

Energy efficiency renovations & housing tenure
status:
energy-savings or rebound effect ?

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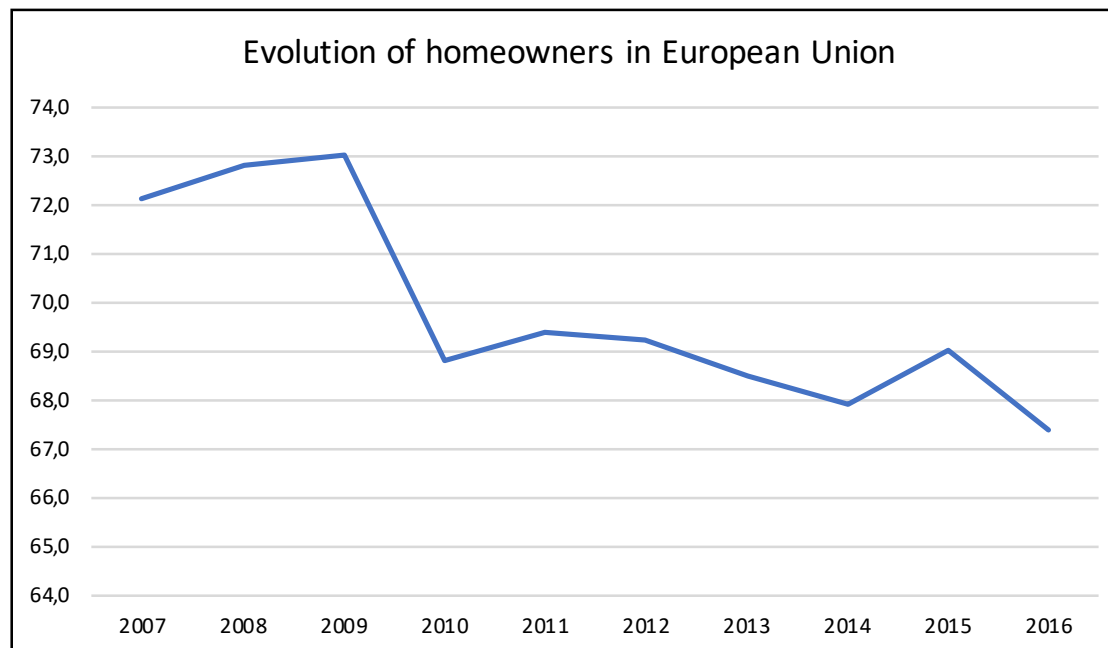
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Context

- Reducing energy consumption: one of the priorities of policy makers in many developed countries
- Residential sector :
 - Represents 25.4% of final energy consumption in the European Union (Eurostat, 2016) and about 27.9% in the United States (EIA, 2017)
 - A high potential for energy-savings through renovations (European Commission, 2011)
 - Introduction of policies to induce energy-saving renovations

Context

- The energy paradox : barriers to investment (Brown, 2001; Jaffe and Stavins, 1994; Sanstad et al., 1995; Van Soest and Bulte, 2001)
- Split incentives between owners-occupied and tenants (Gillingham and al., 2012; Philips, 2012) and the share of homeowners tends to decrease



Source : Eurostat

Context

- Household behaviour after the renovation and the rebound effect
 - Rebound effect for heating use up to 60% (Sorrell and Dimitropoulos, 2008)
 - Heterogeneity in the rebound effect (Erdal et al., 2017)

