BRISKEE

Behavioural Response to Investment Risks in Energy Efficiency

BRISKEE BRIEF

INSIGHTS FROM MICRO-LEVEL ANALYSIS FOR THE MODELLING OF ENERGY EFFICIENT TECHNOLOGY ADOPTION IN ENERGY-ECONOMIC MODELS VIA IMPLICIT DISCOUNT RATES (IDRS)

Authors: Joachim Schleich, Corinne Faure, Xavier Gassmann

Grenoble Ecole de Management (GEM)

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1 Objective

In this document we derive implications for the modeling of energy efficient technology adoption in energy-economic models relying on

- Econometric analyses of the factors related to the adoption of energy-efficient technologies (D2.3)
- Econometric analysis of the factors related to standard time preferences, risk preferences, present bias, and environmental identity, and access to capital (D 2.4)

2 The role of Implicit Discount Rates in energy-economic models

In energy models, **IDRs (or subjective discount rates) are used to govern investment decisions by economic agents** (e.g. households and companies). The higher the IDR of a particular energy efficiency investment project, the less likely it is that the model will select this project to be implemented.

For parameterization of the IDRs, modelers typically rely on estimates from the empirical literature. An IDR is estimated from observed technology adoption choices and net present value calculations as the discount rate that renders the observed technology choice reasonable (→ Box 1). Implicit discount rates (are used for positive analyses, in contrast to social discount rates which are used for normative analyses.

In practice, **most energy-economic models are characterized by little differentiation in IDRs by decision makers** ("representative consumer"), **technologies**, or **countries**. Also, **the factors behind the IDR tend to remain fractional**.

Box 1: Example: What are Implicit Discount Rates?

For example, suppose an energy efficient technology (EET) has upfront costs of 120 Euros and annual operating costs of 20 Euros. Yet the consumer decides to purchase an alternative technology with upfront costs of 100 Euros, and annual operating costs of 50 Euros. So despite of large differences in future energy costs savings and relatively small differences in investment costs, the consumer chose the less energy efficient alterative technology. For simplicity, assume the lifetime of either technology is one year. In this case, the implicit discount rate which renders the adoption of the alternative (less energy efficient) technology reasonable would be 0.5 = (50-20)/(120-100) – 1. Yet, the underlying reasons for this choice are not known. One possible factor would be impatience, i.e. a high value of time. Likewise, energy cost savings may be uncertain and consumer risk-aversion may drive the observed choice in favor of the less energy efficient alternative technology. Moreover, if the (additional) costs of investing in EET are evaluated as a loss, loss aversion may impair the adoption of the EET. Annex I provides an overview of the factors "inside" the implicit discount rate.

3 BRISKEE Survey

The data for the econometric analysis is based on the BRISKEE survey, i.e. a representative online survey of households in 8 EU countries in July/August 2016, with 1500/2000 observations per country, accounting for about 80 % of EU population, energy use and CO_2-emissions.
The survey included questions on:

(i) **Preferences** [e.g. standard time preferences (patience), risk aversion, loss aversion, present bias, environmental identity (Whitmarsh and O'Neill, 2010), social norms, psychological and cultural factors]

Two alternative methods were employed to elicit patience, risk aversion, and present bias:

a) **Multiple price list (MPL) lotteries** (incentivized) following Coller and Williams (1999) and Holt and Laury (2002). (Loss aversion was only elicited via MPL, not via Likert scale items)

b) **Likert scale items** reflecting willingness to take risk, standard time preferences (patience) and present bias (Dohmen et al., 2010; Falk et al., 2016). Dohmen et al. (2010) argue that these scales better reflect general time and risk preferences of individuals;

(ii) **Socio-demographic characteristics** (e.g. age, gender, education, income, mobility...)

(iii) **Dwelling characteristics** (size, age, …)

(iv) **Adoption** of energy efficiency measures:

a) Last **light bulb** purchased in the last 2 years (efficient if LED was purchased)

b) Last **appliance** purchased in the last 5 years (efficient if EU energy label ≥ A++)

c) **Retrofit measures** in the last 10 years (insulation of roof or ceiling, insulation of exterior walls, insulation of basement, installation of double-glazed windows, or installation of triple-glazed windows)

4 Results of econometric analyses (Summary)

We estimated individual binary response models (Probit) on the adoption of LEDs, energy efficient appliances, and retrofit measures. The results are summarized in Table 1 together with implications for modeling. The categorization and the factors correspond to the underlying framework of the implicit discount rate developed within BRISKEE (see Annex I). In Annex II we present qualitative findings of the regressions on standard time preferences, risk preferences, present bias, environmental identity and access to capital.

