Have Renewable Portfolio Standards Raise Electricity Rates? U.S. Electric Utilities

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Motivations

- ## What is a Renewable Portfolio Standard?

  - ### Requires a portion of a utility's electricity sales to be generated from renewable energy

  - ### Implemented at the state level in the U.S.

    - As of 2008: 32 states and District of Columbia

    - RPS in new climate change bill:

      - 6% in 2012, 9.5% in 2014, …, 20% in 2021-2039

  - ### RPS policies outside the U.S.

    - U.K., Sweden, Belgium, Italy, Japan, Australia

Motivations

- **How RPS works**
  - Sets final RPS goal and target year (e.g. 20% by 2020)
  - Set annual requirements to reach goal
  - Set eligible renewable technologies
  - Electric utilities may comply in three ways
    - own a facility that produces electricity from renewable energy sources
    - Purchasing electricity from renewable sources
    - Purchasing a Renewable energy Certificate (REC)

Motivations

- **Benefits of a RPS**
  - Environmental benefits
    - Global climate change mitigation through reduced CO_2 emissions
    - Reduced air pollution
  - Other benefits
    - Increased diversity and security of energy supply
      - Reduced dependence on fossil fuels
    - Reduced volatility of power prices
      - Displacement of high-cost marginal supply

Motivations

- ## Costs of a RPS
  - Cost to suppliers of electricity
    - Renewable technology costs
      - Higher capital costs compared to fossil fuels
    - Cost of Renewable Energy (RE) certificate
    - Costs of integrating RE into electricity grid
      - e.g. integrating remote wind turbines
  - Cost to consumers of electricity
    - Technology costs passed on to consumers
    - Increase in retail electricity prices

Study Goals

- What is the effect of an RPS mandate on retail electricity prices?

  - Why should we care?

  - spillover effect

    - Impact of RPS on affected vs. un-affected utilities

  - Heterogeneity of the RPS effect

    - state renewable energy potential, age of RPS policy, stringency of RPS requirement

    - Large vs. small utilities

    - Impact across retail electricity sectors

Current Evidence

- **Palmer and Burtraw (2005)**
  - Simulated impact of a 15% national RPS
  - Electricity price impact: +2% by 2020
- **U.S. EIA (2001, 2003)**
  - Simulated impact of a 20% national RPS
  - Electricity price impact range: +3 to +4% by 2020
- **Chen et al. (2008)**
  - Survey of 31 state-commissioned studies
  - Simulated electricity price impact: -5% to +9%
  - Median simulated electricity price impact: +0.5%

Summary of Results

- Electric utility Residential rates are 3 to 4 % higher in RPS states

- No evidence of spillover effect
  - No effect on rates of unaffected utilities in RPS states

- RPS effect is significantly lower in states with a higher wind and/or solar energy potential

- Magnitude of RPS effect increases with RPS requirement
  - Elasticity of res. rates WRT RPS requ. is 0.3

Data

- **Electric Utilities: EIA form 861 database**
  - all electric distribution utilities in the U.S.
  - retail revenues, sales and customer count
  - by retail sectors (i.e., residential, commercial)
  - ownership structure of utility
    - Three major types: Investor-owned, municipal, electric cooperative
  - state served by utility
- **Time: 1990-2006**
  - Sample: 44,000 obs., utilities operating in 1 state
  - Balanced panel

Table 3: Average Electricity Rates (Cents per kilowatt-hour), 1990-2006

	RPS states[1] (1)	Non-restructured RPS states[2] (2)	Non-RPS states (3)	Mean Difference (1) – (3)	Mean Difference (2) – (3)
1990					
Residential rate	8.28	7.22	7.23	1.06**	0.00
	(1.91)	(2.12)	(1.38)		
Commercial rate	7.48	6.41	6.60	0.88**	0.19
	(1.76)	(2.25)	(1.18)		
All-retail rate	7.05	5.92	6.07	0.98**	0.15
	(1.80)	(2.02)	(1.32)		
2006					
Residential rate	12.30	11.87	8.91	3.38***	2.95**
	(3.88)	(6.56)	(2.12)		
Commercial rate	10.99	10.25	7.76	3.23***	2.49**
	(3.63)	(6.28)	(2.00)		
All-retail rate	10.86	9.92	7.47	3.38***	2.45**
	(3.65)	(6.08)	(2.11)		

Standard deviations are in parentheses. *** Significant at the 1% level. ** Significant at the 5% level.

