Households' Preferences and Willingness-To-Pay for Heating System Attributes

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Introduction

➢ Decarbonisation of heating in residential sector is among the UK strategies to achieve net zero emissions by 2050.

➢ Almost a third of total UK carbon emissions is from heating for homes and workspaces. Residential heating, account for about 60% of the UK's heat consumption.

➢ Heating systems should be replaced with low-emission alternatives: government bans for gas boilers, encouraging heat pumps and electric boilers, heat networks.

➢ Demand-side analysis is necessary to inform the support of such plans.

➢ How technology attributes affect household choice?

➢ Scarpa and Willis (2010): for UK capital cost significant, Schleich et al 2020: rebates have a considerable impact in Poland and Sweden but not in the UK, Lang et al 2021: For Switzerland energy efficiency more significant than capital cost.

➢ This study applies choice experiment for heating technologies for Surrey Country Council in UK.

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Overview of heating systems in the UK

DESNZ Public Attitudes Tracker 2023, 3573 respondents in winter 2022.

Residential main heating system in the UK 2022

Heating systems	Percent
Gas (central heating)	57
Electric (portable heaters)	11
Solid fuel & wood	7
Electric (storage)	5
Oil (central heating)	4
Electric (not storage)	4
Natural gas	4
Communal or district heating (heat network)	2
Heat pump	1
Other	2

- Gas central heating is the most popular heating technology (57%) while heat networks and heat pumps only make up 3% of households' heating system.

- Gas boilers, heat pumps and heat networks have very different features which affects consumer's choice.

- Government encourages heat pumps and heat networks for decarbonization of heating.

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Data

- Data is collected through an online survey using SurveyEngine platform.

- Surrey County Council residential sector-homeowners

- Survey was carried out in July/August 2022

- The survey was designed in two parts:

  - Socio-demographic and property questions

  - Choice experiment (8 tasks)

- We ran the first pilot survey with 11 respondents. After revising the survey, we then ran a second pilot with 12 respondents.

- In total, 79 households completed the final survey

- Our survey is representative of gender, age and location in Surrey County Council.

Gender	Percent	Property	Percent
Male	53.16	Detached House	31.65
Female	46.84	Semi-Detached House	26.58
Marital status	Per cent	Terraced or End-Terraced House	18.99
married/Civil partnership	58.23	Flat	16.46
Single	29.11	Cottage	1.27
divorced/separated	6.33	Bungalow	3.80
Other	6.33	Other	1.27
Age	Per cent	**Children**	Per cent
less than 20	1.27	None	53.16
20-29	20.25	1	22.78
30-39	22.78	2	16.46
40-49	18.99	3	6.33
50-59	17.72	4 and above	1.27
60-69	8.86	**Adults**	Per cent
70 and up	10.13	1	32.91
Education	Per cent	2	46.84
Below High School (BHS)	1.27	3	17.72
High School	17.72	4 and above	2.53
A-Level or equivalent	24.05	**EPC rating**	Per cent
Bachelor's Degree	29.11	A	17.72
Master's Degree	20.25	B	12.66
PhD or higher	6.33	C	20.25
Other	1.27	D	15.19
Employment	Percent	E	5.06
Employed full-time	65.82	F or G	1.27
Employed part-time	7.59	Do not know	27.85
Unemployed	5.06	**Location**	Per cent
Self-employed	6.33	Elmbridge Borough Council	12.66
Retired	15.19	Epsom and Ewell Borough Council	16.46
Income	Percent	Guildford Borough Council	15.19
Less than £25,000	16.46	Mole Valley District Council	3.80
£25,000 to £3500	20.25	Reigate and Banstead Borough Council	11.39
£35,000 to £50000	25.32	Runnymede Borough Council	5.06
£50,000 to £70000	13.92	Spelthorne Borough Council	2.53
£70,000 to £100000	16.46	Surrey Heath Borough Council	10.13
£100,000 to £200000	5.06	Tandridge District Council	7.59
More than £200,000	2.53	Waverley Borough Council	8.86
		Woking Borough Council	6.33

Attributes and levels for the choice experiment

Attributes	Levels
Investment cost, including installation (£)	2500
	10000
	20000
	0
Annual fixed cost (e.g., standing charge, connection fee) (£)	100
	165
	350
	650
Annual variable fuel cost (£)	400
	700
	1000
Annual CO$_2$ emissions	Very low
	Low
	Medium
	High
	Very high
Grant option available (share of a grant from investment cost)	0
	30%
	50%
Energy Efficiency	Medium
	Very high
	High
Energy supplier switching option	No
	Yes

