UNIVERSITY OF LJUBLJANA
SCHOOL OF ECONOMICS AND BUSINESS

IVANA JOVOVIĆ

THE ROLE OF INFORMATIVE MEASURES, SOCIAL CAPITAL, AND FINANCIAL AND ENERGY LITERACY IN ENERGY-EFFICIENT HOUSEHOLD DECISION MAKING

DOCTORAL DISSERTATION

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AUTHORSHIP STATEMENT

The undersigned Ivana Jovović, a student at the University of Ljubljana, School of Economics and Business, (hereafter: SEB LU), author of this written final work of studies with the title The role of informative measures, social capital, and financial and energy literacy in energy-efficient household decision making, prepared under supervision of Professor Jelena Zorić, PhD

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SUMMARY

This thesis explores the roles of social capital, housing-related lifestyle (HRL), informative measures (in the form of energy performance certificates for buildings – EPCs and energy labels for household appliances), energy literacy, and financial literacy in explaining energy-efficient decision making in Slovenian households. The first chapter studies the impact of social capital, housing-related lifestyle, and other factors on energy-efficient retrofits. The results of retrospective panel data analysis suggest that various factors such as income, the age of respondents and the surface of their home, subsidies, and previous experience with retrofits play a significant role in driving energy-efficient retrofits. On the other hand, high regional temperatures and negative GDP growth are identified as barriers to retrofitting. In addition, the positive influence of housing-related lifestyle (energy-saving behavior and 'do-it-yourself' approach to repairs and maintenance) and social capital (ease of agreement, as well as the formal organization in the building) is also established. The second chapter focuses on the role of energy performance certificates when making real estate purchase decisions. Bivariate probit model results show that financial literacy, pro-environmental attitude, energy-efficient behavior, surface of the dwelling, and a low energy rating of the dwelling increase the likelihood of selecting an energy-efficient home. Providing information on energy savings in monetary terms does not significantly impact the choice, which can be attributed to the low energy literacy levels identified in our sample. The third chapter explores the role of energy labels in facilitating the selection of cost-efficient household appliances. Choice experiment data analysis identifies financial literacy and energy literacy as key factors influencing the selection of cost-efficient appliances. On the other hand, the absence of monetary information on the energy label, a heuristic decision making strategy, and tenant status act as barriers to rational decision making. The combined conclusions point to a need for a policy mix based on a better promotion and clarification of information on the energy performance certificate and the energy label, simplification and the display of monetary information on the energy label, educational and informational campaigns to raise energy literacy and financial literacy, subsidies for energy-efficient retrofits, and measures that promote community building and better formal organization within a dwelling.

KEYWORDS:

Residential energy efficiency, energy-efficient retrofits, energy-efficiency measures, barriers, drivers, social capital, housing-related lifestyle, energy literacy, financial literacy, energy performance certificates, energy labels, discrete choice models

POVZETEK

Pričujoča disertacija raziskuje vlogo socialnega kapitala, z domovanjem povezanega življenjskega sloga, ukrepov informiranja (v obliki energetskih izkaznic stavb in energijskih nalepk za gospodinjske aparate), ter finančne in energetske pismenosti pri pojasnjevanju energetsko učinkovitega obnašanja slovenskih gospodinjstev. Prvo poglavje obravnava vpliv socialnega kapitala, življenjskega sloga, povezanega z bivanjem v domu, in drugih dejavnikov pri spodbujanju energetsko učinkovitih prenov. Ugotovitve analize z uporabo retrospektivnega modela panelnih podatkov kažejo, da so dohodek, starost anketiranca, površina stanovanja, predhodno izvedene prenove in razpoložljivost subvencij spodbujevalci, medtem ko predstavljajo visoke regionalne temperature in negativna stopnja rasti BDP ovire za energetsko učinkovite prenove. Poleg tega je ugotovljen tudi pozitiven vpliv življenjskega sloga, povezanega z bivanjem v domu (varčno ravnanje z energijo in nagnjenost k vzdrževanju in popravilom doma po načelu "naredi sam") in socialnega kapitala (enostavnost dogovarjanja med stanovalci in vzpostavljena in delujoča formalna organizacija stavbe). Drugo poglavje se osredotoča na proučevanje vloge energetskih izkaznic pri nakupu nepremičnine. Rezultati bivariatnega probit modela kažejo, da so finančna pismenost, pozitiven odnos do okolja, energetsko učinkovito obnašanje, površina stanovanja in slab energetski razred stanovanja spodbujevalci izbire energetsko učinkovitega doma. Vključitev denarnih informacij o prihrankih energije na energetskih izkaznicah ne vpliva značilno na sprejemanje odločitev, kar je najverjetneje odraz ugotovljene nizke ravni energetske pismenosti v vzorcu. Tretje poglavje preučuje vlogo energijskih nalepk pri izbiri stroškovno učinkovitejšega gospodinjskega aparata. Analiza podatkov, pridobljenih na podlagi izvedenega poskusa izbire pokaže, da finančna in energetska pismenost značilno in pozitivno vplivata na izbiro stroškovno učinkovitega aparata. Odsotnost denarnih informacij na energijskih nalepkah, hevristična strategija odločanja in status najemnika se po drugi strani kažejo kot ovire za sprejemanje racionalnih odločitev. Skupne ugotovitve treh poglavij kažejo na potrebo po mešanici politik, ki bi temeljila na boljši promociji in pojasnjevanju informacij o energetskih izkaznicah in energijskih nalepkah, poenostavitvi energijskih nalepk in energetskih izkaznic, prikazu denarnih informacij na energijski nalepki, izobraževalnih in informacijskih kampanjah za povečanje energetske in finančne pismenosti, subvencijah za energetsko učinkovite prenove, ter ukrepih, ki spodbujajo gradnjo skupnosti in boljšo formalno organizacijo stavb.

