New Relationships: Ethanol, Corn, and Gasoline Price Volatility

Zibin Zhang and Michael Wetzstein
Department of Agricultural & Applied Economics
University of Georgia

This Research is Supported
by the Office of Energy Policy and New Uses, USDA

Transition to a Bioeconomy: Risk, Infrastructure and Industry Evolution Conference
Berkeley, CA, June 24-25

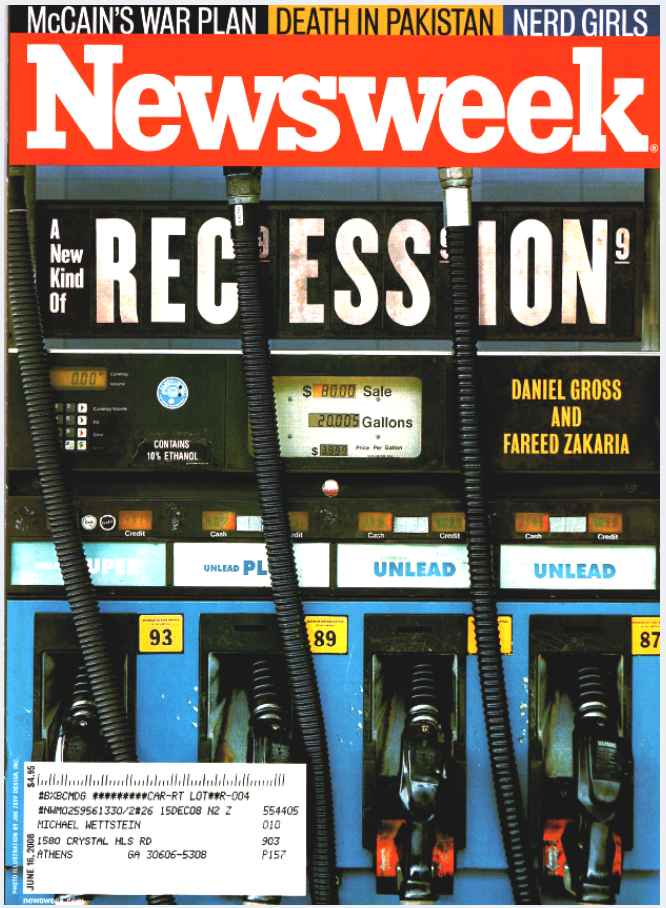
“America is addicted to oil”

