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Making the implicit explicit: A look inside the implicit discount rate

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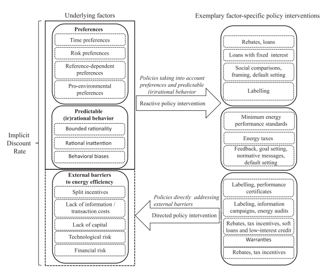
HIGHLIGHTS

- Implicit discount rates (IDRs) reflect preferences, predictable (ir)rational behaviors and external barriers.
- The factors underlying the IDRs can be used to design directed and reactive policies.
- IDRs in energy models should vary by household and technology characteristics.

GRAPHICAL ABSTRACT



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ABSTRACT

Implicit discount rates (IDRs) are employed in energy models to capture household investment decisions, yet the factors behind the IDR and their respective implications for policy-making usually remain blurred and fractional. The proposed comprehensive framework distinguishes three broad categories of factors underlying the IDR for household adoption of energy-efficient technologies (EETs): preferences (notably over time, risk, loss, debt, and the environment), predictable (ir)rational behavior (bounded rationality, rational inattention, behavioral biases), and external barriers to energy efficiency. Existing empirical findings suggest that the factors underlying the IDRs that differ across household characteristics and technologies should be accounted for in energy models. Furthermore, the framework allows for a fresh look at the interplay of IDRs and policies. We argue that a simple observation of high IDRs (or observing correlations between IDRs and socio-economic characteristics) does not provide guidance for policy-making since the underlying sources cannot be identified. Instead, we propose that some of the factors underlying the IDR - notably external barriers - can be changed (through directed policy interventions) whereas other factors - notably preferences and predictable (ir)rational behavior - are innate and can only be taken into account (through reactive policy interventions).

1. Introduction

Discount rates play a crucial role in model-based policy evaluations such as energy-efficiency policy assessments. Conceptually, two types of discount rates may be distinguished. First, social discount rates, which essentially compare costs and benefits that accrue at different points in time, typically reflect pure time preferences and decreasing marginal utility of consumption or the government's opportunity costs of capital (e.g. the long term return on government bonds) (e.g. Arrow et al., 1996). Second, so-called subjective discount rates govern decision makers' actual adoption behavior. For parameterization of the subjective discount rates, models typically rely on implicit discount rates (IDRs). An IDR is estimated from observed technology adoption choices and

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net present value calculations as the discount rate that renders the observed technology choice reasonable (Dubin and McFadden, 1984).[1]

Starting with the seminal work by Dubin and McFadden (1984), Hausman (1979), and Train (1985), the empirical literature on household energy technology adoption decisions has found IDRs to typically exceed the opportunity costs of capital. Unlike social discount rates, IDRs also reflect external "barriers to energy efficiency" such as imperfect information, capital constraints or the landlord-tenant (split-incentive) problem. As recognized by Jaffe and Stavins (1994), high IDRs are more of a restatement than the source of the so-called "energy-efficiency paradox", which postulates that decision makers may fail to invest in energy-efficient technologies (EETs) even though these appear to pay off under prevailing market conditions.[2] In any event, since IDRs are derived from EET adoption behavior (i.e. IDRs are estimated to be higher when EET adoption is lower), there is a direct link between empirical results obtained about EET adoption and IDR estimates used in models.

Clearly, the two types of discount rates serve very different purposes; yet this distinction is often not made in actual model-based policy assessments. This problem has been recently noted by Hermelink and Jager (2015) and Steinbach et al. (2015), among others, within the discussion of the energy efficiency target in EU's 2030 energy and climate policy framework and the corresponding impact assessment (European Commission, 2014).[3] While there is an extensive body of literature discussing the social discount rate (e.g. Stern, 2006; Nordhaus, 2007), the factors behind the implicit discount rate and their respective implications for policy making usually remain blurred and fractional. In this paper, we aim to contribute to closing this gap. We present a comprehensive framework of the underlying factors of the IDR for household adoption of EET, relying in particular on insights from the behavioral economics literature. More specifically, our framework distinguishes three broad categories of factors underlying the IDR: (i) preferences such as time preferences, risk preferences, reference-dependent preferences and pro-environmental preferences; (ii) predictable (ir)rational behavior, i.e. bounded rationality, rational inattention, and behavioral biases, such as present bias or status quo bias; and (iii) external barriers to energy efficiency such as split incentives, lack of information or lack of capital (e.g. Sorrell et al., 2004).

