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RESEARCH PAPER

What are the Policy Drivers to Undertake Green Retrofitting Investments? The Role of Tax Incentives and Communication in Italian Households' Decision-Making

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Abstract
This paper explores households' decision-making process to undertake green retrofitting investments, with the aim to identify the key behavioural drivers to adoption. We developed a discrete choice experiment survey and collected data from a sample of 434 individuals to explore the influence of monetary and non-monetary incentives on energy saving investment choices, focusing on the case of Italy, where a tax relief scheme (the so-called Superbonus) was introduced in 2020 to encourage green retrofitting investments. Our results show that the level of savings on energy bills, the environmental sustainability of the intervention and the comfort achieved all similarly contribute to adopt energy saving measures. Tax incentives, differently, were found to be less important drivers, except for those respondents who have a high level of green retrofitting cognition, suggesting a pivotal role of education and knowledge in driving choices. Our findings also indicate that communication matters: we show that green retrofitting decisions are influenced by the non-technical communication of the environmental benefits, while the use of technical expressions is found to be ineffective. These results are relevant to guide more efficient policy design and point to the need to combine targeted tax interventions with communication to encourage the uptake of energy saving measures.

Keywords Energy savings · Green retrofitting · Fiscal measures · Communication · Education · Discrete choice experiment

JEL Q51, Q58, G41, G51, G53.

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1 Introduction

The building and construction sector has a considerable impact on the environment, by causing habitat degradation, air pollution and greenhouse gas emissions – of special concern given the ongoing climate crisis (IEA 2011; Dräger and Letmathe 2022). The building and construction sector, in fact, accounts for more than 30% of the world's total energy consumption and is responsible for 26% of global energy-related greenhouse gas emissions (IEA 2023). Most of these emissions are from the residential building sector, which has grown by about 30% between 2005 and 2019 (Cabeza et al. 2022). Households' decisions of both home building, purchase and renovation can therefore have a significant impact on climate change (Banfi et al. 2008). To reduce the climate impact of the sector, the IPCC (2019) highlights that energy saving measures can play the biggest impact by contributing to a 42% reduction from baseline emissions in the building industry[1]. Green retrofitting, which is about the upgrading of existing buildings to improve the energy, environmental performance, comfort, and quality of space in a way that is financially beneficial to the owner (Jagarajan et al. 2017) represents a promising example of an energy saving measure. Green retrofitting decisions therefore require the consideration of many aspects, which may involve trading-off conflicting priorities, such as energy conservation, bill savings and thermal comfort (Li et al. 2021). For example, if households feel uncomfortable in an indoor environment, they will increase the usage of air-conditioning or heating systems to improve their thermal comfort, but this would result in higher energy consumption and costs, which income-constrained individuals might not be able to afford (Bardazzi et al. 2023). Therefore, governments should identify the most effective green retrofitting measures by considering the technical viability of the different solutions and their potential to increase the energy performance of buildings, while limiting the investment costs for homeowners (Ballarini et al. 2017). A large body of research has been developed to assist policy-makers with evidence on the cost-effectiveness of different energy saving measures in the context of home refurbishments (see, for example, Ma et al. 2012; Ferreira et al. 2013; Verbeeck and Hens 2005). However, as indicated in the existing literature, the effectiveness of energy efficiency measures depends on several variables (drivers and barriers), including information and policy measures, economic factors, thermal comfort, technical and building characteristics, socio-economic and behavioural factors of household members (Dolšak 2023). For policymakers, it is important to identify the factors that motivate and discourage households from implementing energy-efficient retrofits, as these aspects can make the difference between a successful and unsuccessful policy.

Since the seminal paper of Hirst and Brown (1990), the so-called 'energy efficiency gap' - the fact that individual investments in energy efficiency fall short of what would be economically and environmentally desirable - essentially depends on two types of aspects: structural and behavioral factors. While the former is the result of (public or private) actions beyond the control of individuals, behavioral barriers have to do with processes that are internal to the individual decision-making process,

[1] For a review of the literature on the effect of energy efficiency on climate change mitigation, see Belaïd and Massié (2023a).

such as personal environmental concerns or the perceived risk of energy efficiency investments (Bakaloglou and Belaïd 2022; Belaïd and Flambard 2023; Rockstuhl et al. 2021, 2022).

The two types of barriers to energy efficiency investments, presented as separate issues in Hirst and Brown (1990), can, however, be interconnected, even if this has barely been studied in the literature (Economidou et al. 2020; Bertoldi 2022).

In fact, there is a flurry of studies focusing on understanding people's behavior concerning energy choices (Belaïd and Garcia 2016) and what are the theoretical (Markle 2013) or empirical separate and specific factors (Ding et al. 2017) promoting household pro-environmental or pro-energy-saving behaviors. Some studies, for example, focused on the role of information and nudges (Abrahamse et al. 2005; Thaler and Sunstein 2009) - including awareness-raising campaigns, education, energy feedbacks, social norms and peer pressure, incentives, and rewards (Belaïd and Flambard 2023) - in driving energy saving behaviours. Few studies also analysed the role of boosting individuals' competencies to encourage well-informed choices within the energy domain (Lazaric and Toumi 2022; Belaïd and Flambard 2023).

There is, however, still little knowledge about the inter-relationships between these factors – for example the role of behavioural barriers on the adoption of structural solutions to energy efficiency. The effectiveness of structural energy saving policies is, in fact, frequently analyzed by neglecting the underlying psychological determinants that might come into play (Abrahamse et al. 2005). Without considering this interplay between structural and behavioural aspects, policymakers have limited knowledge to design tailored and efficient measures to effectively incentivize private investments.

To fill this gap, we studied residential energy-saving behaviours and, in particular, green retrofitting decisions to shed light on the role of behavioral factors, including dimensions that are under the control of the individual (such as saving personal money, desire for personal comfort, etc.), and the role of structural factors that are not under the control of the individual (such as the provision of tax incentives). The geographical scope of the study was Italy, where in May 2020 the Government introduced a fiscal incentive scheme (the so-called "Superbonus") to promote structural measures to improve the energy performance in residential buildings.

To explore the above, we designed and conducted a Discrete Choice Experiment (DCE) survey. DCEs are survey-based methods in which respondents are asked to make choices among alternative options (here, green retrofitting measures), each described in terms of a series of attributes (here, the potential barriers or enabling factors) with different levels. Through the choices made by respondents, information can be obtained on the relative weight of the different aspects on respondents' utility and the trade-offs that individuals are prepared to make between the different aspects (Louviere 2001). In our study, which we carried out with a sample composed of professionals from the building sector, entrepreneurs, and students, varying in terms of their age and their degree of acquaintance with the building sector[2], we focused

[2] Although the Superbonus was in place at the time of the study, the aggregate statistics available - see Sect. 3 – cannot provide information on individuals' preferences for alternative green retrofitting mea-

on different determinants that could drive the decision to make a green retrofitting investment.