Objectives

1. What are the key variables in the decision-making to renovate
 - for owners-occupied ?
 - for tenants ?

2. Are households decrease their energy consumption after a renovation ?

Data

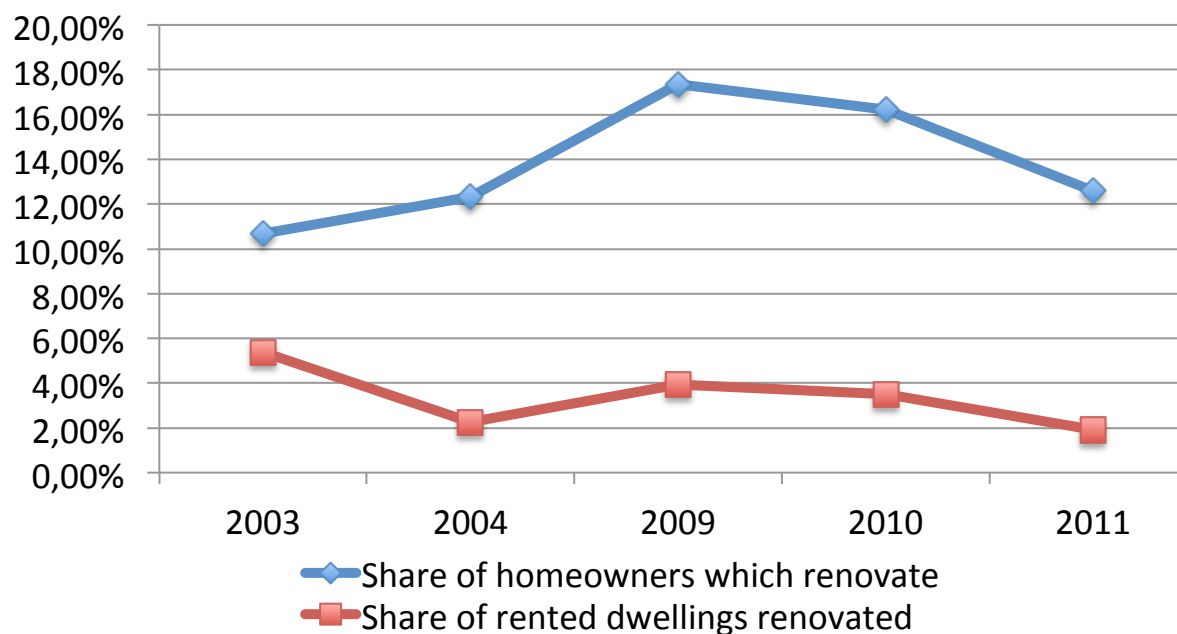
- French database : *ADEME-SOFRES Maîtrise de l'énergie* surveys
 - 16,209 households (12,690 owners-occupied and 3,519 tenants)
 - Five years : 2003, 2004, 2009, 2010 and 2011
 - Unbalanced panel data

Data

- Information on :
 - energy-saving renovations (insulation, improvement of heating system and adoption of renewables)
 - households and housings characteristics
 - energy used and energy bill
 - renovations before and after the introduction of an energy tax credit
- Complementary data :
 - Unified degree-days (SOeS)
 - Energy prices (*Pegase* database)