Identification Issues

- ## Identification issue 1:
  - Time-invariant unobserved utility characteristics affect both prices and RPS adoption
  - Classical OLS will lead to an inconsistent estimate of the effect of RPS
  - Addressed via utility fixed effects (FE)

- ## Identification issue 2:
  - Deregulation occurred during the same period
  - Other regulations to promote RE (PBF, GDR, MGPO)
  - These policies could confound RPS effect
  - Estimation isolates the effect of RPS mandates from both deregulation and other RE policies

Identification Issues

- **Identification issue 3:**
  - Time-varying unobserved utility affect both prices and RPS adoption characteristics
  - RPS policy is endogenous
  - FE estimate of RPS effect is inconsistent
  - Test for the endogeneity of the RPS regulatory variable following Hausman (1978)
  - Results suggest not an issue for the effect of RPS on residential rates

Econometric Model

$$\log pr_{ist} = \alpha \cdot RPS_{st} + \beta \cdot Deregulated_{st} + \gamma \cdot Otherregulation_{st}$$
$$+ \delta \cdot controls_{st} + \varphi \cdot year_t + \theta \cdot utility_i + \varepsilon_{ist}$$

pr_{ist}: log of the average residential nominal price

RPS: =1 if a state RPS mandate is effective

$Deregulated$: =1 if has deregulated electricity

$Otherregulation$: =1 if other statewide renewable energy regulations

$year$: year fixed-effect

$controls$: state controls

$utility$: utility fixed-effect

Assumption: $E[\varepsilon_{ist}|RPS_{st}]=0$, i.e. RPS policy is exogenous

Table 4: The Effect of RPS Adoption on Residential Electricity Rates

Variables	(1) OLS Full Sample	(2) FE Full Sample	(3) FE Full Sample	(4) FE Full Sample
RPS	0.0143***	0.0388***	0.000901	0.399***
	(2.75)	(14.19)	(0.18)	(14.64)
RPS *Affected			0.0540***	
			(9.29)	
RPS* Solar potential				-0.0180***
				(-6.17)
RPS* Wind potential				-0.0875***
				(-11.66)
RPS requirement (%)				
RPS years				
Deregulated	0.0298***	0.0121***	0.0164***	0.0112***
	(4.55)	(4.77)	(6.34)	(4.43)
Other renewable energy policies	-0.0926***	-0.00582***	-0.00629***	-0.00471**
	(-24.80)	(-2.98)	(-3.22)	(-2.42)
Population	-0.00579***	0.0144***	0.0212***	0.0151***
	(-17.57)	(11.65)	(14.83)	(9.72)
Population density	0.000113***	-0.00104***	-0.00135***	-0.00111***
	(9.02)	(-11.49)	(-13.35)	(-11.47)
Coal price*Primary fuel is coal	0.000183***	0.000196***	0.000223***	0.000223***
	(5.71)	(5.49)	(6.21)	(6.20)
Natural gas price*Primary fuel is gas	0.000408***	0.0000316***	0.0000402***	0.0000398***
	(32.34)	(5.29)	(6.66)	(6.55)
Year Fixed-effects	Yes	Yes	Yes	Yes
Utility (Firm) Fixed-effects	No	Yes	Yes	Yes
F-value for Utility Fixed-effects	-	141.7***	141.6***	139.8***
R^2	0.0898	0.329	0.330	0.332
Observations	44,149	44,149	44,149	44,149

* Significant at 10 percent level. ** Significant at 5 percent level. *** Significant at 1 percent level.
T-statistics are in parentheses. Dependent variable is log of average electricity rate.