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***

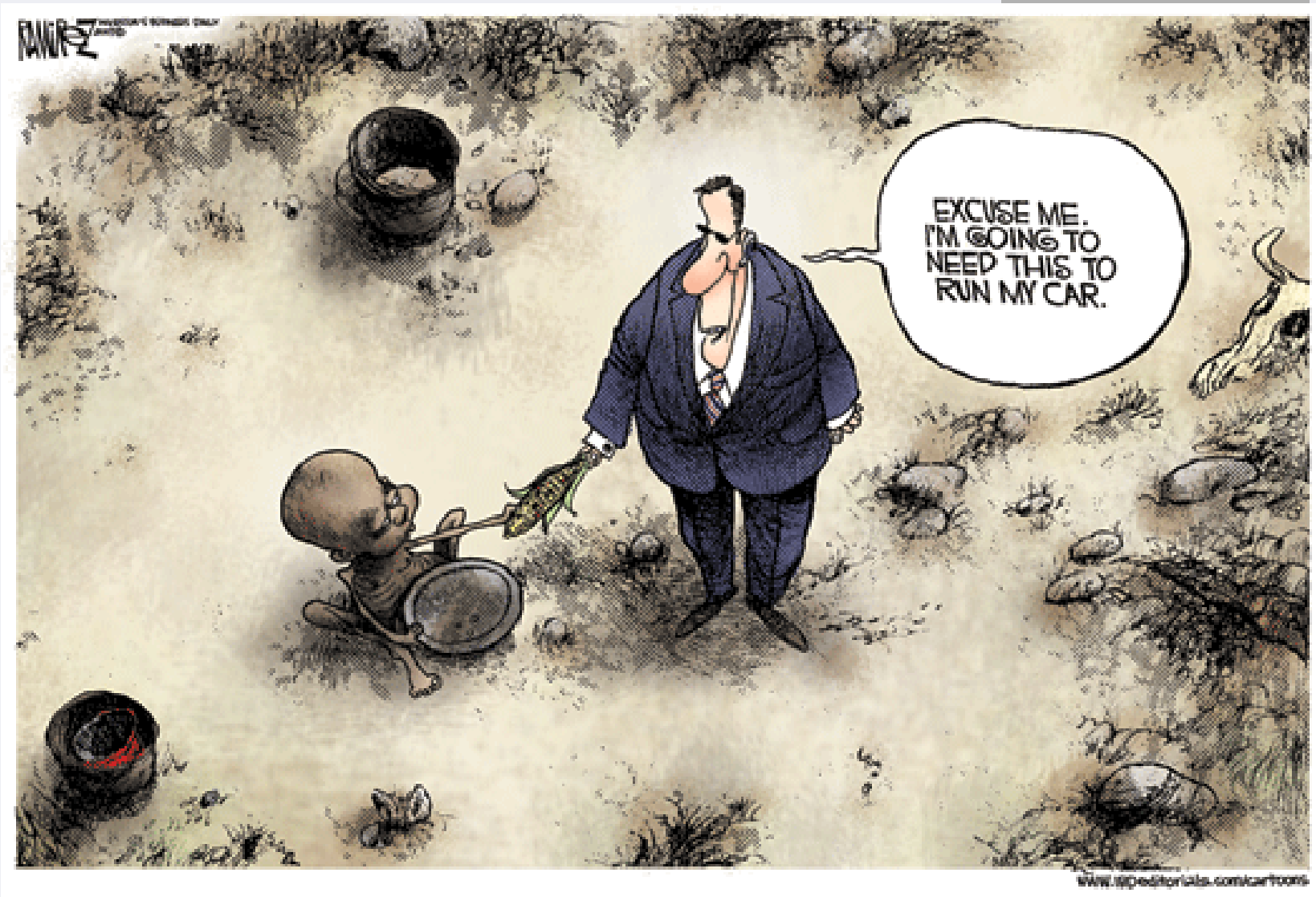
External Costs (cents/gallon)

External Costs	Ethanol		Gasoline
	Brazil	United States	
Fuel Related Costs			
Greenhouse Gases	4.8¢	4.8¢	6.0¢
Oil Dependency	0	0	12
Mileage Related Costs			
Local Air Quality	42	42	42
Congestion	105	105	105
Accidents	63	63	63
Total	214.8	214.8	228

Sources: Jacobson, Environmental Sc. Tech., 2007.
Perry, et al., J. of Econ. Literature, 2007.
Searchinger, et al., Science, 2008.

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

Food vs. Fuel Issue



Address the Relations Among Biofuel and Fossil-Fuel Prices:

With Consideration of Environmental and Food Security Implications

Tandem Investigations:

Zhang, Z., L. Lohr, C. Escalante, and M. Wetzstein. "Mitigating Volatile U.S. Gasoline Prices and Internalizing External Costs: A Win-Win Fuel Portfolio." Principal Paper at the AAEA Meetings, Orlando, FL, 2008.

Zhang, Z., L. Lohr, C. Escalante, and M. Wetzstein. "Ethanol and Corn Price Relations in a Volatile Vehicle-Fuels Market." Selected Presentation at the AAEA Meetings, Orlando, FL, 2008.

Data: Wholesale prices

- Portfolio (1998-2007):
  - Brazilian Ethanol
  - U.S. Petroleum Fuel
  - U.S. Ethanol
- Food vs. Fuel (Ethanol/Corn Volatility)
  - U.S. Ethanol
  - Corn
  - Gasoline
  - Oil

United States Department of Agriculture

Energy Information Administration
Official Energy Statistics from the U.S. Government