First, we explore the role and expected effectiveness of fiscal incentives versus other monetary benefits and non-fiscal non-monetary incentives. The "Superbonus" scheme in Italy relies on tax incentives for households wanting to implement retrofitting measures to improve energy efficiency in their residential buildings. Given contradictory conclusions in the literature on the effectiveness of fiscal measures in driving energy savings, as shown in Sect. 2.1, it is important to better understand the role of monetary incentives (and tax reliefs) versus non-monetary incentives – these latter being increasingly considered as possible tools to encourage effective behavioral change (Caballero and Ploner 2022; Ebrahimigharehbaghi et al. 2022). Given this, in the design of our DCE, we described one attribute of the proposed green retrofitting measure as the fiscal benefits that respondents would receive, in order to effectively mimic the "Superbonus" tax relief scheme in place in Italy. The remaining attributes reflected additional monetary incentives (annual savings and cost of the investment) and non-monetary benefits, such as the environmental impact of the green retrofitting measure and the comfort[3] that could be achieved in the house.

By looking at the relative preferences for these attributes, we first question whether fiscal benefits play a larger role, compared to the remaining monetary and non-monetary attributes, in stimulating consumers towards energy efficiency measures.

Second, given that information is increasingly considered a cost-effective way to influence people's behavior (Newell and Siikamäki 2014; Giraudet 2020), we looked at the role of information (and different types of information) on green retrofitting choices. In addition to checking the type of drivers that play a role, we also looked at whether the way of conveying the message (*communicating* the information, in our case) plays a role (Linciano et al. 2018). We tested the impact of two alternative messages about the environmental sustainability performance of the green retrofitting investment as two separate attributes of our DCE. On the one hand, we considered an attribute conveying technical environmental information (i.e., CO_2 emission reductions achieved and the expected reduction in non-renewable energy sources). On the other hand, we considered another attribute containing the *same* environmental information conveyed in a non-technical form (i.e., using a simple sustainability indicator). To the best of our knowledge, and as shown in Sect. 2, the effect on preferences of environmental benefits communicated using a technical versus non-technical language has not yet been analysed.

Furthermore, given that disclosed information also needs to be *understood* by respondents and latent (cognitive) processes might play a role (as increasingly recognized by the literature - see Faccioli et al. 2020 or Gabriele 2023), we explored whether decisions may be *mediated* by the respondent's level of knowledge on green retrofitting. As a measure of cognition, we considered the latent scale developed by He et al. (2019) and adapted it to the Italian case to measure respondents' knowledge

sures and the factors affecting such choices. Thus, the collection of specific data (through a DCE) was needed for the purposes of our research.

[3] As described in Sect. 4.1, in our DCE, comfort refers to indoor air quality, thermal and acoustic comfort, quantity and quality of ventilation, and the level of electromagnetic interference.

regarding the Minimum Environmental Criteria (*criteri ambientali minimi- CAM*)[4] applied to the building sector.

Our findings indicate that fiscal incentives are not the main drivers of respondents' choices for the adoption of energy saving measures. Overall, we show that the level of savings on energy bills, the environmental sustainability of the intervention, and the comfort achieved are all more important factors than tax incentives, except for those respondents who have a high level of green retrofitting cognition. Our findings also indicate that communicating the environmental benefits achieved via green retrofitting using technical terminology is not effective for the adoption of energy saving measures, while a non-technical message of "sustainability" significantly encourages uptake.

Ours is, as far as we know, the first research work focusing on understanding the role of a range of possible determinants of households' decisions to make green retrofitting investments. The results are, therefore, important to guide policy-makers in the design and implementation of policies that work to encourage energy savings.

The remainder of this study is structured in six sections. The next section summarizes the main literature on the topic and presents the theoretical context, while Sect. 3 provides a description of the "Superbonus" fiscal incentive. In Sect. 4, we present the experimental design for the DCE and the model employed to analyze the data. We discuss the results of the analysis in Sect. 5, before we end with conclusions and policy implications in Sect. 6.

2 Theoretical Context and Literature Review

In this section, we present an overview of the literature on household preferences for energy efficiency investments in residential buildings and the main determinants, with the objective of highlighting the research gaps addressed in this study. In recent years, different studies have investigated the drivers of energy efficiency investments and the role of individual preferences in explaining the adoption of energy-efficient measures. These studies provided policymakers with useful insights in terms of how to address the so-called energy-efficiency gap, by highlighting that contextual factors (e.g., costs, policy regulations, and incentives), socio-demographic factors (e.g., income, household structure, age, and gender), as well as behavioral failures (e.g., behavioral biases) have a major role in explaining the under-investment in energy efficiency in the residential sector. In the following sub-section, we briefly review different strands of literature by examining the monetary and non-monetary drivers of energy-saving investments.

[4] The Minimum Environmental Criteria (CAM) are a set of systematic standards that specify the environmental requirements that need to be met at the various stages of the life cycle of a product or technology for it to be identified as environmentally-friendly.

2.1 Monetary Drivers of Energy Efficiency Investments

The first strand of literature comprises studies focusing on the monetary drivers of energy-efficient investments. So far, both policymakers and the literature have mostly focused on fiscal incentives as the main tools to stimulate households' decisions towards the adoption of energy saving measures. Indeed, although the application of energy retrofits in the residential sector can lead to a large amount of energy – and CO_2 – savings, it requires also significant financial capacity and the adaptation of energy policy strategies (Belaïd et al. 2021). Italy, for example, was one of the first (since February 2007) EU member states to apply income tax reliefs (of up to 55%) to those homeowners incurring expenses for certain energy efficiency renovations. In 2019, Italian households invested 3.5 billion euros to carry out more than 395 thousand energy-efficiency upgrades, saving about 1,250 GWh/year (ENEA 2020). Based on a household survey in Italy, Fiorillo and Sapio (2019) explored the relationship between energy-saving behaviours and monetary and non-monetary drivers, suggesting that monetary motivations are the main drivers of energy-saving behaviours. Alberini and Bigano (2015), in fact, reported that Italian homeowners are more likely to agree to replace their heating equipment when savings on the energy bills are larger and when rebates are offered. Similarly, Bonazzi and Iotti (2016) find that tax incentives can promote energy efficiency in Italy's housing sector. Alberini et al. (2014) found, however, that the effects of tax credits are different depending on the type of renovations undertaken, with a stronger uptake in renovation rates when tax credits are offered for window replacements and no effect when heating system replacements are considered. In the same vein, but in different settings, the study of Villca-Pozo and Gonzales-Bustos (2019) finds that no tax incentives have been effective in Spain in stimulating investments in energy efficiency, especially in old construction buildings. Using a theoretical model, Dubois and Allacker (2015) assess the performance of different energy saving policies, highlighting that commonly applied subsidies for renovation projects with minor energy savings are both ineffective (in terms of energy reduction achieved) and inefficient (in terms of welfare impacts). The above overall implies that, while tax incentives are key to achieve a reduction in home energy savings, other criteria apart from cost savings also play a role. The literature has shown in different settings - Canada (Sadler 2003), the Netherlands (Poortinga et al. 2003), Switzerland (Jakob 2007), Sweden (Ek and Söderholm 2010; Nair et al. 2010), France (Belaïd and Garcia 2016) and Germany (Achtnicht 2011) - that multiple dimensions (including environmental and economic) still need to be investigated to fully understand the effectiveness and efficiency of policies to encourage energy savings in the housing sector. In this context, the study of Belaïd and Joumni (2020) provides further insights to improve the effectiveness and efficiency of energy saving policies, by highlighting the potential role of factors such as (i) housing attributes, (ii) socio-demographic factors, (iii) ideological and situational factors, and (iv) energy control solutions and obstacles.

