar

- Helen R. Neill, Associate Dean of Undergraduate Education and Assessment, Greenspun College of Urban Affairs
Public policy issue: economics of energy use and greenhouse gas emissions

- With the production of Output = f(land, labor, & capital) waste is produced.

- Scientific community reporting evidence of changes in temperature, precipitation, wind patterns etc. (NNSF EPSCoR & USEPA)

- Potential policy response: raising price of greenhouse gases i.e. carbon dioxide (CO$_2$). Uncertainty about economic impacts.
Figure 2.0 Primary Energy Consumption by Source and Sector, 2011
(Quadrillion Btu)

Source

<table>
<thead>
<tr>
<th>Source</th>
<th>Percent of Sources</th>
<th>Percent of Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petroleum¹</td>
<td>35.3 (36%)</td>
<td>71</td>
</tr>
<tr>
<td>Natural Gas²</td>
<td>24.8 (26%)</td>
<td>23</td>
</tr>
<tr>
<td>Coal³</td>
<td>19.7 (20%)</td>
<td>5</td>
</tr>
<tr>
<td>Renewable Energy⁴</td>
<td>9.1 (9%)</td>
<td>1</td>
</tr>
<tr>
<td>Nuclear Electric Power⁵</td>
<td>8.3 (8%)</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>97.3</td>
<td></td>
</tr>
</tbody>
</table>

Sector

<table>
<thead>
<tr>
<th>Sector</th>
<th>Percent of Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td>27.0 (28%)</td>
</tr>
<tr>
<td>Industrial</td>
<td>20.3 (21%)</td>
</tr>
<tr>
<td>Residential &amp; Commercial⁶</td>
<td>10.7 (11%)</td>
</tr>
<tr>
<td>Electric Power</td>
<td>39.3 (40%)</td>
</tr>
</tbody>
</table>

Notes:
1. Does not include biofuels that have been blended with petroleum—biofuels are included in the same category as the fuels they are blended with.
2. Does not include supplemental gaseous fuels.
3. Includes less than 0.1 quadrillion Btu of coal coke net imports.
4. Includes industrial combined-heat-and-power (CHP) and industrial electricity-only plants.
5. Includes conventional hydroelectric power, geothermal, solar, photovoltaic, wind, and biomass.
6. Includes commercial combined-heat-and-power (CHP) and commercial electricity-only plants.
7. Electricity-only and combined-heat-and-power (CHP) plants whose primary business is to sell electricity, or electricity and heat, to the public. Includes 0.1 quadrillion Btu of electricity net imports not shown under “Source.”

U.S. Primary Energy Consumption Estimates by Major Source, 1949-2011

Source: U.S. Energy Information Administration Annual Energy Review, Table 1.3.
U.S. Primary Energy Consumption Estimates by Source, 1775-2011

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>Capacity Factor (%)</th>
<th>Levelized Capital Cost</th>
<th>Fixed O&amp;M</th>
<th>Variable O&amp;M (including fuel)</th>
<th>Transmission Investment</th>
<th>Total System Levelized Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Coal</td>
<td>85</td>
<td>65.3</td>
<td>3.9</td>
<td>24.3</td>
<td>1.2</td>
<td>94.8</td>
</tr>
<tr>
<td>Advanced Coal</td>
<td>85</td>
<td>74.6</td>
<td>7.9</td>
<td>25.7</td>
<td>1.2</td>
<td>109.4</td>
</tr>
<tr>
<td>Advanced Coal with CCS</td>
<td>85</td>
<td>92.7</td>
<td>9.2</td>
<td>33.1</td>
<td>1.2</td>
<td>136.2</td>
</tr>
<tr>
<td>Natural Gas-fired</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional Combined Cycle</td>
<td>87</td>
<td>17.5</td>
<td>1.9</td>
<td>45.6</td>
<td>1.2</td>
<td>66.1</td>
</tr>
<tr>
<td>Advanced Combined Cycle</td>
<td>87</td>
<td>17.9</td>
<td>1.9</td>
<td>42.1</td>
<td>1.2</td>
<td>63.1</td>
</tr>
<tr>
<td>Advanced CC with CCS</td>
<td>87</td>
<td>34.6</td>
<td>3.9</td>
<td>49.6</td>
<td>1.2</td>
<td>89.3</td>
</tr>
<tr>
<td>Conventional Combustion Turbine</td>
<td>30</td>
<td>45.8</td>
<td>3.7</td>
<td>71.5</td>
<td>3.5</td>
<td>124.5</td>
</tr>
<tr>
<td>Advanced Combustion Turbine</td>
<td>30</td>
<td>31.6</td>
<td>5.5</td>
<td>62.9</td>
<td>3.5</td>
<td>103.5</td>
</tr>
<tr>
<td>Advanced Nuclear</td>
<td>90</td>
<td>90.1</td>
<td>11.1</td>
<td>11.7</td>
<td>1.0</td>
<td>113.9</td>
</tr>
<tr>
<td>Wind</td>
<td>34</td>
<td>83.9</td>
<td>9.6</td>
<td>0.0</td>
<td>3.5</td>
<td>97.0</td>
</tr>
<tr>
<td>Wind – Offshore</td>
<td>34</td>
<td>209.3</td>
<td>28.1</td>
<td>0.0</td>
<td>5.9</td>
<td>243.2</td>
</tr>
<tr>
<td>Solar PV</td>
<td>25</td>
<td>194.6</td>
<td>12.1</td>
<td>0.0</td>
<td>4.0</td>
<td>210.7</td>
</tr>
<tr>
<td>Solar Thermal</td>
<td>18</td>
<td>259.4</td>
<td>46.6</td>
<td>0.0</td>
<td>5.8</td>
<td>311.8</td>
</tr>
<tr>
<td>Geothermal</td>
<td>92</td>
<td>79.3</td>
<td>11.9</td>
<td>9.5</td>
<td>1.0</td>
<td>101.7</td>
</tr>
<tr>
<td>Biomass</td>
<td>83</td>
<td>55.3</td>
<td>13.7</td>
<td>42.3</td>
<td>1.3</td>
<td>112.5</td>
</tr>
<tr>
<td>Hydro</td>
<td>52</td>
<td>74.5</td>
<td>3.8</td>
<td>6.3</td>
<td>1.9</td>
<td>86.4</td>
</tr>
</tbody>
</table>

