WIND GENERATION SUBSIDIES
The impact on the capacity fuel mix, welfare implications and other market consequences
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INTRODUCTION

In the context of liberalized competitive electricity markets US policy makers have conflicting goals – both at the Federal and that the State level –

Environmental Goals

Promotion of Wind Generation Capacity
Recent policies
- Renewable Electricity Production Tax Credit (PTC)
- Renewable Portfolio Standards (RPS)

Guarantee Adequate Reliable Supply
- Increasing concern about the Resource Adequacy problem or “Missing Money” problem
- Potential solutions
  - Capacity Markets (PJM, ISO-NE, NYISO, etc.)
  - Operating Reserve Demand Curve (Texas ERCOT)

Having that in mind, we are interested in analyze: what is the tradeoff of the renewable promotion?

GOALS

- Investigate the impact on the electricity market of subsidies to the renewable energy production
  - In particular, we focus our attention to subsidies to wind generation
- Explore the consequences for the generation capacity fuel mix
  - We challenge previous studies that argue that subsidies to wind are more likely to displace peak load generation (natural gas)
    - E.g. Cullen (2008), Wynne et al. (2009), Blossman et al. (2009)
- Putting aside the environmental gains: what are the consequences for consumers?
  - Taking into account the intermittent nature of renewables, we explore the impact on Consumer Surplus and Price Volatility

METHODOLOGY: THE MODEL

We set up a theoretical framework with cost heterogeneous electricity generators and stochastic demand

Demand

- Unit one continuum of risk averse consumers
- Reservation price $p^b$ (VOLL)
- Quantity demanded: $b$ stochastic
  - non-negative random variable
  - uniformly distributed over the interval $[0, 1]
  - cumulative distribution function $F(b)$
  - w.l.o.g. normalize this support such that $b = 0$ and $F = 1$

Timing

1. Generators decide how much to invest in capacity
   - $k_0, b, p \in \{0, 1\}$
2. Demand is realized
   - $b \in [0, 1]
3. Generators compete in uniform-price auction to sell electricity
   - market-clearing price: $p^* \in [0, \min\{p^b, p^w\}]

Solve by backward induction

Supply

- Unit measure continuum of identical
  - wind load electricity generators
  - base load electricity generators (e.g. coal)
  - peak load electricity generators (e.g. natural gas)
- Costs
  - variable cost: $c_k = 0\quad c_k = 24.5\quad c_k = 42$
  - per unit capacity cost: $c_w > c_k > c_b$
- Production function
  - wind generators (intermittent?): $0 \leq q_w \leq [1 - \rho]k_0$
  - base and peak generators: $0 \leq q_k \leq k_0, i \in \{b, p\}$

Market Equilibrium

- First we find a unique equilibrium in the wholesale market
  - Equilibrium bids and productions: $p, q, \in \{b, p\}$
  - Equilibrium surplus: $H(VOLL)$
  - Equilibrium price cap: $p$.
  -Solve by backward induction

Testing the model: ERCOT data

We use the following to simulate the equilibrium capacities

- Texas ERCOT data
  - Hourly load data (in MW) from 1995 to 2014
  - not available for 2001 and 2002
- Parameters:
  - VOL and Price Cap: $p^b = 0.00\quad p^w = 2.50$
  - Variable cost: $c_k = 0\quad c_k = 24.5\quad c_k = 42$
  - Per capacity cost: $c_w > c_k > c_b$
  - Wind subsidy: $w = 22$

- Free-entry: $\rho = 25$

Welfare and Market analysis

- Fuel generation mix - measured in percentage
- Price volatility - measured as the expected variance
- Consumer Surplus - measured according to the following (standard) formula

\[
\text{CS} = \int_0^1 (p^b - c_k) \theta dF(\theta) + \int_0^1 (p^w - c_k) \theta dF(\theta) + \\
+ \int_b^1 \left(\max(p^b - p^w, 0)\right) KdF(\theta)
\]

MAIN PLOTS

Capacity Fuel Mix with Price Cap ($\$w^b$) at $2.500$ per MWh

Impact of Wind Subsidies on Consumer Surplus

Impact of Wind Subsidies on Price Volatility

MAIN FINDINGS

- Contrary to the aforementioned authors, we find that an increase of the wind capacity tends to displace base load facilities (coal)
  - Therefore, subsidies to wind will promote Natural Gas facilities while displacing Coal generation
- On the other hand, and putting aside the environmental gains, the promotion of wind capacity has negative impact on consumers
  - An increase in the expected price reduces ex-ante Consumer Surplus
  - Due to the intermittent nature of wind, Natural Gas (which is more expensive than coal) is the back up technology
- These consequences may be mitigated with the introduction of a Capacity Market

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