Economic Analyses for Enhanced Oil Recovery

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Today’s presentation will highlight current economic work in the EORI. Projects include:

- Evaluating Risk in an EOR Project.
- Forecasting the Impact of CO₂ Subsidies and Taxes.
- Estimating Costs and Tariffs for a Pipeline Infrastructure.
Evaluating Risk
In January 2009 we reported on the distribution of profits for the FRC Lance-Leo when the following were all allowed to change:

- Original Oil in Place (OOIP)
- Injection Rate (Injectivity)
- Project Area in Acres
- CO₂ Prices
- Oil Prices.
Risk: Critical Data Parameters and Uncertainty

- Treating observations as means, we can define a probability distribution with a range of higher and lower values for each FRC:

  - OOIP (-20%, +20%) triangular
  - Injection Rate (-50%, +50%) triangular
  - Project Area (-10%, +10%) triangular
  - CO₂ Prices ($1.00 - $3.00) uniform
  - Oil Prices ($40 - $100) uniform
Risk: Triangular Distribution for OOIP

- Consider a triangular (bounded) probability distribution for OOIP:
We randomly sample a value from these distributions.

Repeating this process thousands of times (say 5,000) gives us a distribution of profits and other outcomes.
A confidence interval can be constructed for basin CO$_2$ demand and oil supply.
CO₂ Pricing
Progress on CO$_2$ Pricing

**FIGURE 1.** Observed CO$_2$ prices in West Texas Permian Basin and predicted CO$_2$ prices based on linear adjustment to oil price.
Pricing: CO₂ Contract Clauses

- “The price to be paid by Buyer for all volumes purchased shall be calculated on a monthly basis, and shall be (**)% of the average of West Texas Intermediate Crude . . .”
- The typically % is 2.7% up to March 1986 and 2.2% thereafter.
- Data show that shipping charges are about $.50/mcf.
Pricing: Future CO₂ Pricing Behavior

- These price relations are apt to change as taxes and subsidies on CO₂ are set.
- The IRS has published guidelines for receiving a $10/ton subsidy on CO₂ stored through EOR.
Carbon Taxes & Sequestration Subsidies Implications for CO₂ Pricing

- “Cap & Trade” Bills Moving Through Congress
CO₂ Subsidies

- Subsidies for Carbon Capture & Storage
  - H.R. 2454, $90/ton for first 10GWe (90% capture)
  - S. 1733, $96/ton for first 10GWe (90% capture)
  - Limited to First 10 Years of Operation

- Lower Subsidies for Enhanced Oil Recovery
Experimental results show that with a simple subsidy paid to either the buyer or seller, 20-30% is bargained away to the other party (Phillips, et al (2009)).
Taxes and Subsidies

- Suppose there is a tax on $\text{CO}_2$ emissions or subsidies in the form of tax credits paid to use $\text{CO}_2$ in EOR or CCS.
- $\text{CO}_2$ sales are privately negotiated.
- The impact of the taxes and subsidies can be estimated with simulated markets.
Experiment Design

- Participants Divided into Buyers & Sellers
  - Buyers (can “buy” sequestration or be taxed for their output)
  - Sellers (represent pore-space owners and “sell” sequestration)

- Buyers Have a Two-Part Decision
  - First, Decide How Much to Produce (i.e. electricity to generate)
  - Second, Privately Negotiate with Sellers to Buy Sequestration in a Computerized Trading Environment
Average Sequestration Price by Treatment

![Graph showing the average sequestration price by treatment with different subsidy and tax levels.](image)

- **s60t0**: subsidy 60, tax 0
- **s40t20**: subsidy 40, tax 20
- **s30t30**: subsidy 30, tax 30
- **s20t40**: subsidy 20, tax 40
- **s0t60**: subsidy 0, tax 60
Summary of Experiment Insights

- **EOR Operators & Pore-Space Owners**
  - Share the Benefits from the Sequestration Subsidies
  - Could Mean Much Lower CO₂ Prices for EOR (more profitable projects, CO₂ availability)

- **CO₂ Sources / Power Companies**
  - Current Law Gives Pore-Space Ownership to Surface Owner (mineral supremacy)
  - CO₂ Ownership and Liability Stays with Operator
  - Bargaining Advantage + Liability Issues Could Mean Sources will want to Own the Pore-Space i.e. Vertically Integrate
Costs and Tariffs of a Pipeline Infrastructure
The Bigger Infrastructure Picture

Time Path of CO$_2$ Pipeline Deliveries

- Enhanced Coalbed Methane Recovery Deliveries
- Continued EOR Deliveries
- Other Sequestration Deliveries
Big Horn Basin Demand and Supply of CO$_2$
Green River Basin Demand and Supply of CO$_2$
Laramie Basin Demand and Supply of CO₂
Powder River Basin Demand and Supply of CO$_2$
Wind River Basin Demand and Supply of CO₂
Powder River Basin
Demand: EOR 115.3; ECBM 2362 Mmcfpd
Supply: 1,616 Mmcfpd

Bighorn Basin
Demand: EOR 368.0 Mmcfpd

Wind River Basin
Demand: EOR 146.0
Supply: 50

Green River Basin
Demand: EOR 89.7; ECBM 787.7 Mmcfpd
Supply: 2,672 Mmcfpd
Questions and Comments