KLJUČNE BESEDE:

Energetska učinkovitost gospodinjstev, energetsko učinkovite prenove, ukrepi energetske učinkovitosti, spodbujevalci , ovire, socialni kapital, z domovanjem povezan življenjski slog, energetska pismenost, finančna pismenost, energetske izkaznice stavb, energijske nalepke, modeli diskretne izbire

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LIST OF ABBREVIATIONS:

DIY – do it yourself

EC – European Commission

EEREN – energy-efficient retrofit

EPC – energy performance certificate

EU – European Union

GDP – gross domestic product

GHG - green-house gas

HRL – housing-related lifestyle

JRC - European Commission's Joint Research Center

KWh – kilowatt hour

NECP – Integrated National Energy and Climate Plan

ME – marginal effect

ML – maximum likelihood

PC – principal component

PCA – principal component analysis

RES - renewable energy sources

SORS - Statistical Office of the Republic of Slovenia

1 INTRODUCTION

1.1 The dissertation's research area

This dissertation explores the role of informative measures (energy performance certificates, energy labels), financial and energy literacy, as well as social capital and housing-related lifestyle in explaining energy-efficient decision-making in Slovenian households. It is widely acknowledged by academia, energy industry professionals, and policymakers that energy efficiency is a critical issue. In 2023, this question seems more relevant than ever. Looking no further than the energy crisis, inflation, and climate change, the mitigation of many modern problems and challenges rests on energy efficiency measures to ensure that as a society and individuals, we retain the same quality of life and continue to develop and grow sustainably. The European Union's (EU's) New Strategic Agenda 2019-2024 sees energy efficiency as a key component to achieving the goal of a climate-neutral and green Europe (European Council, 2019).

However, as noted by Patterson (1996), although universally highlighted, the importance of energy efficiency is contrasted with little attention dedicated to its precise definition. Energy efficiency can generally be defined as using less energy to produce the same amount of services or useful output (Patterson, 1996). While this is an early definition and has been since updated and disputed, we find it relevant for understanding the term's intuition, meaning, and universality. Defined this way, the concept of energy efficiency can easily be applied to any aspect of life, from household energy use to industry processes and even country level of energy use. Patterson also identifies four groups of indicators that monitor changes in energy efficiency and provides a simple formula to calculate it as the ratio of the useful output of the process and the energy input of the process. This measure is also referred to as energy intensity and is a very broad term. Despite the prevalence of its use as a proxy for energy efficiency, energy intensity is, however, not a very precise measurement.

A compelling argument is that the measurement and definition of energy efficiency should be based on microeconomic foundations, more precisely the production theory, and that energy demand should be observed as a derived demand for services that the use of energy provides (Filippini & Hunt, 2015). This approach to energy efficiency measurement includes a frontier analysis, performed by estimating a parametric or non-parametric best-practice frontier for the use of energy. Energy efficiency is then computed as the difference between actual and best-practice energy use, leading to a more precise estimate of energy efficiency levels (Filippini & Hunt, 2011; Filippini & Hunt, 2016)

Researchers commonly use the term energy efficiency gap to describe the difference between optimal and actual energy consumption (Allcott & Greenstone, 2012; Jaffe & Stavins, 1994). The relevant literature recognizes two types of market failures that are the main culprit for the energy efficiency gap: energy use externalities and investment

inefficiencies (Allcott & Greenstone, 2012). It should be noted that investment inefficiencies in the context of residential energy efficiency may refer to imperfect information and inattention that lead to suboptimal decision-making. Bridging the energy efficiency gap is a challenge because overcoming both types of market failures, i.e., externalities and investment inefficiencies, requires different energy policy measures. While externalities are addressed through Pigouvian taxes and cap-and-trade programs, investment inefficiencies are tackled through subsidies, provision of information, or mandates. A more comprehensive understanding of the energy efficiency gap also includes the behavioral component (Allcott & Mullainathan, 2010), recognizing that traditional literature often overlooks behavior as an important consideration (Lopes et al., 2015).

