Energy Research & Social Science 47 (2019) 37–45

Contents lists available at ScienceDirect

Energy Research & Social Science

journal homepage: www.elsevier.com/locate/erss

Original research article

Neither a borrower nor a lender be: Beyond cost in energy efficiency decision-making among office buildings in the United States

Alexander Davis*, Gabrielle Wong-Parodi, Tamar Krishnamurti

Department of Engineering and Public Policy, Carnegie Mellon University, 5000 Forbes Avenue, United States

ARTICLE INFO

Keywords:
Energy efficiency
Decision-science
Debt aversion
Uncertainty

ABSTRACT

Even when the benefits seem to outweigh the costs, many building owners do not invest in energy efficiency. Here a framework is presented for understanding energy efficiency investment decisions drawing on methods from behavioral decision research. The approach begins with a normative analysis that characterizes how building owners should behave, compares this to interview and survey data from decision-makers, then concludes with policy recommendations suggesting how to bridge that gap. The framework is demonstrated with a sample of class B and C office building owners in Pittsburgh, a population believed to under-invest in energy efficiency. Interviews (n = 16) and a survey (n = 132) found that while uncertainty and a lack of information about costs and energy savings play a critical role in decision-making, a significant proportion of the respondents also express aversion to debt and a lack of sensitivity to split incentives. Based on the results, providing owners of class B and C offices cost–benefit information and resolving energy savings uncertainty through guarantees, trial periods, or grants that fully subsidize energy efficiency for a small part of a building may be a way to enhance investment. The approach can be applied to other energy efficiency decision-making contexts by anyone with training in behavioral research.

1. Introduction

Energy efficiency is one of the most important tools for mitigating climate change [1], and the commercial buildings sector has a large potential for implementing cost-effective energy efficiency improvements (e.g., occupancy sensors) [2]. Unfortunately, this sector also has a track record of slow market diffusion of energy efficiency improvements [3–5]. To better understand the causes of this slow diffusion, researchers have examined the barriers faced by owners of commercial buildings. However, work has solely focused on larger commercial buildings, that face very different constraints (e.g., corporate social responsibility [6,7]) than smaller commercial buildings, that are informally rated as class B or C according to their value, amenities, and expected rental price.[1]

To understand the decision-making of owners of class B and C offices, the present paper uses the tripartite analytical approach of behavioral decision research [8], an approach that has been applied across a variety of domains, from health decisions [9] to energy policies [10] and decisions related to climate and energy systems [11,12]. von Winterfeldt and Edwards [8] divide the approach into three components: (1) a *normative analysis*, considering when and why a building owner with economically focused and well-constructed preferences should invest in energy efficiency,[2] (2) a *descriptive analysis*, complementing existing behavioral findings by using interviews and a survey to identify the concerns that actually matter to building owners, and (3) a *prescriptive analysis* that suggests how energy efficiency program designers, such as utilities or regulators, might use the results to improve program performance. The approach embraces both the formalism of decision analysis [13] and the empiricism of complementary social sciences (e.g., psychology, anthropology, sociology), using normative analyses to carefully specify the decision problem, and descriptive analyses to test that characterization and allow new results to emerge. The approach is illustrated using the energy efficiency investment decisions of owners of class B and C offices in Pittsburgh PA.

1.1. Normative analysis

The normative analysis in this work draws on previous research

* Corresponding author.
E-mail addresses: alexdavis@cmu.edu (A. Davis), gwongpar@cmu.edu (G. Wong-Parodi), tamar@cmu.edu (T. Krishnamurti).

[1] http://www.boma.org/research/pages/building-class-definitions.aspx.

[2] While the meaning of the term “normative” varies across contexts, here normative means the analyst's conception of what a rational decision-maker should do given a description of the decision problem.

https://doi.org/10.1016/j.erss.2018.08.008
Received 15 July 2017; Received in revised form 4 August 2018; Accepted 11 August 2018

investigating influences on energy efficiency decision making [14–20]. It focuses on four factors that have substantial theoretical and empirical support, and were relevant from informal discussions with experts familiar with class B and C offices. These four factors are necessary conditions for investment by building owners with economically focused preferences: (1) low uncertainty in energy savings, (2) capital availability, (3) time preference, and (4) incentive alignment between landlord and tenant. These are normative influences on decision-making because they are consistent with the axioms of rational preferences [21], and how those preferences should be related over time [22].

First, building owners should be wary about investing in energy efficiency if the energy savings are uncertain, depending on the occupancy patterns of the building, weather, and technology performance [14,23]. For example, in one study of 447 commercial buildings retrofitted with energy saving measures, Greely *et al.* [24] found that most (two-thirds) of the actual energy savings deviated from the predicted energy savings by more than 20%. Investing in energy efficiency means that the building owner accepts this uncertainty, with its potential downside. As expected from this analysis, homeowners in the residential sector [25,26] who are more risk averse are less likely to invest in energy efficiency. Second, building owners may not purchase energy efficient equipment because they simply do not have enough money to pay the up front capital costs [27]. There is evidence that some firms are unwilling (or unable) to use debt to finance energy efficiency investments [28]. Third, rewards in the future are often discounted, tipping the balance against energy efficiency, that promises delayed rewards (energy savings) in exchange for immediate capital costs [27]. Previous economic studies have found that the discounting of energy savings is both large and variable [29,30]. Finally, building owners do not always directly benefit from investments that make their building more energy efficient because in many buildings tenants pay the utility bills. For example, Schleich [31] conducted a cross-sectional survey of 2000 organizations in the commercial and services building sector in Germany and found that buildings with renters tended to be less likely to adopt at least half of the relevant energy efficiency measures for their building compared to owners that also occupied the building.

