Technology adoption, inattention and heuristic decision-making: Evidence from a UK district heating scheme

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PART I: Presentation Overview

PART I: Background

- Intro
- Energy efficiency paradox
- Rational inattention
- Heuristics

PART II: Survey data and empirical methodology

- The data
- The experiment
- The empirical methodology

PART III: Analysis

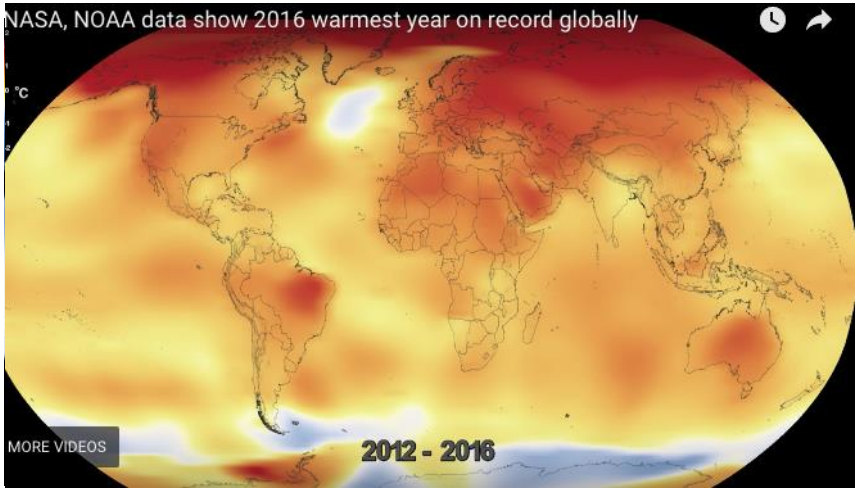
- Results

PART IV: Conclusion and policy implications

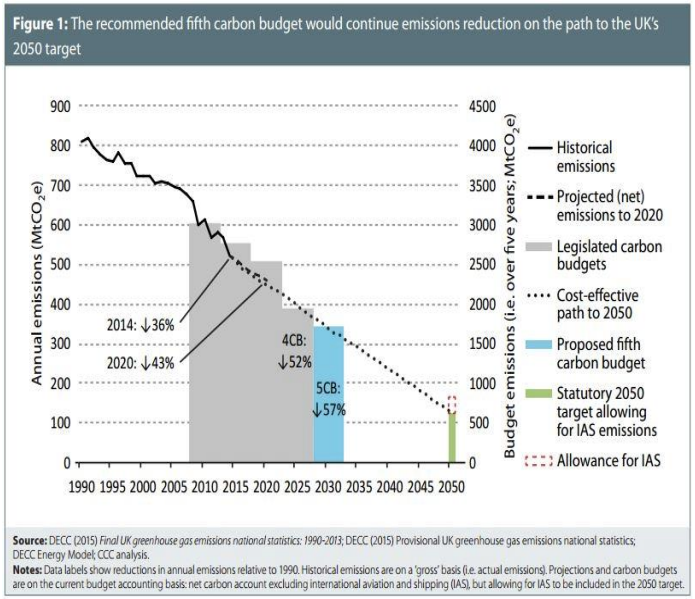
PART V: Q&A

PART I: Why energy efficiency?

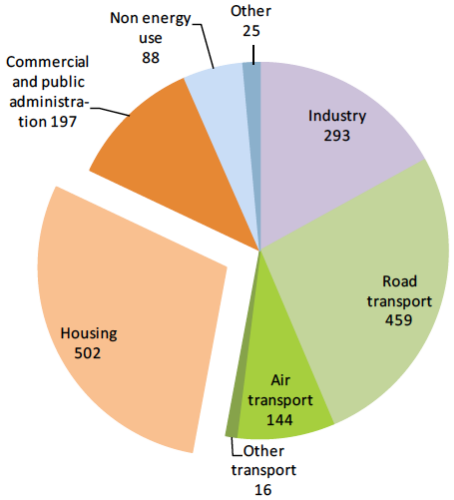
Temperature's rising (Mobb Deep, 1995)