Portfolio

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

Markowitz, 1990 Nobel Prize winner

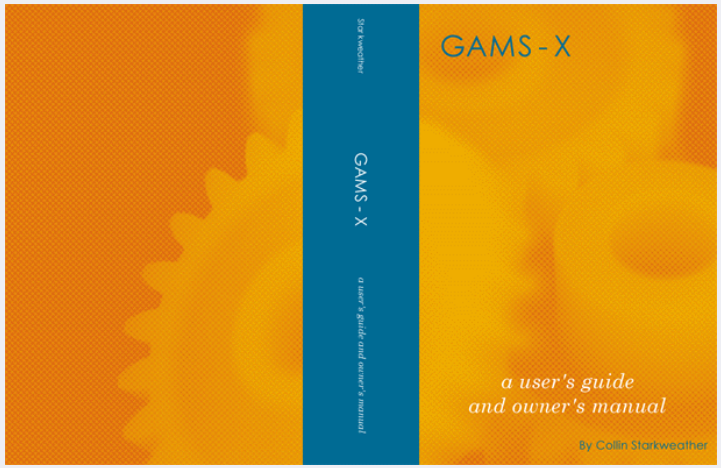
Engle, 2003 Nobel Prize winner

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

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

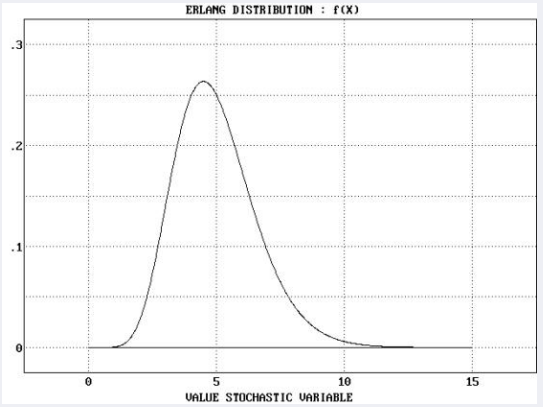
- This approach resulted in the discovery of how we can simultaneously reduce price volatility and address environmental concerns

Model: Expected Portfolio Price

- 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 α_B, α_E, and α_G are the associated weights for the respective expected prices with their sum equaling unity.