After describing these underlying factors, we illustrate through selected examples the effects of covariates such as household and technology characteristics on the IDR at the factor level. By combining established concepts from various disciplines, our framework organizes notions around the IDR in a novel way, provides insights into the interplay of IDRs and policy interventions, and offers guidance for improved energy modeling and policy assessment. While all policies aim at lowering the IDR, this framework distinguishes between directed and reactive policies. Directed policies aim at directly lowering the external barriers (e.g. mandatory building certificates addressing split-incentives). Reactive policies take into account the factors underlying the IDR that cannot be changed such as preferences (e.g. offer loans with fixed interest rates to risk-averse household with a high time discount rate).

The remainder of our paper is organized as follows. Section 2 presents our framework for categorizing the factors underlying the IDR in a comprehensive manner. This section also documents the findings from the literature on the correlation of these factors with selected household and technology characteristics. Based on this framework, Section 3 explores the interplay of policy interventions and the IDR. The concluding Section 4 summarizes the main findings, points to future research, and highlights the contributions of the paper for conceptual underpinning of the IDR, policy making, and modeling household adoption of EETs.

2. Framework

Studies that empirically estimate the IDR for the adoption of EETs, based on observed behavior in private households (e.g. Train, 1985 for an early review), find that the IDRs vary substantially across technologies, but also within similar technology classes. For example, the IDRs for refrigerators range from 34% (Hausman, 1979) to 300% (Meier and Whittier, 1983). Similarly, for an oil-based heating system, IDRs are estimated to be as low as 14% (Corum and O'Neal, 1982) and as high as 127% (Ruderman et al., 1987). Clearly, these figures are higher than the costs of capital, i.e., the rates at which households can borrow money.[4] The previous empirical literature (e.g. Train, 1985) and modelers (e.g. ICCS, 2014./ICCS PRIMES, 2014) casually note that certain factors, such as barriers to energy efficiency, help explain this difference. The more conceptual literature focuses on factors explaining the "energy efficiency paradox", thus highlighting external barriers to energy efficiency (e.g. Brown, 2001; Sathaye et al., 2001; Sorrell et al., 2004), emphasizing the distinction between market failures and external barriers (Jaffe and Stavins, 1994), or concentrating on behavioral factors (Gillingham et al., 2009; Gillingham and Palmer, 2014). Since the objective of this conceptual literature was not to explain the IDR, it only offered a partial picture, and typically neglected the role of consumer preferences. Consequently, a comprehensive framework of the factors underlying the IDR and their implications for modeling and policy interventions has not yet been presented.

Fig. 1 provides a graphical representation of our proposed framework for looking inside the IDR, which includes as overarching factor categories (i) preferences, (ii) predictable (ir)rational behavior, and (iii) external barriers to energy efficiency.[5] These will be discussed in more detail below.

2.1. Preferences

The first category of factors in our IDR framework reflects individual preferences, which are assumed to govern individual choice between alternatives. In particular, we focus on preferences

[1] To illustrate, suppose an energy efficient technology 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. For simplicity, assume the lifetime of either technology is one year. In this case, the implicit discount rate which explains the adoption of the alternative technology would be $0.5=(50-20)/(120-100)-1$.

[2] Note that the "energy-efficiency paradox" differs from the "energy efficiency gap" (e.g. Gerarden et al., 2015b). The "energy efficiency paradox" refers to the notion that some energy-efficiency technologies that would be profitable for adopters are nevertheless not adopted. In comparison, the "energy-efficiency gap" means that adoption is lower than socially optimal, e.g. because energy prices do not adequately reflect environmental externalities.

[3] Since they are substantially higher than social discount rates, applying IDR rather than social discount rates typically leads to less ambitious energy efficiency targets.

[4] More recent studies eliciting IDRs tend to rely on stated (rather than observed) behavior, thus limiting the comparability of findings. Yet those studies also find IDRs to vary substantially and to exceed market interest rates (e.g. Min et al., 2014; Newell and Siikamäki, 2015; Revelt and Train, 1998).

[5] Ceteris paribus, the total size of the IDR depends on the difference in upfront investment costs between the adoption of an EET and an alternative technology, on the difference in operating costs, and on how these are distributed over time. But these differences do not explain the energy efficiency paradox and are neglected in the subsequent discussion.