# Increasing Block Rate Electricity Pricing and Propensity to Purchase Electric Appliances: Evidence from a Natural Experiment in Russia

**Salim Turdaliev**

**IES FSV, Charles University**

- Acknowledgement:

The financial support was provided by the Grant Agency of Charles University (grant number 454120) and the European Union's H2020-MSCA-RISE project GEMCLIME-2020 under GA 681228.

# This Research

Provides empirical evidence on the relationship between increasing-block-rate (IBR) pricing of electricity and the propensity of households to purchase major electric appliances.

Exploits variation from a natural experiment in Russia that introduced IBR pricing for residential electricity in a number of experimental regions in 2013.

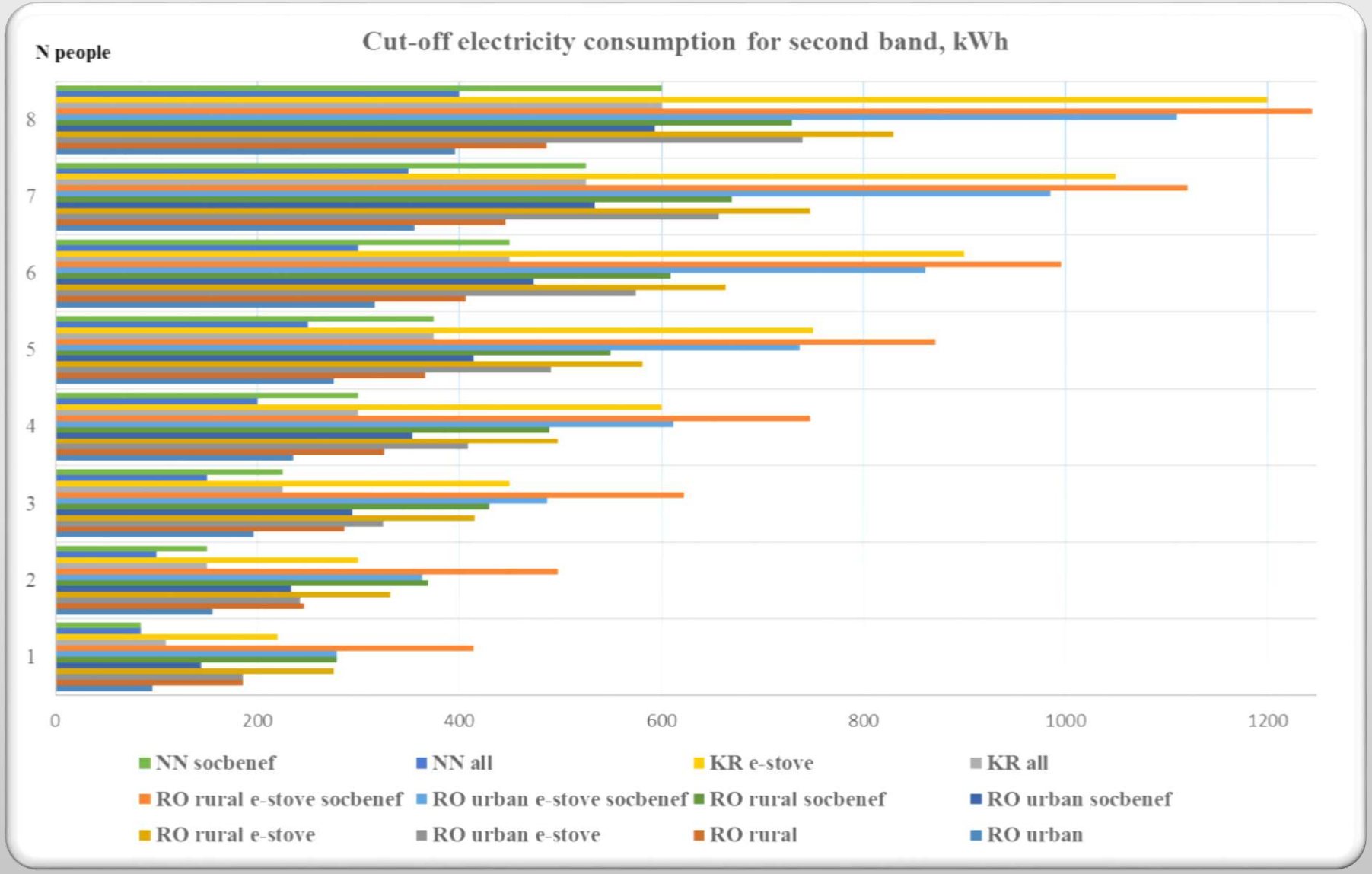
Using difference-in-differences specification I show that in the regions with IBR pricing the purchase of major electric appliances has increased by more than 20 percent (2 percentage points).