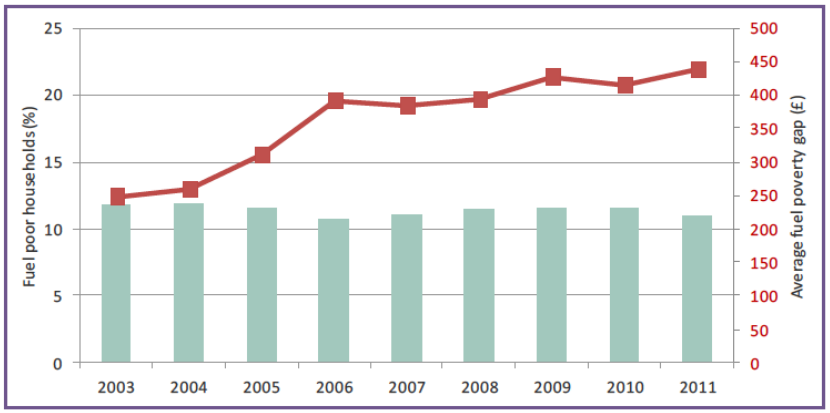
UK Climate Change Act (2008)



Domestic consumption



Fuel poverty



PART I: Energy efficiency paradox
Classic Approach

The energy efficiency paradox:

- An observed rate of uptake of energy efficient technologies that is too low
  (Gillingham, Newell and Palmer, 2009, pp.7)
- I.e. energy efficient technologies that would pay off are not adopted
  (Newell, Stavins and Gerarden, 2015, pp.1)

What explains the paradox?

- Internal discount rates are much higher than market rate of interest
  (Hausman, 1979, pp. 51)
- Discount rate for central heating ranges between 6 and 36%
  (Train, 1985)

What else explains the paradox?

- Traditional market features (e.g. un-priced externalities)
- Behavioural factors?

PART I: Energy efficiency paradox - The Behavioural Approach

Does inattention explain the paradox?

- Consumers are rationally inattentive: high search costs > benefits

  (Sallee, 2015)

- Limited empirical evidence in energy market: a gap we aim to address

  (Allcott, 2011; Palmer and Walls, 2015)

- Micro (and macro) policy can be slow and ineffective

  (Reis, 2006; Sims, 2003)

Does heuristics explain the paradox?

- Consumers adopt simple 'rules-of-thumb' in the energy market (e.g. MPG)

  (Larrick and Soll, 2008; Attari et al, 2010; Allcott, 2011)

- Qualitative evidence is mixed over use of payback period

  (Kempton and Montgomery, 1984; Turrentine and Kurani, 2007)

- More evidence is needed…(Newell, Stavins and Gerarden, 2015)

PART I: Hypotheses

Hypotheses

- **Hypothesis 1:** Consumers discount too heavily the financial benefits accrued from the use of energy efficient technologies, i.e. their internal discount rates is significantly higher than the market rate of interest.

- **Hypothesis 2:** The adoption of energy efficient technologies is negatively affected by consumers' inattention.

- **Hypothesis 3:** A high number of years required to pay back the outlays for an energy efficient technology reduces the consumers' likelihood to install it.

PART II: The Data & Methodology

District heating:

- Birmingham district heating scheme: reduce prices and fuel poverty

The sampling strategy:

- Telephone survey (May-June 2014) carried out by IFF Research
- Random Digit Dialling and proportionate sampling (self-weighted)
- 20 minutes average, 67 questions max.
- 784 complete questionnaires

The sample:

- Representative of Birmingham and (to a lesser extent of England) across a wide range of demographic, housing and energy efficiency characteristics
- Less representative of young, single and living in flats/apartments

PART II: The Data & Methodology

Stated preference - Contrastive Vignette Technique (CVT):