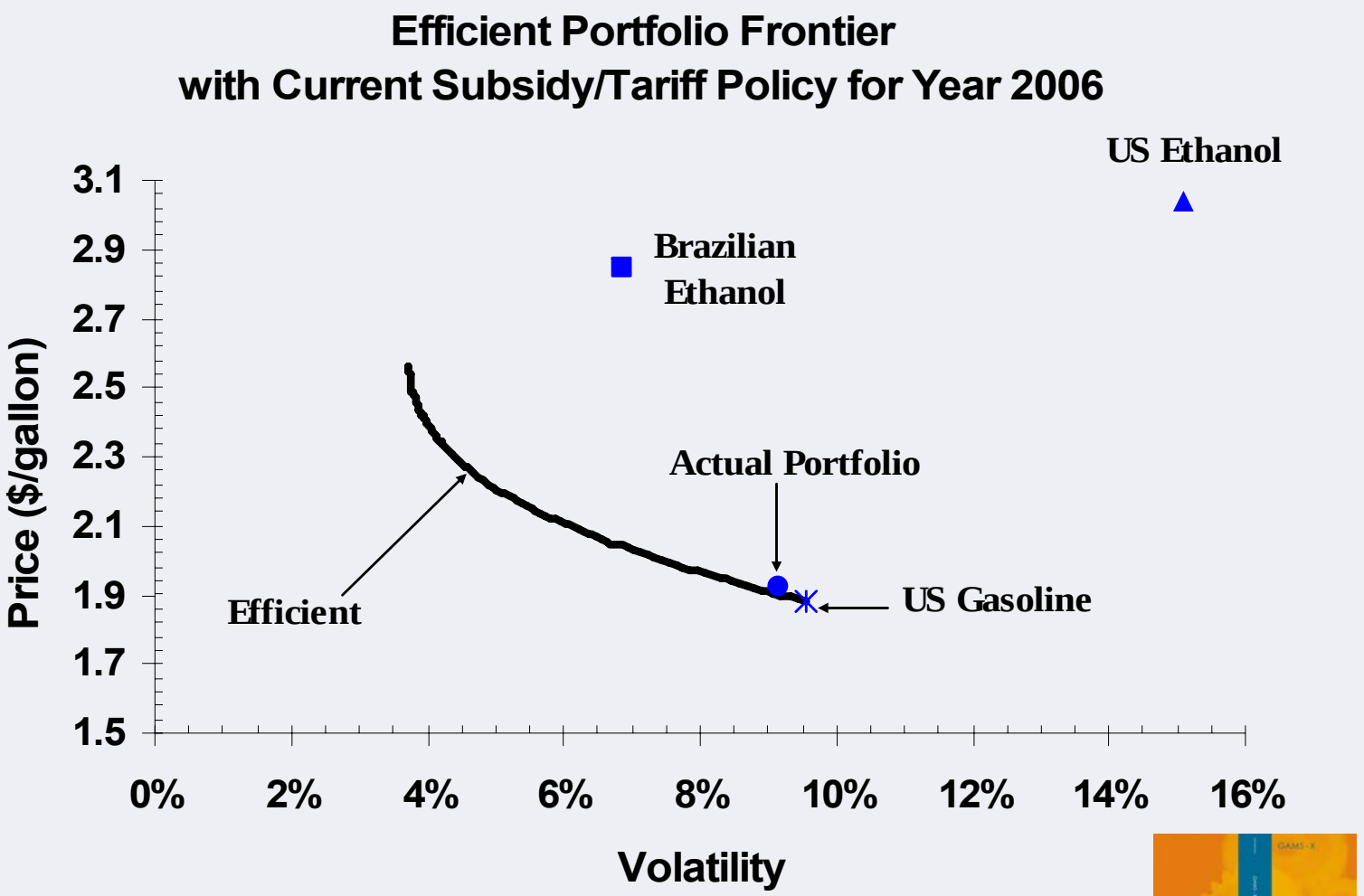
Model: Portfolio Variance

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

$$\sigma^2 = \alpha_B^2 \operatorname{var}(p_B) + \alpha_E^2 \operatorname{var}(p_E) + \alpha_G^2 \operatorname{var}(p_G)$$
$$+ 2\alpha_B\alpha_E \operatorname{cov}(p_B, p_E) + 2\alpha_B\alpha_G \operatorname{cov}(p_B, p_G) + 2\alpha_E\alpha_G \operatorname{cov}(p_E, p_G)$$

