Permit Allocation Design & Incentives for Banking: Evidence from the Nitrogen Oxides Budget Program

Ian Lange & Frans de Vries

Mechanism Design & the Environment

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Research Question

- Theoretical evidence that updating permit allocation design alters firms incentive to produce

- If true, allocation method would affect banking behaviour and potentially expose plant to different level of risk

- How do plants alter their banking behaviour given the design of the permit scheme?

Analysis

- Reduced form analysis of U.S. Nitrogen Oxides Budget Program banking behaviour of plants

- State variation in allocation method identifies effect of mechanism design on banking
  - Ability to control for within firm behaviour also

- Focus on banking allows for a longer term impacts of design to be revealed

Nitrogen Oxides Budget Program (NBP)

- Began in 2003 for all large boilers in a subset of states

- Tradable permit scheme to reduce NOx emissions during summer months
  - Cap set at 33% of counterfactual emissions

- Allowances allocated by states, different methods used

Previous Research

- Bohringer and Lange (2005)
  - Output-updating more efficient than grandfathering of permits

- Fischer and Fox (2007)
  - Output subsidy implicit in output-updating allocation can mitigate tax interaction effects

- Fowlie (2011)
  - Empirically analyze short-term firm decisions for evidence of output subsidy effect, fails to reject no effect hypothesis

Electricity Industry

- Coal largest emitter, some from fuel oil and gas

- Many firms have plants in multiple states
  - Ability to share permits across different design schemes

- SCR widely available to reduce emissions by 90%
  - SNCR and overfire air available but smaller reduction potential

Importance of Banking

- Evidence that permit price volatility reduces the efficiency of permit markets
  - Especially relative to taxes

- Saving/Banking of permits helps to increase efficiency as emissions are able to "adjust" as shocks occur

Compliance

- Each program allocates permits to boilers within plants

- Costless for firm to move permits between its plants (intra-firm trading)

- Permits saved (banked) are available for us at a later date

Intra-firm decision making

- Since permits are transferable within firm, sister plant characteristics are relevant for plant decision making

- Market design in one state could alter plant's decisions in other states

Allocation Methods

- ## Grandfathering
  - Allocation fixed, dependent upon past decisions

- ## Input-Updating
  - Allocation changes every couple of years depending on the amount of heat input each plant used

- ## Output-Updating
  - Allocation changes every couple of years depending on the amount of electricity generated at each plant

Data

- Energy Information Administration (EIA) Form 767
  - Design Information on Plants
- EIA Form 920
  - Fuel Use & Grid Information
- EIA Natural Gas and Electric Power Annual
  - Natural Gas and Electricity Prices
- EPA NBP Compliance Report
  - Permit Allocation & Emissions Information

Allocation Method by State

- Grandfathering:
  - Delaware, District of Columbia, Illinois, Maryland, Ohio, Rhode Island, North Carolina, Indiana, Tennessee, South Carolina

- Updating:
  - Kentucky, New York, Pennsylvania, Virginia, West Virginia, Connecticut, Massachusetts, New Jersey

Empirical Models

Random Effects w/ Firm Level Error Clusters

$$B_{i,j,t} = a + \varphi_1 U_{j,t} + \varphi_2 P_{i,j,t} + \phi_3 F_{i,j,t} + \phi_4 C_{i,j,t} + \nu_i + \varepsilon_{i,j,t}$$

Dynamic Panel models were attempted; little statistical evidence of lag effects

Independent Variables: Allocation method, main fuel, presence of SCR, electricity market structure, fuel price; electricity price; Year & Grid Dummies

Expected Signs

- Updating
  - If there is a production subsidy, then banking should be lower at those plants
- Number of plants within a firm
  - Bigger firms have more plants to spread the risk around; smaller bank per plant
- Presence of SCR
  - Plants with lower abatement costs should bank more permits to sell/transfer within firm

Summary Statistics

Sample	All	Output Updating	Input Updating	Grand-fathered	T-Test (Grand= Updating)
Variable	Mean	Mean	Mean	Mean	T-Statistic
Bank	38.68 (851.95)	75.43 (324.33)	10.67 (747.79)	68.73 (1238.74)	-0.94
Allocated	595.56 (1079.90)	230.96 (365.03)	582.73 (983.80)	895.94 (1471.12)	-7.53
Number of Plants in Firm	6.74 (14.79)	7.94 (21.01)	7.43 (14.93)	4.42 (6.10)	4.21
SCR Plant	0.17 (0.37)	0.16 (0.36)	0.17 (0.37)	0.19 (0.39)	-1.05
Coal Plant	0.16 (0.23)	0.05 (0.13)	0.15 (0.24)	0.24 (0.25)	-9.34
Gas Plant	0.44 (0.37)	0.54 (0.35)	0.41 (0.36)	0.42 (0.38)	1.45
Oil Plant	0.38 (0.30)	0.40 (0.32)	0.42 (0.30)	0.33 (0.30)	5.38
Natural Gas Price	10.38 (1.96)	10.45 (2.71)	10.19 (1.77)	10.73 (1.51)	-4.71
Electricity Price	7.31 (2.48)	10.40 (2.09)	6.77 (1.83)	6.10 (2.02)	13.64
Standard Deviation in Parenthesis					

NBP Results

Dependent Variable: Annual Number of NBP Permits Banked, 2003-2008	
Variable	
Updating Allocation	-152.23* (83.64)
Updating Allocation* Gas Plant	251.84** (81.90)
Number of Plants in Firm	-0.75 (6.79)
Combined Heat and Power Plant	92.63 (59.97)
SCR Plant	533.17** (235.13)
Gas Plant	57.91 (164.67)
Oil Plant	354.27** (196.61)
Natural Gas Price	15.72 (18.45)
Electricity Price	43.06** (16.50)
Observations	2509
Panels/Clusters	488/18
*, **, *** indicates 10%, 5%, and 1% statistical significance, respectively.	
Notes: Standard Errors Clustered by State in Parenthesis. Other Controls included are Year and Grid Network Dummy Variables.	

Discussion

- Some evidence that updating plants saved less than grandfathered
  - Interacting updating allocation with gas plant shows that they bank a little more

- Plants with SCR save more permits
  - No evidence large firms save less per plant

- Some Grid Networks had statistically different banking levels
  - Does transmission rules play a role?

Next Steps

- Structural model of dynamic banking decision

- Aggregate data at the firm level
  - Is the result robust?

- Happy to hear your thoughts

Expected Signs

- State Natural Gas Price
  - Smaller savings as more coal-fired generation
- State Electricity Price
  - Ambiguous effect on savings
- Gas, Coal, or Fuel Oil Plant
  - Gas and Fuel Oil would have larger savings due to lower emissions
- Year, Grid, State Dummies