Table 4 Continued

Variables	(5) FE Full Sample	(6) FE Small Utilities	(7) FE Mid-Size Utilities	(8) FE Large Utilities
RPS	0.0317***	0.0671***	0.0297***	0.0229***
	(10.38)	(9.89)	(8.17)	(5.26)
RPS *Affected				
RPS* Solar potential				
RPS* Wind potential				
RPS requirement (%)	0.00288***			
	(3.65)			
RPS years	0.00171***			
	(4.18)			
Deregulated	0.0129***	0.0175**	0.00253	0.0256***
	(5.02)	(2.47)	(0.75)	(7.30)
Other renewable energy policies	-0.00448**	-0.00348	-0.00491*	-0.0102***
	(-2.26)	(-0.65)	(-1.85)	(-3.82)
Population	0.0132***	0.0364***	0.0182***	0.0101***
	(10.51)	(7.27)	(11.38)	(6.06)
Population density	-0.00100***	-0.00139***	-0.000954***	-0.000856***
	(-10.89)	(-4.29)	(-7.91)	(-7.20)
Coal price*Primary fuel is coal	0.000212***	0.000141	0.000173***	0.000264***
	(5.93)	(1.20)	(3.71)	(5.74)
Natural gas price*Primary fuel is gas	0.0000317***	0.0000262	0.0000313***	0.0000417***
	(5.31)	(1.52)	(3.91)	(5.19)
Year Fixed-effects	Yes	Yes	Yes	Yes
Utility (Firm) Fixed-effects	Yes	Yes	Yes	Yes
F-value for Utility Fixed-effects	140.9***	112.2***	121.5***	113.9***
R^2	0.330	0.255	0.360	0.460
Observations	44,149	12,971	20,077	11,101

* Significant at 10 percent level. ** Significant at 5 percent level. *** Significant at 1 percent level.
T-statistics are in parentheses. Dependent variable is log of average electricity rate.

Table 5: The Effect of RPS Adoption across Retail Electricity Sectors

Variables	Residential (1)	Commercial (2)	All-Retail (3)
RPS	0.0388***	0.0268***	0.0353***
	(14.19)	(6.32)	(13.40)
Deregulated	0.0121***	0.0209***	0.0172***
	(4.77)	(5.32)	(7.03)
Other renewable energy policies	-0.00582***	-0.00225	-0.00576***
	(-2.98)	(-0.74)	(-3.06)
Population	0.0144***	0.0130***	0.0144***
	(11.65)	(6.79)	(12.03)
Population density	-0.00104***	-0.00133***	-0.00125***
	(-11.49)	(-9.40)	(-14.25)
Coal price*Primary fuel is coal	0.000196***	0.000290***	0.000199***
	(5.49)	(5.26)	(5.80)
Natural gas price*Primary fuel is gas	0.0000316***	0.0000630***	0.0000460***
	(5.29)	(6.80)	(7.99)
F-value for Utility Fixed-effects	141.7***	58.0***	161.5***
R^2	0.329	0.119	0.230
Observations	44,149	43,393[†]	44,149

* Significant at 10 percent level. ** Significant at 5 percent level. *** Significant at 1 percent level. T-statistics are in parentheses. Dependent variable is log of average electricity rate.

Table 6: Hausman Test for the Endogeneity of RPS

Variables	Residential (1)	Commercial (2)	All-Retail (3)
RPS	0.0384***	0.0285***	0.0354***
	(13.93)	(6.65)	(13.34)
RPS_hat[†]	0.0267	-0.105***	-0.00722
	(1.20)	(-3.05)	(-0.34)
Deregulated	0.00991***	0.0295***	0.0177***
	(3.19)	(6.11)	(5.93)
Other renewable energy policies	-0.00549***	-0.00356	-0.00585***
	(-2.78)	(-1.16)	(-3.08)
Population	0.0112***	0.0257***	0.0152***
	(3.82)	(5.62)	(5.37)
Population density	-0.000981***	-0.00157***	-0.00126***
	(-9.38)	(-9.67)	(-12.54)
Coal price*Primary fuel is coal	0.000179***	0.000357***	0.000204***
	(4.67)	(6.01)	(5.52)
Natural gas price*Primary fuel is gas	0.0000242***	0.0000922***	0.0000480***
	(2.82)	(6.92)	(5.81)
F-value for Utility Fixed-effects	127.7***	51.7***	146.4 ***
R^2	0.332	0.119	0.303
Observations	44,149	43,393[‡]	44,149

T-statistics are in parentheses. Dependent variable is log of average electricity rate.

* Significant at 10 percent level. ** Significant at 5 percent level. *** Significant at 1 percent level.

[†] Predicted value of the RPS variable from the reduced form regression of RPS on a set of instruments Z.

Summary of RPS Effect Residential Rates

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- No evidence of spillover effect
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- RPS effect is significantly lower in states with a higher wind and/or solar energy potential
- Magnitude of RPS effect increases with RPS requirement
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