A Tale of Two Studies

Ian Lange

Director, Mineral and Energy Economics program

ilange@mines.edu

Goal

- It is the best of times; it is the worst of times
- Projections of the future will be the next couple of talks
- Focus here is to discuss two empirical analyses undertaken
  - Characteristics of CCS Plants that make it to Operation
  - Impact of Primacy on Permitting Decisions
- Going to try to not focus on US in discussion, but US is a big market

Background

- Academic Economist with zero engineering training
- Was at a Scottish University 2008-2014 when Europe put a bunch of money into CCS
- Jumped in and out of federal government over the last 15 years; spent time at Department of Energy, Environmental Protection Agency, and Council of Economic Advisers

Economic Determinants of Success in CCS Installation

What Makes a Good CCS Project

- At this point there have been enough projects to be able to understand generally what factors help or hinder development
- Some theory/ beliefs to guide our expectations but testing these against the data is not common
- Run a statistical analysis to correlate project success with its characteristics

Ideal CCS Situation

- Consistent running CO2 source
- Pure stream of carbo n
- Near mature oil fields for utilization of CO2
- Substantial price on Carbon
- Firm owning more than one asset that is enhanced by CCS
- No natural source of CO2 nearby
- High price of oil

Empirical Analysis

- From *The Electricity Journal* article "Determining the Success of Carbon Capture and Storage Projects" 29(7), Sept. 2016
- Basic Model Specification:

$$y_i = \beta_0 + T_i \beta_1 + E_i \beta_2 + P_i \beta_3 + \varepsilon_i$$

- Two Specification of dependent variable (y_i):
  - Ordinal: 0 = Cancelled, 1 = On Hold, 2 = Planning, 3 = Under Construction, 4 = Operational

Explanatory Variables

- Technical Variables:
  - Size (MTons/year), Pilot, Storage Type (Saline, EOR, Depleted Reservoir), Storage Site Confirmed at time of announcement, Capture Process (Post-Combustion, Pre-Combustion, Oxyfuel, Industrial Separation, Natural Gas Processing), Feedstock (Coal, Gas, Oil, Other)
- Economic Variable:
  - Previous CCS experience
- Policy Variables:
  - Presence of Carbon Policy (EU, Norway, British Columbia, Alberta), Public Funding

Data

- Combination of Information from: MIT, ZeroCO2, & Global CCS Institute CCS project database
  - Updated via online search Jan 2016 (missing data issue)
  - Only full CCS chain projects considered; No size or sector limitation
  - Projects must have been announced, meaning money is being allocated, to be in sample
  - Projects at all stages, from cancelled to operational
- Sample size relatively small (~60) so models must be parsimonious
  - Some sets of variables either highly correlated with others or never statistically significant so dropped from analyses

Results Discussion

- A negative effect for projects in areas with carbon policy
  - Policies tend to be market-based; non-capital abatement option are generally cheaper
  - No carbon policy, CCS so projects are not “announced” so they are not in our data

- A negative effect of prior CCS project experience
  - Experienced investors might be more willing to put on hold/abandon projects as they gain more information during project development
  - Experienced project partners and investors often active in more than one project, focus on most promising project dropping the remaining

- A negative effect of public funding
  - Two possible answers: Gov’ts fund marginally profitable projects or firms adverse select worse projects for gov’t funding

Results Discussion

- Size
  - Estimates imply a U-shaped relationship between success and size
  - However all of our sample observations occur before the bottom of the U, so decreasing change of success at a decreasing rate
- Negative effect for Saline Aquifer storage
  - Given commercial benefit of EOR uses, not surprising result
  - However, concerning result given that most of storage sites worldwide are saline aquifer
- Pre-combustion capture more likely to succeed than Post-combustion/Oxyfuel capture
- Positive effect for Storage Site Confirmed

Takeaway I

- Many aspects need to come together for a successful large-scale CCS project to emerge
- Caution with how gov’ts distribute funding, so far they are “picking losers”
- Saline aquifers are the most common storage sites, but they offer no private benefit
- Current carbon policy seems to be all carrots, little sticks

Primacy (What is it Good For)?