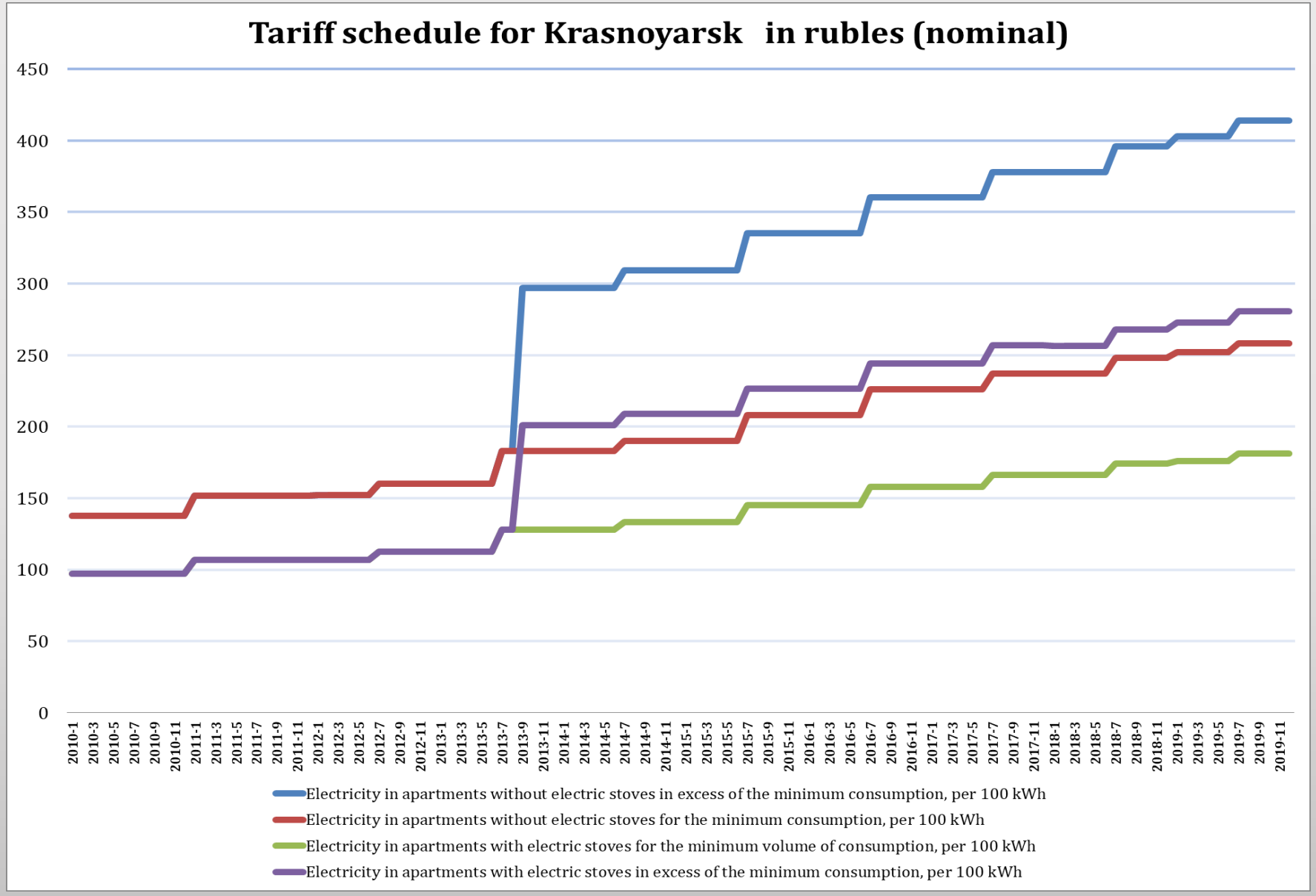
# Natural experiment

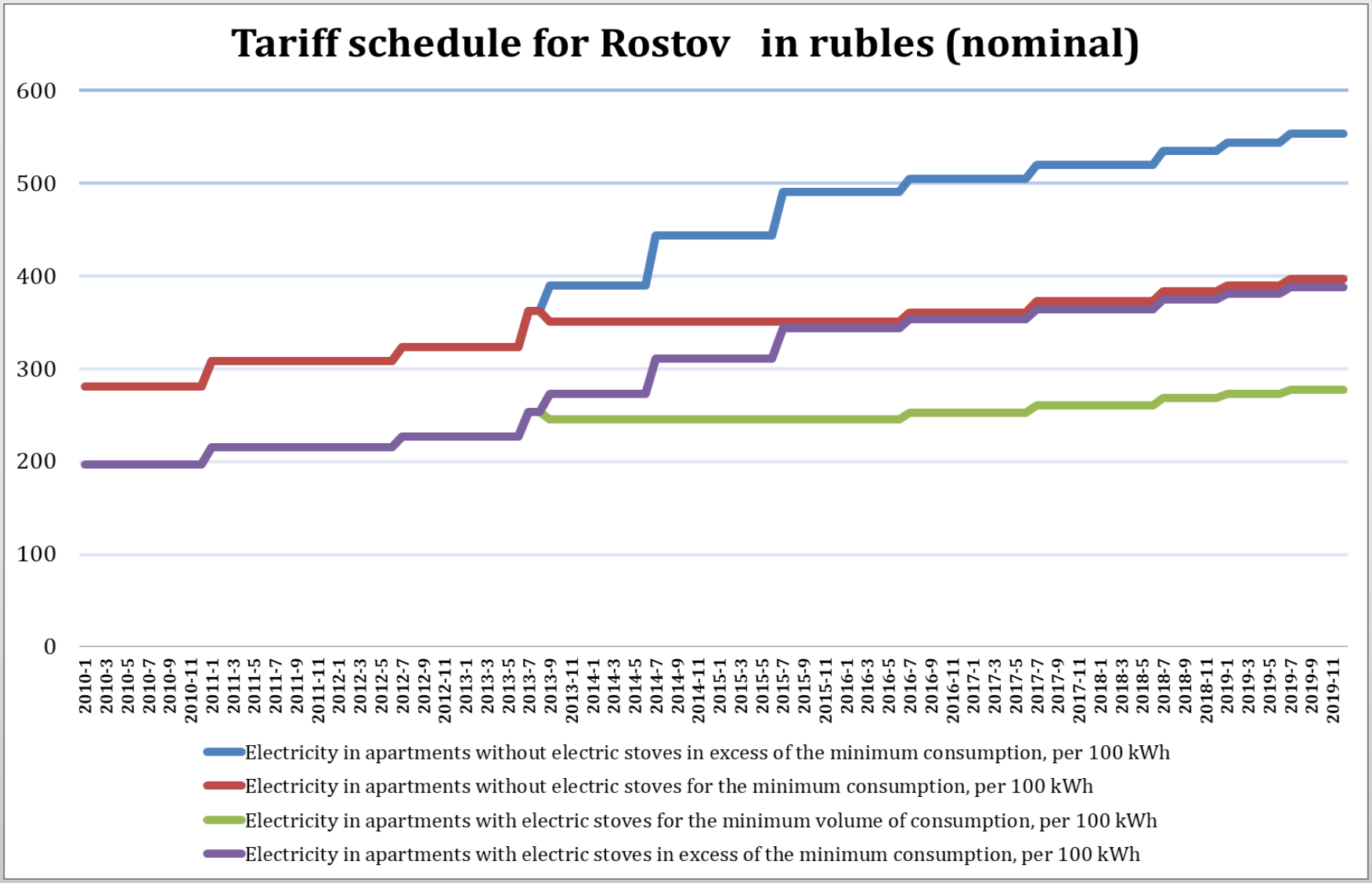
- Russia introduced **social norms for electricity consumption** in seven regions starting from summer 2013 (**3 out of 7** are observed in dataset).
- This was done to cross subsidize consumption: Households with a relatively higher electricity consumption subsidize part of the cost of the relatively lower electricity consuming households.
