

Rational habits in residential electricity demand

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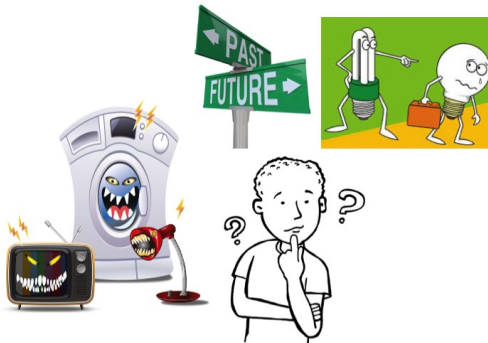
Paris, June 13, 2016



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Prices, income, weather, appliances, habits...

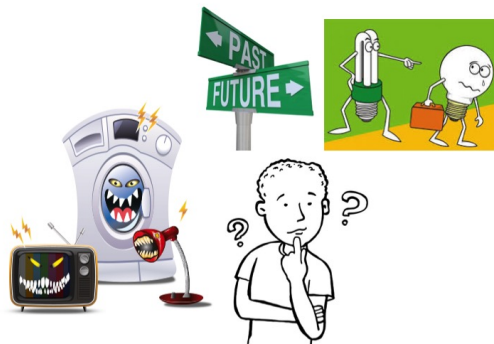
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What about expectations about future consumption?

Past and future consumption

Past consumption matters

- Appliance stock cannot be replaced immediately
- It takes time to change behavioral patterns

Do expectations matter?

- Rational agents have expectations for the future
- Expectations impact today's consumption decision

What are the potential implications for

- Demand estimation?
- Policy evaluation?

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Example: announcement of CO₂ tax for next year



source: cleantechnica.com

Two effects: Direct impact on next year's consumption.

But also: impact on **today's consumption**.

Impact on next year's consumption might be **underestimated!**

What we do in this paper

- Estimate residential electricity demand in the US using a panel of 48 states over 17 years
- Intuition: households consider the future in their consumption decision

Our methodology

- Apply concept of "rational habits" to energy demand
- Include future consumption in demand estimation

The results

- Future consumption matters
- Potential important implications for demand estimation and policy evaluation

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Literature residential electricity demand (aggregate data, no info on capital stock)

Static model of electricity demand

- Immediate adjustment of appliance stock and habits
- Short-run analysis
- Azevedo et al.(2011); Cebula et al.(2012); Eskeland and Mideska (2010)

Dynamic partial adjustment model:

- Sluggish adjustment of appliance stock and habits
- Short- and long-run analysis
- Alberini and Filippini (2011); Paul et al.(2009); Bernstein and Griffin (2005)

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Rational habits

Rational habits = forward looking behaviour

Idea from health economics:

- Consumers anticipate future consequences of current alcohol and cigarette consumption
- Expected future consumption has an impact on current consumption
- Becker et al.(1994); Baltagi and Griffin (2002)

Rational habits and gasoline consumption:

Scott (2012)

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The rational habits model for electricity demand

Households maximize utility from energy services:

- E.g. Light, hot water, cooling, entertainment
- Energy services are produced from electricity and el. appliances

Household utility at time t :

$$U_t = u(e_t, e_{t-1}, c_t; x_t)$$

where e_t is current electricity consumption, e_{t-1} is past electricity consumption, c_t all other consumption goods, and x_t environmental factors.

Lifetime utility function of the household:

$$\sum_{t=1}^{\infty} \delta^{t-2} U_t = \sum_{t=1}^{\infty} \delta^{t-1} u(e_t, e_{t-1}, c_t; x_t)$$

where $\delta = (1 + r)^{-1}$ is the constant rate of time preference and r is the interest rate.

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Appliances and habits

Appliance stock equation:

$$A_t = (1 - \rho)A_{t-1} + e_{t-1}$$

where ρ is the depreciation rate of the appliance stock.