2.2 Non-Monetary Drivers of Energy Efficiency Investments

By focusing on the case of Canada, Sadler (2003) shows that intangible benefits, such as thermal comfort, have a greater influence on consumers' utility than prices. Along these lines, Nair et al. (2010) analyze the influence of personal factors (such as income, education, and age) and contextual factors (including age of the house, perceived thermal discomfort, past investment, and perceived energy costs) as potential drivers of homeowners' adoption of energy efficiency measures in Sweden, finding that a combination of different factors plays a role. Similarly, Jakob (2007) shows that, in the case of Switzerland, energy-efficient renovations are driven to a large extent by technical factors (e.g. lifetime of façade or roof) rather than personal aspects (income, age, or education). In the same way, Poortinga et al. (2003) find that technical improvements (e.g., installation of specific technologies) had a bigger role than behavioral aspects (e.g., strategies to reduce direct energy use) in driving energy savings. This is probably because technological changes are one-off, easier-to-implement actions compared to behavioral changes, which require continuous efforts. These conclusions align with the literature showing that measures that do not require lifestyle changes are, generally speaking, more acceptable.

Other studies so far have accounted for the role of environmental factors in explaining people's preferences for energy-saving measures, but they provide mixed evidence. Achtnicht (2011) was the first study to explicitly include the environmental benefits of building energy retrofitting in a choice experiment study of German homeowners' stated preferences. Results reveal that house owners care about the negative environmental externalities associated with their residential energy use, suggesting that people are aware of the repercussions of their choices on the environment. Belaïd and Massié (2023b), using a sample of French homeowners, find that environmentally conscious individuals are significantly more likely to undertake energy renovation measures. On the one hand, Aravena et al. (2016) find no positive relation between the environmental benefits of energy efficiency measures and individuals' intention to adopt such measures in Ireland.

Other research highlights the role of environmental psychology - the study of cognitive processes, perceptions, and attitudes towards the environment - in understanding and promoting pro-environmental behaviours (Steg and Vlek 2009).

In addition, Ek and Söderholm (2010) point to the role of information as a tool to increase the willingness of households to adopt energy-saving measures. More specifically, their results suggest that differences in the level of detail of the information provided in the questionnaire had a statistically significant impact on the reported willingness to decrease energy use. Informational issues are also crucial in explaining energy efficiency investments by households at different stages in their decision-making process (Aravena et al. 2016; Kastner and Stern 2015). Indeed, informational problems (due to both missing and asymmetric information) were found to represent one of the main drivers of the energy-efficiency gap (Huntington et al. 1994; Palmer and Walls 2017). At present, there is little awareness of the importance of providing information about retrofitting and energy consumption, so that the public has generally insufficient knowledge about this topic, which, in turn, results in low public engagement in the retrofitting process (Jia et al. 2018). A notable exception is the study by Belaïd and Flambard (2023) suggesting that individuals who receive information that boosts their confidence exhibit a higher propensity to invest in efficient energy systems, compared to those who do not receive any confidence boost.

While progress was made by the literature towards understanding preferences for green retrofitting measures, limitations have also to be acknowledged. In most cases, the focus of previous research was on selected aspects without accounting for the wide range of drivers (monetary and non-monetary) that can influence people's preferences for green retrofitting measures and the trade-offs involved. Also, the results of existing studies tend to focus each time on a particular type of energy efficiency measure rather than a range of building retrofitting measures. Instead, we focus on a conceptual framework that we applied to residential energy-saving behaviors, in which we investigate if and how individual decision-making is triggered by a wide range of monetary and non-monetary drivers. We analyze stated preferences for green retrofitting by considering individual perceptions of a range of determinants. In particular, we focus on two issues barely studied by the literature so far: first, how individuals differently perceive structural aspects, such as fiscal incentives; second, how different monetary and non-monetary drivers, including the way (either technical or not technical) in which the environmental benefits are communicated, might shape energy-saving behaviors.

3 The Italian Case of the Superbonus for Residential Buildings

The housing sector in Italy at the moment displays several characteristics that make it similar to the housing sector in the majority of the other EU countries, namely the prevalence of dated buildings with scarce structural safety, poor insulation, and inefficient from an energy saving perspective (Pohoryles et al., 2022). Given the ongoing climate emergency, this situation needs to be changed. A first attempt in this direction was the introduction of a relatively recent EU regulation on the energy performance of buildings (e.g., the Energy Performance of Buildings Directive 2010/31/EU, the Energy Efficiency Directive 2012/27/EU, the Energy Performance of Buildings Directive (2018/844/EU), aiming to achieve carbon-neutrality in the building sector by 2050. As part of the European Green Deal, in October 2020, the Commission additionally presented its Renovation Wave Strategy (RWS) containing an action plan with concrete regulatory, financing, and enabling measures to boost the upgrading of buildings in member states. Starting from the RWS, the Italian Government launched in 2020 a new incentive scheme, the "Superbonus", aimed at promoting the implementation of structural measures in buildings to improve energy performance (and earthquake protection). The incentive integrates the previous so-called "Ecobonus" and "Sismabonus" schemes by increasing the level of the tax deduction to 110% of the real cost of the intervention, with the objective to incentivize the recovery of the building sector after the structural crisis that started in 2008 and continued more recently during the COVID-2019 pandemic (Macchiaroli et al. 2023). Essentially, through this subsidy, people can receive more than the cost of the retrofit: building owners can transfer the tax deduction to the company that performs the renovation, or they can recover their investment and an extra 10% in the form of deductions over five years (i.e., the tax deductions of the "Superbonus" exceed the nominal value of the project). So far, one of the main success factors has undoubtedly been the fact that the scheme covers the entire cost of the interventions (also including the ancillary expenses, e.g., project and design of the intervention) and requires no extra investments from households, apart from some upfront financing to cover the building contractors, which can be claimed back.