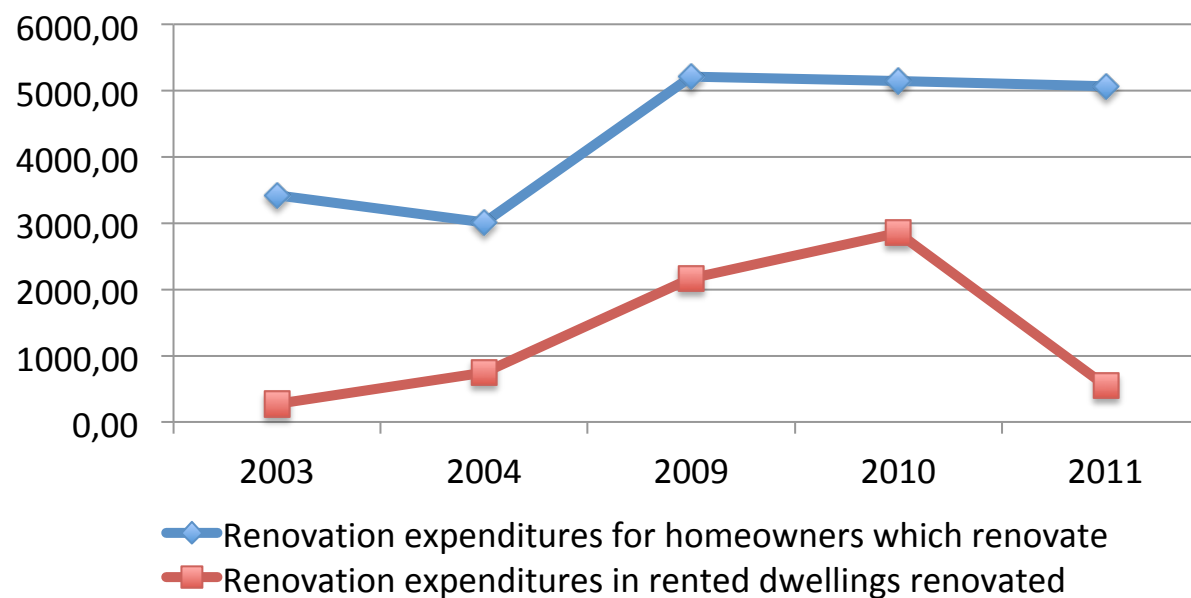
Renovation rate

13.9% of owner-occupied dwellings renovated over the period compared to only 2.5% of rented dwellings



Renovation expenditures

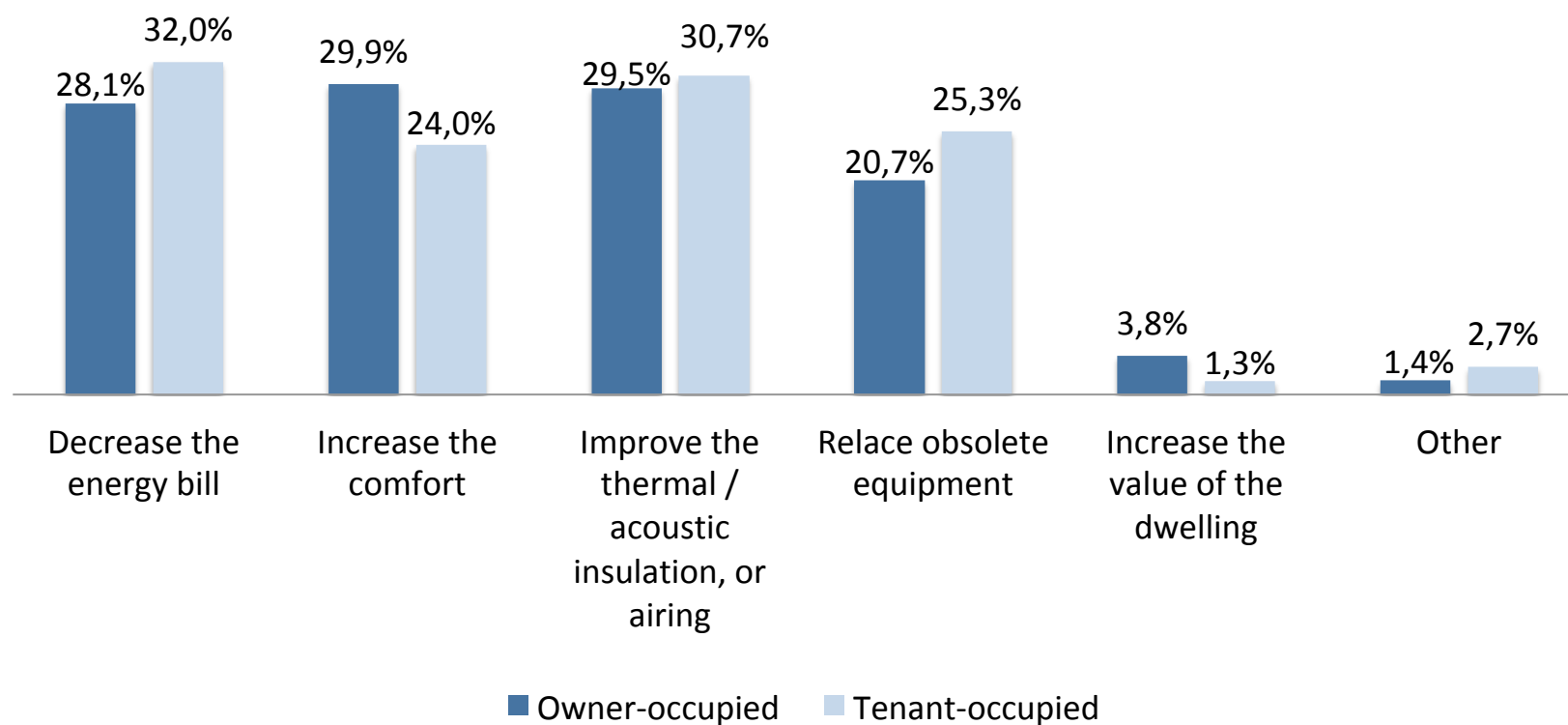
Renovations carried out by homeowners more significant : 4,576 euros and only 1,550 euros in rented dwellings



