

Renovation and Energy-related Household Behaviors in French Dwellings

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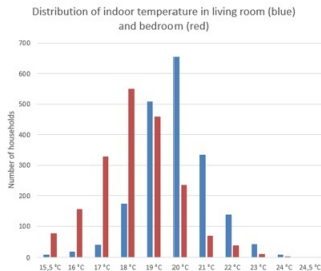
Agenda

- 1 Introduction
- 2 Household choice model
- 3 Choice experiment survey
- 4 Estimation results
- 5 Conclusion

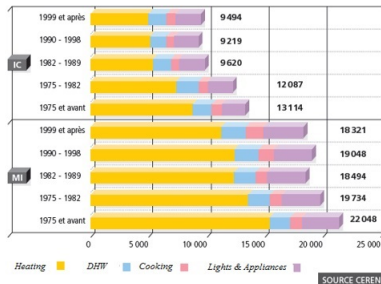
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Key figures for energy use in French residential sector



- Energy consumption: 154.4 Mtoe and 26.5% of total consumption
- Main residences: 27 800 000
- New-build dwellings: 346 462
- Renovated dwellings: 3 336 000
 - double glazing 33%
 - insulation 37%
 - new heating system 11%



- Policy target:
 - Label "Low Consumption Buildings" for new dwelling from 2013
 - Near zero energy building from 2020
 - Decrease in primary energy by 38%
 - Mean household consumption in dwelling from 240 kWh/m²/year to 150 kWh/m²/year

Introduction

Objectives

- Investigate the preferences for space heating systems in France.
- Calculate the marginal willingness-to-pay and reservation prices for attributes of residential space heating system.
- Comfort: study if the preferences are perceived differently by households.

Methodology

- Choice Experiments – Individuals choose the most preferred space heating system between three hypothetical offers characterized by offers' attributes
- Discrete choice model allows us to estimate the choice probability
- Clustering the households in groups with different level of thermal comfort (not implement yet)

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Random utility model

- The utility of household n derives from choosing offer j of RSHS¹ in choice situation t is specified as :

$$U_{jnt} = \alpha_t \text{Inv}_{jnt} + \sum_{s=1}^S \beta_{jnt}^s X_{jnt}^s + \xi_{jn}$$

- α_t – price coefficient in choice situation t , Inv_{jnt} – amount of investment, β_{jnt}^s – non-monetary coefficient for attribute X_{jnt}^s and household n and ξ_{jn} – iid extreme value distribution.
- Multinomial Logit model (MNL) – β_{jnt}^s is same for all respondents.
- Mixed Logit (MIXL) – β_{jnt}^s is given by the density of $f(\beta, \theta)$ (normal, lognormal, uniform, triangular, etc.)

Willingness-to-pay and thermal comfort

- The marginal Willingness-to-pay (reservation price in the case of categorical variable) for s attribute from choice situation t is calculate as:

$$WTP_t^s = -\frac{\beta_{jnt}^s}{\alpha_t}$$

- In order to detect the impact of thermal comfort on preferences, we divide the sample in two groups:
 - Household who are willing to heat space at 19°C
 - Household who refuse to heat space at 19°C and prefers the indoor temperature at 20°C and more

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Survey

- Representative sample of French population, both owners and tenants, all dwelling types
- Choice environment: no constraint on the dwelling situation (e.g. access to all energy source, no home loan, all respondents are home owners, etc.)
- 1820 observations after cleaning
- 30 questions about household, dwelling and socio-economic characteristics, as well as energy related attitudes
- 4 choice situations :
 - Situation 1 and 2 : choice of space heating in order to replace old irreparable system
 - Situation 3: replace old and irreparable space heating system by electric heating
 - Situation 4: decision to invest in new energy efficiency space heating and/or insulation (not impliment)