US EIA (2011)
Table 1.5 Energy Consumption, Expenditures, and Emissions Indicators Estimates, 1949-2011, Energy Expenditures as Share of GDP

Source: U.S. Energy Information Administration

http://www.eia.gov/totalenergy/data/annual/showtext.cfm?t=ptb0105
US Greenhouse Gas Emissions

- Carbon Dioxide: 84%
- Methane: 10%
- Nitrous Oxide: 4%
- Fluorinated Gases: 2%

USEPA

http://epa.gov/climatechange/ghgemissions/gases.html
Pounds of CO2 emitted per million BTU of energy for various fuels:

- Coal (anthracite) 227
- Coal (bituminous) 205
- Coal (lignite) 215
- Coal (subbituminous) 213
- Diesel fuel & heating oil 161
- Gasoline 156
- Propane 139
- Natural gas 117

Source: US EIA at http://www.eia.gov/tools/faqs/faq.cfm?id=73&t=11
CO₂ Emissions Drive Increased Concentrations


Source: http://www.epa.gov/climatechange/emissions/globalghg.html
World coal production by region, 1980-2010

- North America: 1.2 billion short tons
- Europe: 0.7 billion short tons
- Former Soviet Union: 0.6 billion short tons
- Asia: 4.7 billion short tons
- Central & South America: 0.3 billion short tons
- Oceania: 0.5 billion short tons

Graph shows production trends from 1980 to 2010.
World dry natural gas production by region, 1980-2010
trillion cubic feet

- North America: 29
- Europe: 11
- Former Soviet Union: 26
- Asia: 15
- Middle East: 17
- Central & South America: 5
- Oceania: 2

2010

Chart showing production trends from 1980 to 2010 for different regions.
We can buy better probabilities if we stabilize concentrations, e.g. at approx 550 ppmv.

Source: MIT Joint Program on the Science and Policy of Global Change
http://globalchange.mit.edu/resources/gamble/policy_F.html
Economists consider the following with respect to resource allocation:

- Resources are scarce
- For every $ we spend to reduce a problem we give up a $ somewhere else (opportunity cost).
- We observe exchanges between buyers and sellers in markets.
- Buyers and sellers bargain which leads to an efficient market allocation of goods and services.
- Challenges arise for common resources or externalities.
- Too much carbon emissions (waste product) is a market failure. Obama Administration estimates social cost of CO$_2$ (i.e. benefit of reducing CO$_2$) $5$ to 65/ton
Economic response con’t

- Prices don’t reflect damage to the environment.
- Damages are externalities.
- An economy-wide price on [green house gases] ensures that all economic decisions incorporate both private and social costs.
  - Relatively large range of social cost estimated for CO$_2$ ($5$ to $65$/ton)
  - EPA estimated that a $32$ per ton price would increase price of gasoline $0.30$ per gallon
- Provide a level of climate protection that maximizes net social benefits. (Adele Morris, 2012)
Categories of Economic Effects

- Benefits from avoided climate damages
- Costs to the U.S. economy overall of mitigation policy
- Distribution of benefits and costs (who wins, who loses?)
- Ancillary costs and benefits of policies