The "Superbonus" scheme allowed homeowners to fully recover the expenses incurred for certain types of retrofitting interventions, such as thermal insulation of façades and/or roofs (such as external cladding) and the replacement of heating systems, including in combination with the installation of photovoltaic systems or micro-cogeneration systems (Ministry for Ecological Transition 2021). To benefit from a 110% tax relief, homeowners have to achieve an improvement by at least two categories in the building's energy efficiency rating as a result of the interventions.

As mentioned above, the "Superbonus" offers the beneficiary the option of transferring the tax credit to a third party (such as the companies carrying out the measure or financial intermediaries), which enables energy retrofitting measures to take place even when the homeowner is not able to make the initial investment. In other words, the tax credit is converted into money, thus allowing the intervention to be carried out despite financial constraints from the homeowner. This makes the "Superbonus" an impactful measure to fight those cases of house energy inefficiency driven by economic constraints. The "Superbonus" was initially going to cover expenses incurred up to the 31st of December 2021, but the 2021 Italian Stability Law subsequently extended it by one year. A further extension of the scheme was granted in 2022, thanks to additional funding awarded via Italy's National Recovery and Resilience Plan (NRRP), as part of the NextGenerationEU recovery package set up by the European Union. The "Superbonus" scheme was officially terminated at the end of 2023.

Although, in absolute terms, the "Superbonus" has been a great success (494,406 funded interventions, as of March 2024, worth around 122 billion euros in total, according to the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA)[5]), in relative terms the situation might be less optimistic. A detailed indicator would need to be computed to assess the success of the tax measure, which would require comparing the number of interventions carried out per type of building and per type of intervention, compared to the total number of buildings that would need energy efficiency measures, including those with low energy efficiency ratings. Unfortunately, no such detailed comparison is available, and the most recent general estimates accessible are those published on the Chamber of Deputies of the Italian Government web page (year 2024)[6]. According to these data (given that the number of residential buildings in Italy is 12,187,698) it is possible to conclude that the "Superbonus" scheme was used to carry our green retrofitting investments in only slightly more than 4% of the total number of Italian residential buildings (more specifically, 6% of multi-family buildings and slightly less than 3.5% of single-family housing residential buildings surveyed in Italy).

[5] https://www.efficienzaenergetica.enea.it/images/detrazioni/Avvisi/Report_31_03_2024.pdf.

[6] https://temi.camera.it/leg19/post/la-dimensione-economica-del-superbonus.html.

4 Methodology

For the purposes of our research, we relied on the Discrete Choice Experiment (DCE) method, which is one of the most widely used non-market economic valuation techniques (Mahieu et al. 2014; Glenk et al. 2024) to disentangle individuals' preferences for, and trade-offs between, goods that are not traded in markets (such as environmental goods, etc.). The DCE method, in particular, is based on the theory of value presented by Lancaster (1966), according to which consumers' utility depends on the characteristics or properties of goods rather than on the goods themselves. Given that, DCEs rely on the presentation (through a survey) of a series of scenarios (alternatives), each described by a different combination of given attributes (characteristics of the alternative) that should matter in utility terms. In our study, the alternatives presented (green retrofitting investments) are assumed to be valued by respondents because of their specific characteristics or attributes, including their price, their impact on the environment, the effect on bills, the gains in terms of thermal comfort in the house and so on (as we will explain below). To be able to estimate the impact (the importance) on utility of each of the attributes, respondents are generally asked to choose their most preferred option out of each set of alternatives presented, which requires evaluating the trade-offs across the different attributes displayed and their levels. By repeating the task several times, estimations can be made (using appropriate econometric modelling) on the economic importance (in utility terms) attached by respondents to changes in each attribute. The resulting information is of value to decision-makers because it sheds light on which aspects respondents value more (or less) and, therefore, what dimensions should be prioritized to make sure that the design and implementation of interventions are effective and efficient (maximize welfare).

4.1 DCE Survey Design

In our research, we designed a DCE survey, where respondents were asked to repeatedly choose their most preferred among a set of alternatives describing the outcomes of different hypothetical green retrofitting interventions to improve house energy savings. Out of the three alternatives presented each time, one alternative was constant across the choice situations and represented a "no intervention" option.

The choice of the attributes used to describe each alternative in our DCE survey was informed by the review of previous studies (Scarpa and Willis 2010; Kwak et al. 2010; Achtnicht 2011; Alberini et al. 2013; Ruokamo 2016; Galassi and Madlener 2017) and by focus group discussions. To describe the choice of undertaking a green retrofitting investment, a range of different attributes was identified. Specifically, three monetary attributes were included, namely the total cost of the intervention, the annual monetary savings that would be incurred by the household because of the green retrofitting measure (lower energy bills), and the % level of tax incentive that the respondent would benefit from (in case of undertaking the investment), which included values in line with the "Superbonus" regulation. We also included some non-monetary attributes. Three of these were environmental attributes, describing the impacts on the environment of the proposed energy efficiency measures. Two of these environmental attributes were described using technical terminology (the reduction in CO_2 emissions achieved and the reduction in energy demand from non-renewable sources), and the third was described using non-technical language (the overall level of environmental sustainability achieved, using a scale from 0 to 10).[7] We also considered as a non-monetary attribute, a measure of individual wellbeing, namely the level of living comfort achieved in the building after applying the green retrofitting intervention (using an indicator from 0 to 10).[8] While almost all attributes in our study are commonly considered in DCEs related to energy efficiency investments (although it is infrequent to have all attributes accounted for in the same study), the environmental sustainability attributes are innovative and designed to test whether the environmental sustainability associated with the investment is a source of concern affecting individuals' energy retrofitting decisions. Indeed, experiments conducted in other fields have revealed the importance (for investors) of the environmental sustainability of financial investments (Gutsche and Ziegler 2019; Lagerkvist et al. 2020). Table 1 describes the attributes (and their levels) employed in our DCE survey.

The levels of the attributes were the result of engineering calculations and simulations modelled by members of the research team by assuming the application of a range of green retrofitting interventions in a reference building with specific characteristics.[9] This was to formulate and present *realistic* values for all attributes in the DCE.

The seven attributes considered, each taking four levels (except for the tax incentive attribute), were combined into sets of three possible unlabeled alternatives presented in different choice sets. The combinations of attributes were obtained using

[7] The level of environmental sustainability achieved was measured using a scale between 0 and 10 based on the scores obtained from the Institute for Innovation and Transparency of Subcontracting and Environmental Compatibility (ITACA) Protocol Urban Scale. Following this Protocol, the environmental sustainability of a building is evaluated against e.g. the impact of the building on land use, the consumption of resources (e.g., the use of water, of recycled materials), waste production etc. Therefore, this attribute is different from, and captures more than, just the degree of energy use of the building (and its impacts in terms of emissions).