Source : ADEME SOFRES data – authors calculations

Data

Main reasons to undertake a renovation



Source : ADEME SOFRES data – authors calculations

Energy-saving renovations: Econometric model

We estimate the following model :

$$y_{it}^* = \alpha_i + \beta x'_{it} + \epsilon_{it}$$

y_{it}^* represents renovation expenditures (first, for all the sample and then, for homeowners and tenants separately)

x_{it} are control variables :

- household characteristics (income, age, number of persons in the household, moving into the dwelling since less than 5 years)
- housing characteristics (house, year of construction, surface area, localisation)
- the energy expenses per m² (lagged),
- the temperature in the dwelling (lagged) and unified degree-days by region (lagged)
- the introduction of an energy tax credit

Energy-saving renovations: Econometric model

- Censorship problem :

The renovation expenditures can be observed only partially : We know the expenses only for households which undertake a renovation and we do not know how many, households that have not renovated, would have spent if they had undertaken a renovation

$$y_{it} = \begin{cases} y_{it}^* & \text{if } y_{it}^* > 0 \\ 0 & \text{if } y_{it}^* \leq 0 \end{cases}$$

→ We use a Tobit model

Energy-saving renovations: Results – Complete sample

	Complete sample		
	Marginal effects E(y* y>0)	Standard errors	
owner-occupied	0.6562	0.0299	***
energy expenses per m ² (in log - lagged)	0.0635	0.0322	**
indoor temperature (lagged)	-0.0312	0.0120	***
after the introduction of the tax credit	0.1987	0.0296	***
Other controls :			
dwelling characteristics	yes		
households characteristics	yes		
unified degree-days	yes		
Number of observations	16209		
Log likelihood	-9280.747		

Note: ***significant at 1%; **significant at 5%; *significant at 10%.

Energy-saving renovations: Results – Owners and tenants

	Owners occupied		Tenants	
	Marginal effects $E(y^* y>0)$	Standard errors	Marginal effects $E(y^* y>0)$	Standard errors
<i>dwelling characteristics</i>				
year of construction : before 1948	0.6168	0.0917 ***	0.0808	0.0487 **
between 1949 - 1974	0.7412	0.0939 ***	0.0515	0.0298 **
between 1975 - 1981	0.6332	0.1094 ***	0.1276	0.0710 ***
after 1982	ref		ref	
energy expenses per m ² (in log)	0.1187	0.0520 **	-0.0140	0.0119
<i>households characteristics</i>				
income : below 12000 € / year	ref		ref	
12000 - 15700 € / year	0.0765	0.1203	-0.0084	0.0205
15700 - 19000 € / year	0.1082	0.1124	0.0305	0.0350
19000 - 23000 € / year	0.1941	0.1066 *	0.0221	0.0305
23000 - 36600 € / year	0.2452	0.0853 ***	0.0175	0.0237
more than 36600 € / year	0.3165	0.1024 ***	0.0248	0.0393
indoor temperature (lagged)	-0.0451	0.0195 **	-0.0053	0.0042
after the introduction of the tax credit	0.3195	0.0471 ***	0.0062	0.0127
Other controls on households and housing characteristics, unified				
degree-days	yes		yes	
Number of observations	12690		3519	
Log likelihood	-8962.5661		-304.3522	