Morris, 2012
Economic valuation approaches

- Market data

- Nonmarket valuation techniques
  - Contingent Valuation Method
  - Travel Cost Method
  - Hedonic Price Model
    - Multiple regression analysis
    - Sales price of a home = f (Housing, neighborhood, & location characteristics)
Hedonic Price Method Literature

- Estimate of nonmarket factors such as environmental and public goods to provide marginal & aggregate $ benefits.
- Estimate of housing price indices to reveal individual characteristics to citywide trends.
- Fewer studies estimate impact of related market on sales price.
Additional impacts

- Cross-price elasticity of demand - two markets are related when a 1% change in price of one good leads to a (+/-) X% change in the quantity demanded of another good.
  - Substitutes (+)
  - Complements (-)
Motivation

- Given the problem of carbon emissions and proposed solution of internalizing externality cost such as a carbon tax, we’re interested in the potential impact of higher prices on households.
- While we can’t observe higher costs of carbon emissions yet we do have data on higher gasoline prices and real estate.
- There are relatively few papers on this topic.
    - 10% increase in Price of gasoline leads to a 10% decrease in new home construction in locations with large commutes.
Research question

- What is the relationship between price of gasoline and housing market in Las Vegas?
Standard Hedonic Property Price Model

\[ y_{ism} = \alpha_s + \gamma_t + \beta' X_i + \lambda_0 g_m + \lambda_s g_m \alpha_s + \mu_0 u_m \]
\[ + \mu_s u_m \alpha_s + \epsilon_{ist} \]

- House = \( i \)
- census tract = \( s \)
- gas price in months = \( m \)
- \( X_i \) includes of property characteristics of house \( i \)
- \( \alpha_s \) are census tract fixed effects and
- \( \gamma_t \) are year indicators
price elasticity of homes in census tract $s$ with respect to the price of gasoline is:

$$\lambda_0 + \lambda_s = E_s$$
Table 1. Descriptive Statistics of Housing Transactions \( (N = 930,702) \)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property price</td>
<td>245,018.7</td>
<td>146,315.4</td>
<td>40,005</td>
<td>2,309,211</td>
</tr>
<tr>
<td>Living space (ft(^2))</td>
<td>1904</td>
<td>759</td>
<td>280</td>
<td>7988</td>
</tr>
<tr>
<td>Lot size (acres)</td>
<td>.16</td>
<td>.15</td>
<td>.01</td>
<td>5</td>
</tr>
<tr>
<td>Home age (years)</td>
<td>9.32</td>
<td>12.48</td>
<td>0</td>
<td>109</td>
</tr>
<tr>
<td>Pool indicator</td>
<td>.21</td>
<td>.41</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Full bathrooms</td>
<td>2.19</td>
<td>.58</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Foreclosure indicator</td>
<td>.063</td>
<td>.244</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Townhouse indicator</td>
<td>0.07</td>
<td>0.26</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Multiplex indicator</td>
<td>0.01</td>
<td>0.09</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Price per gallon of gasoline ($)</td>
<td>2.18</td>
<td>0.62</td>
<td>1.22</td>
<td>4.08</td>
</tr>
<tr>
<td>Nevada state-level unemployment rate (%)</td>
<td>6.44</td>
<td>3.16</td>
<td>3.8</td>
<td>14.9</td>
</tr>
</tbody>
</table>
Number of Observations by Year of Sale
New and Existing Homes

![Chart showing number of observations by year of sale for new and existing homes.](chart.png)
Geographic Distribution of Property Transactions in Clark County
U.S. Census Data (2000)

Population

Legend
Population
- 87 - 1,456
- 1,457 - 2,255
- 2,256 - 2,883
- 2,884 - 3,440
- 3,441 - 3,987
- 3,988 - 4,587
- 4,598 - 5,571
- 5,572 - 6,674
- 6,675 - 8,437
- 8,438 - 12,179

Median Family Income

Legend
Median Family Income
- 21,078 - 29,034
- 29,035 - 36,223
- 36,224 - 42,647
- 42,648 - 48,092
- 48,093 - 54,539
- 54,540 - 60,417
- 60,418 - 68,112
- 68,113 - 80,193
- 80,194 - 93,612
- 93,613 - 129,733
Simple test to compare our data with the results of Malloy & Shan (2010)

- If homes and gasoline are complementary goods then we would expect to see in the long run a negative relationship between the two goods.