- Dwelling-specific, social norms are used to define the cut-off consumption for IBR pricing

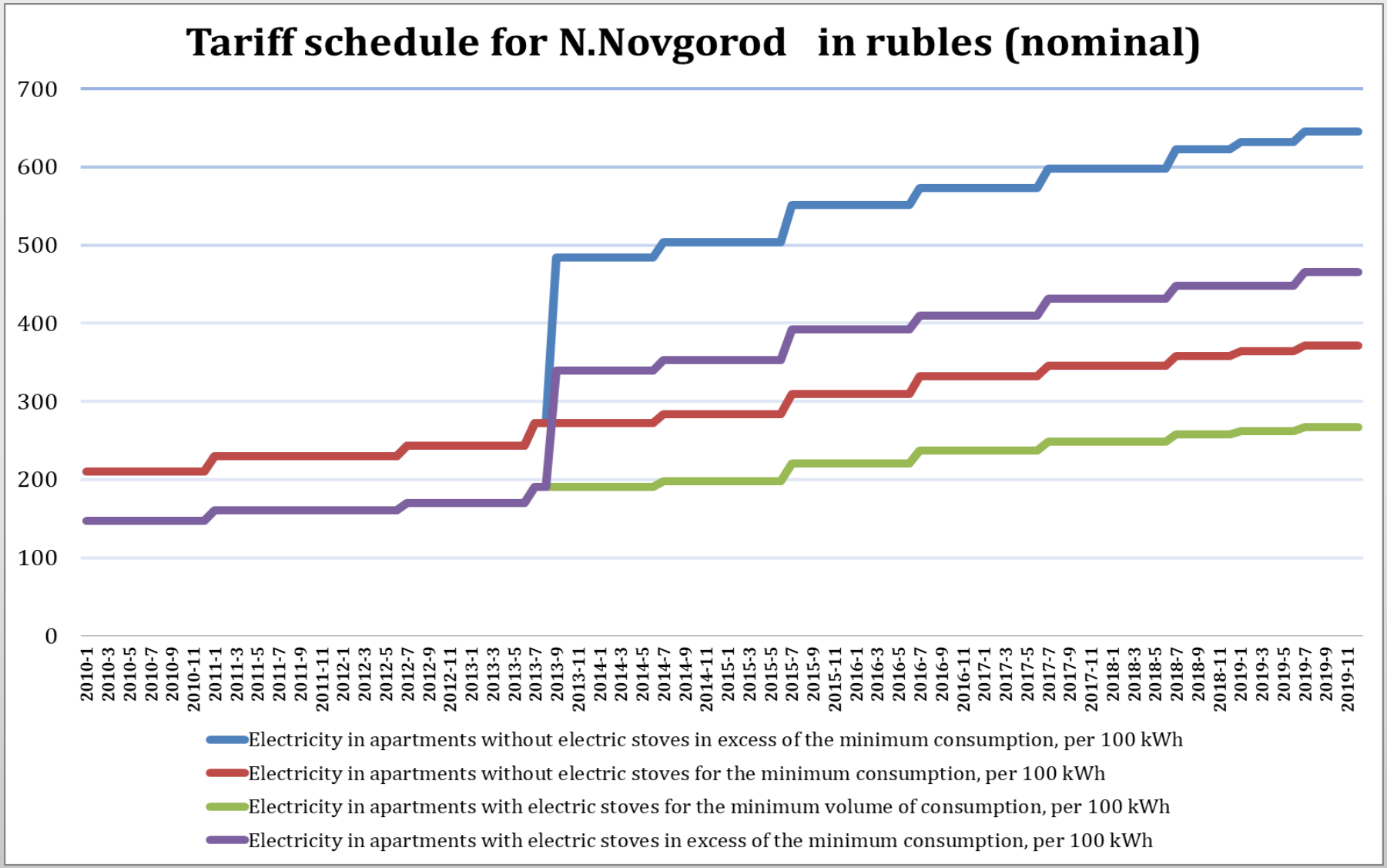
| Social norms for three experimental regions (kwh) | urban area | rural area | urban area and using an electric-oven | rural area and using electric oven | …if receiving social benefits |
|---|---|---|---|---|---|
| **Rostov** | | | | | |
| **1-person** | 96 | 186 (96+90) | 186 (96+90) | 276 (96+90+90)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

