INSPIRING IDEAS AND TALENT

Energy efficient technology adoption in low-income households in the European Union – What is the evidence?

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Background

- Increasing concerns about « energy poverty »
  - 11% of the population of the European Union (EU) cannot afford to properly heat their homes (Pye et al., 2015)
  - up to ¼ of EU population at risk of energy poverty (BPIE 2014)
  - 50-160 million people (10-30%) are energy poor (Stoerring, 2017)

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Background

- Reasons for energy poverty
  - **rising energy prices, low income, poor energy performance of dwellings** (e.g. Bouzarovski, 2011)
  - **vicious cycle between low-income status and energy performance of dwellings** – low-income households benefit in particular from adopting energy-efficient technologies (EETs)
  - **energy poverty** particularly prevalent in Central and Eastern EU Countries, but also in some Southern EU countries and **high-income countries** – notably UK
  - **landlord-tenant problem**: focus on tenants, because low income households tend to be tenants
  - BUT: **homeowners may also be energy poor**:

    32% to 66% of homeowners in France are energy poor (Legendre and Ricci, 2015)

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Objectives

- Empirically analyze relation of income and adoption of energy-efficient technologies (EET) in EU countries
    - adoption rates of high-cost (retrofit), medium-cost (appliances), and low-cost EETs (LEDs) by income groups across eight EU member states.
    - implementation of retrofit measures is explored for homeowners, thus checking whether adoption rates differ between low- and high income homeowners
    - Adoption of energy efficient appliances and LED is explored for tenants and homeowners

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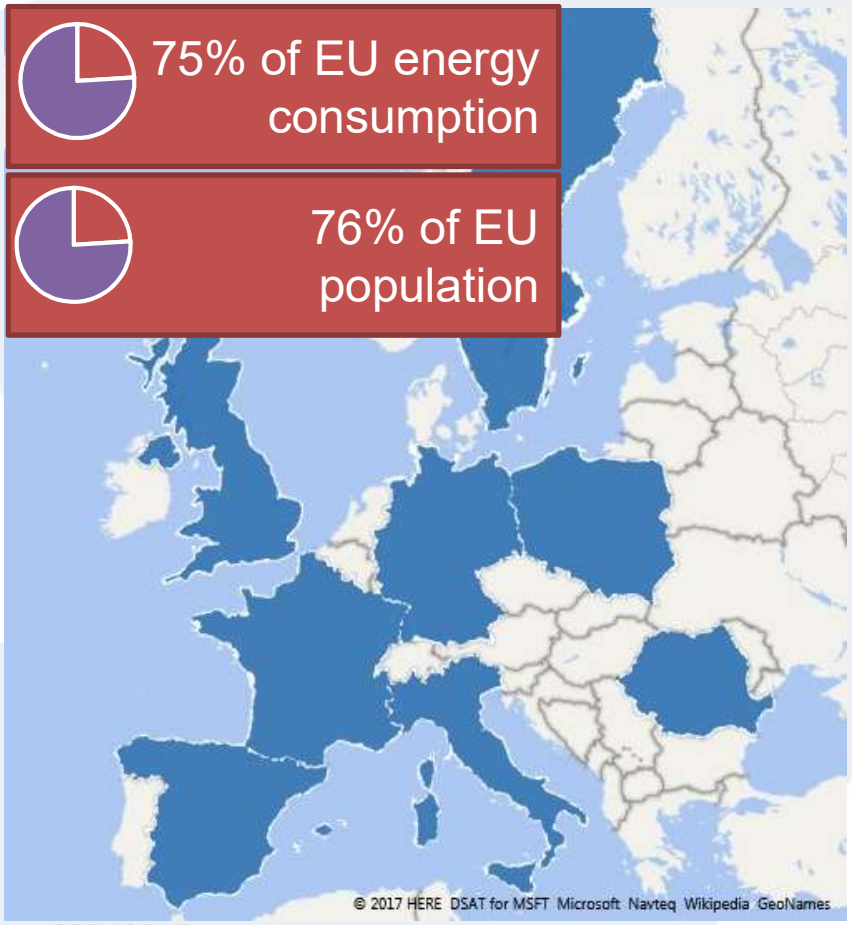
Data: Household survey in 8 EU countries



- Demographically representative, online, July/August 2016
- Ca. 15.000 participants
- 1500/2000 participants per country

France
Germany
Italy
Poland
Romania
Spain
Sweden
UK

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Data

A representative online survey across 8 EU countries

- >15,000 participants
- Data collected between July and August 2016
- Stated adoption of retrofit, appliances and LEDs
- Wide range of household, dwelling, and individual characteristics as control factors

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Energy efficiency adoption behavior (= dependent variable)

LED: Participants who had changed a new light bulb in the past 2 years were asked to identify the type of bulb. Only the choice of an LED was considered an energy-efficient decision.

Energy-efficient appliances: Participants (eligible) who had bought a new appliance (refrigerator or fridge/freezer combination, freezer, dishwasher, washing machine) in the past 5 years were asked if the last purchased appliance was top efficiency appliance .