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

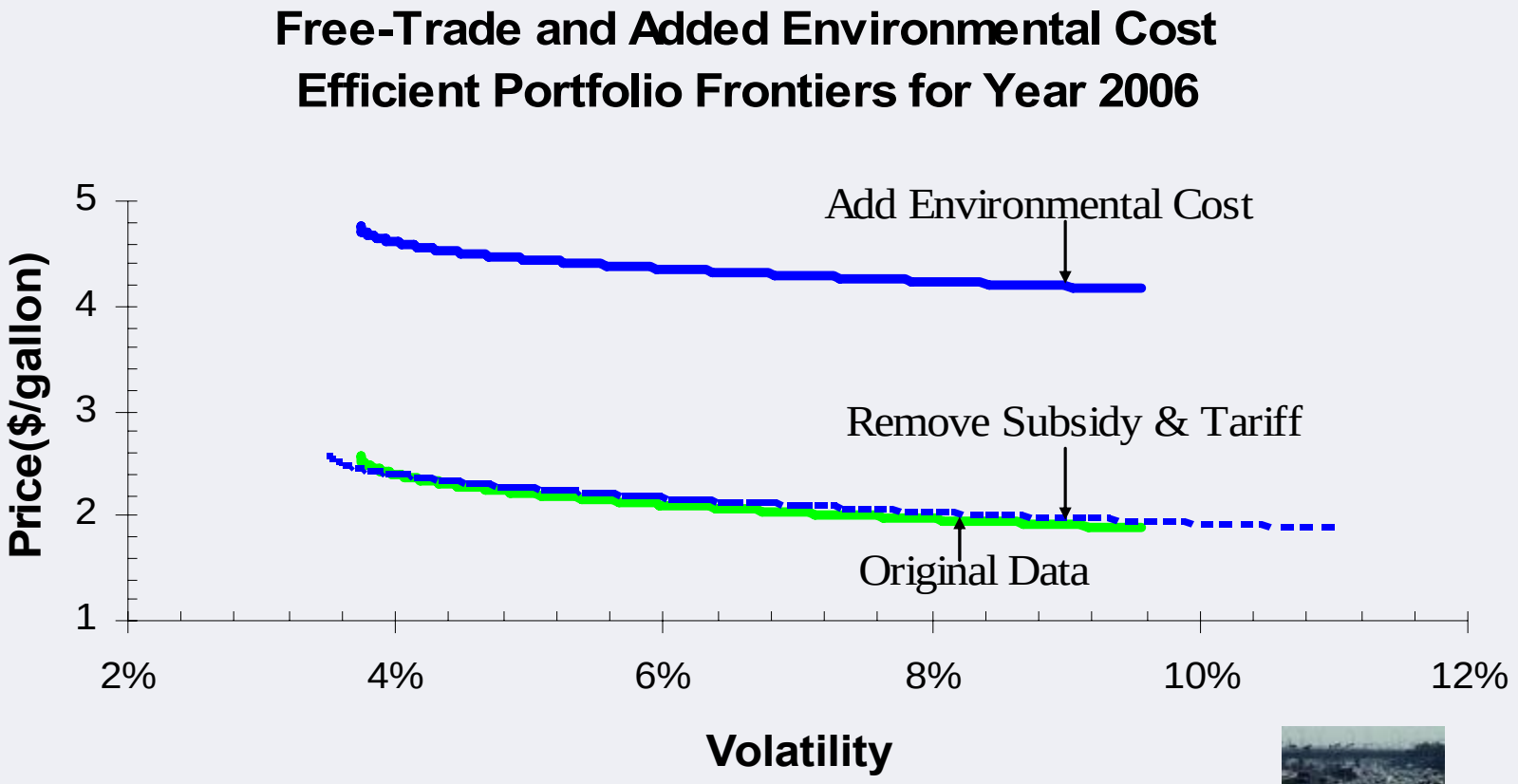
Results


Efficient Portfolio Frontier
with Current Subsidy/Tariff Policy for Year 2006
US Ethanol
Brazilian
Ethanol
Actual Portfolio
Efficient
US Gasoline
Price ($/gallon)
3.1
2.9
2.7
2.5
2.3
2.1
1.9
1.7
1.5
0%
2%
4%
6%
8%
10%
12%
14%
16%
Volatility

Selected Frontier Points for Year 2006

Price ($/gal.)	Subsidy/Tariff Volatility	Subsidy/Tariff Weights			Free-Market Volatility	Free-Market Weights		
		Ethanol		Gasoline		Ethanol		Gasoline
		Brazil	United States	United States		Brazil	United States	United States
1.9	0.092	0.02	0	0.98	0.106	0.02	0	0.98
2.0	0.075	0.12	0	0.88	0.086	0.13	0	0.87
2.1	0.061	0.23	0	0.77	0.069	0.24	0	0.76
2.2	0.051	0.33	0	0.67	0.056	0.35	0	0.65
2.3	0.044	0.41	0.02	0.57	0.046	0.46	0	0.54
2.4	0.040	0.47	0.06	0.47	0.040	0.56	0	0.44
2.5	0.038	0.51	0.11	0.38	0.036	0.67	0	0.33