To characterize these normative issues we present the following simple mathematical model of an idealized energy efficiency investment decision. According to this model, building owners should invest if the annual time-discounted and uncertainty-adjusted sum of the energy savings (ES) from an investment is greater than the annual time-discounted (but certain) sum of the annual cost (AC) of that investment:

$$\sum_{j=1}^{J} \frac{\mathrm{ES}_j}{(1+\delta^{*}+\delta^{o})^{j}} > \sum_{j=1}^{Q} \frac{\mathrm{AC}}{(1+\delta^{*})^{j}} \tag{1}$$

Here, ES_j is the annual energy savings in year $j \in \{1, 2, \ldots J\}$ that accrue to the building owner (not the tenants), δ^{*} is the risk-free discount rate (the market interest rate that would provide building owners a rate of return of δ^{*} per year for sure), δ^{o} (where "o" stands for "other") is the rate at which the energy savings are discounted above and beyond the risk-free rate (e.g., taking other factors into account, such as uncertainty). *AC* is the annual cost of a fully amortized loan (or building owner's capital if self-financed) over $j \in \{1, 2, \ldots Q\}$ years:

$$\mathrm{AC} = P \times \frac{i(1+i)^{q}}{(1+i)^{q}-1} \tag{2}$$

where *P* is the capital cost, *i* is the effective annual interest rate, and *q* is the number of years of the loan. The normative analysis holds that an energy efficiency investment must: (1) provide a rate of return greater than market alternatives (time discounting, δ^{*}), (2) provide that rate of return with enough certainty (uncertainty aversion, δ^{o}), (3) be within the budget or financing constraints of the building owner (capital constraints, *AC*), and (4) provide financial benefit to the building owner, not just the tenants (split incentives). Further, the analysis considers only narrow self interest, as opposed to broader altruistic environmental concerns, as well as assumes that the building does not face other regulatory constraints such as new building codes.

1.2. Descriptive analysis

The normative analysis specifies what building owners should care about, if their preferences adhere to the axioms of rational choice and they value only economic outcomes. In reality, descriptive studies have demonstrated violations of these axioms, reflecting the use of a number of simplifying choice heuristics [32–34], and concerns other than the economics of investments, such as social and organizational factors [35]. For example, cognitive studies in the decision sciences find that decision processes are swayed by the characteristics of available options and salient reference points [36,37]; that people are often uncertain about what they want [38–40] and give different responses to choice tasks that are logically identical but described differently [41]; and that decisions made over time reflect more than pure time preferences [22]. Studies looking at social factors have found that people are influenced by social norms, doing what they think others do, or following social rules that they believe society prescribes [42]; that people care about things other than money, such as the harm done to others by air pollution [43–45]; and that subtle cues about what is expected of them can change energy conservation behavior [46]. Thus, the normative analysis is contrasted with descriptive research using interviews and a survey of class B and C office building owners in Pittsburgh, to determine whether and to what extent the normative analysis captured their concerns. Our descriptive analysis focuses on individual decision-making (rather than group or organizational decisions), because individuals are the dominant owners of class B and C offices in our sample (both from the database we compiled and their self-reports).

To conduct the descriptive analysis, data were obtained on building class and owner contact information from a combination of sources, including the commercial real estate database firm CoStar,[3] real estate searches using the Allegheny County Assessment, deed searches in the Allegheny County records, and other internet sources (e.g., Googling). Our sample frame included the entire population of class B and C offices in Pittsburgh, including 327 owners of 504 buildings.

2. Interviews

The descriptive analysis began with 16 semi-structured interviews [47,10] conducted in-person or by phone. These interviews started with an unstructured section, giving us an opportunity to learn what building owners had on their mind, followed by a structured section, where specific topics of the normative analysis were examined in greater detail.

2.1. Interview recruitment and participants

Interviewees were recruited by cold-calling building owners for whom contact information was publicly available. The interviews lasted about an hour and interviewees were compensated with $50 in cash or a gift card. Interviewee ages ranged from 38 to 91 years; the majority of interviewees were male, and one was female, reflecting the skew toward male owners in the population; they had a variety of professions including business owner, marketing professional, real estate manager, physician, school teacher, financial advisor, and engineer; their education levels spanned a wide range, from bachelor's degree to PhD; their reported gross annual income from the building ranged from $-40,000 (a loss) to a $2,000,000 gain; their buildings ranged in size from 2500 ft^2 to 150,000 ft^2; about half were class B and half were class C

[3] http://www.costar.com/.