Primacy for Class VI Wells

- Lots of industry/ policy shop discussion of the importance of primacy for Class VI wells
- My brain takes these discussions and tries to find data from previous experiences to understand the likely impact of future policy decisions
- National Pollution Discharge Elimination System is a good case study as we have data and all states now have primacy

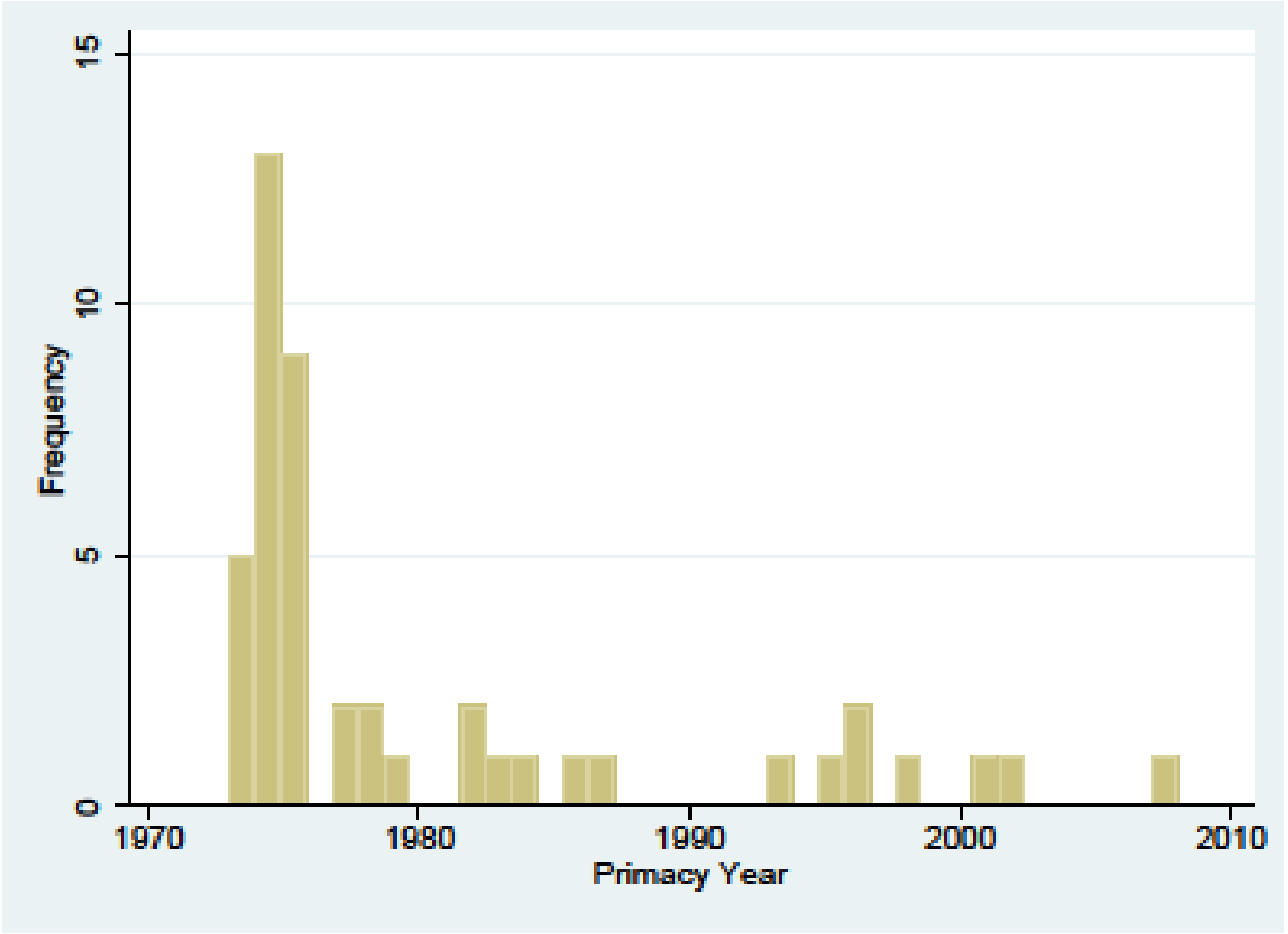
National Pollution Elimination Discharge Permits