[8] The level of comfort achieved was measured on a scale from 0 to 10, which captured the overall living quality of an indoor environment, using an approach developed by the national reference standards on Environmental Sustainability in Construction (UNI/Pdr 13:2019). Specifically, the parameters considered were indoor air quality, thermal and acoustic comfort, quantity and quality of ventilation, and the level of electromagnetic interference.

[9] The residential building taken as a reference in the DCE, and over which green retrofitting interventions were modelled and simulated, was among the most popular type of housing in Italy. In the project, it was assumed that this reference building is located in Milan, consists of six housing units and was built in the 1980s with a reinforced concrete load-bearing structure and brick infill (for more details on the technical engineering details of the experiment, see http://www.sofia.univpm.it/sites/default/files/Revelation%20technical%20architecture%20of%20the%20CE.pdf). The green retrofitting interventions simulated for this type of building include: thermal insulation of windows and façades, installation of photovoltaic panels, and replacement of the existing heating system with a new modern energy-efficient one. All these simulated interventions comply with the minimum requirements specified in the Interministerial Decree from the 26th of June 2015 (Application of energy performance calculation methodologies and definition of prescriptions and minimum requirements for buildings), as well as with the technical requirements specified in the Interministerial Decree from the 6th of August 2020 (Technical requirements for access to tax deductions for energy upgrading of buildings).

Table 1 Description of the attributes and levels used for the choice experiment

Attributes [unit of measurement]	Description	Levels
Monetary		
Cost of the intervention [€]	Investment (capital cost) to carry out the intervention.	€8,000 €107,000 €136,000 €418,000
Annual monetary savings [€ /year]	Monetary savings on energy bills that would be achieved annually, as a result of the energy-saving measure.	€ 2,618 € 2,969 € 3,830 € 6,859
Tax incentive percentage [%]	Percentage of tax relief that the respondent would benefit from by implementing the retro-fitting measure.	50 65 110
Non-monetary and environmental (technical)		
Reduction of CO_2emissions [kg/m^{2}per year]	Reduction of carbon dioxide emissions from fossil fuel sourced energy in the building.	13.59 15.46 19.87 35.80
Reduction in energy consumed from nonrenewable sources [kWh /m^{2}per year]	Reduction in non-renewable energy needs. Non-renewable energy is obtained from sources that tend to be exhausted over time, such as fossil fuels (coal, oil and natural gas).	68.95 78.62 100.82 182.40
Non-monetary and environmental (non-technical)		
Sustainability achieved [0–10]	Score between 0 and 10 assessing the sustainable aspect of the measure. Higher scores are associated with interventions that allow to achieve a higher level of environmental sustainability.	3.0 3.5 5.0 8.0
Non-monetary and individual well-being		
Comfort level achieved [0–10]	It identifies the overall quality of an indoor environment through various factors, including indoor air quality, thermal and acoustic comfort, adequate quantity and quality of ventila-tion and the level of electromagnetic interference.	2.7 2.9 5.6 7.1

a D-efficient experimental design. To generate the D-efficient design, we used the Fedorov's modified algorithm included in the package -idefix- of the R software (Traets et al. 2020). This algorithm generates an initial random design from the set of profiles, iteratively changes the levels of the attributes in the combinations, and delivers a final design that minimizes the D-error (Huber and Zwerina 1996; Pérez-Troncoso 2022). To make sure that the scenarios presented for evaluation to the respondents are realistic, a sub-set of the most plausible choice sets was selected for display in the survey (i.e., ten choice sets out of the twenty generated by the experimental design software)[10]. For each of the ten choice sets identified, respondents were asked to indicate the most preferred among the displayed alternatives. Figure 1 shows an example of a choice set.

4.2 Sample and Data Collected

Our sample consisted of a miscellaneous group of individuals, ranging from professionals from the building industry (engineers, architects, and surveyors) to entrepreneurs, as well as young individuals, such as university students. The reason was to include a range of different perspectives in order to study individuals' decision-making process for green retrofitting investments across different age, income, and professional groups. This choice was motivated by previous literature on the topic (Belaïd and Garcia 2016; Belaïd and Joumni 2020; Belaïd and Flambard 2023), which showed that household income, technical competence, education, and age can influence green retrofitting and, more generally, energy-saving decisions. The sample of respondents was identified, due to the funder's constraints, within a specific geographical region of Italy (Marche), which, however, can be considered representative of most other regions of Italy in terms of the socio-economic and environmental situation (ISTAT 2023).

Several steps were taken before data collection. During January-March 2021, we ran focus group sessions to discuss (face-to-face) the survey content with individuals representing the sample of interest to test the language used to describe the attributes and the cognitive load of the DCE survey. After incorporating the necessary amendments and suggestions that emerged from focus groups and subsequent pilot sessions, the final questionnaires were administered face-to-face during April-September 2021 in different training/educational workshops organized with the sample of professionals and university students. To encourage participation, course credits were awarded to both students and professionals who took part in the survey.

Filling out the survey took about 15 to 30 min on average. The questionnaire consisted of three parts: the choice experiment itself (part 1), questions about Green retrofitting cognition (He et al. 2019) (part 2), and the socio-economic and demographic information (part 3). An explanation of the purpose of the research and the background information on the context and attributes of the DCE was provided at the beginning of the questionnaire (see the complete survey in Appendix 1). The final

[10] The choice of selecting the scenarios based on their realism was motivated by the fact that D-efficient experimental design methods only aim to maximize the efficiency of the design, but unless respondents find the alternatives also plausible the choice data that are collected only provide limited information.

Current status (no intervention)	
Cost of intervention	-
Current CO_2 emission level	38,07 Kg/m^2 per year
Current expenditure on energy	7.376,00 €/per year
Current demand for non-renewable energy	192,6 kW h/m^2 per year
Current comfort level [0-10]	2,7
Tax incentive percentage	0 %
Current environmental sustainability [0-10]	0

Interventions attributes	**Intervention A**	**Intervention B**
Cost of intervention	418.000,00 €	136.000,00 €
CO_2 emission reduction	13,59 Kg/m^2 per year	35,80 Kg/m^2 per year
Annual monetary savings on energy expenditures	2.618,00 €/per year	2.969,00 €/per year
Reduction in energy demand from non-renewable sources	78,62 kW h/m^2 per year	100,82 kW h/m^2 per year
Comfort level achieved [0-10]	2,9	2,7
Tax incentive percentage	65 %	50 %
Environmental sustainability [0-10]	8,0	5,0

- o Intervention A
- o Intervention B
- o I do not carry out the intervention.