Retrofit: Participants (eligible) who had implemented a retrofit measure in the past 10 years (insulation of roof or ceiling, insulation of exterior walls, insulation of basement, installation of double-glazed or triple-glazed windows).

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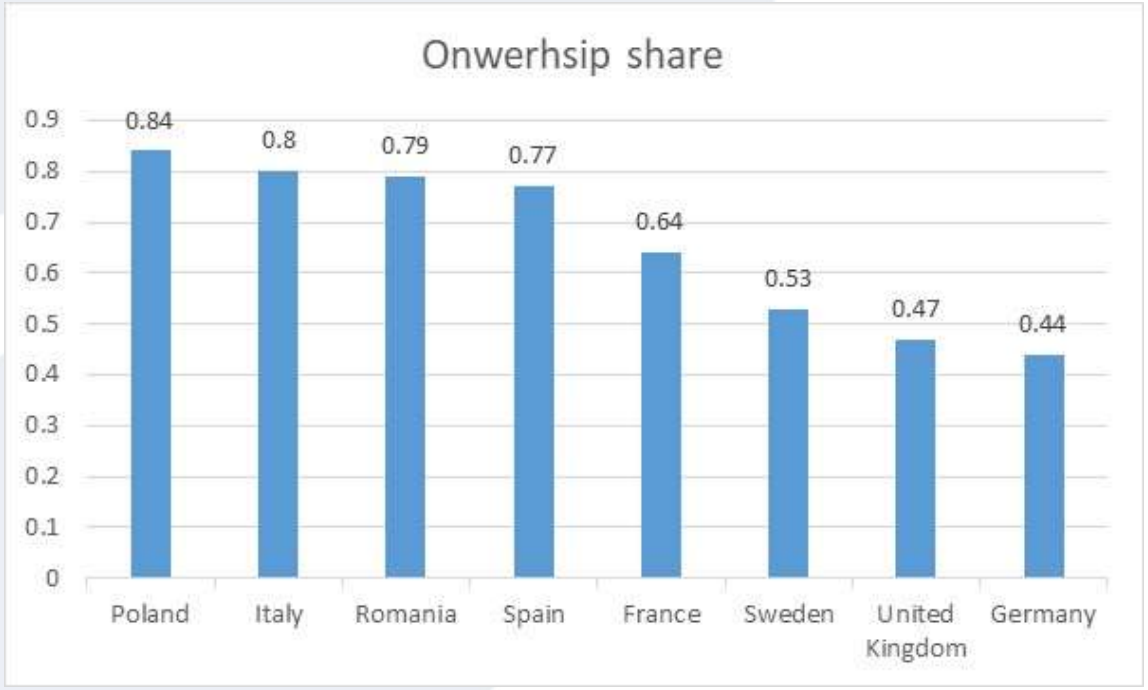
Onwnership shares of dwellings across countries in sample



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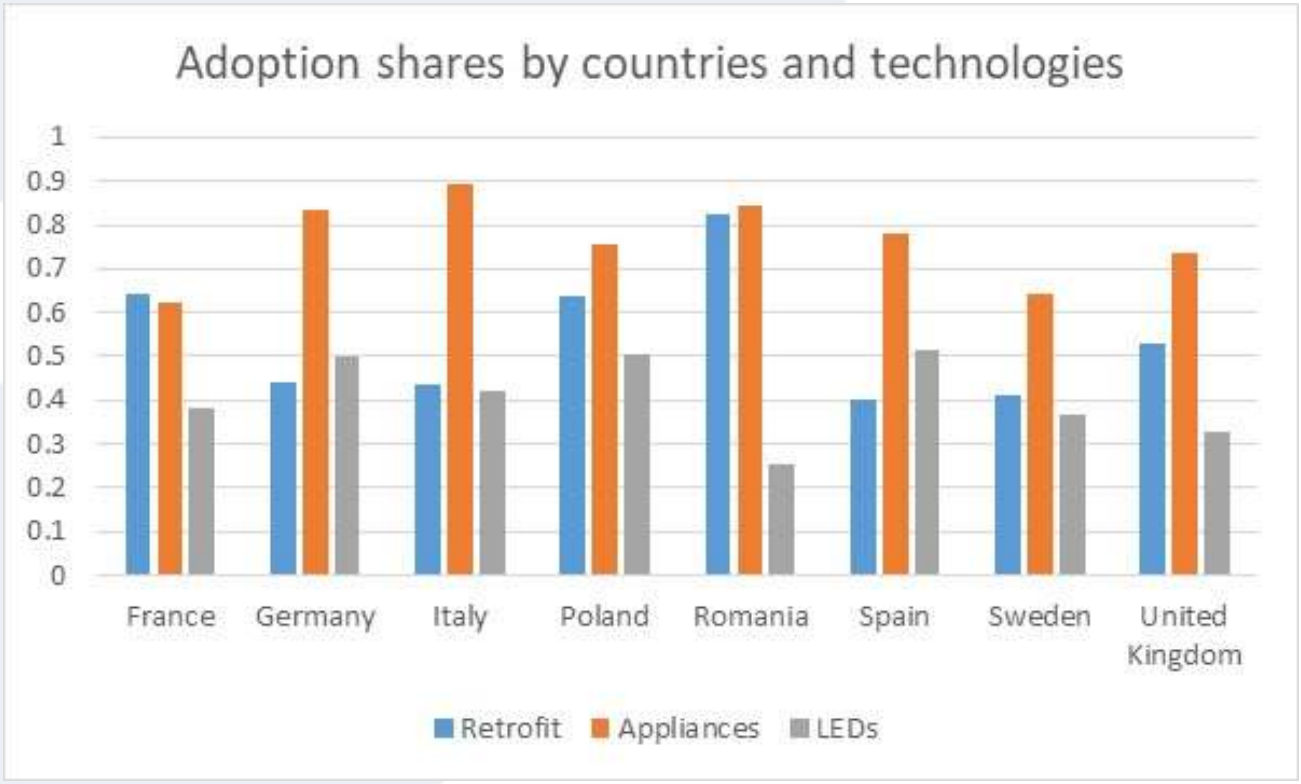
Adoption shares by countries and technologies