Description of attributes and levels

Choice situation	Attribute	Description	Levels
1,2,3	Investment	Acquisition costs for houses (€) Acquisition costs for apartments (€)	5000, 10000, 15000, 20000 3000, 8000, 12000, 15000
1,2,3	Reduction	Saving potential in % of actual amount of energy bill Saving potential for Direct Electric Heating	10%, 25%, 40%, 55% 5%, 10%, 15%, 20%
1	RSHS	Type of Residential Space Heating System	Gas boiler, Direct Electric Heating, Heat Pump, Wood Burning Stove
1	Guarantee	Guarantee of RSHS in year	0,2,4
1,3	Setting	Temperature setting for RSHS	None, Programmable, Remote controle, SMART
2	Energy	Energy type for space heating	Electricity, Gas, Wood, Renewable Energy Source
2	Grant origine	Origine of grante for energy efficient retrofits	Local, Tax aid, Energy Utility company, National Housing Agency (ANAH)
2	Grant Amount	Amount of grant in % of acquisition costs (€)	10%, 25%, 40%, 55%
2	Grant available	Grant is available immediately or not	Immediately, one year after
2	Loan	Loan for retrofits	None, Interest-free loan, 4% rate
2	EPC	Diagnostic of energy performance is made before retrofits	1 if Yes, 0 otherwise
3	Electricity tariff	Type of electricity tariff	Plat, Peak and off-peak Season of Use, Time of Use
3	Tariff fee	Fixed fee of tariff for houses (€/year) Fixed fee of tariff for apartment (€/year)	150, 200, 250, 300 90, 120, 150, 200
3	Contract duration	Electricity prices unchanged during the contrac (in years)	1,2,4

Experimental design

- Orthogonal Fractional Factorial Design
- Main effects only
- 48 offers per situation
- Each respondent makes only one choice per situation
- Each experimental offer appears about 42 times

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Estimation results

Coefficient	MNL	MNL (19C)	MNL (> 19C)
Inv. cost for house	-0.000108***	-0.000103***	-0.000126***
Inv. cost for apartment	-0.00017***	-0.000173***	-0.000191***
Reduction	0.0343***	0.0355***	0.0322***
Best inv ¹ × Price signal ²	0.299***	0.132***	0.621***
Guarantee	0.183***	0.181***	0.177***
Same RSHS	1.169***	1.2***	1.15***
Gas boiler	–	–	–
Direct Electric Heating	0.1	0.144	0.033
Heat Pump	0.868***	0.826***	0.96***
Wood burning stove (house)	0.4***	0.391***	0.373*
Wood burning stove (apartment)	-0.343**	-0.43**	-0.365
None	–	–	–
Programmable	0.693***	0.517***	1.01***
Remote controle	0.537***	0.214	1.03***
Smart temperature setting	0.776***	0.448**	1.334***
Pseudo ρ^2	0.226	0.223	0.253
Log-likelihood	-1525	-964	-511
Observations	1820	1173	633

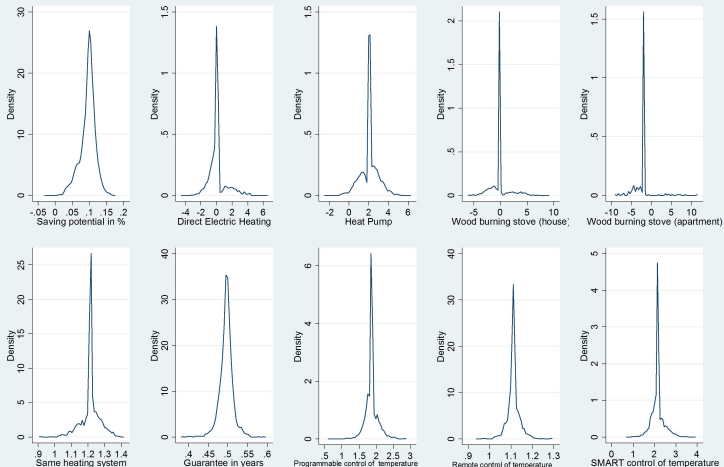
¹ Equal to 1 if one offer proposes RSHS at 3000–5000 \$ against 15000–20000 \$ for two other offers