Fig. 1 Example of a choice set scenario. *Source*: Authors' own work. *Note* To facilitate the decision-making process and ease the cognitive understanding of the alternative interventions offered (right side of Fig. 1) compared to the Current status (left side), the status quo attributes were displayed in each choice set

sample included 434 individuals, providing 4,340 choices (given that each respondent had to make 10 choices). It was possible to achieve this sample size thanks to the support of associations of firms and professionals in the building sector (Confindustria and Engineers Association, respectively) and universities, which provided help with the recruitment. Table 2 gives details on the demographic profile of the sample.

4.3 Statistical Model

The theoretical foundations to model respondents' choices for the green retrofitting alternatives is the theory of value by Lancaster (1966), which assumes that individuals derive utility from the observed characteristics of a good (here, the attributes of the green retrofitting alternative). Individuals' utility is then modelled by relying on the random utility maximization framework (McFadden 1974), which assumes that respondents choose the alternative that yields the highest utility. Based on this framework, the utility that individual *i* derives from choosing alternative *j* in choice task *t* can be decomposed into a deterministic component (V_i) that depends on observable characteristics of the good (the attributes' levels) and a stochastic component (ε) that captures factors unobserved by the econometrician that influence the individual's utility (choices). Given that, we specified the utility as follows:

$$U_{ijt} = \mathbf{X}_{ijt}\beta_i + \alpha_i c_{ijt} + \varepsilon_{ijt}\,, \tag{1}$$

Where c_{ijt} denotes the level of the monetary cost of the intervention; $\mathbf{X}$ represents the levels of all other attributes associated with a green retrofitting intervention; β_i and α_i are individual-specific parameters to be estimated that express the individual's preferences towards the project's characteristics.

In our model, we assume that the preference parameters β_i and α_i are individual-specific (to capture heterogeneity in respondents' preferences) and are normally

Table 2 Summary of the sample's demographics

Demographics	Percentage
Gender	
Female	37.79
Male	62.21
Education	
Pre high-school diploma	0.23
High-school diploma	40.09
University degree	49.08
Post-graduate specialization	10.60
Age	
20–25	49
26–36	13
37–45	15
46–55	13
56–67	9
over 67	3
Profession	
Architect	3.23
Employee on a permanent basis	8.29
Employee on fixed-term contract	3.92
Engineer	28.80
Freelancer/Self-employed person	2.76
Retired	2.76
Student	47.70
Surveyor	1.84
Other	0.69
Household's monthly net income	
Less than 1,000 euros	3.46
Between 1,000 and 1,500 euros	5.99
Between 1,500 and 2,000 euros	15.67
Between 2,000 and 3,000 euros	28.57
Between 3,000 and 5,000 euros	33.41
over 5,000 euros	12.90

distributed, except for the parameter of the cost attribute which is log-normally distributed. Allowing the choice parameters to vary across respondents (following a given random distribution) due to unobserved factors is generally recommended to better represent the choice behaviour (Hensher and Greene 2003). This is not only because preferences do indeed change across individuals, but also because this modelling approach allows to account for the correlation in the observations proceeding from the same respondent in cross-sectional data (Train 2002). Considering all these properties, the resulting model (i.e., a mixed logit model) represents a better (and generally more flexible) framework compared to the simpler multinomial logit (MNL) or other random utility models (McFadden and Train 2000).

In particular, the mixed logit model we estimate is a hybrid choice model (Ben-Akiva et al. 2002; Czajkowski et al. 2017). Hybrid choice models are structural models that allow to include psychological and cognitive considerations (e.g. perceptions and beliefs), which are latent constructs, into a random utility model to isolate the effect of latent (psychological or cognitive) factors on preferences (Mariel and Meyerhoff 2016; Vij and Walker 2016; Mariel et al. 2021). Given our expectations that preferences might be affected by the respondent's level of knowledge, we assume that our preference parameters depend on a latent variable ($\mathbf{LV}_i$) measuring the level of cognition of respondents regarding green retrofitting:

$$\beta_i = \boldsymbol{\Lambda}'\mathbf{LV}_i + \beta_i^* , \tag{2}$$

$$\alpha_i = \exp\left(\tau'\mathbf{LV}_i + \alpha_i^*\right) , \tag{3}$$

Where $\boldsymbol{\Lambda}$ and τ are coefficients to be estimated, while β_i^* and α_i^* are, respectively, the normal and the log-normally distributed preference parameters, with mean and standard deviations to be estimated.

The latent variable capturing cognition ($\mathbf{LV}_i$) is not directly observable, given that a person's knowledge is not a visible characteristic (such as age or gender) and it needs to be uncovered using appropriate indicators. To approximate the measurement of the latent variable, we therefore relied on the existing literature (He et al. 2019), which developed a 7-points and 7-questions Likert scale (reported in Table 3) to measure green retrofitting cognition. To increase the salience and realism of the questions, we adapted this scale to the Italian context by making reference to the Minimum Environmental Criteria (criteri ambientali minimi- CAM).

We assumed that the self-reported answers of respondents to the cognition scale (indicator) are a function of the real, unobserved level of knowledge ($\mathbf{LV}_i$). The relationship between the indicator and the $\mathbf{LV}_i$ can then be formalised in a measurement equation as follows:

$$\mathbf{I}_i = \boldsymbol{\Gamma}'\mathbf{LV}_i + \eta_i , \tag{4}$$

Table 3 Statements to measure the level of cognition of the respondent on green retrofitting

1 The green retrofitting of existing residential buildings is in line with the concept of sustainable development. 2 Green retrofitting can increase the value of housing rental and sale. 3 The green retrofitting technology for existing residential buildings is mature, and the green materials are safe and reliable. 4 Implementing green retrofitting investments is low cost. 5 Green retrofitting can improve the performance of existing residential buildings and extend the life of buildings. 6 Undertaking green retrofitting investments in existing residential buildings doesn't take long, and retrofitting is convenient. 7 The living space after implementing green retrofitting investments is comfortable and undertaking green retrofitting investments reduces energy consumption and operating costs.	Completely disagree (1)-Completely agree (7)

Source He et al. 2019

Where $\mathbf{I}_i$ are indicator variables (self-reported Likert-scale measures of cognition), $\boldsymbol{\Gamma}$ is a matrix of coefficients and η_i is a vector of error terms.

Provided that respondents' self-reported cognition indicators were measured using an ordered Likert scale, we relied on ordered probit models as the functional form in the measurement equations.

Such modelling approach is superior to directly interacting the preference parameters in the choice model with the indicator variables, which is a frequently employed choice modelling approach when dealing with attitudes and perceptions. Given that indicator variables are just functions of attitudes or perceptions, not a direct measure of these, adding such indicators directly in the choice model introduces measurement biases (Budziński and Czajkowski 2022).

