The Effect of Non-Linear Tariffs on Electricity Demand and Emissions: Evidence from A Natural Experiment in Russia

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Our contribution

- We estimate the price elasticity for residential electricity demand in Russia in a context of natural experiment.
  - We compare consumption of households living in regions with **a flat price** and with **a dwelling-specific increasing block rate (IBR) tariff**, and **before and after** the IBR was introduced in the treated regions (in 2013).
  - We exploit **micro-level household data** on Russia (RLMS), appended with region-specific **weather** and electricity price data.

Treated regions starting from 2013 (with data in RLMS in purple)

- Zabaykalsky Krai
- Krasnoyarsk Krai
- Vladimir Oblast
- Nizhny Novgorod Oblast
- Oryol Oblast
- Rostov Oblast
- Samara Oblast

Control regions (available in RLMS)

- Leningrad oblast
- Kaluga
- Krasnodar
- Kazan
- Udmurtia
- Altay
- Vladivostok
- Komi Republic
- Tambov
- Volgograd
- Orenburg
- Tomsk
- Amur
- Siktikvar
- Tver
- Stavropol
- Chuvashia
- Kurgan
- Saint Petersburg
- Moscow
- Novamoskva
- Moscow oblast
- Penza
- Tula
- Lipetsk
- Kabardino-Balkaria
- Saratov
- Chelabinsk
- Biysk
- Smolensk
- Krasnodar
- Saratov
- Krasnoarmeysky
- Berdsk
- Perm

Natural experiment

- Russia introduced **social norms for electricity consumption** in seven major regions starting in summer 2013.
- This was done to cross subsidize consumption: Households with a relatively higher electricity consumption subsidize part of the cost of the relatively lower electricity consuming households,

- Dwelling-specific, social norms are used to define the cut-off consumption for IBR pricing

Social norms for three experimental regions (kwh)	urban area	rural area	urban area and using an electric-oven	rural area and using electric oven	…if receiving social benefits
Rostov					
1-person	96	186 (96+90)	186 (96+90)	276 (96+90+90)	*1.5
2-persons	156 (96+60)	246 (96+60+90)	242 (96+60+43*n)	332 (96+60+90+43*n)	*1.5
3+ persons	(96+60) + 40*(n-2)	(96+60) + 40*(n-2) + 90)	96+60 + 40*(n-2) + 43*n	(96+60+40*(n-2)+90+43*n)	*1.5
Krasnoyarsk					
1-person	110		110+110		Na
2-persons	n*75		n*75+n*75		Na
3+ persons	n*75		n*75+n*75		Na
Nizhny Novgorod					
1-person	85		Na		85
2-persons	100 = 50+(n-1)*50		Na		*1.5
3+ persons	50+(n-1)*50		Na		*1.5

Data

- Panel data, RLMS-HSE.
- About 7000 randomly selected households with approximately 18000 individuals each year.
- Our study period: 2010-2016.
- Regional weather data from meteoblue.com

Characteristics of the Dwellings

	Control regions	Treatment regions
Type of Home:		
Single-family home	28.5%	24.2%
Apartment in multi-family building	71.3%	75.6%
Size of the dwelling in m2	56.43	54.81
Urban	72.9%	93%
Have Electric Stove	18.7%	35%
Has central delivery of:		
Gas	70.5%	53.6%
Heating	68.6%	74.5%
Hot water	63.4%	71.8%
Cold Water	87.7%	90.4%

Respondent characteristics

Average or percent of the sample (standard deviation in parentheses)	Control regions	Treatment regions
Household size	2.78	2.79
Household monthly income (RU)	28786	28817
Receiving discounts for utilities	21.1%	23%
Receiving subsidies for utilities	28.6%	24.3%
Owe money (arrears) to the Utilities	7%	5.9%
Education:		
Secondary	33.2%	29%
Professional-technical	23.9%	25.3%
High education (MSc, BSc, DiS)	24.7%	26.9%
Other	17.8%	18.2%