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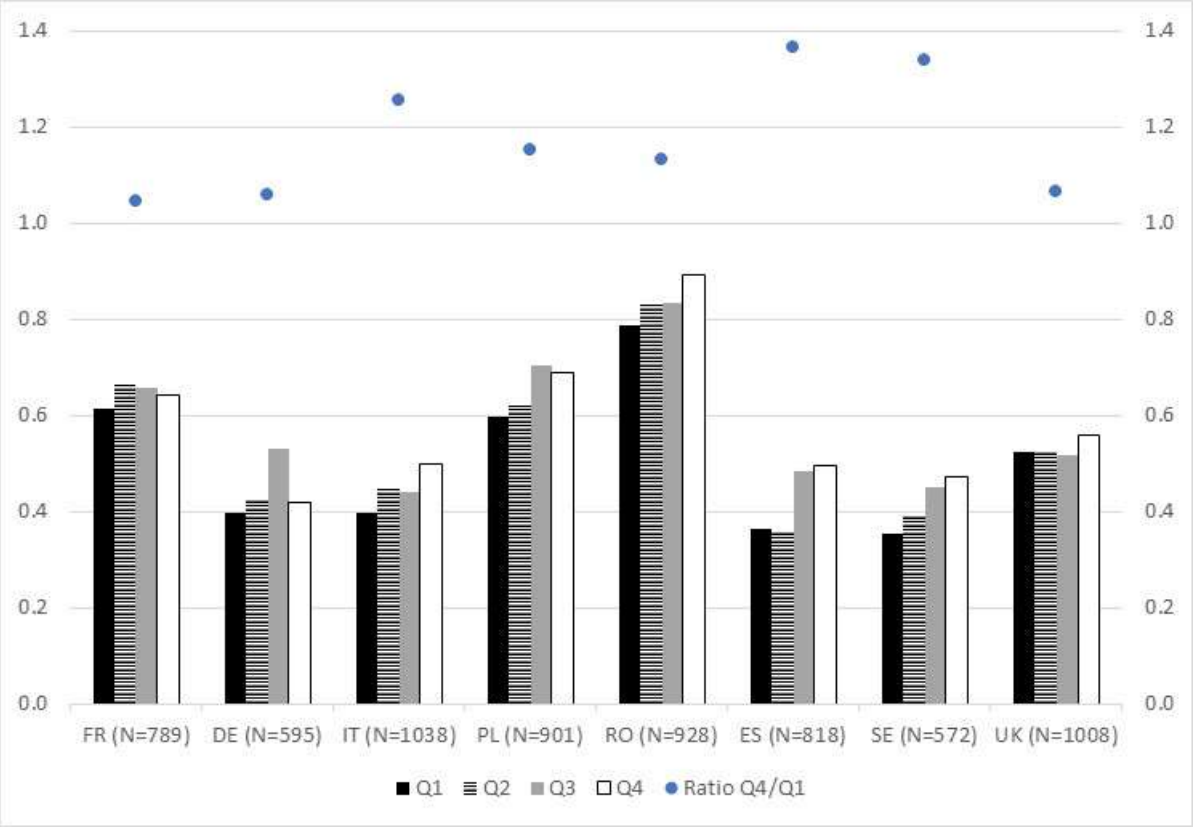
Results : Descriptive statistics – Retrofit by income quartiles (Q1, Q2, Q3, Q4)