- Simulates a real life decision-making 'scenario'
  (Wason, Polonsky and Hyman, 2002)
- Useful when observed behaviour is infeasible
  (Caro et al., 2009)
- Use between variation in responses to a systematic change in the scenario
  (Alexander and Becker, 1978; Burstin, Doughtie and Raphaeli, 1980)
- Allows for systematic variation of three cost dimensions (yearly bill; installation; and maintenance costs) across three levels
- Evaluate the effect of price and profitability of the DH investment

Other CVT studies:

- Implemented in studies of crime, marketing, racism, managerial decisions, network effects, happiness, health care, social norms, elderly residential decisions, hiring, job behaviour and job settings and nudges.

PART II: The Data & Methodology

Classic Model: Life time cost

$$U_i = b_1 UC_i + b_2 AC_i + X_i' g + e_i$$

where, $$\text{LTC}_i = \text{UC}_i + \sum_{t=1}^{T} \frac{AC_i}{(1+r)^t}$$

$$UC_i = \frac{1}{b_1}\left[U_i - (b_2 AC_i + X_i' g + e_i)\right]$$

$$\frac{\Delta UC_i}{\Delta AC_i} = -\frac{b_2}{b_1}$$

$$\therefore \frac{b_1}{b_2} = \left[\frac{1-(1+r)^t}{r}\right]^{-1}$$

PART II: The Data & Methodology

Ordered Probit

$$P(D_i = j) = \Phi(\alpha_j - \beta_1 UC_i - \beta_2 AC_i - \sum_{j=1}^{3} \delta_j(IN_{1i}) - \sum_{j=1}^{3} \lambda_j(IN_{2i}) - \sum_{j=1}^{4} \xi_j(PB_i) - X_i'\gamma) -$$

$$\Phi(\alpha_{j-1} - \beta_1 UC_i - \beta_2 AC_i - \sum_{j=1}^{3} \delta_j(IN_{1i}) - \sum_{j=1}^{3} \lambda_j(IN_{2i}) - \sum_{j=1}^{4} \xi_j(PB_i) - X_i'\gamma)$$

$$And, \quad D_{ij} = \begin{cases} 1 \; if \; 'Definitely \; Unlikely' \\ 2 \; if \; 'Unikely' \\ 3 \; if \; 'Not \; Sure' \\ 4 \; if \; 'Likely' \\ 5 \; if \; 'Definitely \; Likely' \end{cases}$$

PART II: The Data & Methodology

Inattention variables

$$IN_1 = \begin{cases} 1 = \textit{Direct Methods of Information} \\ 2 = \textit{Indirect Methods of Information} \\ 3 = \textit{No Information} \end{cases} \qquad \text{where, } d_3 < d_2 < 0$$

$$IN_2 = \begin{cases} 1 = \textit{Low Expected Savings} < £300 \\ 2 = \textit{High Expected Savings} > £300 \\ 3 = \textit{Unsure or Doesn't Know} \end{cases} \qquad \text{where, } l_3 < l_2 < 0$$

Decision heuristics – payback period

$$\textit{Payback}_i = \frac{UC_i}{S_i} = \frac{UC_i^{DH}}{AC_i^{C} - AC_i^{DH}} \qquad \textit{where, } PB_i = \textit{quartiles of ln(payback)}$$