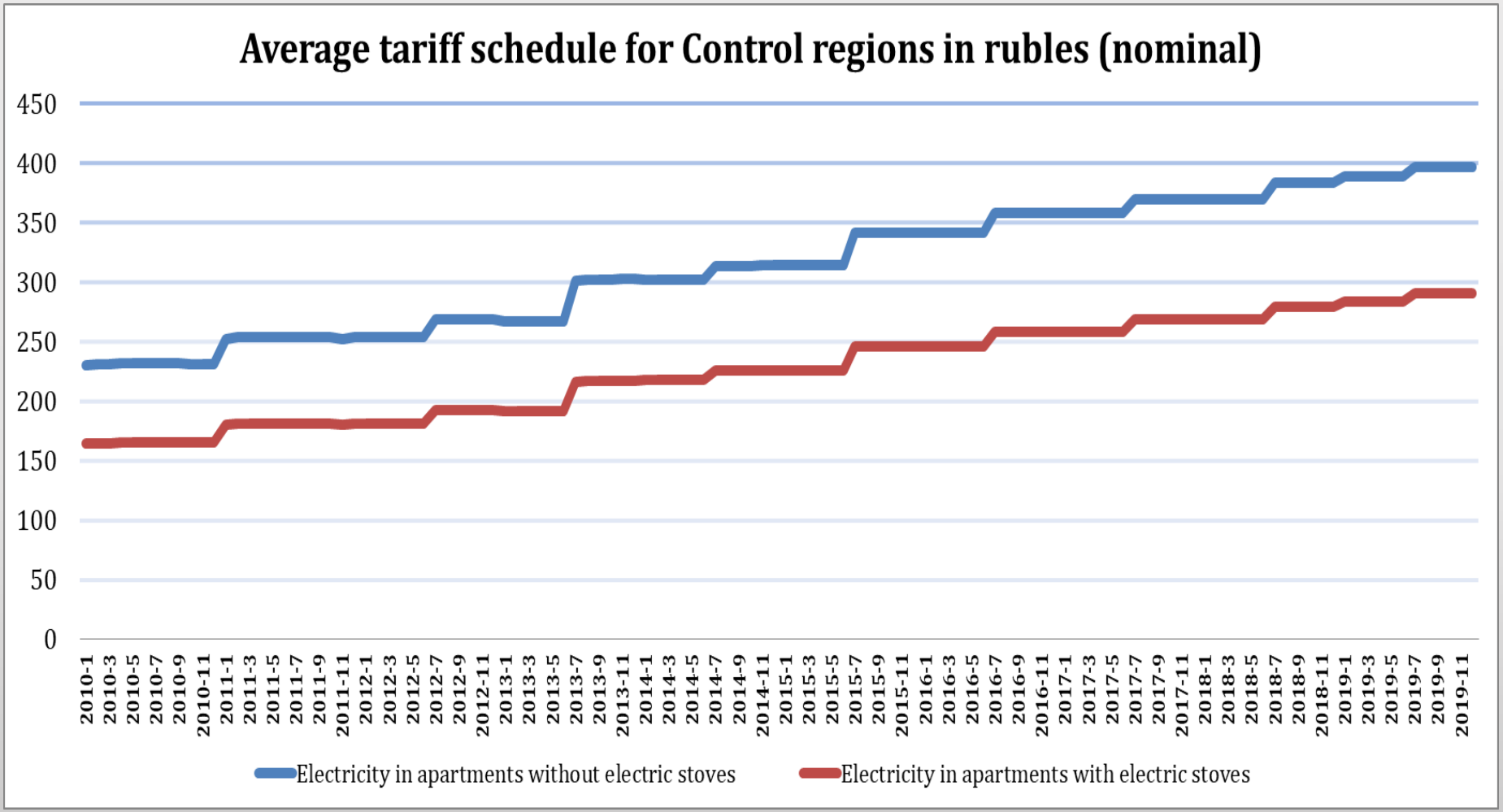
*Source: regional electricity providers*