5 Discrete Choice Experiment Results[11]

After excluding those respondents with missing data on some of the key variables needed to estimate the model (i.e. responses to Green Retrofitting cognitive Likert scale questions), we estimated our hybrid mixed logit choice model, whose results are presented in Table 4.

The discrete choice component of the model, displayed in the upper part of Table 4, reports respondents' preferences (mean and standard deviation) for each of the attributes of the green retrofitting interventions proposed. On average, we show that offering respondents a fiscal incentive (*Tax incentive percentage*) positively and significantly influences choices to make green retrofitting investments (mean = 0.150). Additionally, the model shows that individuals' propensity to undertake green retrofitting investments significantly increases also in response to other monetary attributes, such as the possibility to save on energy bills (*Annual monetary savings*, with average = 0.242). Based on our findings, some of the non-monetary attributes also play a role in driving respondents' investment decision, including the level of comfort achieved in the house as a result of the retrofitting (*Comfort*, with average = 0.204) and the overall degree of environmental sustainability achieved after the intervention (*Sustainability achieved*, with average = 0.201). Note that, with respect to the non-monetary and environmental attributes considered in the experiment, only the one communicated using non-technical terminology, namely, i.e., *Sustainability achieved*, exerts a statistically significant effect on retrofitting preferences. Conversely, Table 4 shows that the other two non-monetary and environmental attributes, communicated using technical language, have a non-statistically significant effect on the average preferences for green retrofitting, i.e., the *Reduction in CO_2 emissions* following the investment (average = 0.055) and the *Reduction in non-renewable energy* associated with the adoption of energy saving measures (average = 0.075).

[11] The Models in this sub-section were estimated by using a DCE package developed in Matlab and available from http://github.com//czaj//DCE. The code and data used for estimation purposes in this paper are available as Matlab files in the Appendix (Appendix 2 and dataset).

Table 4 Estimates of the hybrid mixed logit model (in preference-space)

The choice component

	Means	Standard deviations	Interaction with LV_1 (green retrofitting cognition)
SQ [multiplied by 10]	-0.326*** (0.031)	0.208*** (0.031)	-0.042 (0.027)
CO_2 emission reduction [divided by 10]	0.055 (0.047)	0.374*** (0.052)	-0.055 (0.049)
Annual monetary savings [divided by 1,000]	0.242*** (0.031)	0.037 (0.128)	0.000 (0.033)
Reduction in non-renewable energy use [divided by 100]	0.075 (0.068)	0.010 (0.153)	0.000 (0.074)
Comfort	0.204*** (0.018)	0.198*** (0.019)	0.006 (0.020)
Tax incentive percentage [divided by 10]	0.150*** (0.021)	0.164*** (0.026)	0.051** (0.020)
Sustainability achieved	0.201*** (0.025)	0.175*** (0.035)	0.003 (0.027)
- Cost [divided by 10,000] (€)	-2.824*** (0.08)	0.667*** (0.078)	0.027 (0.076)

The measurement component[a]

	LV_1 (green retrofitting cognition)
The green retrofitting of existing residential buildings is in line with the concept of sustainable development	0.7252*** (0.081)
Green retrofitting can increase the value of housing rental and sale	0.9352*** (0.095)
The green retrofitting technology for existing residential buildings is mature, and the green materials are safe and reliable	0.7507*** (0.081)
Implementing green retrofitting investments is low cost	0.1786*** (0.060)
Green retrofitting can improve the performance of existing residential buildings and extend the life of buildings	1.487*** (0.167)
Undertaking green retrofitting investments in existing residential buildings doesn't take long, and retrofitting is convenient	0.369*** (0.064)
The living space after implementing green retrofitting investments is comfortable and undertaking green retrofitting investments reduces energy consumption and operating costs	1.068*** (0.106)

Model diagnostic

LL at convergence	-7,550.20
LL at constant(s) only	-8,494.20
McFadden's pseudo-R2	0.11
N (observations)	4,170
R (respondents)	417
k (parameters)	73

[a] The estimated ordered logit threshold parameters are not reported here due to space constraints, but they are included in the online supplementary materials (Appendix 3)

To test for the equivalence of the effects of the different preference parameters that have a non-zero (significant) influence on utility and to answer our research questions, we further conducted a Wald test on the model results, as reported in Table 5.

Table 5 shows that the magnitude of the parameters reflecting the preferences for *Annual monetary savings* and the two non-monetary attributes (*Sustainability* and *Comfort)* are not statistically different from each other, on average. On the contrary, the magnitude of the parameter for the *Tax incentive* attribute appears to be significantly different from *Annual monetary savings, Comfort, and Sustainability*.

Based on our model results, we further find that the mean preferences for the Tax incentive attribute are also the only ones affected by the latent variable considered in our hybrid model. Such latent variable captures - as indicated in the measurement component panel of the estimation output - the level of green retrofitting cognition of the respondents, measured based on the answers to the statements presented in Table 3. In particular, what we observe is that respondents with a high level of green retrofitting cognition tend to be more sensitive to tax incentives when deciding whether to undertake a green retrofitting investment or not. For these individuals, the importance of accessing tax reliefs becomes comparable (in terms of magnitude) to that of the remaining significant parameters for *Annual monetary savings, Comfort*, or *Sustainability achieved* with the investment. Overall, as Belaïd (2024) points out, promoting energy-saving behaviors and energy efficiency investments requires differentiated public policies that consider individual preferences.

6 Discussion

The literature recognizes that both structural and behavioral aspects, namely factors that are external and internal to the individual, can pose a barrier that prevents society from closing the energy-efficiency gap (Weber 1997; Gerarden et al. 2017). In our research, we shed light on a range of factors – both *internal*, such as saving money (*Annual monetary savings*) or achieving personal comfort (*Comfort*), and *external*, such as the existence of *tax incentives* – to determine if, and to what extent, they facilitate or hinder the implementation of energy-saving investments in residential buildings. The joint study of these aspects and of the trade-offs between them represents one of our contributions to the existing literature.

