INSPIRINC IDEAS AND TALENTS

Free riding and rebates for residential energy efficiency upgrades

A multi-country contingent valuation experiment

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Introduction Energy efficiency subsidies and free riding

- Subsidy effectiveness overestimated due to rebound, moral hazard, free riding
- Free rider estimates in literature

	Study	Country	Measure	Policy	Free-ridership
Ex post	Joskow & Marron 1992	US	Multiple, residential and commercial/industrial	Utility DSM programs	0-62%
	Malm 1996	US	Residential heating systems	Utility DSM programs	≤89%
	Boomhouwer & Davis Mexico 2014		Refrigerators and air conditioners	Direct cash- 50% back	
	Grösche & Vance 2009 Germa		Retrofit measures	Grants 50%	
	Nauleau 2014	France	Insulation measures	Tax credit	40-85%
	Alberini et al. 2014	Italy	Doors/windows Heating systems	Tax credit	70% 100%
Ex ante	Alberini & Bigano 2015	Italy	Heating systems	Rebate	70-74%

Introduction **Research objectives**

- Evaluate effectiveness of subsidizing premature residential heating system replacement *ex ante*.
- To evaluate the correlations between a household's reservation rebate and its characteristics.
- To compare rebate effectiveness across countries.

Method Household survey in 8 EU countries (BRISKEE)



- Households
- Representative
- Home owners
 - N = 10334

Map source: http://philarcher.org/diary/2013/euromap/

Method A contingent valuation choice experiment



Method **Econometric estimation**

• Maximize (Cameron & James, 1986)

 $\Pr(R\downarrow i\uparrow L < R\downarrow i\uparrow * \leq R\downarrow i\uparrow U) = \Phi\uparrow U - \Phi\uparrow L$

• Specification

 $R\downarrow i\uparrow * = \alpha + \mathbf{x} \mathbf{\downarrow} i \beta + \mathbf{z} \mathbf{\downarrow} i \delta + \varepsilon \mathbf{\downarrow} i$

 $R\downarrow i\uparrow *$ unobservable subsidy required for adoption $x\downarrow i$ technology variables $z\downarrow i$ household characteristics

Estimates Mean reservation rebates

	All countries	FR	DE	IT	PL	RO	ES	SE	UK
Rebate	775***	889***	990***	665***	437***	354***	995***	1212***	876***
Sigma	1205***	1477***	1650***	1224***	861***	755***	1367***	1395***	972***
Ν	6265	801	508	894	1132	419	1155	541	815
Log likelihood	-5736.4	-710.3	-444.5	-820.4	-1102.7	-401.8	-998.8	-435.9	-729.9
<i>p</i> -values in parer	ntheses								

*** *p* < 0.01



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Estimates Effect of household characteristics

Correlations of the reservation rebate with socio-demographic and attitudinar variables.							
Variable	Coeff.	<i>p</i> -value					
Savings amount	-0.17 **	(0.041)					
Savings duration	4.44	(0.349)					
Gender	-10.45	(0.772)					
Age	1.13	(0.443)					
Education	-5.18	(0.897)					
Income	2.60 **	(0.013)					
Missing income	34.76	(0.467)					
Household size	-60.78 ***	(0.000)					
Environmental orientation	-98.49 ***	(0.000)					
Cognitive Reflection Test	131.17 ***	(0.000)					
Willingness to Wait	-91.23 ***	(0.000)					
Willingness to Take Risks	-127.12 ***	(0.000)					
Country dummies	Yes						
Constant	751.91 ***	(0.000)					
Sigma	1134.34 ***	(0.000)					
N	6265						
Log likelihood	-5554						

Correlations of the reservation rebate with socio-demographic and attitudinal variables.

*** *p* < 0.01, ** *p* < 0.05

Simulations **Equations for cost calculations**

• Free riders and incentivized adopters

 $sfr + N\downarrow wfr + N\downarrow ia$ = $(a+b(0)+[b(R)-b(0)])\cdot N\downarrow pop \cdot R$

 $b(R) = \Pr(adoption|R)$

Simulations Free-rider shares



Simulations **Equations for cost calculations**

• Rebate expenses

 $sfr + N\downarrow wfr + N\downarrow ia$ = $(a+b(0)+[b(R)-b(0)])\cdot N\downarrow pop \cdot R$

 $b(R) = \Pr(adoption|R)$

• Specific rebate costs

 $c = C/\Delta E = (a+b(0)+[b(R)-b(0)]) \cdot R / [b(R)-b(0)] \cdot \Delta e \cdot \gamma$

Simulations **Specific rebate costs (€/t-CO₂)**



Conclusions

- Free riders make up large share (majority) of expected beneficiaries of subsidies for heating system upgrades.
 >50% at rebate = €1000
- Contingent valuation approach yields free-rider shares ex ante that are comparable to ex post assessments.
- The share of weak free riders is greater than the share of strong free riders in most countries.
- High mean reservation rebates suggest that premature replacement is associated with high opportunity costs.

Implications

- Free riding makes subsidizing heating system upgrades to reach energy/emissions targets substantially more expensive.
- For a rebate of 1000 euros, the specific rebate costs for most countries exceed 500 €/t-CO₂.
- Country differences suggest that coordination can yield reductions in public subsidy expenditures.
- Subsidy expenditures would be much lower if low-cost (information) programs could turn weak free riders into (non-incentivized) adopters.

That's all. Thank you.



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Simulations Parameter assumptions

		FR	DE	IT	PL	RO	ES	SE	UK
	Sample size ^a	915	634	1089	1311	706	1299	594	948
	# of households ^b (x 1000)	28,920.4	40,257.8	25,788.6	14,113.4	7,469.7	18,376.0	5,099.8	28,218.5
$\Delta e \left\{ - \left\{$	Savings (€)	1000	1000	1000	1000	1000	1000	1000	1000
	Gas price ^c (€/kWh)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
$\gamma = \left\{ \begin{array}{c} \gamma & \gamma \end{array} \right\}$	CO_2 factor (kg-CO ₂ /kWh)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Share of strong free riders ^d (%)	12.4	19.8	17.9	13.6	40.6	11.1	8.9	14.0

^a Subsample of homeowners, who stated that they did not purchase a new heating system during the past ten years and who live in a dwelling built before the year 2000 (corresponds to *N↓sample* in the analytical model)

^b Eurostat (2016a)

^c Eurostat (2016b)

^d Share of strong free riders in the subsample

Simulations Specific rebate costs



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Limitations

- Hypothetical bias?
 - Stated vs. observed behavior
 - Likely small compared to free-rider bias
- Ignores administration costs
- Ignores rebound effects
- Eliminates uncertainty of future savings
- Hides consideration of 'hidden costs'

Conclusions

- Free riders > additional adopters
- Weak free riders > strong free riders
- High mean rebate: opportunity cost premature replacement
- Free riding makes subsidizing expensive
- High specific rebate costs (> 500 €/tCO₂)
- Contingent valuation approach credible *ex ante* method

Implications

- Coordinate internationally to exploit country differences
- Low-cost programs first to mitigate weak free riding