The impact of renovations on energy consumption

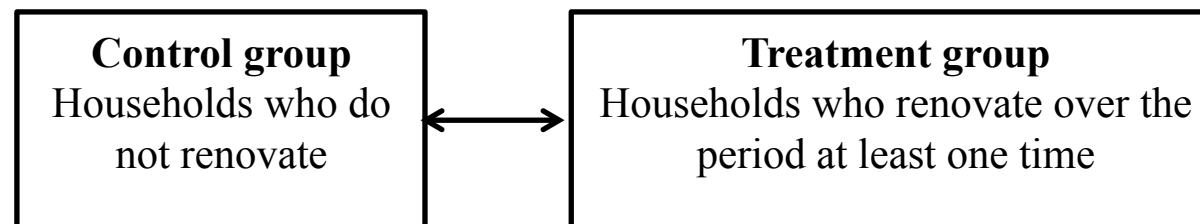
- 4,609 households renovate over the observed years
- In average, the energy consumption is 1.4 kWh/m² higher the year after the renovation compared to the year before
- 53% of households increase their energy consumption the year after the renovation

→ Presence of a rebound effect ?

The impact of renovation on energy consumption

Econometric model

- Matching method (Rosenbaum and Rubin, 1983; Heckman, Ichimura and Todd, 1998)
 - Objective : measure energy consumption with the renovation – energy consumption that would have been observed without the renovation



- To match each household that renovate (*treated group*) with household that do not renovate (*control group*), with the same observable characteristics
 - Propensity score matching (Rosenbaum and Rubin, 1983)

The impact of renovation on energy consumption

Results

	Effect on energy consumption in kwh/m2		
	Whole Sample	Homeowner sample	Tenant sample
Effect of living in a renovated dwelling	0.0199	0.0144	0.0793
Standard error	0.0065***	0.00841*	0.0291***
Number of controls	11,600	8,493	3,107
Number of treated	4,609	4197	412