An illustrative example of a choice task

	Option 1	Option 2	Option 3
Investment costs, including installation (£)	10000	20000	0
Annual fixed costs (e.g., standing charge, connection fee) (£)	650	100	165
Annual variable fuel costs (£)	1000	400	700
Annual CO2 emissions	Medium	High	Very high
Grant option available (share of a grant from investment costs)	30%	0	50%
Energy efficiency	Medium	Very high	High
Energy supplier switching option	No	Yes	No
Which option would you choose?	Option 1	Option 2	Option 3

Each of the 79 respondents had 8 choice tasks, so total number of observations was 632 for model estimation.

Methodology: mixed logit

$$U_{ijt} = V_{ijt} + \varepsilon_{ijt}$$

$$U_{ijt} = A'_{ijt}\beta_i + w'_{ijt}\delta + Z'_i\gamma_j + \varepsilon_{ijt}$$

$$P_{ijt} = \frac{\exp(\lambda V_{ijt})}{\sum_{l=1}^{J}\exp(\lambda V_{ilt})}$$

$$WTP = -\frac{\delta_{attribute}}{\delta_{price}}$$

- i: consumer, j: alternative, t: task
- U: utility
- V: systematic part of the utility (observable factors)
- ε is a random part that captures the unobserved variability
- w: attributes
- Z: Scio-demographic and property variables
- P: conditional probability of j
- WTP: willingness to pay

Results

Mixed logit model estimation: the effect of attributes on heating choice

Alt-specific variables	Coeff. (Std. Err.)	WTP
Investment cost	-6.83e-05*** (1.12e-05)	--
Variable costs	-0.000256 (0.000225)	-3.754
CO_2: Low vs very low	0.227 (0.147)	3322.3821
CO_2: Med. vs very low	-0.0782 (0.172)	-1145.5593
CO_2: High. vs very low	-0.244 (0.182)	-3567.8302
CO_2: VH. vs very low	-0.344* (0.190)	-5034.6105
Grant: 30% vs 0	0.123 (0.105)	1798.5168
Grant: 50% vs 0	0.174 (0.114)	2540.8067
Energy eff.: High vs medium	0.283** (0.128)	4136.5198
Energy eff.: Very high vs medium	0.270** (0.116)	3952.4744
Switching: Yes, vs no	0.302*** (0.107)	4420.9165
Fixed costs	-0.000328 (0.000233)	-4.8009

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Individual-specific variables	Heat pump	Heat network	Individual-specific variables	Heat pump	Heat network
Gender female vs male	-0.443*	-0.0574	HH size: medium vs small	-0.0324	-0.361
Edu. High school vs BHS	-0.592	-0.954**	HH size: large vs small	0.401	0.758**
Edu. A level Vs BHS	-0.644	-0.840**	Property type: 2 vs 1	0.0095	0.208
Edu. Bachelor's vs BHS	-0.376	0.0627	Property type: 3 vs 1	0.854**	0.747*
Edu. Master's vs BHS	-0.0986	-0.245	Property type: 4 vs 1	0.138	0.303
Edu. PhD/higher vs BHS	-0.799*	-0.535*	EPC_cat: CD vs AB	0.321	0.290
Edu. Other vs BHS	2.171***	-0.287	EPC_cat: EFG vs AB	1.294*	2.198***
Income: level 2 vs level1	0.0911	-0.0285	EPC_cat: DontK vs AB	0.202	0.863**
Income: level 3 vs level1	0.414	0.311	Constant	0.117	-0.437
Income: level 4 vs level1	-0.317	-0.643			
Income: level 5 vs level1	-0.143	-0.518			
Income: level 6 vs level1	0.987	0.796*			
Income: level 7 vs level1	0.842	1.410			

Mixed logit model estimation: the effect of socio-demographics on heating choice

Results

Respondents' predicted preference for heating systems

Alternatives	Margin	Std. Err.	z	P>z	[95% Conf. Interval]	
gas boiler	.3465	.0173	19.98	0.000	.3125	.3805
heat pump	.3750	.0179	20.97	0.000	.3400	.4101
heat network	.2785	.0147	18.89	0.000	.2496	.3074

Based on our model and sample, we expect 38% of households choose heat pumps, 35% choose gas boiler and 28% choose heat network.