² I am very suspicious to low inv. : totally agree (-4), maybe agree (-1), maybe disagree (1), totally disagree (4)

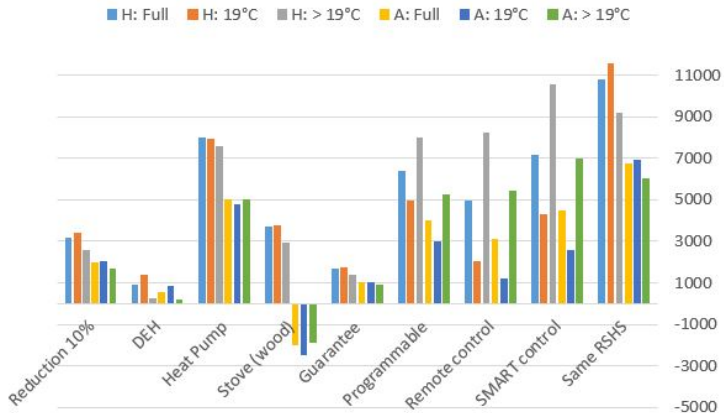
Asterisks denote statistical significance of the *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ level

Taste heterogeneity

Kernel distribution of the individual-level coefficient



Willingness to pay for significant attributes in €

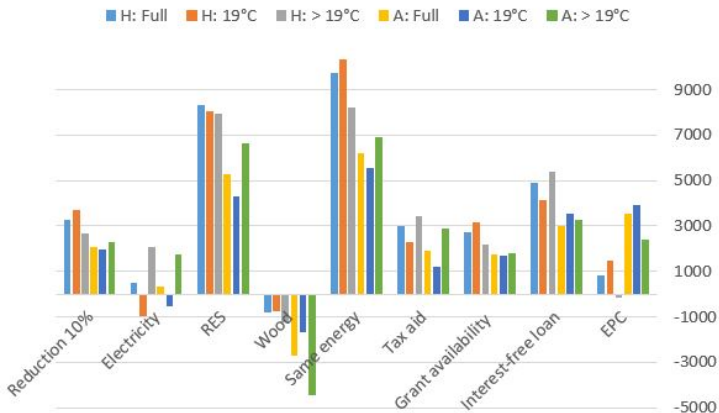


Estimation results

Coefficient	MNL	MNL (19C)	MNL (> 19C)
Inv. cost for house	-0.000093***	-0.000083***	-0.000127***
Inv. cost for apartment	-0.00014***	0.000154***	-0.000151***
Reduction	0.0308***	0.0305	0.0343***
Best inv × Price signal	0.242**	0.195	0.479*
Same energy	0.91***	0.857***	1.04***
Amount of grant	0.00016***	0.00016***	0.00019***
Grant availability	0.256***	0.264***	0.275***
EPC (house)	0.079	0.121	-0.02
EPC (apartment)	0.519***	0.604***	0.36**
Gas	–	–	–
Electricity	0.04	-0.08	0.267*
RES	0.781***	0.668***	1.01***
Wood (house)	-0.07	-0.06	-0.161
Wood (apartment)	-0.39***	-0.262	-0.67**
Local aid	–	–	–
ANAH aid	0.11	-0.06	0.396***
EUC aid	0.088	-0.05	0.24
Tax aid	0.281**	0.19***	0.43***
None	–	–	–
Interest-free loan (house)	0.46***	0.343***	0.684***
Interest-free loan (apartment)	0.44***	0.551***	0.49**
4% rate loan (house)	0.02	-0.016	0.14
4% rate loan (apartment)	0.03	0.12	-0.13
Pseudo ρ^2	0.172	0.163	0.224
Log-likelihood	-1652	-1050	-537
Observations	1820	1173	633

Asterisks denote statistical significance of the *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ level

