New Relationships: Ethanol, Corn, and Gasoline Price Volatility

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“America is addicted to oil”

President Bush, 2006 State of the Union Address
“America is addicted to oil”

President Bush, 2006 State of the Union Address

- Gasoline prices are more volatile than prices for 95% of products sold domestically
- Gasoline price volatility is partially responsible for the 2001 and 2008 recessions
- Diversifying into renewable fuels, such as ethanol, can reduce gasoline-price volatility

Price Volatility: An unpredictable price change
Investigate Alternative Portfolios

- **Diversified Fuel Portfolio**
  - Petroleum Gasoline
  - Fuel Ethanol
    - U.S.
    - Brazil

- **Will a Diversified Portfolio yield lower gasoline price volatility?**

**Fuel Diversification:**

*A risk management tool that mixes fuels into a fuel portfolio*

**Fuel Portfolio:** *A collection of fuel types*
## External Costs (cents/gallon)

<table>
<thead>
<tr>
<th>External Costs</th>
<th>Ethanol</th>
<th>Gasoline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Brazil</td>
<td>United States</td>
</tr>
<tr>
<td><strong>Fuel Related Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greenhouse Gases</td>
<td>4.8¢</td>
<td>4.8¢</td>
</tr>
<tr>
<td>Oil Dependency</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Mileage Related Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local Air Quality</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>Congestion</td>
<td>105</td>
<td>105</td>
</tr>
<tr>
<td>Accidents</td>
<td>63</td>
<td>63</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>214.8</td>
<td>214.8</td>
</tr>
</tbody>
</table>


Fuel External Costs (negative externalities): *Drivers do not bear all of the costs of driving*
Food vs. Fuel Issue

EXCUSE ME. I'M GOING TO NEED THIS TO RUN MY CAR.
Address the Relations Among Biofuel and Fossil-Fuel Prices:

With Consideration of Environmental and Food Security Implications

Tandem Investigations:


Data: Wholesale prices

  - Brazilian Ethanol
  - U.S. Petroleum Fuel
  - U.S. Ethanol

- Food vs. Fuel (Ethanol/Corn Volatility)
  - U.S. Ethanol
  - Corn
  - Gasoline
  - Oil
Portfolio

Apply portfolio theory to the application of vehicle-fuel prices and volatility

Markowitz, 1990 Nobel Prize winner

Employ a MGARCH model to estimate the variances and covariances of the three fuels

Engle, 2003 Nobel Prize winner

MGARCH: A statistical time series model
Policy Analysis

- Free-market ethanol: removing the federal fuel-ethanol tax credit (subsidy) and ethanol import tariff

- Automobile-environmental issues: greenhouse gases, oil dependency, air quality, congestion, and accidents
Research Discovery

- This approach resulted in the discovery of how we can simultaneously reduce price volatility and address environmental concerns
Expected portfolio price, $E(p)$, is composed of Brazilian and U.S. ethanol prices along with the petroleum gasoline price

$$E(p) = \alpha_B E(p_B) + \alpha_E E(p_E) + \alpha_G E(p_G)$$

where $E(p_B)$, $E(p_E)$, and $E(p_G)$ are the prices of Brazilian ethanol, U.S. ethanol and gasoline, and $\alpha_B$, $\alpha_E$, and $\alpha_G$ are the associated weights for the respective expected prices with their sum equaling unity.
Model: Portfolio Variance

- The volatility associated with expected portfolio price, \( E(p) \), is represented by the portfolio’s variance

\[
\sigma^2 = \alpha_B^2 \text{var}(p_B) + \alpha_E^2 \text{var}(p_E) + \alpha_G^2 \text{var}(p_G)
+ 2\alpha_B \alpha_E \text{cov}(p_B, p_E) + 2\alpha_B \alpha_G \text{cov}(p_B, p_G) + 2\alpha_E \alpha_G \text{cov}(p_E, p_G)
\]

where \( \text{var}(p_B) \), \( \text{var}(p_E) \), and \( \text{var}(p_G) \) are the variances of Brazilian and U.S. ethanol and petroleum fuel prices, and \( \text{cov} \) represents the associated covariance.
Results

Efficient Portfolio Frontier
with Current Subsidy/Tariff Policy for Year 2006

- Brazilian Ethanol
- US Ethanol
- Actual Portfolio
- US Gasoline

Efficient Results
## Selected Frontier Points for Year 2006

<table>
<thead>
<tr>
<th>Price ($/gal.)</th>
<th>Volatility</th>
<th>Subsidy/Tariff Weights</th>
<th>Free-Market Weights</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Ethanol</td>
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</tr>
<tr>
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<td></td>
<td>Brazil United States</td>
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<tr>
<td>1.9</td>
<td>0.092</td>
<td>0.02</td>
<td>0.98</td>
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Policy Analysis

Free-Trade and Added Environmental Cost
Efficient Portfolio Frontiers for Year 2006

Original Data

Add Environmental Cost

Remove Subsidy & Tariff

Original Data

Price ($/gallon) vs Volatility
## Selected Frontier Points for Year 2006

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Implications

- Current U.S. gasoline policies are minimizing the expected prices at the expense of high fuel-price volatility.

- By incorporating ethanol, fuel-price volatility is reduced at a cost of higher prices. Considering the social cost of gasoline, such a shift may be desirable.
Food vs. Fuel

- Price Volatility Measurements
  - Classical
    - Six-week overlapping window for ethanol and corn prices
    - Simple volatility measure (standard deviation)
  - MGARCH
    - Less restrictive
    - Links corn, ethanol, gasoline, and oil prices
- VAR (price level)
Standard Error Regressions

\[ \sigma_{et} = \alpha + \sum \beta_i \sigma_{et-1} + \beta T + \sum \alpha_i \sigma_{ct-1} \]

\[ \sigma_{ct} = \alpha + \sum \beta_i \sigma_{ct-1} + \beta T + \sum \alpha_i \sigma_{et-1} \]
Other factors (gasoline and oil) may contribute to corn and ethanol price volatility.
MGARCH Results

Ethanol Price Volatility

95% C.I.

Corn Price Volatility
VAR: Granger Causality

- Gasoline Price
- Oil Price
- Ethanol Price
- Corn Price

99% C.I.
< 90% C.I.
Implications

- Consistent with Economic Theory
  - Ethanol and oil demand are derived demands from gasoline
  - Given a shock, market signals restore market equilibrium
  - A shock may increase price volatility, but decentralized markets will mitigate the shock’s persistence
Conclusions

- Governmental Policies
  - Promote an increasing share of ethanol in our vehicle-fuel portfolio
  - Provide a buffer in the form of agricultural commodity surpluses
Research Extension

- Introduce soybean prices into the models
  - Prices
    - Ethanol
    - Corn
    - Soybeans
    - Gasoline
    - Oil
  - Consider cointegration among the prices
  - Incorporating these two extensions yields the same general conclusions
Major Caveat

- This is a partial equilibrium analysis
- A general equilibrium analysis is required
  - How do biofuels fit into a portfolio with other alternative energy sources?
  - Parallel avenues exist for kicking our oil addiction
    - Plug-in hybrid vehicles
  - The near future of vehicles is in electric power
    - What place if any will biofuels fit into this future?