Policy Analysis



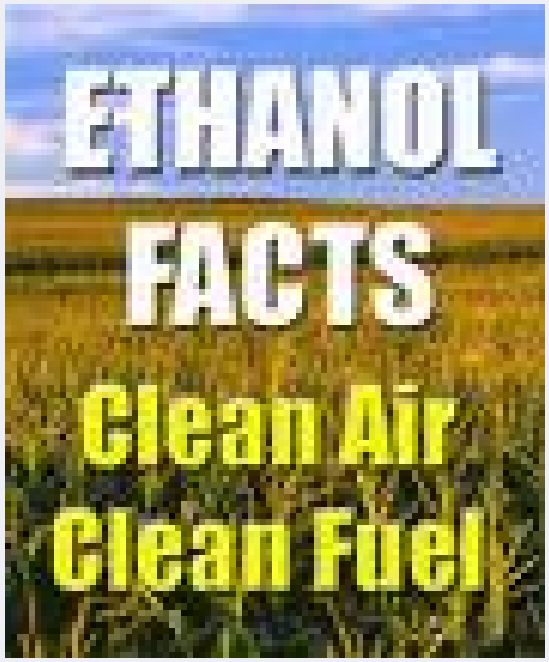
Selected Frontier Points for Year 2006

Price ($/gal.)	Subsidy/Tariff				Free-Market			
	Volatility	Weights			Volatility	Weights		
		Ethanol		Gasoline		Ethanol		Gasoline
		Brazil	United States	United States		Brazil	United States	United States
1.9	0.092	0.02	0	0.98	0.106	0.02	0	0.98
2.0	0.075	0.12	0	0.88	0.086	0.13	0	0.87
2.1	0.061	0.23	0	0.77	0.069	0.24	0	0.76
2.2	0.051	0.33	0	0.67	0.056	0.35	0	0.65
2.3	0.044	0.41	0.02	0.57	0.046	0.46	0	0.54
2.4	0.040	0.47	0.06	0.47	0.040	0.56	0	0.44
2.5	0.038	0.51	0.11	0.38	0.036	0.67	0	0.33

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

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

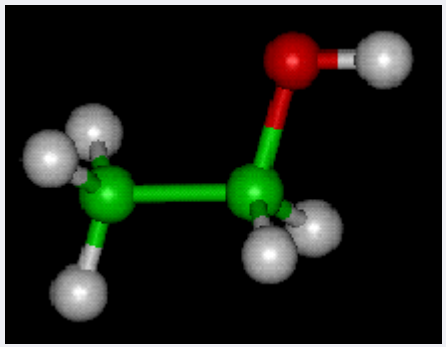
Classical: Granger Causality

Corn
Price Volatility

90%

95%

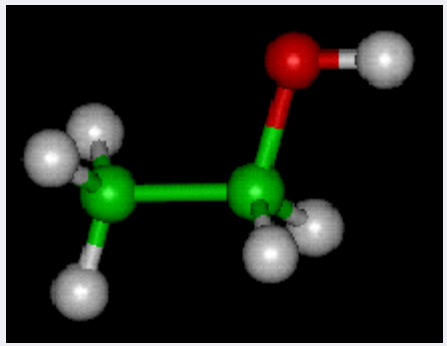
Ethanol
Price Volatility



Other factors (gasoline and oil) may contribute to corn and ethanol price volatility

MGARCH Results

Ethanol
Price Volatility

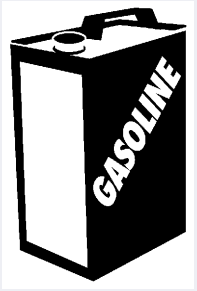


95% C.I.

Corn
Price Volatility

VAR: Granger Causality

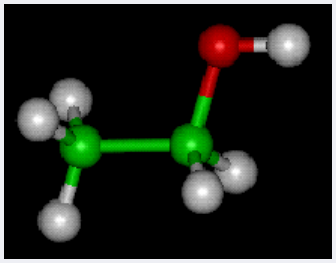
Gasoline Price



99% C.I.

Oil Price

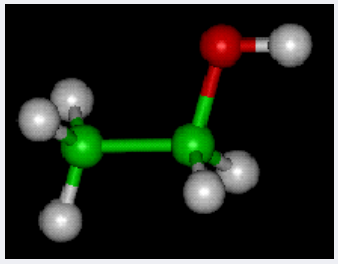
99% C.I.



Ethanol Price

Corn Price

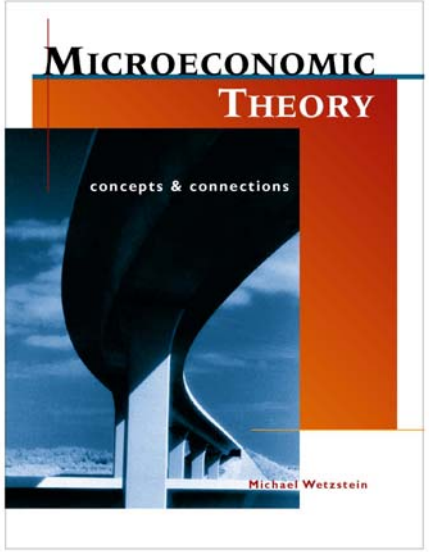
< 90% C.I.