- Appliance stock can be approximated by accumulated past consumption

Stock of habits

- Habituated to certain level of consumption and appliances
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Today's consumption as function of past and future consumption

Assuming appliance or habits stock fully depreciates after one period, maximisations problem is:

$$\sum_{t=1}^{\infty} \delta^{t-1} u(e_t, e_{t-1}, c_t; x_t)$$

s.t.

- $e_0 = E_0$
- $\sum_{t=1}^{\infty} \delta^{t-1} (c_t + P_t e_t) = W^0$

Solution of the FOC leads to the first-difference equation:

$$e_t = \theta e_{t-1} + \delta \theta e_{t+1} + \theta_1 P_t + \theta_2 x_t + \delta \theta_3 x_{t+1}$$

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Empirical model

We modify the first-difference equation to obtain:

$$e_{it} = \beta_0 + \beta_1 e_{it-1} + \beta_2 e_{t+1} + \beta_3 P_{it} + \beta_4 PG_{it} + \beta_5 Y_{it} \\ + \beta_6 HDD_{it} + \beta_7 CDD_{it} + \beta_8 HS_{it} + v_{it}$$

e_{it} : consumption today

P_{it} : price of electricity

PG_{it} : price of gas

Y_{it} : income

HDD_{it} , CDD_{it} : heating and cooling degree days

HS_{it} : numbers of detached houses

Instruments 2SLSFE specification

Following Becker et al. (1994) and Baltagi et al. (2002), we use the following instruments for the lag and lead of consumption as well as the price of electricity:

- Input prices of coal and gas for the electricity sector
- Two-period spatial lags and leads of the price of electricity
- One-period lag and lead of heating degree days

Estimation results 2SLSFE specification

Instrumented:	e_{t-1}, e_{t+1}		e_{t-1}, e_{t+1}, P_t	
	(1)	(2)	(3)	(4)
e_{t-1}	0.432***	(4.90)	0.422***	(4.70)
e_{t+1}	0.221**	(2.85)	0.206**	(2.80)
P_t	-6787.8***	(-4.19)	-8196.7**	(-2.60)
PG_t	-1243.3	(-0.12)	-121.5	(-0.01)
Y_t	0.0309**	(2.87)	0.0325**	(3.02)
HS_t	-562.0**	(-3.11)	-588.6**	(-3.29)
HDD_t	0.185***	(10.16)	0.182***	(9.21)
CDD_t	0.641***	(16.84)	0.635***	(16.76)
N	611		611	
Underidentification test	41.495	[0.0000]	42.007	[0.0000]
Weak identification test	7.096		6.164	
5% critical value	3.78		NA	
Hansen J statistic	9.848	[0.1312]	10.210	[0.1161]

Short and long run elasticities

All elasticities are negative and shown in absolute values.

	Model	Short run	Long run
FE2SLS	(1)	0.1077	0.2087
FE2SLS	(2)	0.1254	0.2352

Short run: residential electricity demand inelastic

Immediate adjustment appliances stock and behavioural habits is costly

Long run: residential electricity demand more elastic

Agents have more time to adapt habits and replace equipment

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Conclusions

Understanding demand:

- Knowing the factors influencing demand is crucial for policy makers
- Especially true for policies targeting energy savings
- DPA models may lead to biased estimates of policy impact

Future consumption impacts current consumption:

- We found evidence for forward looking behaviour
- Effects of long-term policies today may also depend on anticipated effect on future consumption
- Effect of short-term policies might be negligible

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Further ideas

- Work with household-level data
- Behavioural aspects: does forward-looking mean households are completely rational?
- What are the channels that let households take action today in anticipation of future?

Thank you for listening!

You can also contact me at:
bettina.hirl@usi.ch

Estimation results FE specification

	<i>FE</i>	
e_{t-1}	0.476***	(14.97)
e_{t+1}	0.309***	(10.84)
P_t	-5602.4***	(-3.80)
PG_t	-10921.8	(-1.08)
Y_t	0.0114	(1.36)
HS_t	-306.9*	(-2.28)
HDD_t	0.181***	(9.72)
CDD_t	0.724***	(14.18)
<i>Constant</i>	182.5	(0.51)

N	719	
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