Cost Misperceptions and Energy Consumption

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Motivation

- We are interested in understanding the drivers of households' energy consumption
- Energy consumption relevant due to associated externalities
- From a conceptual view, energy demand is determined by
  - Marginal benefits of energy
  - Marginal costs of energy
- We concentrate on marginal costs of energy

Motivation

- Energy costs are given by households' energy bill
- Energy bill is paid after consumption has taken place, i.e. costs occur in the future
- Two elements determine households' valuation of marginal energy costs
  1. Time discounting
  2. Energy price

Motivation

- Energy costs may be misperceived for two reasons
  1. Present bias
  2. Uncertainty

$\longrightarrow$ Households themselves desire different consumption levels

$\longrightarrow$ To what extent do cost misperceptions relate to energy consumption?

Motivation: present bias

- From ex ante perspective: household wishes to consume less energy (eat less fast food, smoke less cigarettes...)
- Once future plans become present: future costs of energy are less important than ex ante
- Consequence: overconsumption of energy compared to ex ante wishes

Motivation: uncertainty

- Many households do not know energy prices ([Blasch et al., 2017], [Brounen et al., 2013])
- Consumption decision depends on the energy prices they expect to pay
- If expected energy price deviates from true energy price: households consume too much or too few energy compared to a decision under certainty

The model: structure

- Household lives $t = 1, ..., T$ periods.
- Flow utility:

$$u_t = v(s_t) + x_t$$

- Budget restriction: $Y = x_t + p_{t-1}s_{t-1}$
- Electricity price p_t is perceived as ex ante uncertain

$\longrightarrow$ Periods are connected through the energy bill

The model: time discounting

- Decision utility:

$$\mathbb{E}(U_t) = u_t(s_t, x_t) + \beta \sum_{i=t+1}^{T} \delta^{i-1} \mathbb{E}(u_i(s_i, x_i))$$

- $\beta \leq 1$: present bias parameter, $\delta \leq 1$: exponential discounting parameter
- β only relevant in decisions involving the present

The model: optimal energy consumption

- FOC on s_t:

$$\frac{\partial v(s_t)}{\partial s_t} - \delta\beta\mathbb{E}(p_t) = 0$$

$\longrightarrow$ s_t^* depends on present bias parameter β and expected price $\mathbb{E}(p_t)$

Related literature

- Energy consumption and time preferences: [Fischbacher et al., 2015], [Bradford et al., 2017]
- Energy consumption and energy literacy: [Blasch et al., 2017], [Brounen et al., 2013]

This paper

To what extent do cost misperceptions relate to energy consumption?

- 581 face-to-face interviews
- Revealed energy consumption: participants showed their last electricity bill to interviewer
- Run experiments to elicit incentivized measures of present bias and price beliefs of each participant
- Sample is representative given federal state, population size, age, gender

Estimating time preferences

To measure time preferences, we confront participants with three decisions sets:

1. Decisions of either receiving 100 Euro today or a larger amount in one month
2. Decisions of either receiving 100 Euro in one month or larger amount in two months
3. Decisions of participating in a lottery with equal chances of winning 300 Euro/ 0 Euro or of receiving a safe payment

Estimating time preferences

- Recall: $U_0 = u_0(e_0) + \beta \sum_{i=t+1}^{T} \delta^{i-1} u_i(e_i)$
- We assume $u(e) = e^{\alpha}$
- α: risk aversion parameter
- $\alpha = 1$: risk neutral, $\alpha < 1$: risk averse, $\alpha > 1$: risk seeking

Estimating time preferences

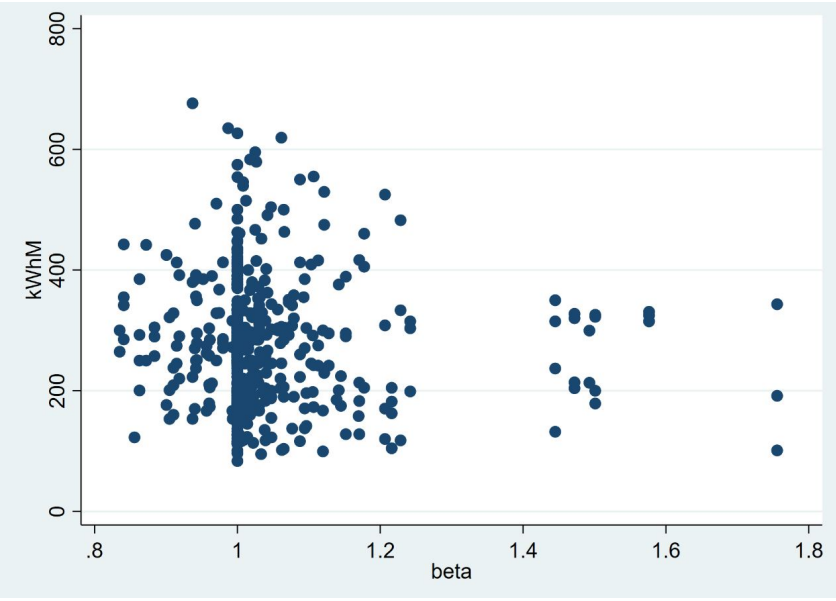
- Participants are indifferent when they are offered $\bar{e}^i$ at decision set i
  1. $(100)^\alpha = \beta\delta(\bar{e}^1)^\alpha$
  2. $\beta\delta(100)^\alpha = \beta\delta^2(\bar{e}^2)^\alpha$
  3. $0.5(300)^\alpha + 0.5(0)^\alpha = (\bar{e}^3)^\alpha$
- Three equations and three unknown parameters