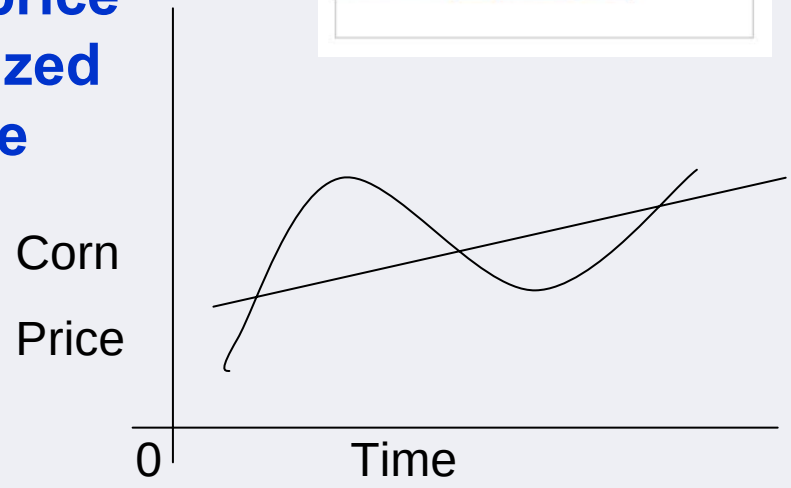


Ethanol Price

Implications

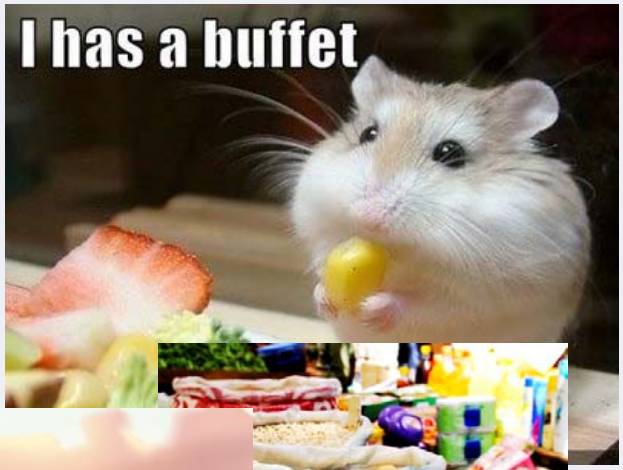
- **Consistent with Economic Theory**
  - **Ethanol and oil demand are derived demands from gasoline**
  - **Given a shock, market signals restore market equilibrium**
  - **A shock may increase price volatility, but decentralized markets will mitigate the shock's persistence**





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?

University of Georgia
Recent Biofuel Economic Articles

- Lohr, L., C.L. Escalante, and M.E. Wetzstein. "Ethanol Fuel Subsidy: Has It Out-Lived Its Usefulness?" *Yale Economic Review.* (2008): Accepted.
- Vedenov, D., J.A. Duffield, and M.E. Wetzstein. "Entry of Alternative Fuels in a Volatile U.S. Gasoline Market." *Journal of Agricultural and Resource Economics*, 31(2006):1-13.
- Vedenov, D. and M.E. Wetzstein. "Toward an Optimal U.S. Ethanol Fuel Subsidy." *Energy Economics*. (2008): Accepted.
- Zhang, Z., L. Lohr, C. Escalante, and M.E. Wetzstein. "Mitigating Volatile U.S.Gasoline Prices and Internalizing External Costs: A Win-Win Fuel Portfolio." *American Journal of Agricultural Economics*, 90(2008): Accepted.
- Zhang, Z., D. Vedenov, and M.E. Wetzstein. "Can the U.S. Ethanol Industry Compete in the Alternative Fuels' Market?" *Agricultural Economics*, 37(2007):105-112.
- Zhang, Z. and M.E. Wetzstein. "Biofuel Economics: Past and Future." *CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources.* 3(2008): Accepted.