Results

Effect of gas boiler investment cost on household choice of heating technologies
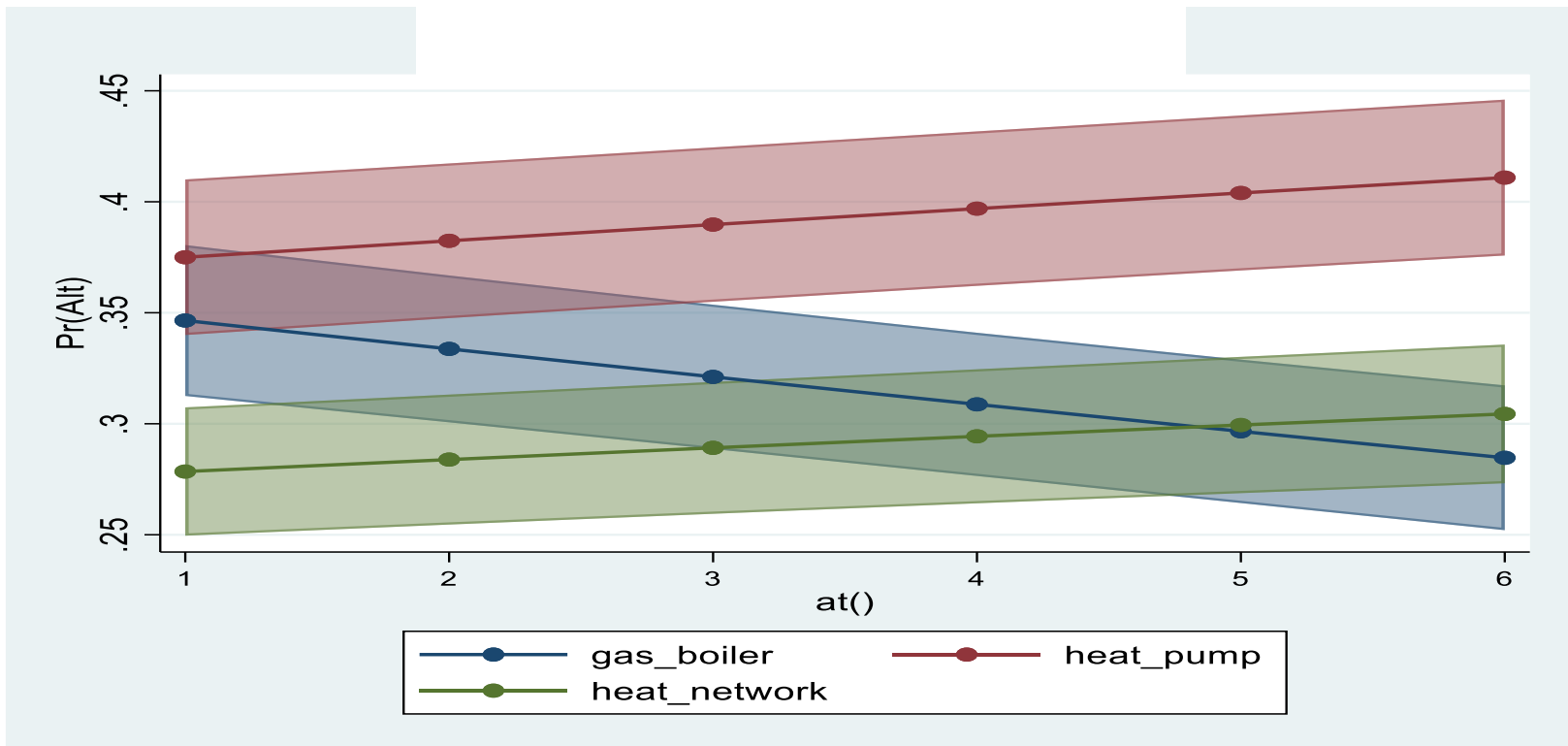
Discussion

- A better understanding of consumer decisions to invest in heating systems, can help in better design of products and policies.

- Our sample suggests:

- Overall emphasis on efficiency

  - ❑ Households' choices are influenced mainly by investment costs (consistent with Scarpa and Willis 2010), energy efficiency (consistent with Lang et al 2021), and supplier switching options.

  - ❑ Government grants are not appealing to homeowners when making their heating choices (consistent with Schleich et al).

  - ❑ Households care about the very high level of CO_2 emissions but not low to high CO_2 emission.

  - ❑ Running cost does not affect heating choice.