PART II: The Data & Methodology

Table 1: Decision to Connect

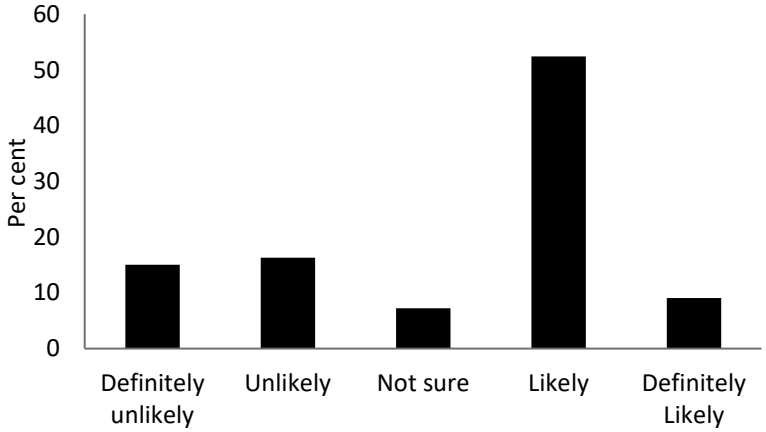


Table 2: Main descriptive statistics

Table 6: Income and socio-economic variables

	Sample					
Variable	N	Mean	S.D.	Median	Min	Max
Income variables						
Annual income	645	22994	18396	18462	2830	201460
Annual energy costs						
Annual gas bill	683	711.79	431.25	611.56	0	3577.82
Maintenance costs	558	224.01	893.44	50	0	15000
Low-income-high-cost indicator						
LILC	784	0.12	0.33	0	0	1
LIHC	784	0.11	0.31	0	0	1
HILC	784	0.23	0.42	0	0	1
HIHC	784	0.22	0.41	0	0	1
UNSURE BILLS/INCOME	784	0.33	0.47	0	0	1
Demographic variables						
NON-OWNER	784	0.65	0.48	0	0	1
DEGREE	784	0.30	0.46	0	0	1
ELDERLY	784	0.35	0.48	0	0	1
SINGLE	784	0.21	0.41	0	0	1
INACTIVE	784	0.36	0.48	0	0	1
DAMP	784	0.67	0.47	1	0	1
KNOWS-DH	784	0.15	0.36	0	0	1

PART III: Results

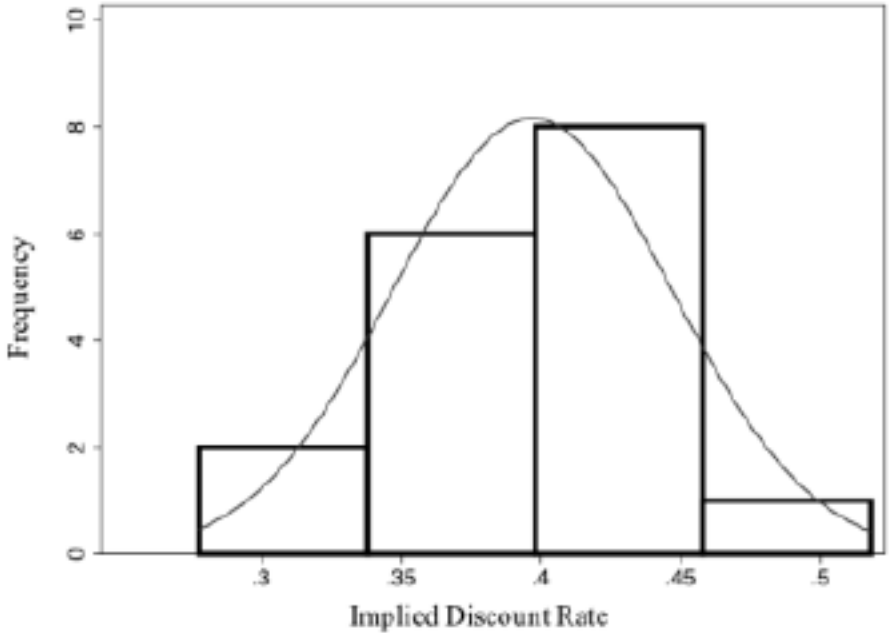
Table 7: Estimated coefficients and implied discount rates for the 'decision to connect' to district heating

