Quantifying Energy Security Benefits of Biofuels

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Biofuels and Energy Security

- 1. Energy security is a primary motive for biofuels
  - Do we have the opportunity and means?
- 2. We need to, and can, define energy security in a meaningful and measureable way
- 3. Magnitude of energy security costs is comparable to climate costs.
  - Biofuels can reduce shock costs, short-run and long-run import costs.
- 4. Flexibility enhances security, and flexibility could be built into biofuels system for further benefit

1. In legislation, policy pronouncements, and public opinion, energy security has been the primary motivation for biofuels

- **EISA = Energy Independence and Security Act**
  - ***Title II: Energy Security Through Increased Production Of Biofuels***
- **Energy Security a salient issue in U.S. public opinion (e.g., CFR and Pew surveys)**
- **Energy Security remains relevant in downturn**

  => Economic security and stability

  => Jobs

U.S. Energy Security broadly defined

- As protecting U.S. economy against risk of significant short-term and long-term increases in energy costs
- Concerns are a result of:
  - Sustained high oil import costs
    - Non-competitive oil supply
  - Vulnerability to episodic shocks
  - Importance of oil to the economy

- We define "Energy Security costs" (or "dependence costs") in a *measurable* way, and include:
  - the long-run economic costs to the U.S. from the sustained exercise of supplier market power;
  - plus the short-run costs of oil shocks measured as:
    - dislocation losses in GDP plus
    - added import costs during shocks

Key Energy Security Challenges Alternative Fuels/Biofuels Must Address

- **1. Net import effect:**
  - **The alternate fuel itself, e.g. Ethanol, may be imported**
  - **what use is substituting one imported fuel for another?**
- **2. Supply stability/reliability:**
  - **Alt fuels may be subject to their own supply and price shocks**
  - **so why substitute one unreliable fuel for another?**
- **3. Costs of Shocks:**
  - **Other fuel (e.g. ethanol) price will just move with oil price**
  - **so how is the economic effect of price shocks diminished?**
  - **Key is substitutability of fuels**

Energy Security Accounting Framework Applied Here: Energy Security "Premium"*

- **Premium =**

  marginal **economic costs associated with security and market power that are *not* accounted by private agents**

- **With a small model for fuel market balances,**
  - **consider LR perturbations in supply/demand balances**
  - **Simulate short-run supply shocks**
  - **measure marginal change in economic costs**

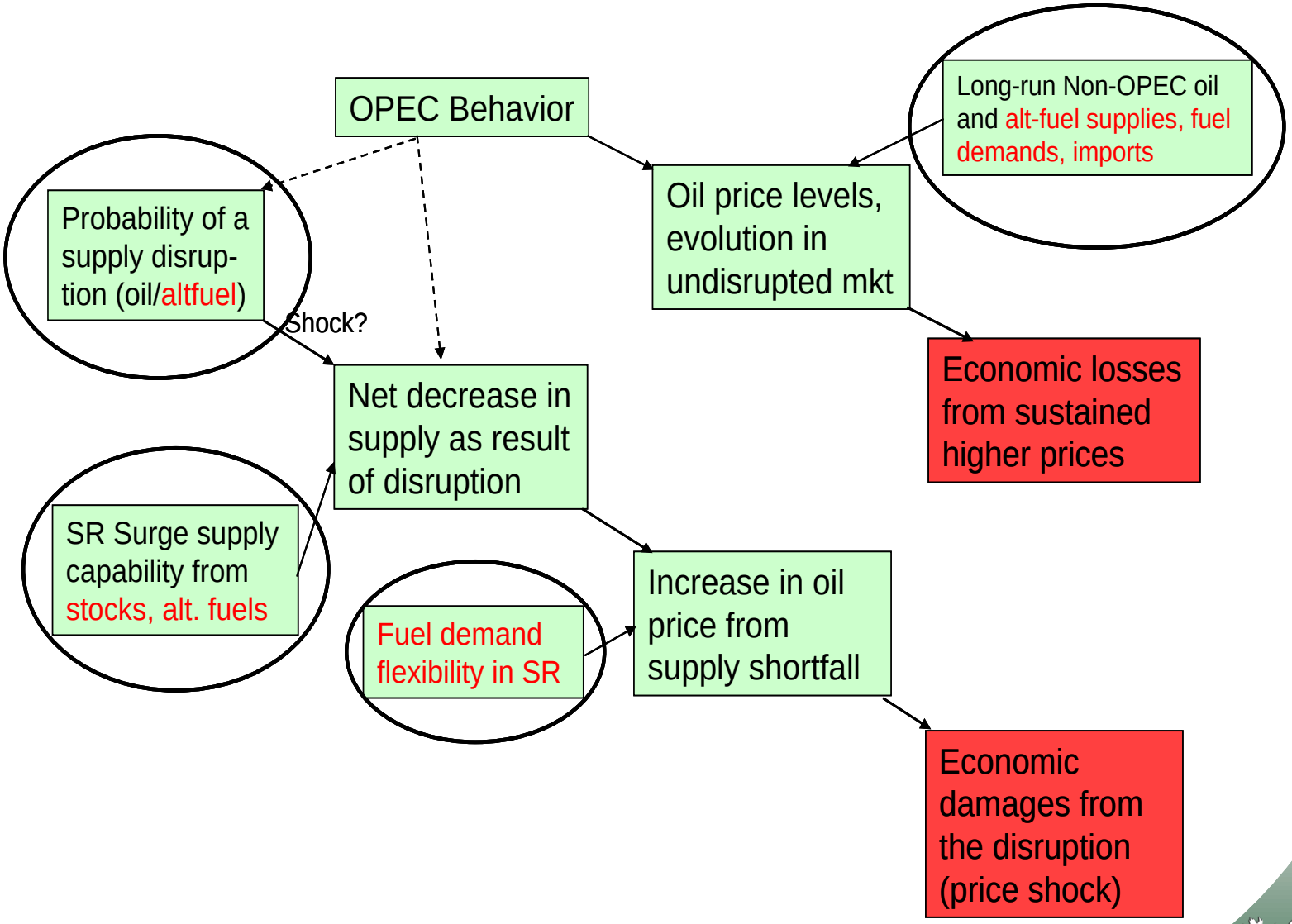
Costs =

(Domestic Supply Cost) + (Import Cost)

+ Expected [GDP losses + Import Costs from shocks]

***Methodology extended to multiple fuels, changes to supply, demand, imports. See Plummer 1981, Bohi and Montgomery 1982, Hogan & Broadman 1986 (optimal tariffs) Parry and Darmstadter 2004, Leiby *et al.* 1997, updated in Leiby 2008 update, Brown and Huntington, 2009**