Cut-off electricity consumption for second band, kWh
N people
8
7
6
5
4
3
2
1
0
200
400
600
800
1000
1200
NN socbenef
NN all
KR e-stove
KR all
RO rural e-stove socbenef
RO urban e-stove socbenef
RO rural socbenef
RO urban socbenef
RO rural e-stove
RO urban e-stove
RO rural
RO urban


Tariff schedule for Krasnoyarsk in rubles (nominal)
450
400
350
300
250
200
150
100
50
0
2010-1
2010-3
2010-5
2010-7
2010-9
2010-11
2011-1
2011-3
2011-5
2011-7
2011-9
2011-11
2012-1
2012-3
2012-5
2012-7
2012-9
2012-11
2013-1
2013-3
2013-5
2013-7
2013-9
2013-11
2014-1
2014-3
2014-5
2014-7
2014-9
2014-11
2015-1
2015-3
2015-5
2015-7
2015-9
2015-11
2016-1
2016-3
2016-5
2016-7
2016-9
2016-11
2017-1
2017-3
2017-5
2017-7
2017-9
2017-11
2018-1
2018-3
2018-5
2018-7
2018-9
2018-11
2019-1
2019-3
2019-5
2019-7
2019-9
2019-11
Electricity in apartments without electric stoves in excess of the minimum consumption, per 100 kWh
Electricity in apartments without electric stoves for the minimum consumption, per 100 kWh
Electricity in apartments with electric stoves for the minimum volume of consumption, per 100 kWh
Electricity in apartments with electric stoves in excess of the minimum consumption, per 100 kWh


Tariff schedule for Rostov in rubles (nominal)
600
500
400
300
200
100
0
2010-1
2010-3
2010-5
2010-7
2010-9
2010-11
2011-1
2011-3
2011-5
2011-7
2011-9
2011-11
2012-1
2012-3
2012-5
2012-7
2012-9
2012-11
2013-1
2013-3
2013-5
2013-7
2013-9
2013-11
2014-1
2014-3
2014-5
2014-7
2014-9
2014-11
2015-1
2015-3
2015-5
2015-7
2015-9
2015-11
2016-1
2016-3
2016-5
2016-7
2016-9
2016-11
2017-1
2017-3
2017-5
2017-7
2017-9
2017-11
2018-1
2018-3
2018-5
2018-7
2018-9
2018-11
2019-1
2019-3
2019-5
2019-7
2019-9
2019-11
Electricity in apartments without electric stoves in excess of the minimum consumption, per 100 kWh
Electricity in apartments without electric stoves for the minimum consumption, per 100 kWh
Electricity in apartments with electric stoves for the minimum volume of consumption, per 100 kWh
Electricity in apartments with electric stoves in excess of the minimum consumption, per 100 kWh


Tariff schedule for N.Novgorod in rubles (nominal)
700
600
500
400
300
200
100
0
2010-1
2010-3
2010-5
2010-7
2010-9
2010-11
2011-1
2011-3
2011-5
2011-7
2011-9
2011-11
2012-1
2012-3
2012-5
2012-7
2012-9
2012-11
2013-1
2013-3
2013-5
2013-7
2013-9
2013-11
2014-1
2014-3
2014-5
2014-7
2014-9
2014-11
2015-1
2015-3
2015-5
2015-7
2015-9
2015-11
2016-1
2016-3
2016-5
2016-7
2016-9
2016-11
2017-1
2017-3
2017-5
2017-7
2017-9
2017-11
2018-1
2018-3
2018-5
2018-7
2018-9
2018-11
2019-1
2019-3
2019-5
2019-7
2019-9
2019-11
Electricity in apartments without electric stoves in excess of the minimum consumption, per 100 kWh
Electricity in apartments without electric stoves for the minimum consumption, per 100 kWh
Electricity in apartments with electric stoves for the minimum volume of consumption, per 100 kWh
Electricity in apartments with electric stoves in excess of the minimum consumption, per 100 kWh


Average tariff schedule for Control regions in rubles (nominal)
450
400
350
300
250
200
150
100
50
0
2010-1
2010-3
2010-5
2010-7
2010-9
2010-11
2011-1
2011-3
2011-5
2011-7
2011-9
2011-11
2012-1
2012-3
2012-5
2012-7
2012-9
2012-11
2013-1
2013-3
2013-5
2013-7
2013-9
2013-11
2014-1
2014-3
2014-5
2014-7
2014-9
2014-11
2015-1
2015-3
2015-5
2015-7
2015-9
2015-11
2016-1
2016-3
2016-5
2016-7
2016-9
2016-11
2017-1
2017-3
2017-5
2017-7
2017-9
2017-11
2018-1
2018-3
2018-5
2018-7
2018-9
2018-11
2019-1
2019-3
2019-5
2019-7
2019-9
2019-11
Electricity in apartments without electric stoves
Electricity in apartments with electric stoves

# Data

- Panel data, RLMS-HSE.
- About 7000 selected households each year.
- Study period: 2010-2019.
- Surveys administered  in October-November
- 3 treatment regions, and 35 control regions
- More than 9-percent of households are located in treatment regions.