Table 1: Summary results from econometric models on factors related to technology adoption and to time, risk, present bias, environmental identity and access to capital

	LED	Appliances	Retrofit†	Implications for modelling
				Reported for average across countries; effects may vary by country
Preferences				
Patience	+		**(+)**	Higher income and better educated households with children are more patient
Risk aversion			**(+)**	Higher risk aversion for older, female, lower educated, lower income households with children
Loss aversion				
Environmental identity	+	+	+	Higher environmental identity for older, female, high education households with children
Social norms	+	+	+	
Behavioral biases				
Present bias	-	-	**- (-)**	Higher present bias for younger, male and better educated participants
External barriers				*General: lower IDR in response to policy addressing barrier*
Renting	-	-	-	Change in propensity to adopt in *percentage points*: -7.0 (LED): -3.1 (appliance), -27.8 (retrofit)
Likely move	-	-	-	Change in propensity to adopt in *percentage points*: -2.5 (LED), -1.6 (appliance), -1.2 (retrofit)
Own meter	+	+	+	Change in propensity to adopt in *percentage points*: +2.9 (LED),+ 6.3 (appliance), +5.4 (retrofit)
Access to capital	+	+	+	Better access to capital for older, male, high income, high educated households with children

Socio-demographic characteristics				
Age	-	+		Change in propensity to adopt in *percentage points* per year (compared to mean): - 0.2 (LED), + 0.2 (appliance)
Gender	+			
Income	+	+	+	Change in propensity to adopt in *percentage points* per 10000 Euros annual disposable income (compared to mean income): +1.0 (LED), +1.0 (appliance), +0.7 (retrofit)
Education	+		-)[a]	Change in propensity to adopt in *percentage points* if above median education in country: +2.5 (LED), -2.1 (retrofit)
Household size				Change in propensity to adopt in *percentage points* per family member (compared to mean): - no effect
Dwelling characteristics				
Dwelling size		+	+	Change in propensity to adopt in *percentage points* per 100m^2 (compared to mean): +5.9 (appliance) +4.5 (retrofit)
Building age	+	+	-)[b]	Change in propensity to adopt in *percentage points* per additional year of age (2016-year of construction): +0.06 (LED), +0.05 (appliance), -0.07 (retrofit)
Detached housing			+	Change in propensity to adopt in *percentage points* if detached home: +7.1 (retrofit)
Country characteristics (Germany is base country)	FR -, IT -, PL -; RO -, SE -, UK -	FR -, IT -, PL -; RO -, ES - SE -, UK -	FR -, IT -, PL -; RO -, ES - SE -, UK -	Account for differences in general propensity to adopt across countries

[†]Findings for patience, risk aversion and present bias using Likert scales are in ()

)[a] Negative sign may be explained by higher educated participants living in better insulated dwellings.

)[b] Negative sign can be explained by the fact that younger buildings tend to already be equipped with good insulation and windows; hence the are less likely to have undergone retrofit measures in the last ten years;

5 Summary (tentative) of implications for modeling of household EET investment decisions (IDRs)

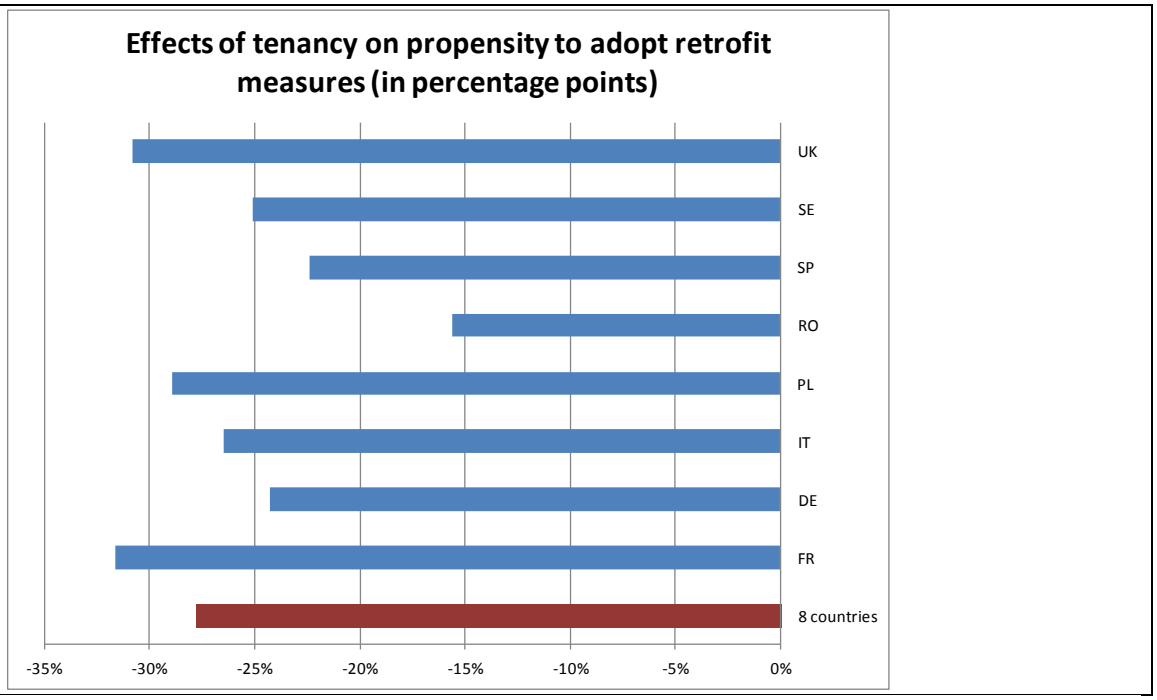
IDRs should vary by (ceteris paribus):