Key Issues and Driving Factors for Oil Security:
Oil Disruption Costs & Long Run Dependence Costs



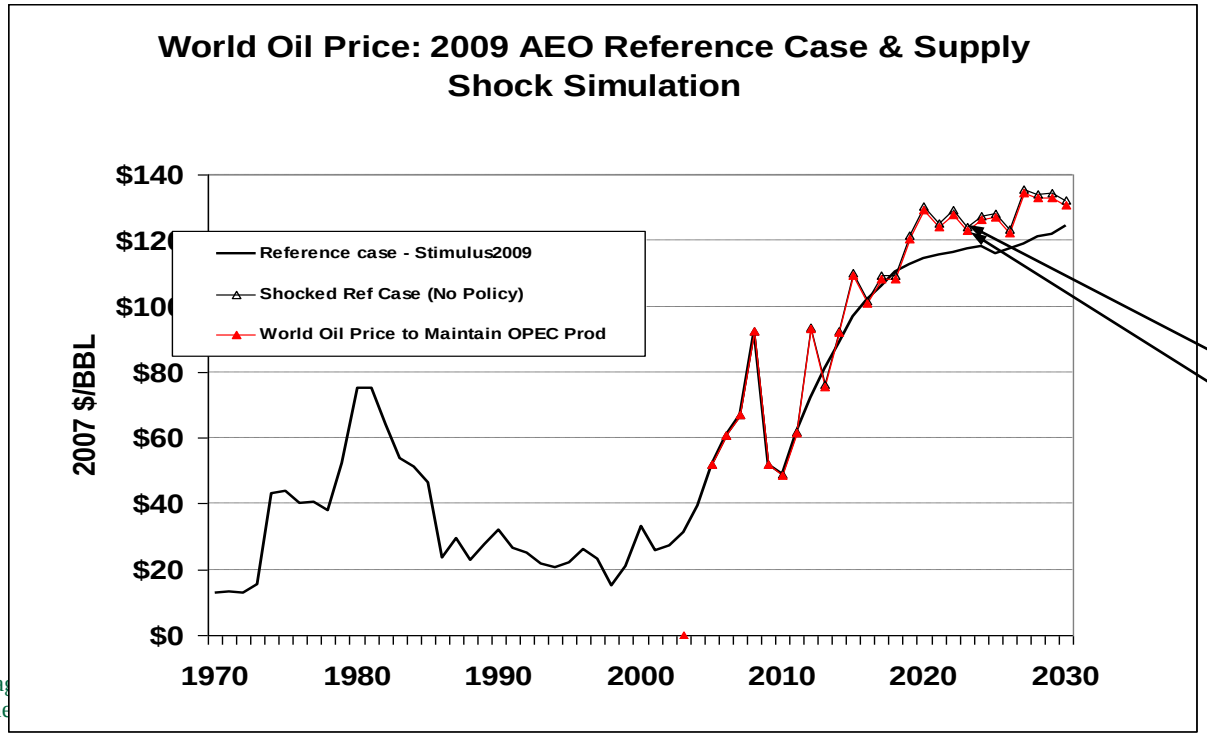
Methodology for security premium – Disruption Component

- **Quantifying Disruption Loss**
  - **Disruption states *j* with probability π_j and supply loss ΔQ_j**
  - **Consider marginal change in disruption import cost (for oil and biofuel) as US import level changes**
  - **Marginal changes in disruption GDP loss as oil/biofuel import and consumption changes**

- **Issues:**
  - **Marginal effect of import reduction on disruption sizes**
    - **due to changed reliance on unstable supplies, induced slack capacity or reduced traded volumes)**
  - **Effect of import reduction on disruption likelihood (assume 0)**
  - **Effect of supply/demand change on size of price increase**
  - **Portion of direct disruption costs anticipated and internalized (consider 25%-100%)**
  - **GDP sensitivity to shocks, and changes to sensitivity**

Represent OPEC Behavior and Supply Disruption Risk as Key Uncertainties

- OPEC represented with three behavioral cases (assumed equally likely)
- Oil supply shocks superimposed on reference oil prices
- Biofuel supply shocks represented based on historical feedstock yield fluctuations



Shocks can have long-lasting effects

Estimated benefits of policy are based on (perhaps small) difference of these two outcome paths through 2030.

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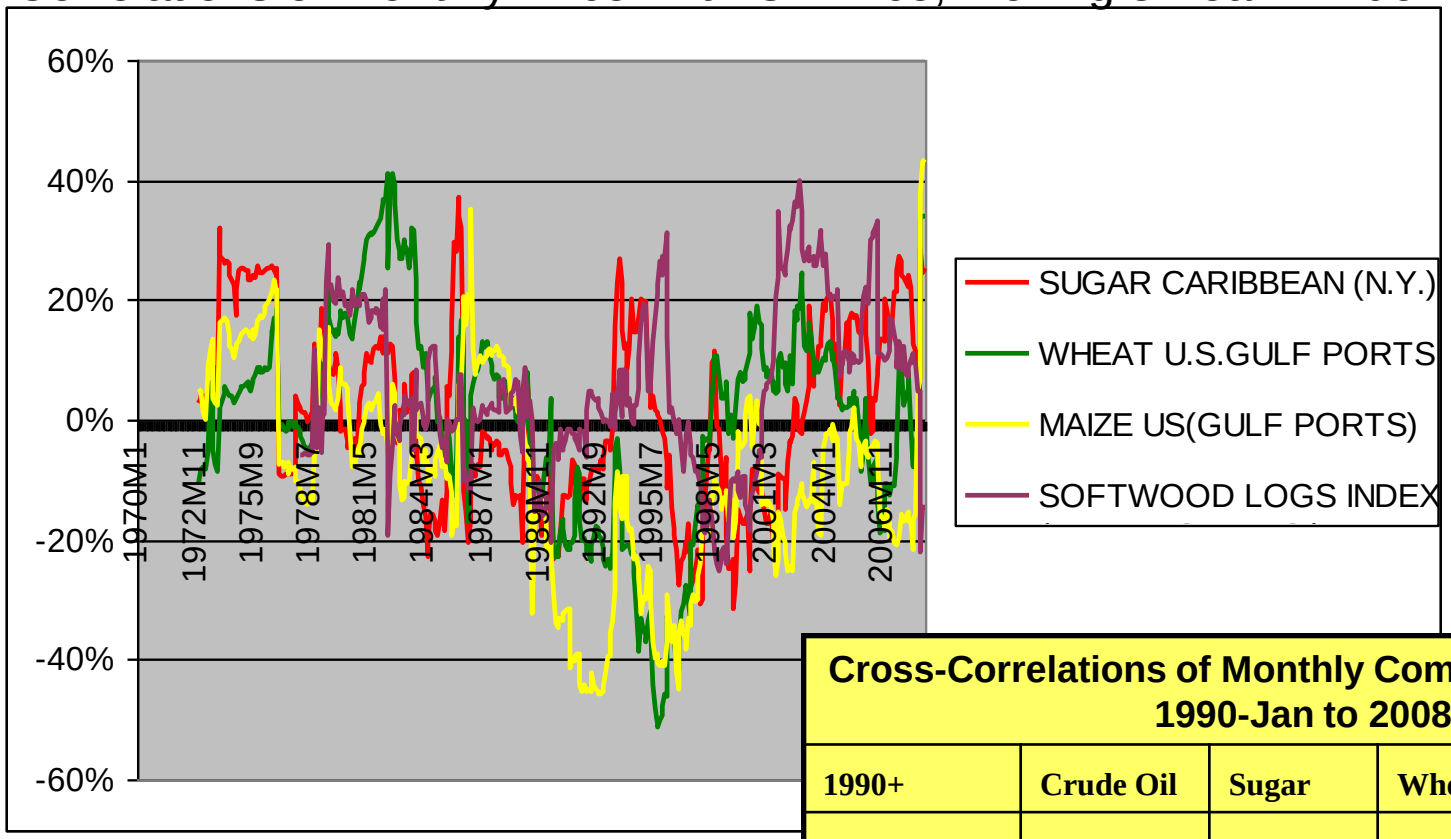
Biofuels Supply Shocks: Importantly, Prices of Key Biofuel Feedstocks Not Correlated with Oil Price