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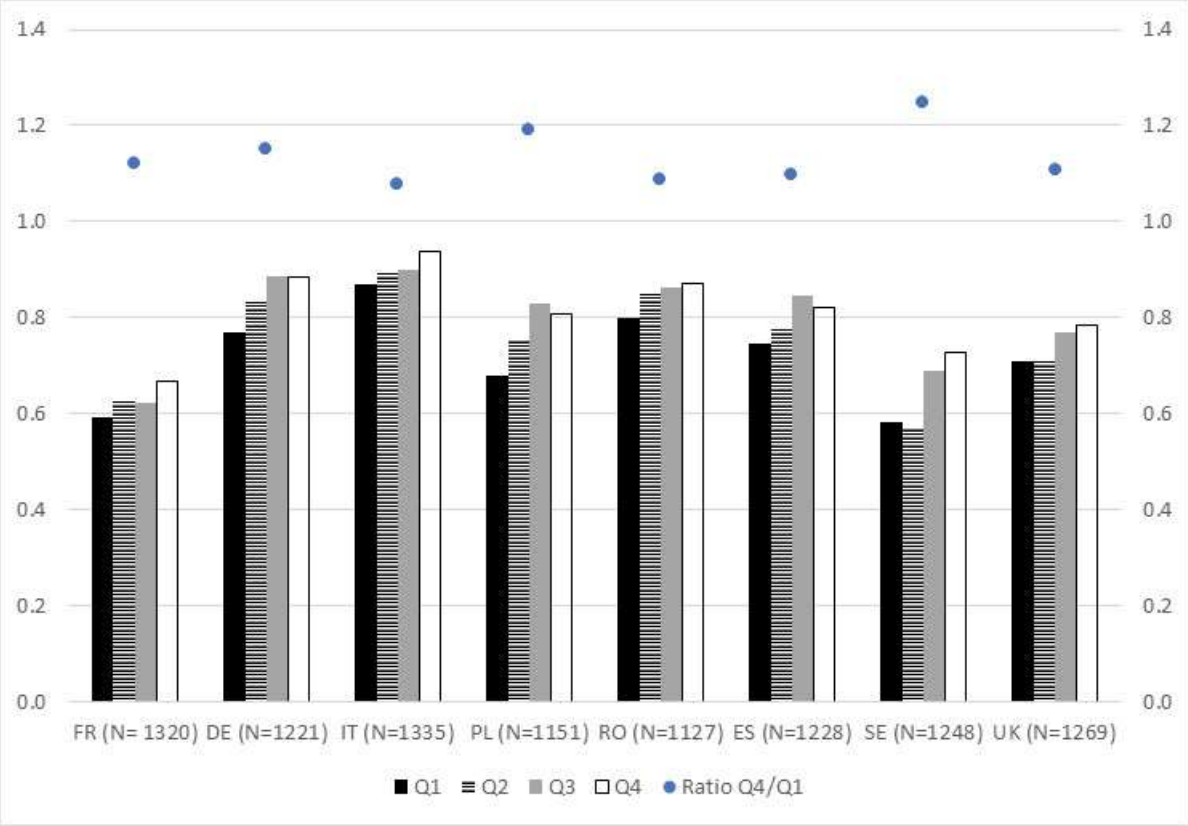
Results: Descriptive statistics – Appliances by income quartiles (Q1, Q2, Q3, Q4)



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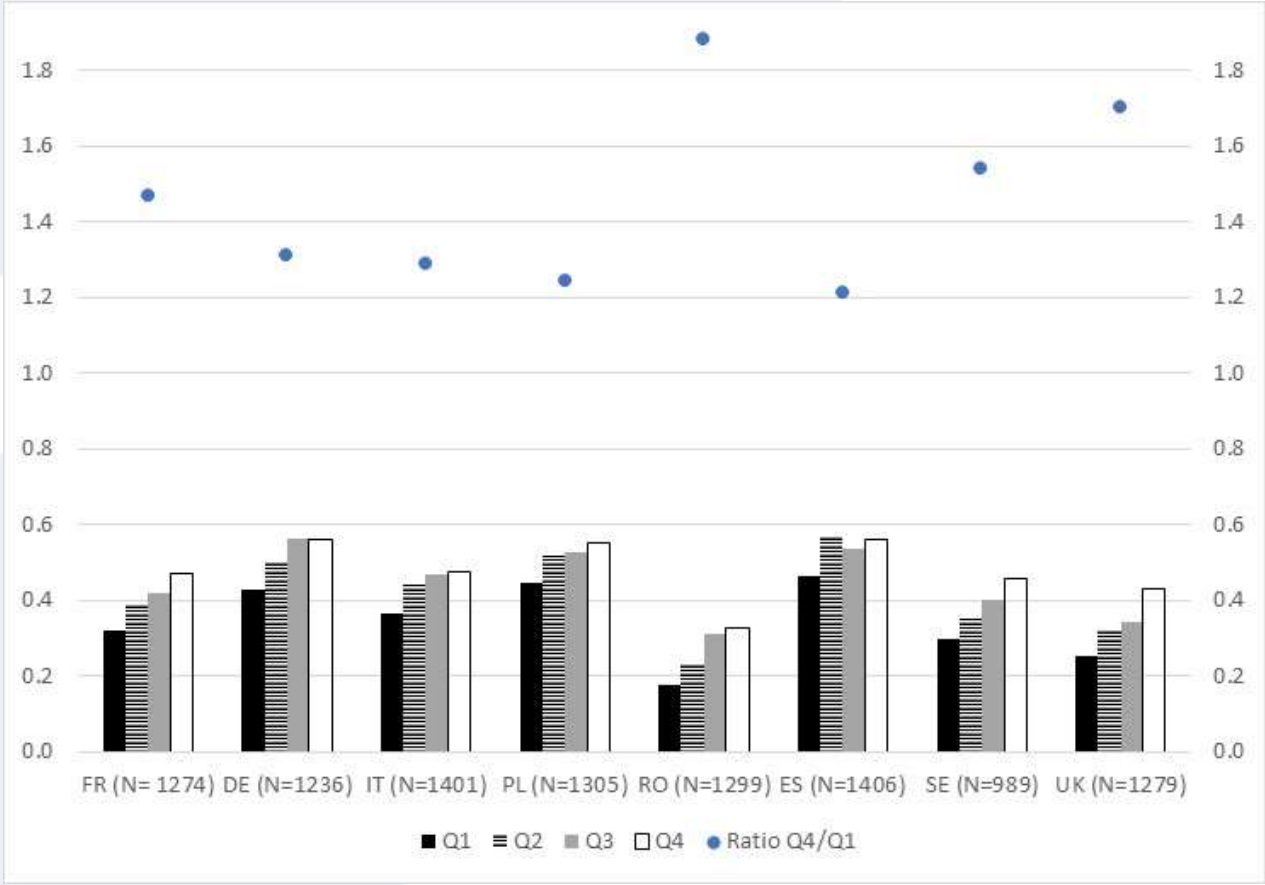
Results: Descriptive statistics – LEDs by income quartiles (Q1, Q2, Q3, Q4)