- A product of the 1972 Clean Water Act
- Requires point sources to receive a permit to discharge into waterbodies
- States should be considering all discharges to ensure minimum level of water quality

Data

- EPA Enforcement and Compliance History Online (ECHO)
- All National Pollution Discharge Elimination System Permits
- Year that a State Gained Primacy
- Average of 82 new permits per year

When States Gained Primacy



Analysis

- States gained primacy in different years
- Compares the number of permits granted in States in the years just before and after they gain primacy
- Utilize statistical analyses to estimate the number of permits issued relative to the year that the state gained primacy

Results

- For the pre-1980 data, looks like primacy provided a temporary increase in permitting
  - Perhaps it alleviated a backlog
- For the full sample, looks more like primacy increases the number of permits
  - However, this is including the time period when NPEDS is a more known process

State Comparison

- I took a look at states that are next to each other/similar who gained primacy before and after 1980
- MS/LA; UT/CO; NY/NJ; WV/VA; KY/TN
- On average, this lead to 1 to 3 more permits but that number is not statistically different than zero

Takeaway II

- Not much evidence that primacy changes the amount of permits granted
- Tried to focus on early dates of the program to match what Class VI is
- Happy to discuss other possibilities with this data (more inspections, more fines?)

Thank you

Questions, Comments…

ilange@mines.edu

Oil

- Having a high oil price, mature fields nearby, and no natural CO2 sources all increase the value of the carbon captured
- Selling CO2 in a forward contract allows investors to see value that is “locked in”
- Higher oil price and no natural CO2 sources allow for a higher price in the forward contract

Firm Structure and Regulation

- Economically regulated firms have to convince a public utility commission to invest in CCS
  - Unregulated firms have to convince the financial market (see Kemper MS plant)

- If a firm has two assets that are enhanced by CCS, more likely to make it happen
  - Own the coal mine and the minemouth coal plant (see Boundary Dam plant)

Issues for CCS: US

- Seemingly little excitement over 45Q tax credits (accept among academics)
  - Utility and ethanol industry have not announced many planned investments
- Most fossil fueled power plants now follow renewables; not consistently running
- No deep carbon policy; CA Low carbon fuel standard (ethanol) or RGGI (power) would likely have depressed markets with a CCS installed