Correlations of Monthly Price With Oil Price, Moving 3-Year Window



Cross-Correlations of Monthly Commodity Price Changes, 1990-Jan to 2008-Dec

1990+	Crude Oil	Sugar	Wheat	Maize	Softwood
Crude Oil	100%	3%	5%	-1%	1%
Sugar		100%	20%	10%	2%
Wheat			100%	46%	-23%
Maize				100%	-10%
Softwood					100%

ORNL Oil Import Premium Estimates: Comparison of Updates

Effect / Study	2007 Study* (2005$/barrel)	2009 Updated* (2005$/barrel)	2009 Updated* For Year 2015 (2005$/barrel)
Monopsony	**$7.41** ($2.77 - $13.11)	**$9.00** ($3.22 - $16.71)	**$11.79** ($4.26 - $21.37)
Disruption/Macro-economic Adjustment Costs	**$4.59** ($2.10 - $7.40)	**$5.45** ($2.59 - $8.69)	**$6.70** ($3.11 - $10.67)
Total Mid-point	**$12.00** (6.67 - $17.95)	**$14.45** ($7.82 - $21.98)	**$18.49** ($7.82 - $21.98)
Assumed Ave Oil Price	**$51.0**	**$68.2**	**$93.0**

- Results in 2005$. Columns report mean and range including 90% of results

- Case 6: AEO2009 Base Outlook, Stimulus case of April 2009, using 2006-2016 average conditions. Source: Leiby, Paul N. 2008. "Estimating the Energy Security Benefits of Reduced U.S. Oil Imports," Oak Ridge National Laboratory, ORNL/TM-2007/028, March 14.

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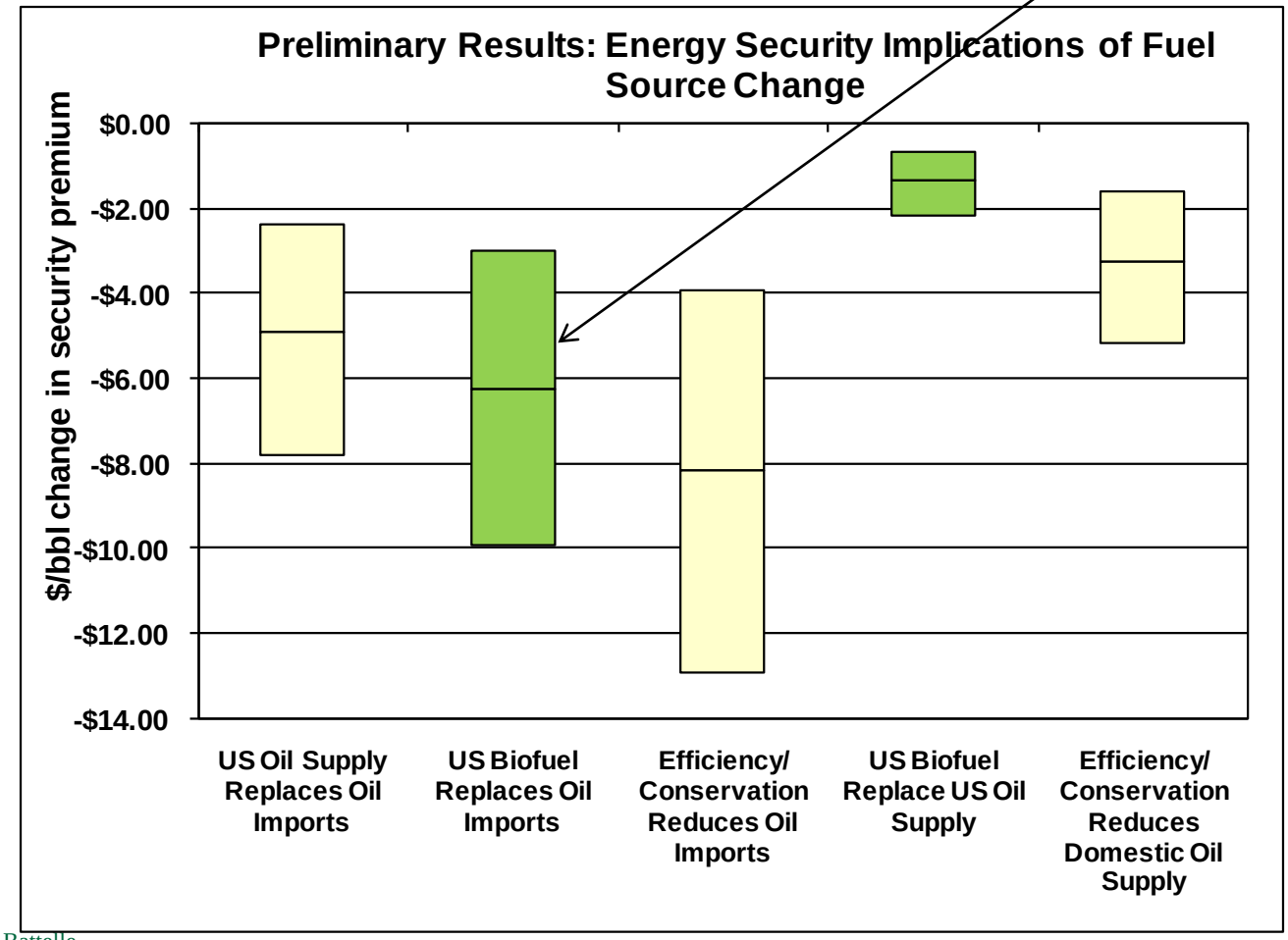
Energy Security Cost Reductions Depend on the Combination of Offsetting Fuel Supplies and Demands