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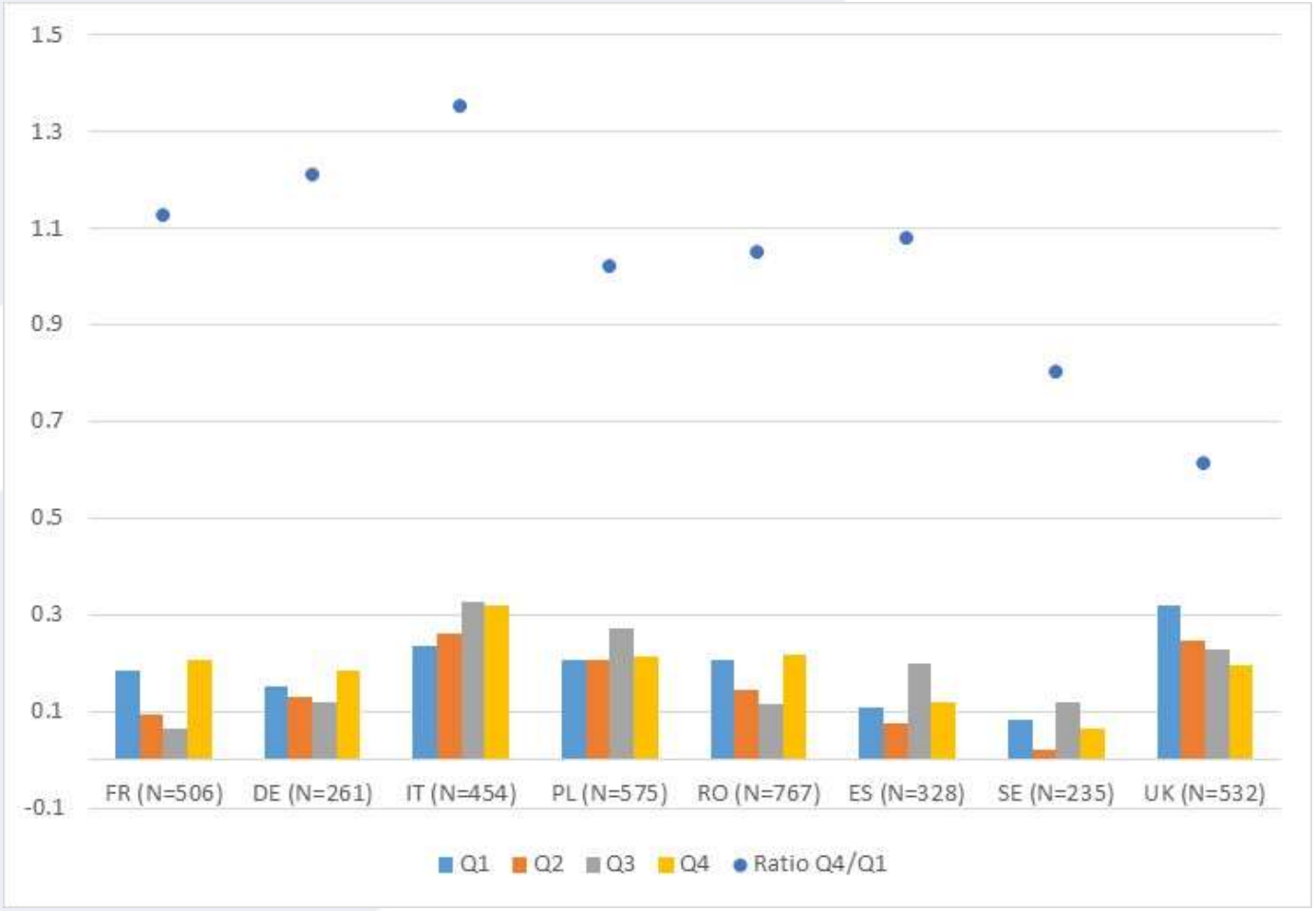
Results: Descriptive statistics – Retrofit support by income quartiles (Q1, Q2, Q3, Q4)