Table 5 Pairwise one-side Wald test for the equivalence of model parameters

	Sustainability	Comfort	Annual monetary savings
Comfort	Wald test = 0.04 *p*-value = 0.8320		
Annual monetary savings	Wald test = 1.03 *p*-value = 0.310	Wald test = 2.00 *p*-value = 0.157	
Tax incentive	Wald test = 2.99 *p*-value = 0.084	Wald test = 4.98 *p*-value = 0.026	Wald test = 11.69 *p*-value = 0.000

Note The Wald test statistic follows a χ^2distribution

Based on our findings, *Tax incentives* can stimulate energy saving measures, along with other monetary (*Annual monetary savings*) and non-monetary aspects (*Comfort* and *Sustainability* achieved, respectively representing a private and public measure of wellbeing). Our results suggest that *Annual monetary savings*, as well as *Sustainability* and *Comfort*, exert a comparable effect on choices, while *Tax incentives* exert a smaller effect. The result that households are only mildly influenced in their green retrofitting decisions by tax incentives is in line with 2024 official statistics for Italy, showing that the "Superbonus" had only a very limited uptake on the ground (and it benefited homeowners in slightly more than just 4% of the total number of Italian residential buildings). This conclusion is important because it highlights that households do not respond strongly to tax incentives, which are often used as tools to encourage the uptake of energy saving measures, but they take into account a range of multi-dimensional factors. Despite previous literature alluded to this being the case (Bonazzi and Iotti 2016), no previous research work simultaneously tested and discussed the effect of a wide range of factors (as we did) within the coherent framework of a specific study. Albeit acknowledging that scientific evidence about the effectiveness of policies incentivizing the uptake of residential energy-efficiency upgrades is, in fact, puzzling, with mixed and contradictory findings produced in separate studies and different contexts, in our research we compare a range of aspects within the coherent framework of a unique experiment.

Of specific interest for the purposes of this study is also the fact that some individuals tend to be more sensitive than others to the *Tax incentive* provided. Those individuals who seem to react more to the presence of fiscal measures are those who have high levels of green cognition and understand the regulation and benefits of applying green retrofitting to buildings. In other words, for these individuals, fiscal benefits could work better in stimulating the adoption of energy saving measures in residential buildings. This finding is important, as it shows the existence of interactions between structural and behavioural factors: the role of tax incentives (which are external, structural factors) is, in fact, mediated by psychological factors (which are internal, behavioral factors). Overlooking the interconnection between these dimensions could therefore provide an inaccurate picture of the real effectiveness of an energy-saving policy (Abrahamse et al. 2005).

Since, theoretically, information provision may facilitate the activation of norms of behavior (see also North 1990), policymakers could consider informing and educating citizens (e.g., about the climate impacts of residential buildings or the urgency to adopt energy saving measures in the housing sector), as a way to further stimulate interest in the adoption of green retrofitting measures.

Our results also contribute to a wider discussion regarding how some of the environmental benefits of energy saving measures should be communicated to be easily understood by people and what aspects should be emphasized to facilitate comprehension and stimulate the uptake of energy saving measures. We show that respondents' decisions to adopt green retrofitting measures is not driven by information regarding, in detail, the possibility to reduce the consumption of fossil fuels and CO_2 emissions. Instead, it is important for households to know that investing in green retrofitting will overall be positive for the environment and for "sustainability". This suggests that communicating technical information to households concerning the environmental benefits of energy savings is not effective in increasing the preferences for green retrofitting measures. Conversely, when environmental information is presented in a simpler way, this is likely to positively affect the stated preferences for a green retrofitting investment. This evidence is in line with results found in previous literature in different domains (Linciano et al. 2018) and it suggests that the government should share information on retrofitting benefits with the public (Jia et al. 2021) without however going into technicalities (Ek and Söderholm 2010).

7 Conclusions and Policy Implications

Energy savings in the housing sector have attracted considerable attention from policymakers, practitioners, and academics because of the potential of green retrofitting to reduce global greenhouse gas emissions. Governments in different countries approved numerous pieces of legislation and specific programs of energy transition, with the aim of reducing energy consumption in residential buildings. However, for policies to work, it is essential to design measures that are positively received by practitioners, the industry, and households – which requires accounting for the actors' preferences, values, attitudes, and (financial) constraints in settings characterized by many complexities. This approach has only partially been explored so far and implemented to guide policy- and decision-making processes, which highlights that more (interdisciplinary) research on the topic is needed.

Our analysis shows that to understand green retrofitting decisions, both soft elements (information) and hard elements (economic motivations) need to be considered. Our investigation of individual preferences suggests that policymakers can use a range of levers (monetary and non-monetary) to stimulate energy efficiency measures. This conclusion is similar to that achieved in Giallonardo and Mulino (2023), who found that combining subsidies on green products with awareness creation can better stimulate the consumption of green products.

Starting with the economic drivers, we show that tax incentives are not the most effective lever to stimulate green retrofitting in that these incentives mostly work with those individuals who are aware of the need, opportunities, and functioning of green retrofitting measures. For these individuals, the importance of tax incentives is *comparable*, but *not superior*, to the importance of other monetary incentives (bill savings) and non-monetary incentives (comfort and sustainability achieved). This finding suggests that awareness-raising and educational tools should be considered to promote socially desirable decisions in terms of green retrofitting. In turn, we find that cost reductions in terms of savings on energy bills seem to be a good incentive to encourage green retrofitting, no matter the level of information and awareness individuals have on the energy saving measures and/or the climate impact of their housing investments.

When looking at the role of information on the decision to make green retrofitting investments, our findings show that the communication of information matters; we found that information on the environmental implications of a green retrofitting measure stimulates individual investments, but only if the information is presented in a simple and familiar (rather than technical) way.

Although further investigations would be needed to generalize our findings beyond the Italian context, the policy implications of our study suggest that tax incentives and other debt-generating incentives might not be fully efficient in fostering green retrofitting, given that people are more responsive to energy bill reductions than tax reliefs.

At the same time, our evidence shows that individuals are sensitive to cost reductions and the environmental consequences of their green retrofitting investments, which altogether highlight the key role of communication. Policy interventions should therefore be focused on targeted information and communication campaigns emphasizing the bill saving effects of green retrofitting investments, by possibly also borrowing recommendations on visual framing from the behavioral literature (Salazar et al. 2022).

Overall, what policy-makers can learn from our study is that they should integrate the use of tax incentives and communication about the benefits of green retrofitting investments (for the environment and for households, in terms of bill savings), in order to implement effective energy saving measures in the housing sector. As Belaïd and Flambard (2023) recently highlighted, while other sectors (e.g., financial sector) have started to harness the benefits of exploiting information to facilitate the decision-making of individuals, soft strategies are hardly being applied in the real-world when it comes to green retrofitting and energy-saving.

Some limitations of the current study and areas of future work are also to be noted. First, more should be understood concerning the role of risk in retrofitting investments and how this could affect households' choices to adopt energy-saving measures. Second, further research is needed on the role of a wider set of measures to promote energy efficiency (such as high-technology solutions, training, and the use of media in different end-use sectors). Third, while our paper focused on the specific case of Italy, more research remains to be done to understand what are the barriers and levers playing a role on energy saving decisions in other countries. Indeed, differences in the institutional, socio-economic, and cultural settings may play an important role in determining household behavioral patterns. Finally, although we chose to focus predominantly on professionals from the building sector and students who are more climate-conscious and represent future generations, our analysis could be expanded by considering a wider set of respondents from the general public to capture the opinions from less informed and less involved individuals.

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Declarations

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