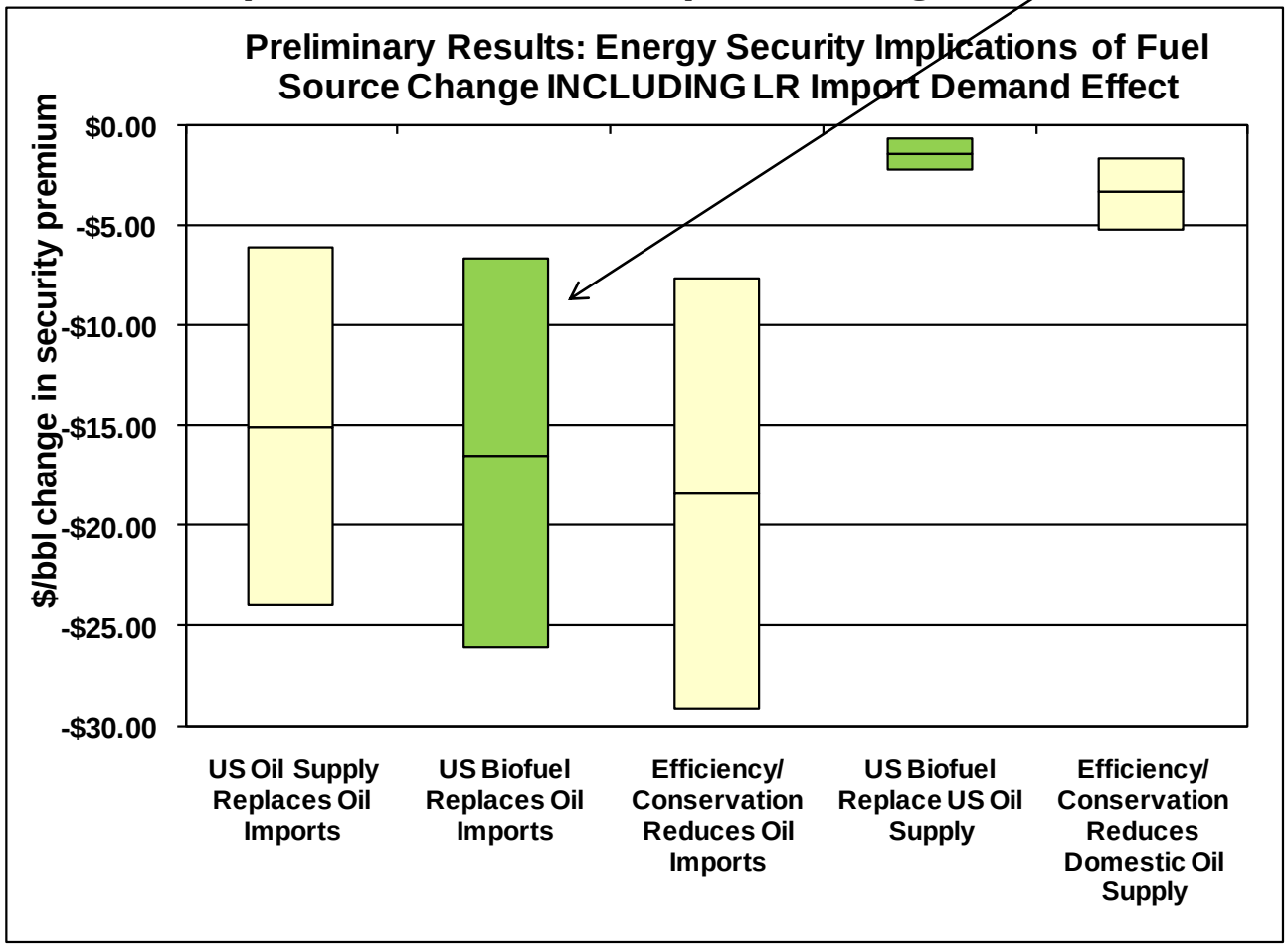
Disruption Component Only: Benefits for Biofuel Replacement of Oil Imports Range $3 -$10/bbl



DRAFT RESULT

Benefits Much Greater if Include Long-run Price Effect of Reduced Oil Imports ("Demand" or "Monopsony" Effect)

Disruption AND Monopsony Component: Benefits for Biofuel Replacement of Oil Imports Range $6 -$26/bbl