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Multivariate analysis

Probit model on each technology
(= 1 if energy efficient)
with right-hand side variables:

Label	Description
DQ1, DQ2, DQ3, DQ4	Dummies representing income quartiles. In the survey, household annual income (after taxes) was measured in 1000 EUR per year (via eleven income categories, which differed by countries to reflect general differences in income levels across countries).
Age	Respondent age in years.
Energycosts	Score calculated from participant stated importance of energy costs when investing in insulation measures or heating systems/appliances/light bulbs (1= played no role to 5= very important).
Env_ID	Score reflecting environmental identity. Constructed using the equally weighted responses to the subsequent scale items (1= strongly disagree to 5= strongly agree): "*Please rate how much you agree with the following statements (i) To save energy is an important part of who I am. (ii) I think of myself as an energy conscious person. (iii) I think of myself as someone who is very concerned with environmental issues. (iv) Being environmentally friendly is an important part of who I am*."
Detached	Dummy = 1 if house was detached.
Buildage	Age of the building based on the following nine age categories: < 1920, 1921-1944, 1945-1959, 1960-1969, 1970-1979, 1980-1989, 1990-1999, 2000-2009, > 2009; Age takes on the value of 1 for the first category, 2 for the second, …, and 9 for the last category.

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Results: marginal effects - retrofit

	FR	DE	IT	PL	RO	ES	SE	UK
DQ1	-0.0397	-0.0745	**-0.1099*****	**-0.0944***	**-0.1185****	**-0.1463*****	**-0.1050****	-0.0321
	(0.400)	(0.150)	(0.006)	(0.089)	(0.021)	(0.001)	(0.047)	(0.494)
DQ2	0.0218	-0.0144	-0.0529	-0.0820	-0.0616	**-0.1464*****	-0.0594	-0.0218
	(0.664)	(0.815)	(0.228)	(0.111)	(0.211)	(0.002)	(0.288)	(0.623)
DQ3	0.0090	0.0826	-0.0514	0.0061	-0.0745	-0.0262	-0.0263	-0.0332
	(0.851)	(0.139)	(0.323)	(0.916)	(0.120)	(0.654)	(0.651)	(0.484)
Age	**0.0026****	-0.0011	-0.0002	**0.0030****	**0.0022***	0.0002	-0.0021	**0.0026****
	(0.030)	(0.474)	(0.830)	(0.024)	(0.059)	(0.908)	(0.175)	(0.025)
Energycosts†	**0.0643*****	**0.0612****	0.0087	**0.0426****	**0.0306****	0.0233	0.0040	**0.0457*****
	(0.002)	(0.020)	(0.682)	(0.027)	(0.047)	(0.149)	(0.849)	(0.007)
Env_ID†	**0.0376***	**0.0433****	**0.0970*****	**0.0650*****	**0.0437*****	**0.0917*****	**0.0749*****	**0.0689*****
	(0.060)	(0.042)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Detached	**0.1523*****	**0.0771****	**0.0635***	0.0278	0.0162	**0.1116*****	**0.1349*****	**0.1071*****
	(0.000)	(0.048)	(0.050)	(0.402)	(0.540)	(0.002)	(0.001)	(0.002)
Buildage	**-0.0356*****	**-0.0605*****	-0.0122	0.0013	0.0152	-0.0057	**-0.0282****	0.0058
	(0.000)	(0.000)	(0.163)	(0.883)	(0.127)	(0.600)	(0.016)	(0.482)
Pseudo R^2 (McFadden)	0.0605	0.0800	0.0313	0.0385	0.0447	0.0492	0.0512	0.0399
N	789	595	1038	901	928	818	572	1008

p-values (robust) in parentheses; *** p<0.01, ** p<0.05, * p<0.1; † z-score of the variable was used

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Results: marginal effects - appliances