	Ordered probit coefficients					
Model (m)	(1)	(2)	(3)	(4)	(5)	(6)
$\beta_{INTERFACE} / \beta_{DH\ BILL}$	0.367†	0.521*	0.293†	0.419**		
	(0.250)	(0.290)	(0.186)	(0.211)		
P-VALUE	0.141	0.073	0.115	0.047		
IMPLIED DISCOUNT RATE	0.358	0.518	0.278	0.412		
Inattention variables						
POSTAL INFORMATION	-0.304***		-0.305***		-0.309***	
	(0.109)		(0.108)		(0.108)	
INDIRECT INFORMATION	-0.644***		-0.634***		-0.653***	
	(0.132)		(0.131)		(0.131)	
INATTENTIVE-A	-1.691***		-1.657***		-1.725***	
	(0.243)		(0.241)		(0.243)	
HIGH UNOBSERVED COSTS	-0.210**		-0.169		-0.219**	
	(0.105)		(0.104)		(0.105)	
INATTENTIVE-B	-0.645***		-0.645***		-0.621***	
Observations	784	784	784	784	784	784
Log-likelihood	-930.01	-992.10	-939.106	-1000.80	-937.35	-1010.10
Pseudo R^2	0.127	0.070	0.119	0.061	0.121	0.052
LR χ^2	271.66***	147.49***	253.47***	130.08***	256.98***	111.49***
LR χ^2(Ho: m=1 vs. m=2,…,6)	-	124.17***	18.19***	141.57***	14.67**	160.17***
AIC	1920.025	2034.197	1928.212	2041.60	1924.7	2050.19
BIC	2059.957	2150.807	2044.822	2134.89	2041.31	2120.16
Df	30	25	25	20	25	15
Residual Pr(Skewness)	0.892	0.895	0.605	0.794	0.879	0.951
Residual Pr(Kurtosis)	0.264	0.521	0.399	0.307	0.281	0.329
Residual Normal (p-value)	0.892	0.805	0.612	0.573	0.552	0.619
Link test $x'\hat{\beta}^2$ (p-value)	0.396	0.878	0.229	0.963	0.413	0.494

*Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses. See Table A.3 Appendix A3 for controls and cut-off points.*

PART III: Results

Figure 1: Spread of the implied discount rate



Mean: 0.397 SD: 0.05 Models: 16

Robustness checks:

- Heterogeneous choice, partial parallel regression and more…

PART III: Marginal Effects – Definitely Likely

LTC Marginal effects:

- £100 increase in annual DH bill → decrease by 1.3%
- £100 increase in upfront DH cost → decrease by 0.1%

Heuristics:

- 2 to 3.5 years → decrease by 6.7% points (c.f. < 2 years)
- 3.5 to 6 years → decrease by 12% points (c.f. < 2 years)

Inattention:

- Indirect Information→ decrease by 5.7% points (c.f. Direct)
- No information→ decrease by 14% points (c.f. Direct)
- Not sure of expected savings → decrease by 6% points (c.f.<£300)

Socio-economic MEs:

- Single, unemployed, aged 60+ and no degree decrease probability by 2-2.5%
- All of the above are significant at the 5% (individual/joint) level of significance

PART IV: Conclusion

Key insights:

Do we observe an energy efficiency paradox which is likely to hinder the expansion of energy efficient technologies in the UK?

- Yes, owner discount rate around 40% but…
- Trade-off between upfront and annual costs weaker after controlling for heuristics and inattention

Is the adoption of energy efficient technologies negatively affected by consumers' inattention?

- Inattentive consumers have 6% points lower probability to be 'definitely likely'

Are consumers less likely to install energy efficiency technology following an increase in the number of years of payback?

- Probability highest between 0-2 years
- Probability reaches minimum up to around 7-8 years

PART IV: Policy Implications

- Discount rates between 30-40% on average for the group most likely to connect (i.e. owners) for district heating
- Our findings suggest consumer behaviour is more in line with simple 'rules of thumb' and 'inattention'
- Energy labels → targeting 'payback' period
- Software to help calculate Net Present Value → make costs of inefficient technology salient at point of purchase
- Health and safety should not be compromised

But also:

- Socio-economic factors: high-income, married and owners of property most likely to connect
- Targeted subsidies/grants needed if district heating were to expand to low-income households

PART V: Q&A

THANK YOU