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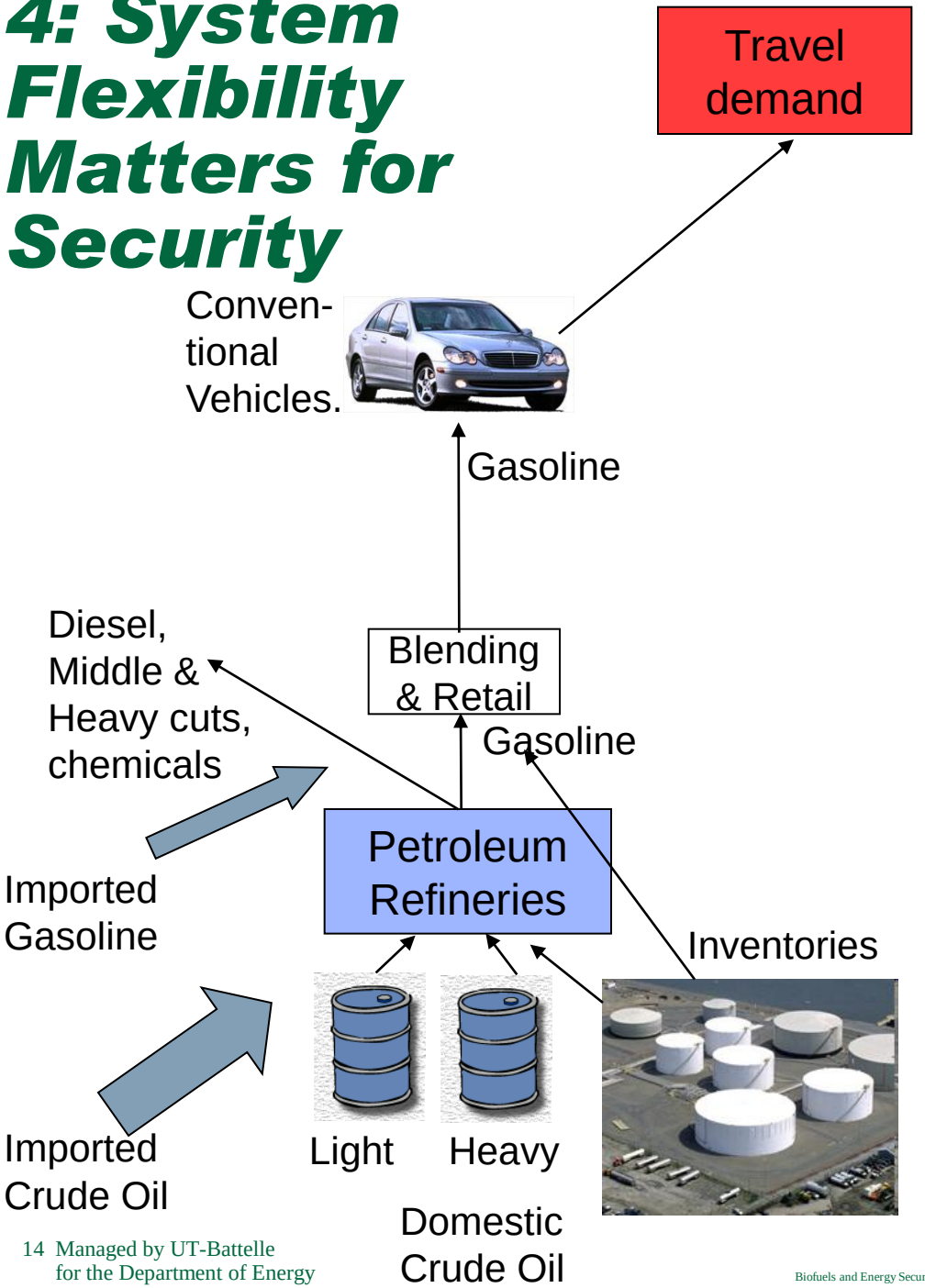
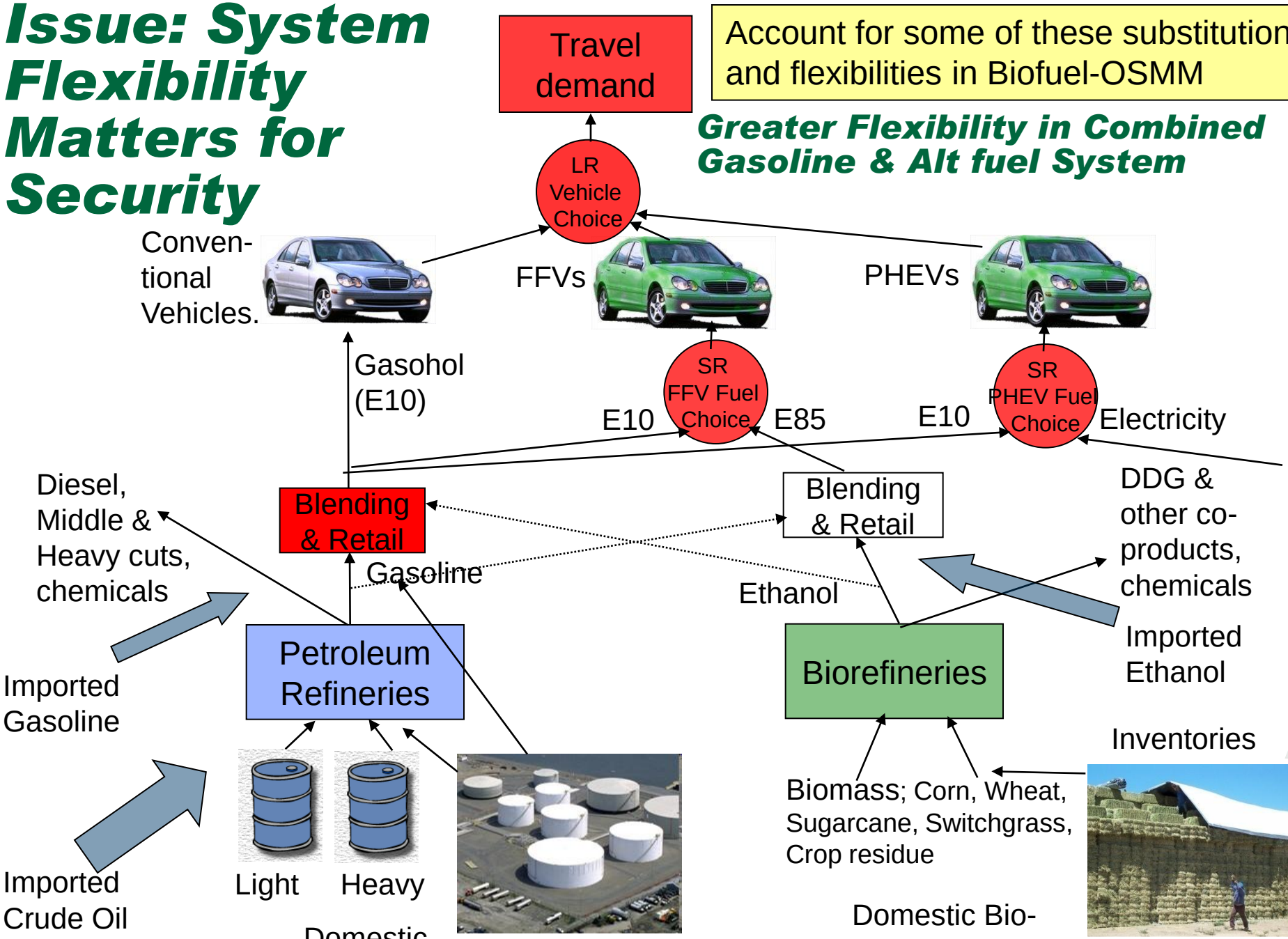
4: System Flexibility Matters for Security



Issue: System Flexibility Matters for Security

Account for some of these substitutions and flexibilities in Biofuel-OSMM

Greater Flexibility in Combined Gasoline & Alt fuel System



Added Fuel and Vehicle Choice from FFVs Can Profoundly Increase Price-responsiveness of fuel demand