	FR	DE	IT	PL	RO	ES	SE	UK
DQ1	**-0.0759****	**-0.1119*****	**-0.0594****	**-0.0938****	-0.0578	**-0.0608***	**-0.1058***	**-0.0645***
	(0.041)	(0.001)	(0.020)	(0.030)	(0.141)	(0.058)	(0.055)	(0.086)
DQ2	-0.0551	**-0.0541***	**-0.0577***	-0.0496	-0.0131	-0.0458	**-0.1327****	**-0.0644***
	(0.198)	(0.079)	(0.062)	(0.193)	(0.725)	(0.225)	(0.013)	(0.078)
DQ3	**-0.0701***	-0.0028	-0.0537	0.0442	0.0020	.02499	-0.0257	-0.0079
	(0.082)	(0.934)	(0.158)	(0.287)	(0.957)	(0.530)	(0.617)	(0.838)
Age	0.0007	**0.0016****	0.0004	-0.0010	0.0002	0.0012	**0.0024***	**0.0023*****
	(0.421)	(0.022)	(0.546)	(0.373)	(0.874)	(0.163)	(0.058)	(0.008)
Energycosts†	**0.1708*****	**0.1104*****	**0.0842*****	**0.0736*****	**0.0461*****	**0.1141*****	**0.1110*****	**0.1205*****
	(0.000)	(0.000)	(0.010)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Env_ID†	**0.0534*****	0.0165	**0.0238*****	**0.0597*****	**0.0407*****	0.0179	0.0273	**0.0337*****
	(0.000)	(0.141)	(0.010)	(0.000)	(0.000)	(0.155)	(0.104)	(0.004)
Detached	**0.0554****	-0.0335	-0.0107	0.0100	**0.0418****	0.0324	**0.0887****	0.0039
	(0.027)	(0.104)	(0.523)	(0.692)	(0.045)	(0.167)	(0.013)	(0.883)
Buildage	**0.0123*****	-0.0007	0.0009	0.0062	-0.0001	0.0080	-0.0024	-0.0053
	(0.009)	(0.861)	(0.805)	(0.249)	(0.987)	(0.146)	(0.774)	(0.273)
Pseudo R^2 (McFadden)	0.1322	0.1866	0.1419	0.0833	0.0634	0.1219	0.1037	0.1309
N	1320	1221	1335	1151	1127	1228	695	1269

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Results: marginal effects - LED

	FR	DE	IT	PL	RO	ES	SE	UK
DQ1	**-0.1409*** **	**-0.1208*** **	**-0.1066*** **	**-0.0839***	**-0.1276*** **	**-0.1175*** **	**-0.1469*** **	**-0.1559*** **
	(0.000)	(0.003)	(0.002)	(0.059)	(0.000)	(0.002)	(0.001)	(0.000)
DQ2	**-0.0835****	-0.0452	-0.0293	-0.0310	**-0.0804****	-0.0182	**-0.0886****	**-0.0954*** **
	(0.036)	(0.260)	(0.444)	(0.455)	(0.019)	(0.661)	(0.035)	(0.006)
DQ3	-0.0564	0.0166	-0.0100	-0.0171	-0.0142	-0.0516	-0.0478	**-0.0711***
	(0.152)	(0.708)	(0.829)	(0.716)	(0.694)	(0.276)	(0.276)	(0.055)
Age	**-0.0018***	**-0.0018***	-0.0015	**-0.0029****	0.0004	-0.0010	**-0.0029****	0.0008
	(0.066)	(0.095)	(0.147)	(0.014)	(0.738)	(0.355)	(0.010)	(0.421)
Energycosts†	**0.1213*** **	**0.1442*** **	**0.0947*** **	**0.1319*** **	**0.1028*** **	**0.1475*** **	**0.0921*** **	**0.0795*** **
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Env_ID†	0.0150	-0.0014	-0.0029	0.0144	0.0026	-0.0150	0.0049	-0.0215
	(0.338)	(0.926)	(0.853)	(0.351)	(0.847)	(0.319)	(0.742)	(0.100)
Detached	**0.0836*** **	0.0086	0.0405	-0.0316	0.0056	0.0005	**0.0922*** **	0.0297
	(0.002)	(0.769)	(0.155)	(0.267)	(0.816)	(0.985)	(0.005)	(0.337)
Buildage	0.0061	0.0071	0.0098	**0.0159*** **	**0.0118***	**0.0178*** **	0.0118	**0.0105***
	(0.241)	(0.245)	(0.117)	(0.009)	(0.092)	(0.008)	(0.101)	(0.051)
Pseudo R^2 (McFadden)	0.0604	0.0717	0.0253	0.0618	0.0720	0.0625	0.0562	0.0427
N	1274	1236	1401	1305	1299	1406	989	1279

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Results: marginal effects – support for retrofit