- *Household characteristics* (e.g. generally lower IDR for well-educated high income households);
- *Technologies* (e.g. higher IDR for higher stakes, and higher technological/economic risk);
- *Tenancy* (e.g. higher IDR for rented buildings – the "landlord-tenant" problem → Figure 1);
- *Dwelling characteristics* (e.g. lower IDR for younger buildings for appliances/LED, but higher IDR for younger buildings for retrofit; lower for detached homes)
- *Country* (e.g. generally lower IDR in De, for example).
- *Household preferences* (e.g. lower IDR for households with high environmental identity);

Box: Example: Effect of landlord-tenant problem on propensity to adopt energy-efficiency measures across countries

Figure 1 below shows the effects of the landlord-tenant problem for retrofit measures. On average (8 countries model), renters are about 28 percentage points less likely to adopt a retrofit measure than home owners. This effect differs across countries ranging from 16 percentage points in Romania to 32 percentage points in France.

Figure 1: Effects of tenancy on propensity to adopt retrofit measures (in percentage points)



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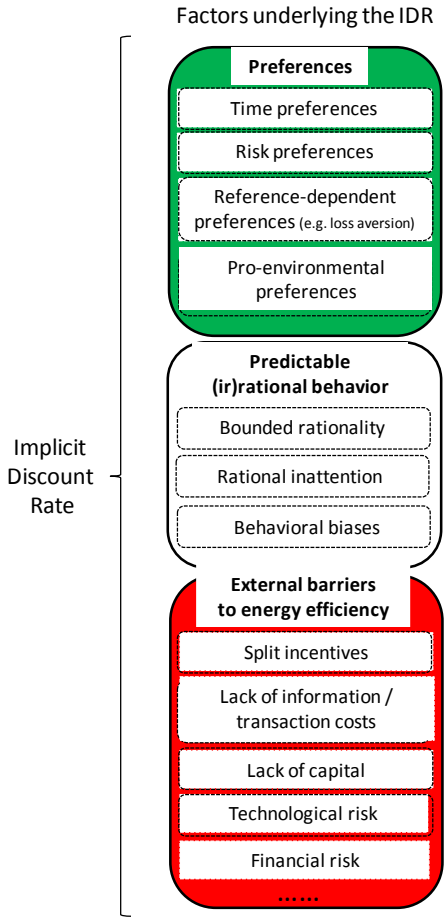
ANNEX 1 The factors underlying the implicit discount rates

The factors underlying the IDR may be grouped into three broad categories (→ Figure A1):

Figure A1: Factors underlying the implicit discount rate



(i) **Preferences** such as time preferences (impatience +), risk preferences (risk aversion +), reference-dependent preferences (e.g. loss aversion – "losses loom larger than gains" +, social preferences "keeping up with the Joneses" effect +/-), pro-environmental preferences (-), or debt aversion (-);

(ii) **Predictable (ir)rational behavior** such as bounded rationality (-), rational inattention (-), and behavioral biases, such as status quo bias (-) or present bias (i.e. overvalue the present compared to the future -);

(iii) **External barriers** to energy efficiency such as split incentives (i.e. landlord-tenant / owner-user problem -) , lack of information (-) or lack of capital (-);

+: factor typically thought to increase the IDR

- : factor typically thought to decrease the IDR

Source: Schleich et al. (2016)

ANNEX II: Results from multivariate analysis of factors related to preferences and access to capital

Socio-demographic characteristics	*Patience (more patient)*	*Present bias (less present biased)*	*Risk aversion (less risk-averse)*	*Environmental identity (higher)*	*Access to capital (better)*
Age		-	-	+	+
Gender (male =1)		-	+	-	+
Income	+		+		+
Education	+	-	+	+	+
Children	-		-	+	+