Home Appliances

	Control regions	Treatment regions
Air Conditioner	8.8%	10.2%
Dishwasher (automatic)	2.9%	2.2%
Refrigerator (no frost)	55.2%	56.6%
Washing machine	77%	82.7%
Electric stove	18.7%	35%
Freezer	12.6%	22.2%
Microwave	64.8%	64.2%
Personal computer (stationary)	43.7%	42.9%
LCD TV	49.6%	54.9%
CRT TV	74.4%	65.6%

Econometric Model

$$lnE_{it} = a_i + \tau_t + \boldsymbol{X}_{it}\gamma_1 + lnP_{it}B_1 + \boldsymbol{S}_{it}\gamma_2 + \boldsymbol{W}\gamma_3 + \varepsilon_{it}$$

$\boldsymbol{lnE_{it}}$ logarithm of electricity consumption of household i in year t

$\boldsymbol{lnP_{it}}$ logarithm of per 100 kWh price of electricity (instrumented with full tariff schedule)

$\boldsymbol{S_{it}}$ any benefits for the utilities

$\boldsymbol{X_{it}}$ control variables

$\mathbf{W_{it}}$ weather variables

Results: 2SLS, based on clustered standard errors:

1st Stage Statistic	
Number of observations	N = 29,595
Number of regressors	K = 16
Number of endogenous regressors	K1 = 1
Number of instruments	L = 47
Number of excluded instruments	L1 = 32
Number of clusters	N_clust = 10,022
Hansen J statistic (overidentification test of all instruments): 35.403	
Chi-sq(31) P-val = 0.2681	

2nd Stage	lnelectconsum
Log(Price)	-0.0998**
Log(Income)	0.0382***
Log(cash transfers for utilities)	-5.64e-05
Log (discounts for utilities)	0.00145
Log(debt for utilities)	0.00288*
Family size	0.0960***
Log(DD)	0.00370
Log(Precipitation)	-0.0119***
Log(Humidity)	0.222***
Log(Winds)	-0.0142
Observations	29,595

Results: 2SLS, based on coarsened exact matching (cem):

Matching Statistics	
Treatment=0: All 40434 ; Matched 33791; Unmatched 6643	
Treatment=1: All 4145 ; Matched 4142; Unmatched 3	
Multivariate L1 distance: 0.69759789	
1st Stage Statistic	
Number of instruments	L = 47
Number of excluded instruments	L1 = 32
Hansen J statistic (overidentification test of all instruments):	36.186
Chi-sq(31) P-val = 0.2392	

2nd Stage	lnelectconsum
Log(Price)	-0. 071*
Log(Income)	0.031***
Log(cash transfers for utilities)	0.000
Log (discounts for utilities)	0.0011
Log(debt for utilities)	0.002
Family size	0.10***
Log(DD)	0.014393
Log(Precipitation)	-0.0141072 ***
Log(Humidity)	0.214474 ***
Log(Winds)	-0.0131396
Observations	24,517

Policy Simulation

- Using the estimated coefficient (approx. -0.10) on price elasticity of electricity demand we predict total change in the revenue and CO2 emissions if the similar IBR policies (average price increase of 10 percent) were implemented across Russia using RLMS data with sampling weights

Carbon intensity of electricity generation, by region in Russia

	Electricity generation from using …				Carbon intensity, in kg CO2 per kWh
Region:	Gas %	Coal %	Hydro %	Nuclear %	
North West	43	15	14	28	0.374394837
Central	60	11	4	25	0.421110277
South	64	1	29	6	0.339690513
Volga	67	2	22	9	0.365336605
Urals	72	25	0	3	0.625707484
Siberia	6	46	48	0	0.500148683
Far East	17	50	33	0	0.59758478

Source: McKinsey, 2009

Simulation of the impact on energy use, CO2 emissions and utility revenues

- Reduction in elect. consumption a year per household and in Russia:

24.716 kWh 1.33 bln KwH

(0.9% of total 136.86 bln)

- Reduction in CO2 emission a year per household and in Russia:

17.768 kg **0.96 mil.T**

(0.06 % of total 1.5 bln t)

- Reduction in electricity revenue a year per hhold and in Russia:

791 rubles **42.54 bln rubles**

(eq. of 691 mil. USD)

Thank you for your attention!