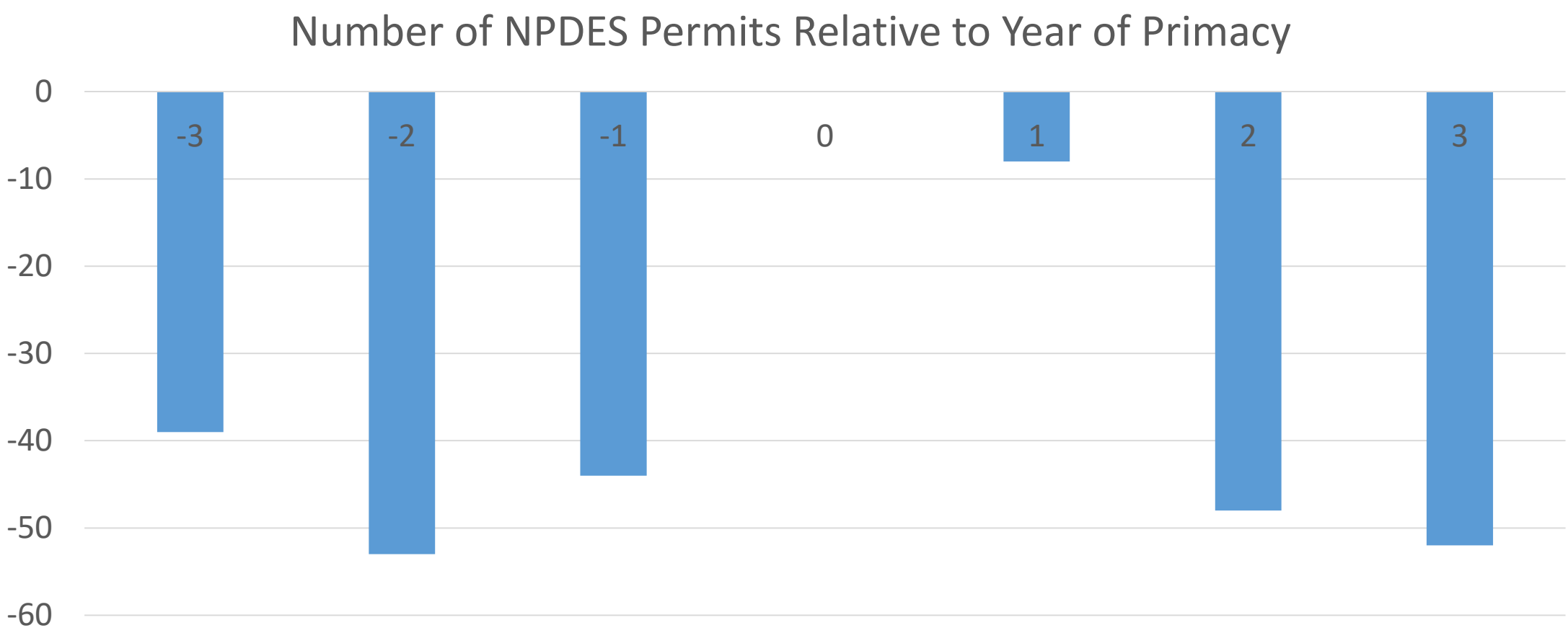
Marginal Effects Ordered Probit

Columns 1 & 3 are effects to make successful projects; 2 & 4 are effects to make project cancelled

Feedstock Results not shown; N=66 and 55, respectively

Sample	All		No Pilots	
Status	Operational	Cancelled	Operational	Cancelled
Variable	Coefficient (S.E.)	Coefficient (S.E.)	Coefficient (S.E.)	Coefficient (S.E.)
Size	-0.18*** (0.05)	0.10*** (0.04)	-0.08** (0.04)	0.07*** (0.03)
Size Squared	0.03*** (0.01)	-0.02*** (0.007)	0.01 (0.01)	-0.01 (0.01)
Public Funding Dummy	-0.15** (0.05)	0.09*** (0.03)	-0.11*** (0.04)	0.08** (0.04)
Storage Site Confirmed	0.29*** (0.06)	-0.17*** (0.03)	0.25*** (0.06)	-0.20*** (0.05)
Carbon Policy	-0.12*** (0.04)	0.06** (0.03)	-0.10** (0.04)	0.08** (0.04)
Previous CCS Experience	-0.23*** (0.07)	0.14*** (0.04)	-0.14** (0.06)	0.11*** (0.05)
Storage Dummies (Reference=Enhance Oil Recovery/Commerical)				
Saline	-0.12*** (0.04)	0.07*** (0.03)	-0.10** (0.05)	0.08** (0.04)
Depleted Oil/Gas Reservoir	0.07 (0.06)	-0.04 (0.03)	0.03 (0.05)	-0.03 (0.04)
Capture Process Dummies (Reference=Post-Combustion)				
Pre-Combustion	0.16*** (0.06)	-0.09*** (0.04)	0.15*** (0.05)	-0.13*** (0.04)
Oxygen	-0.01 (0.09)	0.01 (0.05)	0.06 (0.06)	-0.05 (0.05)
Industrial Seperation	0.36*** (0.10)	-0.21*** (0.06)	0.34*** (0.09)	-0.28*** (0.08)
NG Processing	0.50*** (0.08)	-0.29*** (0.06)	0.45*** (0.08)	-0.37*** (0.08)

Pre-1980 Data



All Years Data