$\longrightarrow$ Exclude 15 outliers who were indifferent with safe payment of 275 Euro and 295 Euro

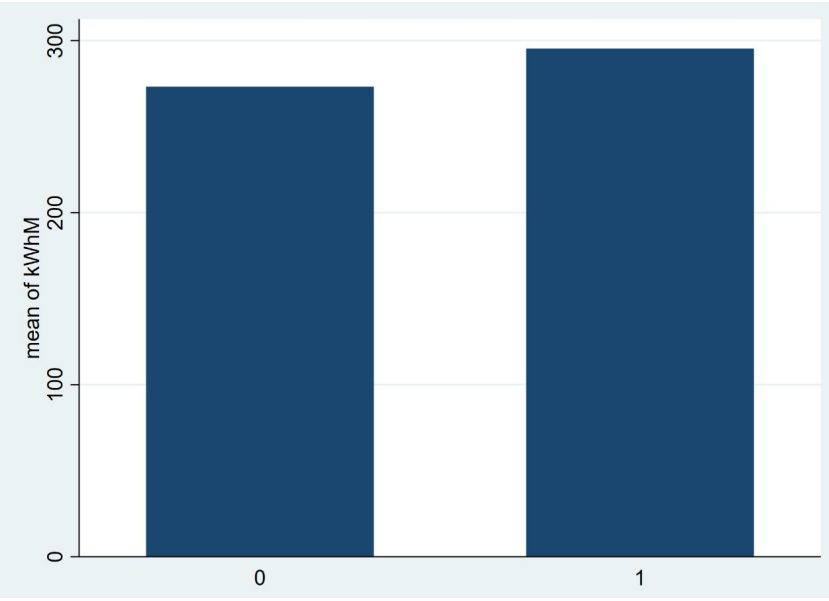
Estimating price expectations

- Explanation of pricing system (base price, retail price of energy)
- 'Now we ask you for a point estimate: which retail price do you think, did you pay in the last contracting year?'
- Payment higher, the more precise the estimate

Strong future bias in β-values



(a) Scatterplot: kWh and β



(b) Barchart: kWh and PresentBias

Empirical model

To what extent do cost misperceptions relate to energy consumption?

1. Present Bias: Dummy for $\beta < 1$
2. Uncertainty: Dummy for $\mathbb{E}(p) < p$: $\mathbb{E}(p)_{min}$

$\longrightarrow$ Both groups will consume more energy than without misperceptions

$$\begin{aligned} log(kWh_i) =& \gamma_0 + \gamma_1 \delta_i + \gamma_2 PresentBias + \gamma_3 \mathbb{E}(p)_{min} \\ &+ \boldsymbol{\gamma_4 X_i} + \epsilon_i \end{aligned}$$

Control variables

1. Preferences: risk aversion, environmental preferences (from 7 statements)
2. Household characteristics: number of persons in household, size of household, number of children in household, true energy price
3. Sociodemographics: age, gender, education, employment, income
4. Investment decisions: equipment with leds

Regression results

	(1)	(2)	(3)	(4)	(5)	(6)
δ	-0.02	-0.02	-0.02	-0.04	-0.04	-0.04
	(0.02)	(0.02)	(0.05)	(0.03)	(0.04)	(0.04)
PresentBias	0.09**	0.11**	0.10**	0.07**	0.08**	0.09**
	(0.04)	(0.05)	(0.05)	(0.03)	(0.03)	(0.03)
$\mathbb{E}(p)_{min}$		-0.03	0.02	-0.02	0.00	0.00
		(0.06)	(0.06)	(0.04)	(0.04)	(0.04)
Controls 1			X	X	X	X
Controls 2				X	X	X
Controls 3					X	X
Controls 4						X
N	519	448	389	364	313	308

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Regression results

Two main results on misperceptions and energy consumption:

1. Present bias significantly correlates with energy consumption
2. Price uncertainty is not correlated with energy consumption

Robustness

- Present bias coefficient stays significant after including controls
- Results robust towards non-parametric estimations without functional assumptions

Sum up

1. To what extent do energy costs misperceptions relate to energy consumption?
2. Run incentivized experiments with 580 subjects to estimate present bias and price uncertainty
3. First evidence that present bias correlates with revealed energy consumption


Blasch, J., Boogen, N., Filippini, M., and Kumar, N. (2017).
Explaining electricity demand and the role of energy and investment literacy on end-use efficiency of swiss households.
Energy Economics.


Bradford, D., Courtemanche, C., Heutel, G., McAlvanah, P., and Ruhm, C. (2017).
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Journal of Risk and Uncertainty, 55(2-3):119–145.


Brounen, D., Kok, N., and Quigley, J. M. (2013).
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