- **Provided supply flexibility in place too, decreased shock costs.**

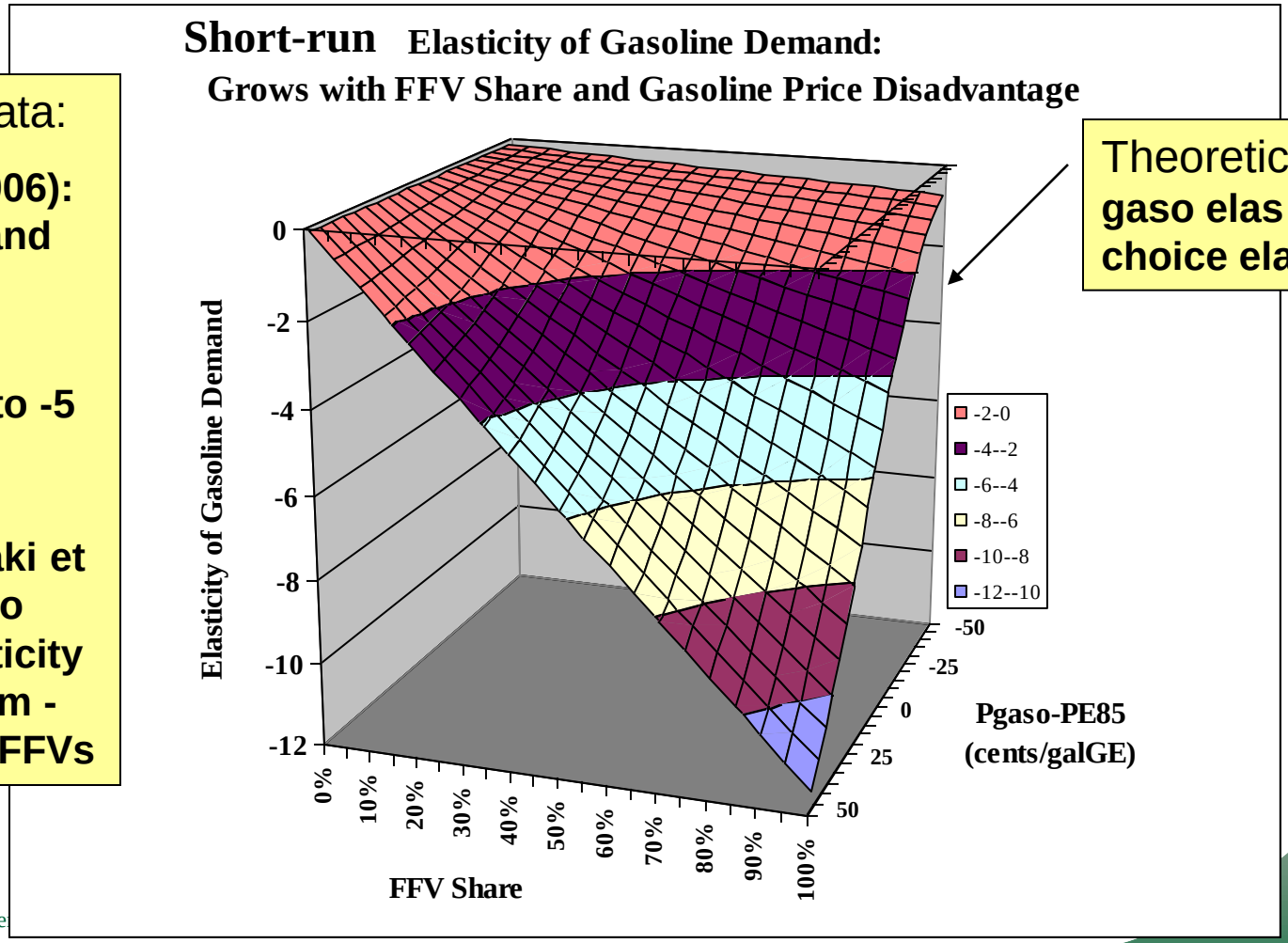
Minnesota data:

Anderson (2006): est E85 demand elas -3 to -20

Greene et al (2009) est -2 to -5

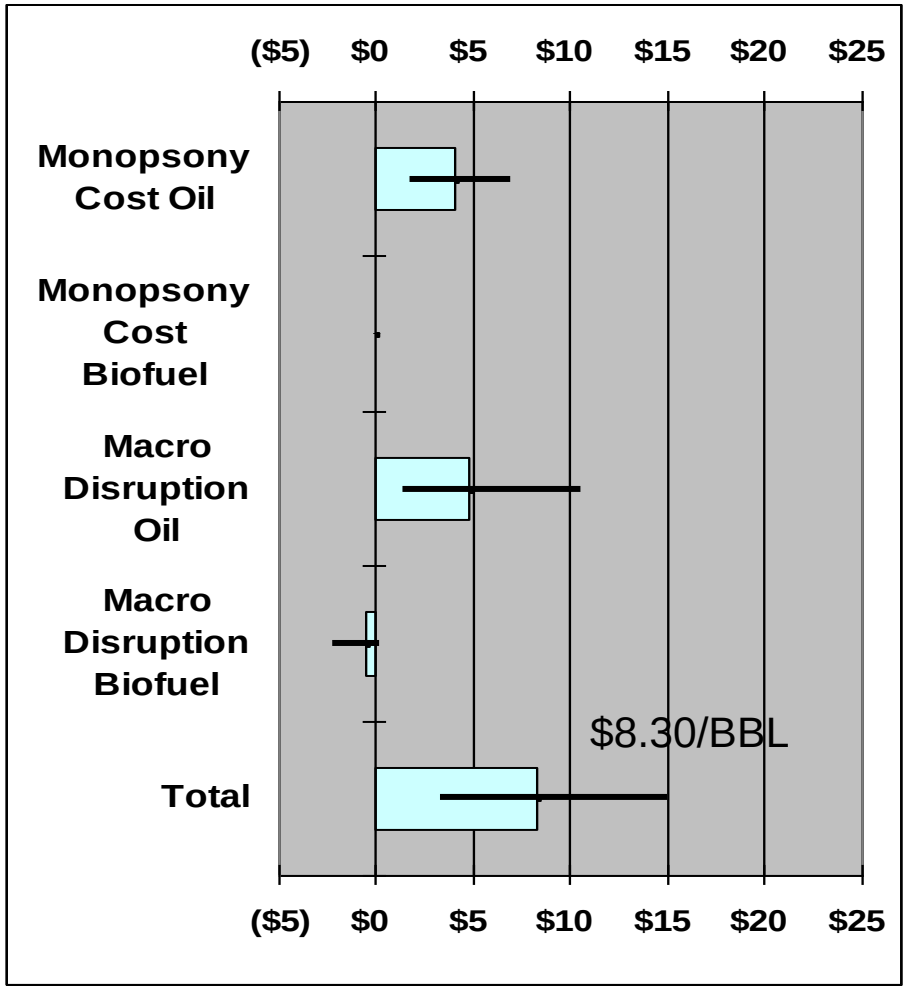
Brazil data:

Ferreira-Tiryaki et al. (2009) gaso demand elasticity increases from -0.9 to -1.5 w/ FFVs



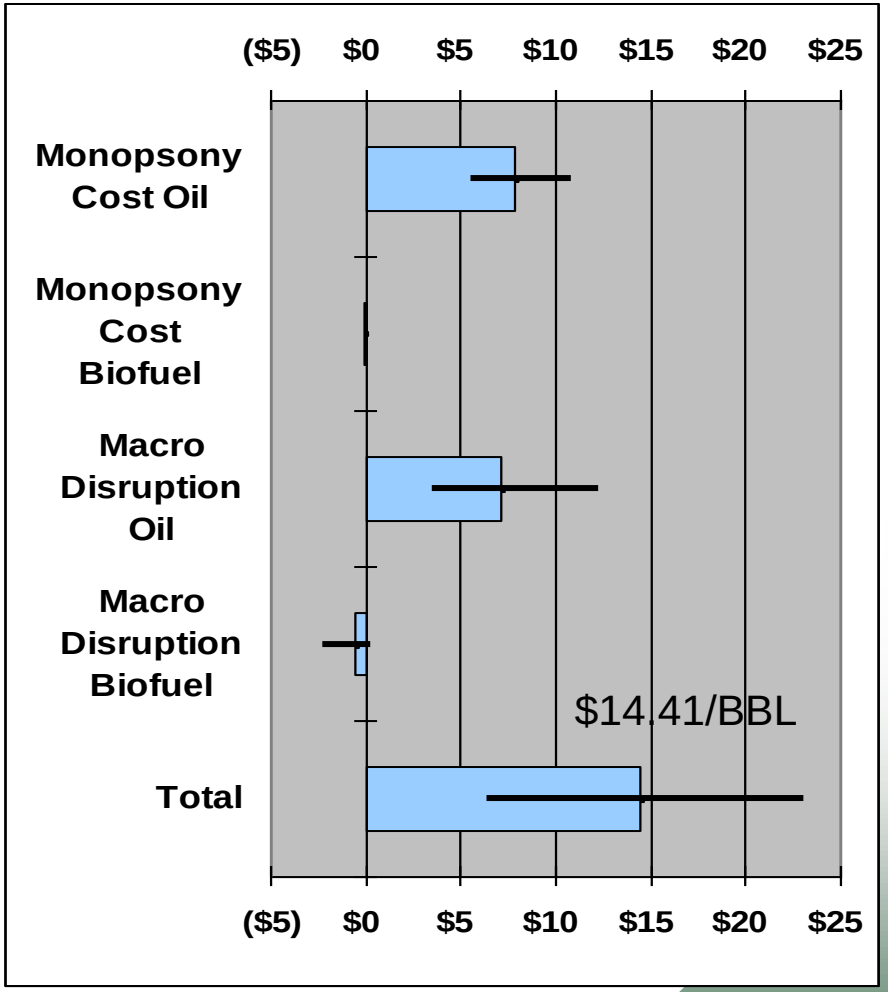
Initial Finding re the Value of Flexibility for Biofuels: Estimated Security Benefits substantially greater accounting for possible increase in motor fuel supply and demand flexibility

Case if No Elasticity Gains



$/BBL Biofuel

Case with Demand Elasticity Gains



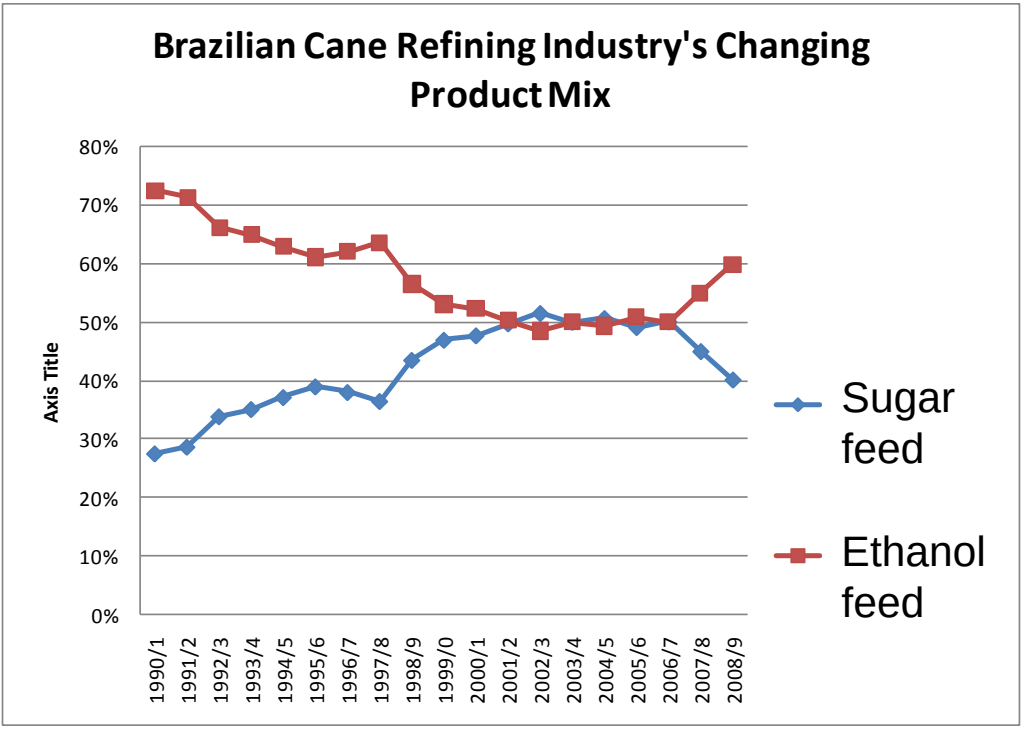
$/BBL Biofuel

Sources of Biofuel Supply Flexibility

- **Inventories (feedstock or product)**
  - **Critical for petroleum sector**
  - **Somewhat more problematic for biomass and biofuels**
- **Biorefinery flexibility**
  - **Biorefinery *input mix flexibility* for feedstock mkt shocks**
    - **requires substitute feedstock supply, could also build/draw feedstock inventory**
  - **Biorefinery *output mix flexibility* for product mkt shocks**
    - **requires demand for substitute co-products, also could build/draw product inventory**