- Hypotheses
  - Ho: No relationship
  - Ha: The relationship is negative
Real gas price per month

Quantity of Residential sales per month
Find similar results as Malloy & Shan (2010)

- Use 420 months of data (1976 – 2010) we find a 1% increase in the real price of gasoline leads to a 1.3% decrease in the quantity of residential properties sold in the Las Vegas Metropolitan Area (n=420, coef =-1.316938, p <0.001, t=-5.92 ).
Table 2. Hedonic Regression Coefficients
Dependent Variable: ln(property sale price)

<table>
<thead>
<tr>
<th>Explanatory Variable</th>
<th>Estimate</th>
<th>Robust Std. Err.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>8.836</td>
<td>*** 0.026</td>
</tr>
<tr>
<td>ln(gasoline price in sale month)</td>
<td>-0.089</td>
<td>*** 0.028</td>
</tr>
<tr>
<td>Nevada unemployment rate (percent)</td>
<td>-0.035</td>
<td>*** 0.002</td>
</tr>
<tr>
<td>ln (Square footage of home)</td>
<td>0.577</td>
<td>*** 0.001</td>
</tr>
<tr>
<td>ln(Lot size in acres)</td>
<td>0.144</td>
<td>*** 0.001</td>
</tr>
<tr>
<td>Age</td>
<td>-0.009</td>
<td>*** 0.000</td>
</tr>
<tr>
<td>Age*Age</td>
<td>0.000</td>
<td>*** 0.000</td>
</tr>
<tr>
<td>Pool indicator</td>
<td>0.068</td>
<td>*** 0.001</td>
</tr>
<tr>
<td>Number of full baths</td>
<td>0.027</td>
<td>*** 0.001</td>
</tr>
<tr>
<td>Multiplex indicator</td>
<td>-0.021</td>
<td>*** 0.004</td>
</tr>
<tr>
<td>Townhouse indicator</td>
<td>0.002</td>
<td>* 0.001</td>
</tr>
<tr>
<td>Foreclosure indicator</td>
<td>-0.134</td>
<td>*** 0.001</td>
</tr>
</tbody>
</table>

Year indicators = Yes, Census tract indicators = Yes, Census tract indicators interacted with ln(gasoline prices), Census tract indicators interacted with Nevada Unemployment rate in sale month = Yes, N = 930,702, F(1045, 929,656 = 4601.85, P > F = 0, R-squared = 0.819 RMSE = 0.22)
Do changes in gasoline prices lead to similar changes in residential sales prices across neighborhoods?
Same map with close up
Las Vegas real estate and labor markets may illustrate extremes yet expenditures on energy per person are similar to the national average.

We’ve tested hypotheses related to neighborhood gas price elasticities and socioeconomic census data to test hypotheses related to vulnerability.

CO₂ is not the only greenhouse gas and pricing only carbon may lead to higher levels of methane.
Additional Information

- Adele Morris
  - http://www.brookings.edu/experts/morrisa
- US EIA
  - http://www.eia.gov/totalenergy/data/annual/showtext.cfm?t=ptb0105
- Greenhouse gases & Energy - USEIA
  - http://www.eia.gov/oiaf/1605/ggccebro/chapter1.html
- Climate Change - EPA
Acknowledgements

- Director Adele Morris, Managing Director Bill Brown, Director Rob Lang and colleagues from Brookings Mountain West & Brookings Institution
- VPR Tom Piechota, Dene Charlet, Prof. Bill Smith & colleagues from Nevada NSF EPSCoR
- Dean Lee Bernick. Professor Krys Stave
Questions?

- Contact: Helen R. Neill, PhD
- (702) 895 – 4892
- helen.neill@unlv.edu
Economic policy response to climate change

- Adaption – identify projects to deal with consequences of climate change
  - Seawalls
  - Moving populations away from low lying areas

- Mitigation – identify ways to internalize carbon emissions in decisions of producers and consumers.
New and existing home sales by year
Table 1.5 Energy Consumption, Expenditures, and Emissions Indicators Estimates, 1949-2011, Gross Domestic Product (GDP)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2,500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7,500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12,500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: U.S. Energy Information Administration
2011 energy consumption and energy-related CO₂ emissions share by fuel

Sources: U.S. Energy Information Administration, Monthly Energy Review (July 2012), Table 1.3 and Table 12.1.
Estimated U.S. Total\(^1\) Carbon Dioxide Emissions From Energy Consumption by End-Use Sector,\(^2\)
1949-2011

Source: U.S. Energy Information Administration Annual Energy Review, Tables 11.2a, 11.2b, 11.2c, 11.2d.
\(^1\)Excludes emissions from biomass energy consumption.
Estimated U.S. Carbon Dioxide\(^1\) Emissions From Energy Consumption by Major Source, 1949-2011

Optimal Portfolio of Policies Balances Costs and Benefits of...

- Economy-wide price on GHGs
- Policies to control distributional effects
- Climate science
- R&D for low-GHG technologies
- Adaptation, including Adaptation R&D
- Support for abatement, adaptation, and development in poor countries
- Diplomacy

Morris, 2012