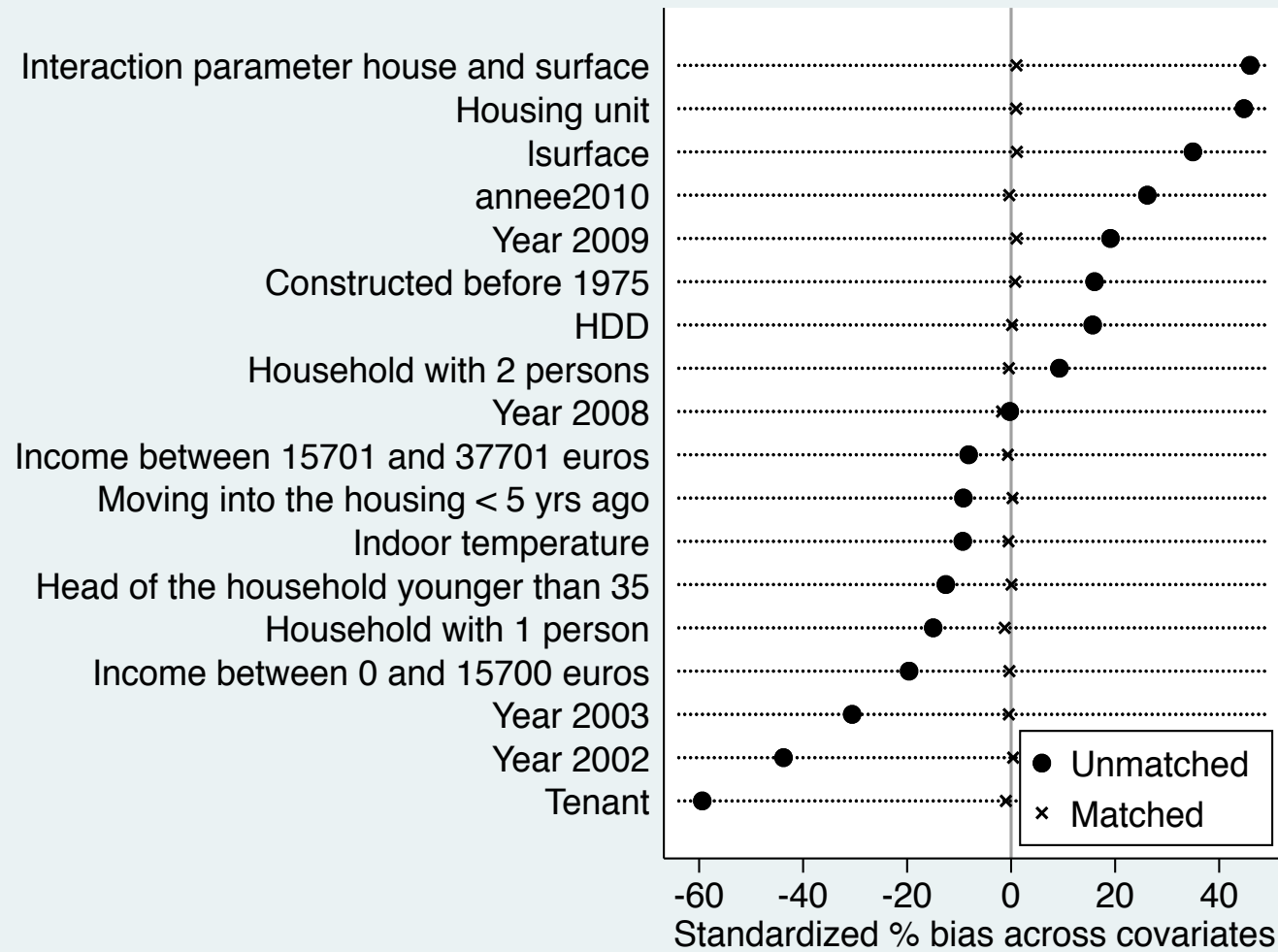
Note: ***significant at 1%; **significant at 5%; *significant at 10%.

Conclusion

- Housing tenure status is an important barrier to reducing energy consumption in housing sector
 - Tenants renovate less than owner-occupied
 - The energy tax credit does not induce tenants to renovate
 - A rebound effect of energy consumption larger than for owners-occupied.
- Policies that encourage energy-saving renovations can lead to a rebound in consumption.

Thank you

Appendix



VARIABLES	Coefficient (Std. Err.)
House	0.485 (0.447)
Construction before 1975	0.565*** (0.0313)
Tenant	-1.358*** (0.0513)
Surface area (in log)	0.153* (0.0902)
rev_Income below 15700 euros	-0.246*** (0.0473)
Income between 15700 and 13000 euros	-0.0802** (0.0381)
Head of the household younger than 35	0.0480 (0.0585)
Household with 1 person	-0.0334 (0.0470)
Household with 2 persons	0.0106 (0.0353)
HDD	0.000101** (5.02e-05)
Moving into the housing < 5 yrs ago	0.179*** (0.0420)
Indoor temperature	-0.0325*** (0.0116)
Interaction parameter housing unit and surface	0.0247 (0.101)
Year Fixed effect	Yes
Observations	16,209
Correctly classified after logit	72.37%