In Brazil, biorefinery output mix flexibility has proven critical to cope with crop yield variations and fuel market volatility

Longer-run evolution of Sugar/Ethanol Product Mix



Estimated Ranges of Output Flexibility in Brazilian Plants (Sugar:Ethanol Ratio)

Andradino (built in 1996 and geared towards ethanol production)

S:E range 9%:91% to 18:82

Ipaussu (built in 1982 and geared towards sugar production)

S:E range 60:40 to 82:18

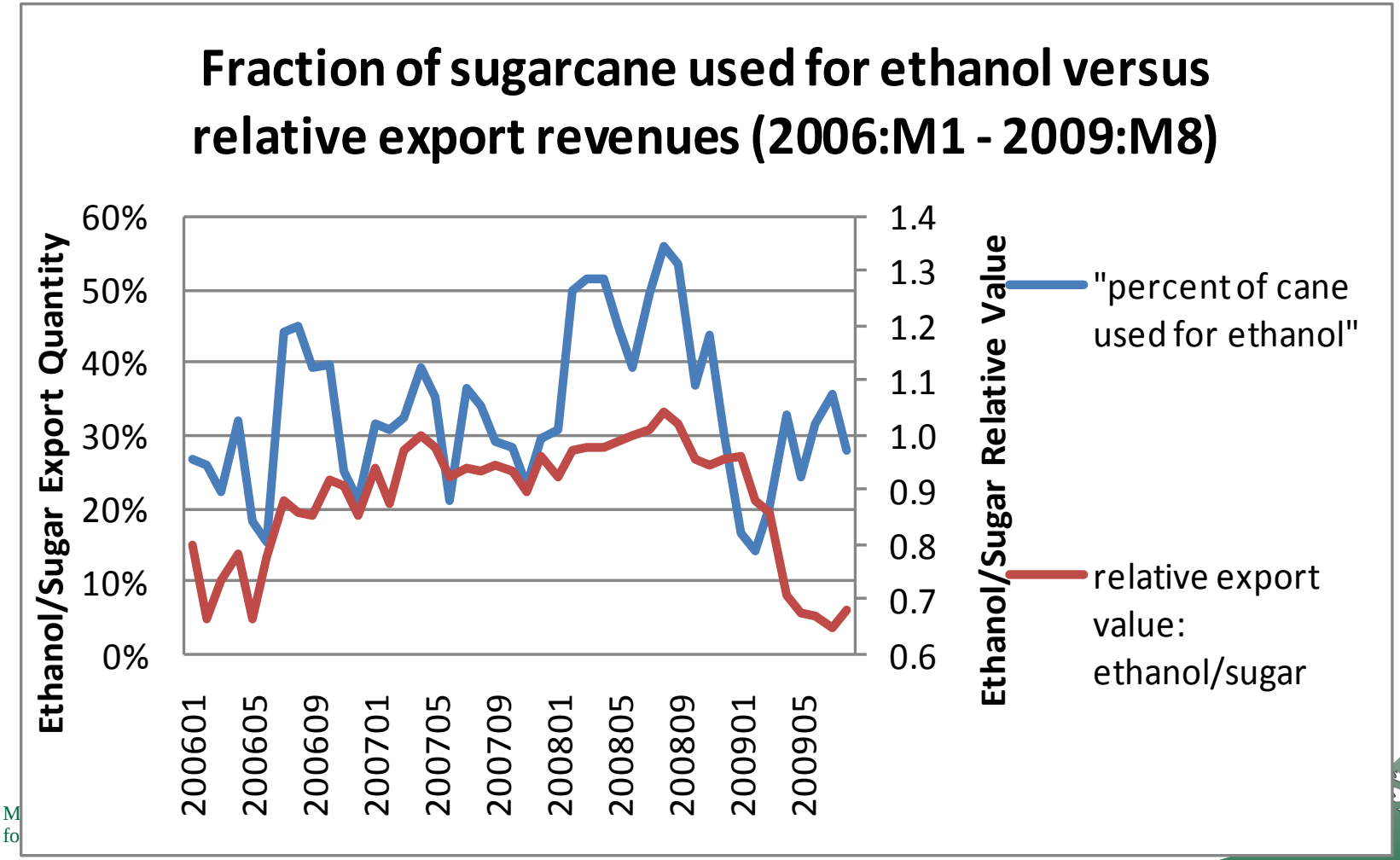
Industry average (slightly geared towards ethanol production)

S:E range 36:64 to 50:50

Most mills in Brazil can produce both Sugar and Ethanol, with a range of flexibility:

Mixed Production/Flexible Plants:	**249**
Ethanol-only Plants	**162**
Sugar-only Plants	**16**
Total	**427**

Insights from Brazil on Biofuel Supply: Large Short-run fluctuations in Biorefinery product mix responding to relative product value (monthly data available for export only)



Both Biochemical and Thermochemical advanced cellulosic plants have scope for flexibility,

Both biochemical and thermochemical processes can be built with ***input flexibility***

	Biochemical	**Flexible Biochemical**	**Thermochemical (pyrolysis)**
Feedstock	Corn stover	Corn stover, Switchgrass,	Corn stover, Switchgrass, Wood chips
Annualized capital cost ($/gallon)	0.187	0.224 (20% premium)	0.197
Ethanol yield (gallons/dry ton)	72.6	70-72.6	67.5
Co-product credit ($/gallon)*	0.07 (lignin burned for electricity) (also C-fiber, others)	0.07 (lignin burned for electricity) (also C-fiber, others)	0.21 (higher alcohols)

*Both biochemical and thermochemical processes can be retrofitted to produce different fuel outputs (e.g., butanol) but it is more capital-intensive than input flexibility

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Conclusions

- **Biofuels expected to enhance security**
  - ***Could*** **strongly enhance security effectively through increased market diversification and flexibility.**
- **It is important which fuel source is replaced by biofuel, for Energy Security and Env. Benefits**
  - **Worst case: (imported) biofuels reduces domestic oil supply, or Canadian oil sands**
  - **Best case: domestic biofuels reduce U.S. oil imports**
    - **Decrease world oil demand and market power of non-competitive suppliers**
    - **Reduce shock size by increasing share of global stable supply**
    - **Reduce U.S. vulnerability to oil shocks by diminishing import costs and GDP oil intensity**
- **Biorefinery input/output flexibility is promising.**
  - **Costs and capabilities need to be carefully studied.**