Willingness to pay for significant attributes in €

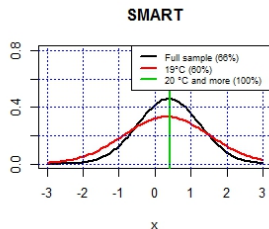
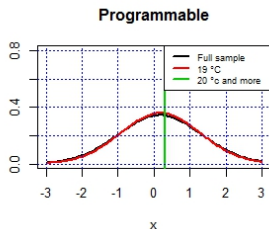
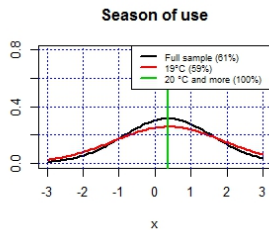
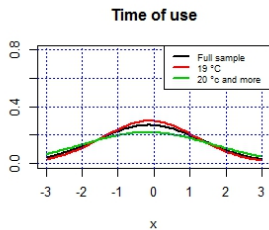


Estimation results

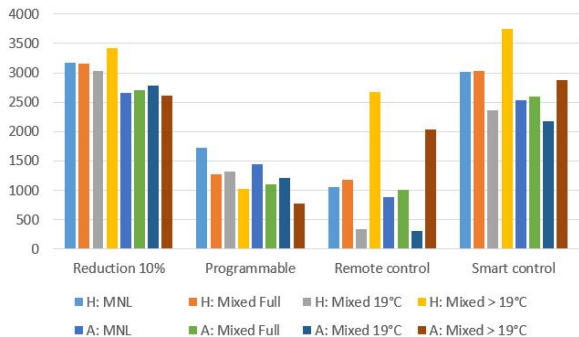
Coefficient	MNL	MIXL (FS)	MIXL (19C)	MIXL (> 19C)
log(Inv. cost) for house	-0.964***	-1.25***	-1.33***	-1.14***
log(Inv. cost) for apartment	-1.15***	-1.46***	-1.45***	-1.49***
Reduction	0.0305***	0.0394***	0.0403***	0.039***
Contract duration (in years)	-0.017	-0.03	-0.047	-0.018
Fixed fee of Two-part tariff	-0.0048***	-0.00597***	-0.00617***	-0.00565***
Plate rate	-	-	-	-
Peak and off-peak	-0.012	-0.148	-0.132	-0.189
sd		1.48***	1.33***	1.82***
Season of use	0.301***	0.355***	0.372***	0.354**
sd		1.26***	1.55***	0.0868
Time of use	-0.09	-0.127***	-0.152	-0.0086
sd		0.114	0.324	0.05
None	-	-	-	-
Programmable	0.166**	0.16	0.175	0.116
sd		1.16***	1.11***	1.28***
Remote controle	0.102	0.148	0.045	0.304**
sd		0.008	0.01	0.033
Smart temperature setting	0.291***	0.378***	0.315***	0.428***
sd		0.868***	1.2***	0.0115
Pseudo ρ^2	0.172	0.174	0.175	0.181
Log-likelihood	-1654	-1651	-1062	-569
Observations	1820	1820	1173	633

Asterisks denote statistical significance of the *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ level

Taste variance for tariff and temperature setting (Normal distribution)



Willingness to pay per investment (left) and per fixed fee of tariff (right) in €



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Global results

- High preferences for renewable energy sources (heat pump or other) except wood with WTP about 3000-8000 €.
- Preferences for well known energy types and systems.
- A higher interest in SMART control of indoor temperature.
- Wood is not seen as renewable energy
- Household is willing to pay additional 60 € of fixed fee to subscribe Season of Use electricity tariff.
- Household group (20°C and more) is especially drawn to the Remote and SMART control of indoor temperature. And they are more attracted by Renewable Energy than other household.

Future research direction

- Latent choice model to include more characteristics about thermal comfort
- Mixed Logit model estimated in Willingness-to-pay space to capture household heterogeneity and to find more realistic distribution of WTP

Thank You!

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