# Characteristics of the Dwellings

| **Variables** | **Control regions:** Percent of the Sample or Mean (standard deviation in parentheses) | **Treatment regions:** Percent of the Sample or Mean (standard deviation in parentheses) | **Difference in Means:** Standard error in parentheses |
|---|---|---|---|
| ***Type of dwelling*:** | | | |
| Single-family home | 27.1% | 21.8% | 5.3%*** |
| Apartment in multi-family building | 72.6% | 77.9% | -5.3%*** |
| Size of the dwelling in square meters | 56.33 (23.65) | 54.63 (20.30) | 1.699*** (0.325) |
| Urban | 67.2% | 94.0% | -26.8%*** |
| Has an Electric stove | 19.7% | 37.4% | -17.7% |
| Electricity consumption (September) | 179.11 (109.80) | 185.88 (98.39) | -6.77*** (1.946) |
| ***Has central delivery of*:** | | | |
| Gas | 70.1% | 52.2% | 17.8%*** |
| Heating | 70.3% | 77.4% | -7.2%*** |
| Hot water | 65.0% | 75.0% | -10%*** |
| Cold Water | 88.1% | 91.9% | -3.8%*** |

# Household's Socioeconomics

| **Variables** | **Control regions:** Percent of the Sample or Mean (standard deviation in parentheses) | **Treatment regions:** Percent of the Sample or Mean (standard deviation in parentheses) | **Difference in Means:** Standard error in parentheses |
|---|---|---|---|
| Household size | 2.743 (1.49) | 2.825 (1.42) | -0.083*** (0.021) |
| Household monthly income (RU) | 65190.51 (57276 | 65484.42 (45529) | 293.91 (775.07) |
| Receiving discounts for utilities | 28.3% | 27.7.0% | 0.6% |
| Receiving subsidies for utilities | 17.8% | 18.6% | 0.7% |
| Have Debt for Utilities | 7.6% | 7.1% | 0.5% |
| ***Education:*** | | | |
| Secondary | 33.4% | 29% | 4.3%*** |
| Professional-technical | 23.6% | 24.8% | 1.2%* |
| High education (MSc, BSc, DiS) | 24.5% | 26.7% | -2.2%*** |
| Other | 18.2% | 19% | 0.8% |

# Major Appliances

| | Control regions | Treatment regions | Difference in Means: |
|---|---|---|---|
| **Appliance:** | **Percent of the Sample** | | |
| Air Conditioner | 9.4% | 10.1% | -0.7%* |
| Dishwasher (automatic) | 3.8% | 2.6% | 1.2%*** |
| Refrigerator (no frost) | 58.2% | 61.5% | -3.4%*** |
| Washing machine (automatic) | 79.3% | 85.3% | 6%*** |
| Freezer | 13.7% | 22.2% | -8.5%*** |
| Microwave | 66.8% | 67.3% | 0.5% |

# Appliances purchase indicator

$IA_{it}$ - Binary indicator for the purchase of any major electric appliance within a 3 month

*"Has your family bought in the last 3 months any household appliances like: refrigerator, washing machine, vacuum cleaner, sewing machine, iron, food processor, and the like?"* *(*"Hse.ru. "Wave 19 Household Data File", 2010, pp. 205*)*

# Econometric Model (diff-in-diff)

$$IA_{it} = a_i + \tau_t + \boldsymbol{X}_{it} b_1 + b_2 lnP_{it} + ln\boldsymbol{S}_{it} b_3 + b_4 DiD + \varepsilon_{it}$$