	FR	DE	IT	PL	RO	ES	SE	UK
DQ1	-0.0039	-0.0357	-0.0748	0.0092	-0.0154	-0.0262	-0.0005	**0.1201***
	(0.915)	(0.518)	(0.148)	(0.876)	(0.663)	(0.562)	(0.990)	(0.056)
DQ2	**-0.0839****	-0.0487	-0.0503	0.0139	**-0.0586***	-0.0673	**-0.0617****	0.0556
	(0.013)	(0.398)	(0.357)	(0.795)	(0.076)	(0.122)	(0.040)	(0.322)
DQ3	**-0.1151*****	-0.0564	0.0039	0.0740	**-0.0804****	0.0820	0.0340	0.0344
	(0.000)	(0.281)	(0.955)	(0.249)	(0.014)	(0.225)	(0.468)	(0.572)
Age	-0.0017	-0.0022	-0.0010	0.0010	-0.0013	**-0.0043*****	**-0.0034*****	0.0002
	(0.111)	(0.193)	(0.525)	(0.473)	(0.265)	(0.002)	(0.008)	(0.871)
Windows	**0.0586****	**0.1524*****	0.0036	**0.1437*****	**0.3263*****	-0.0183	-0.0131	0.0598
	(0.046)	(0.008)	(0.931)	(0.001)	(0.000)	(0.670)	(0.753)	(0.462)
Detached	0.0016	**-0.0957****	**0.1790*****	**-0.0978*****	-0.0242	**0.0673***	-0.0520	-0.0386
	(0.960)	(0.031)	(0.000)	(0.003)	(0.338)	(0.088)	(0.153)	(0.341)
Buildage	0.0004	-0.0021	0.0094	**0.0186***	0.0151	-0.0093	-0.0026	**0.0249*****
	(0.953)	(0.853)	(0.446)	(0.063)	(0.115)	(0.384)	(0.767)	(0.009)
Pseudo R^2 (McFadden)	0.0573	0.0816	0.0376	0.0467	0.1869	0.0763	0.1330	0.0196
N	506	261	454	575	767	328	235	532

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Conclusions

- Homeowners falling into **lowest income quartile** are typically **less likely to have adopted retrofit measures**
- A similar finding holds for all households for adoption of energy efficient appliances and LEDs
- Policies should (subject to cost-benefit type analysis) **not only target retrofit, but also appliances** (e.g. Caritas-**Stromsparcheck** in Germany or **ULISSE** in France) – likely to be particularly effective in lower-income countries (PL, RO)
- Effective policy should **target low-income homeowners/households**, e.g. via soft loans or rebates (subject to CBA);
    - targeting would also **limit free rider problem** (e.g. Olsthoorn et al., 2017)
    - review by Ugarte et al. (2016) suggests that **only few policies in EU specifically target low-income households** (for retrofit/heating systems); policies typically involve **tax breaks** and **soft loans**; or **rebates**, via **energy-efficiency obligation schemes** (Art. 7 of EED) (F, UK)
    - But: (i) tax breaks benefit mostly high income households
    - (ii) soft loans may not be effective if individuals are **debt-averse** (e.g. elderly) (Schleich et al. 2019)

Items capturing access to capital and debt aversion (subjective assessment) in Schleich et al. (2019)

CapitalAccess

Constructed using the responses to the following question (1= very poor access to 5= very good access): "*How would you categorize your access to loans/credits/capital*?"

DebtAversion

Constructed using the responses to the following questions (1= very much like me to 6= not at all like me): "Please rate the following statements:

(i) If I have debts, I like to pay them as soon as possible;
(ii) If I have debts, I prefer to delay paying them if possible, even if it means paying more in total;
(iii) If I have debts, it makes me feel uncomfortable;
(iv) If I have debts, it doesn't bother me;
(v) I dislike borrowing money;
(vi) I feel OK borrowing money for 'essential' purchases e.g. Cars, appliances, mortgage;
(vii) I enjoy being able to borrow money to buy things I like, and to pay for things I cannot afford."

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Do access to capital and debt aversion matter?

Results: marginal effects – retrofit adoption (aggregate model)

	Probit	LPM
CapitalAccess†	0.036***	0.036***
	(0.000)	(0.000)
DebtAversion	-0.017***	-0.017***
	(0.002)	(0.004)
DebtAversion†	-0.021***	-0.021***
X CapitalAccess†	(0.000)	(0.000)
Income	0.001***	0.001***
	(0.001)	(0.001)
Other controls	YES	YES
Country dummies	YES	YES
Wald $\chi^2(17)$	810.01***	
N	6630	6630
R^2		0.127

Access to capital positively related with retrofit adoption

Even households with good access to capital do not want to run debts to finance retrofit adoption

Likelihood to have adopted a retrofit measure is lower for debt-averse homeowners with poor access to capital compared to non-debt-averse individuals with poor access to capital

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Which households should be targeted? (i.e. non-debt averse with poor access to capital) (marginal effects)

	Probit	LPM
Income	-0.002***	-0.002***
	(0.000)	(0.000)
Education	-0.033**	-0.035***
	(0.003)	(0.002)
Age	-0.002***	-0.002***
	(0.000)	(0.000)
Male†	0.027***	0.028***
	(0.007	(0.006)
Children	0.021*	0.021*
	(0.065)	(0.076)
Urban	0.014	0.014
	(0.018)	(0.017)
Constant		0.383
		(0.293)
Country dummies	YES	YES
R^2		0.02
Wald $\chi^2(6)$	187.45***	
N	6630	6630

Soft loans are more likely to be effective for
- less affluent households
- individuals with below median education
- younger individuals
- men
- households with children

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Thank you!

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Literature

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