$\boldsymbol{P_{it}}$ Price of electricity

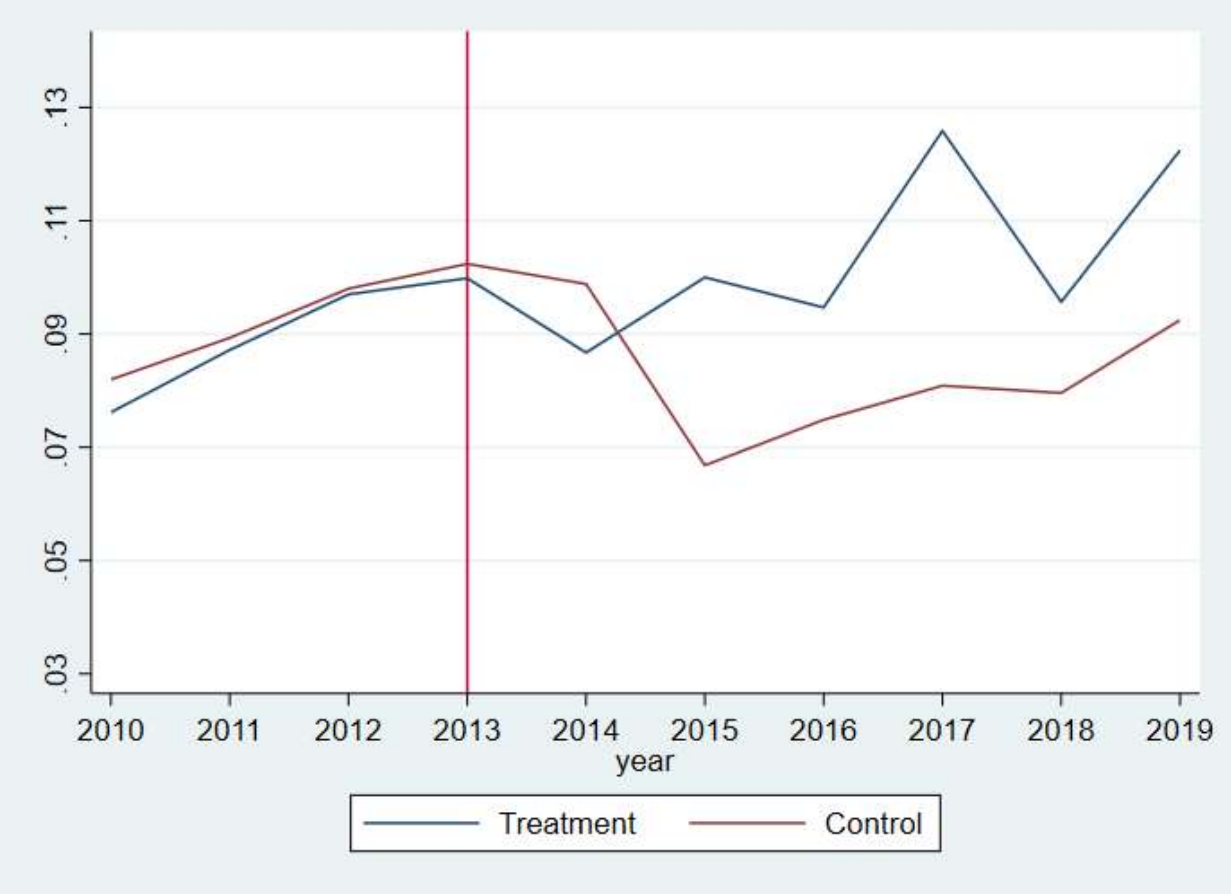
$\boldsymbol{S_{it}}$ Any benefits for the utilities

$\boldsymbol{X_{it}}$ Other household control variables e.g. income, HH-size

**DiD** The main variable of interests (diff-in-diff)

$\boldsymbol{a_i}$ and $\boldsymbol{\tau_t}$ are household and time fixed effects.

# Propensity to purchase major Appliances



# Placebo check

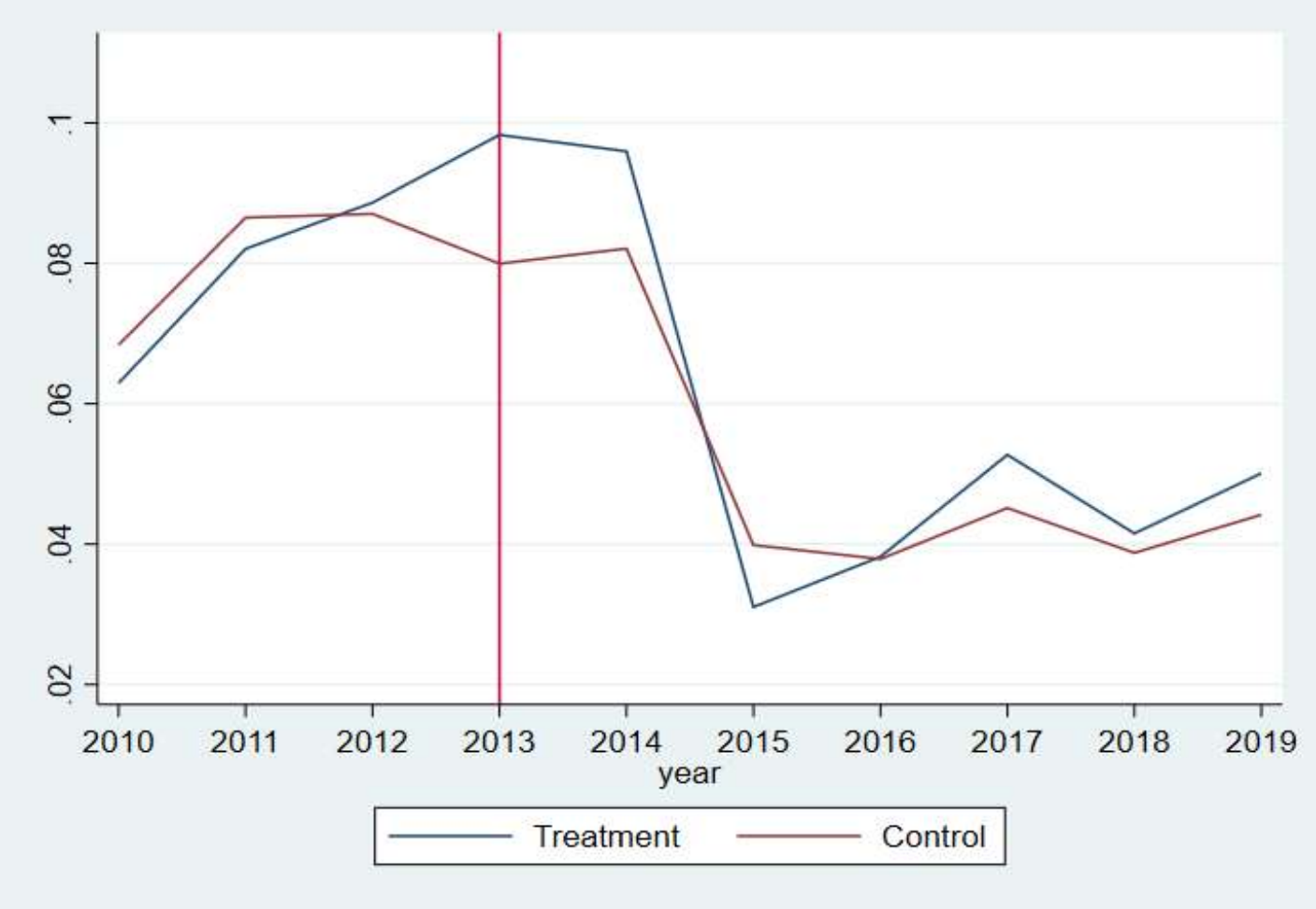
Another binary indicator is used as a placebo check based on the following question in RLMS-HSE:

*"Has your family bought in the last 3 months any recreational appliances like: TV, tape recorder, video, musical instruments, computer, camera and the like?"* (Hse.ru. "Wave 19 Household Data File", 2010, pp. 205).

# Placebo check

- The introduction of the IBR tariff scheme should not affect the purchase decision of recreational appliances.
- Ideally, we should observe change in the purchase of major (energy intensive) home appliances, and not the recreational appliances.

# Propensity to purchase recreational Appliances



# Unconditional DID estimates

**Unconditional DiD estimates for Propensity to purchase major electric appliances**

| | Pre-period | Post-period | Difference (post-pre) |
|---|---|---|---|
| T=1 | 0.0867 | 0.1034 | 0.0167 |
| T=0 | 0.09 | 0.0854 | -0.0046 |
| Diff-in-Diff | | | 0.0213** (0.0086) |

Robust standard error in parentheses $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

**Unconditional DiD estimates for Propensity to purchase recreational appliances (Placebo check)**

| | Pre-period | Post-period | Difference (post-pre) |
|---|---|---|---|
| T=1 | 0.0778 | 0.0586 | -0.0192 |
| T=0 | 0.081 | 0.053 | -0.028 |
| Diff-in-Diff | | | 0.0088 (0.0077) |

Robust standard error in parentheses $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

# Possibly Endogenies Prices

- In our case, the dependent variable is a binary indicator for the purchase of electric appliances, which should not result in a correlation between the electricity price and the error term in equation-1. Therefore, in this study the endogeneity concerns are minimal.
- However, to minimize any endogeneity concerns I also run the model above with instrumenting for the log of average price for electricity by the full tariff schedule.

# Coarsened Exact Matching

- The cem matching technique belongs to the newly developed class of Monotonic Imbalance Bounding'' (MIB) class of matching methods developed by Iacus et al., (2012) from which cem is derived.
- The cem estimator has several advantages over other matching techniques. It requires fewer assumptions and possesses more attractive statistical properties (King & Nielsen, 2019).
- As the measure of imbalance of the covariates between the groups, I use the overall imbalance indicator introduced by Iacus et al., (2008). It is based on the comprehensive imbalance measure L1, the difference between the multidimensional histogram of all pretreatment covariates in the treated group and that in the control group given by:
- $L_1(f, g) = \frac{1}{2}\sum_{l_1 \ldots l_k} | f_{l_1 \ldots l_k} - g_{l_1 \ldots l_k} |$

- Where $f_{l_1 \ldots l_k}$ and $g_{l_1 \ldots l_k}$ are the *k*-dimensional relative frequencies for the treated and control groups respectively calculated from the cross-tabulation of the discretized (coarsened) covariates.

| | FE | FE _matched | FE _2SLS | FE_2SLS _matched |
|---|---|---|---|---|
| DiD | 0.0224* | 0.0224* | 0.0228* | 0.0229* |
| | (0.013) | (0.013) | (0.013) | (0.013) |
| lnPrice | -0.0111 | -0.0120 | -0.0128 | -0.0137 |
| | (0.023) | (0.023) | (0.023) | (0.023) |
| lnIncome | 0.0463*** | 0.0471*** | 0.0463*** | 0.0471*** |
| | (0.004) | (0.004) | (0.004) | (0.004) |
| lnDiscounts | 0.0008 | 0.0007 | 0.0008 | 0.0007 |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| lnSubsidies | 0.0014** | 0.0013* | 0.0014** | 0.0013* |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| HHsize | 0.0032 | 0.0024 | 0.0032 | 0.0024 |
| | (0.003) | (0.003) | (0.003) | (0.003) |
| *N* | 53040 | 51608 | 53040 | 51608 |
| adj. $R^2$ | 0.02 | 0.02 | 0.02 | 0.02 |
| F | 15.3988 | 14.9204 | 15.4031 | 14.9256 |
| p | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ Note: year dummies are not displayed

# Conclusion

Considering the robust trend of newer appliances being more energy-efficient, I can suggest that consumers that purchase new electric appliances are also purchasing more energy-efficient appliances. If this proposition holds, the results of this paper can suggest that price-based energy policies are an effective tool not only in shaping the behavior of the household but also in shaping the households' behavior towards higher energy efficiency, which is considered one of the lowest-cost opportunities for reducing carbon emissions.

Thank you!
The paper is published in “Energies” journal:
https://doi.org/10.3390/en14216954