An early study of barriers to residential energy efficiency identifies consumer-related, equipment manufacturer-related, utility-related, financial institution-related, and government-related barriers (Reddy, 1991). Other taxonomies recognize informational, economic, and cultural-normative barriers (Throne-Holst et al., 2008), as well as micro, meso, and macro-level barriers (Sudhakara Reddy et al., 2014). On the other hand, the drivers of energy efficiency are awareness, decrease in technology price levels, energy prices, technology appeal, non-energy benefits, and environmental regulations (Sudhakara Reddy et al., 2014).

The dissertation's narrower research area is the energy efficiency gap in the residential sector, more precisely, the exploration of various potential drivers of residential energy efficiency. Even though socio-demographic and dwelling-specific categories are often researched in this context, the introduction of concepts more traditionally used in sociology allows for more comprehensive insights. Our research focus on the residential component of energy efficiency is motivated by the impact that this sector has on the final energy consumption in the EU.

In 2021, households accounted for 27% of the final energy consumed in the EU. 64.4% of this energy was used for space heating (Eurostat, 2022c). It is encouraging that households in the EU reduced their green-house gas (GHG) emissions by nearly 114 million tonnes of CO_2 equivalents, which represents a reduction of 13 % between 2008 and 2021 (Eurostat, 2022b). However, the residential sector was still responsible for 20.5% of GHG emissions in the EU and 21.3% of GHG emissions in Slovenia in 2021 (Eurostat, 2022b).

The residential sector is recognized as an opportunity for energy conservation, as it has a notable potential for cost-effective energy savings (Brounen et al., 2012; Held et al., 2014). However, the identified potential is not being realized, highlighting a need for a deeper understanding of the processes behind energy-efficient decision making in households. The issue of heterogeneity of consumers is particularly important in the context of residential energy efficiency, and the need for targeted energy policies is often highlighted (Allcott & Greenstone, 2012). A thorough understanding of the barriers and drivers to residential energy efficiency allows for the design and implementation of such targeted policies.

1.2 Definition of the research problem, goals, and main concepts

There are many ways to bridge the energy efficiency gap in the residential sector. Energy-efficient retrofits lower the energy consumption for space heating. The appropriate choice of household appliances and real estate can significantly reduce the energy consumption in a household. The same is true for energy-efficient and environmentally friendly habits and practices in everyday life. The roles of social capital and housing-related lifestyle in these contexts have been under-researched so far. The impact of informative measures, in particular energy labels and energy performance certificates, is another meaningful area of research interest. Further research on informative measures is particularly relevant keeping in mind that imperfect information is identified as one of the main culprits for the energy efficiency gap. Financial literacy and energy literacy are also important concepts to explore. By focusing on these determinants, we contribute to the prior research on residential energy efficiency by suggesting some novel concepts for consideration in different contexts, and further studying and confirming the role of existing ones.

Our research goal is to establish and confirm these novel concepts as determinants of residential energy efficiency, and in doing so contribute to the energy efficiency gap literature, as well as provide relevant energy policy recommendations that can potentially improve residential energy efficiency.

To have a more complete insight into energy-efficient decision-making in multiple aspects, we divided the main body of the dissertation into three chapters. The first chapter focuses on the role of social capital and housing-related lifestyle in fostering energy-efficient household retrofits. The second chapter explores energy performance certificates, their effectiveness, and the roles of energy literacy and financial literacy in the selection of more energy-efficient real estate. Chapter three focuses on energy labels for appliances, and the roles of energy literacy and financial literacy in the selection of a more cost-efficient appliance. In this section, we provide a brief overview of the determinants we explore.

Social capital is defined as features of social organization, such as trust, norms, and networks, that can improve the efficiency of society by facilitating coordinated action, as well as spontaneous cooperation (Putnam, 1993). Coleman (1990) identifies and describes the multidimensional character of social capital, its productiveness, and the differences and similarities between human and social capital. An important finding is that social capital enables the achievement of certain goals, which could not be attainable in its absence (Coleman, 1990). The role of social capital is explored in this dissertation in the context of energy-efficient household retrofits.

Lifestyle is described as a set of practices that an individual embraces because they give material form to a particular narrative of self-identity (Giddens, 1991). These practices can be more or less integrated, and they do not necessarily fulfill the individual's utilitarian needs. The same author argues that similar to how individuals exist, interact, and move in

different settings throughout their life, certain behaviors and actions might be acceptable and even advantageous in one setting while being inappropriate in another. This is described as a domain-related lifestyle. One aspect of domain-related lifestyle is housing-related lifestyle, defined as the set of practices that individuals exhibit in relation to their homes. The concept has recently been introduced to energy efficiency gap literature by Thøgersen (2017). This author, drawing on the means-end chain theory, operationalized housing-related lifestyle and asserted its importance in achieving energy savings. Additionally, housing-related lifestyle allows for tailored policy recommendations depending on how we relate to our homes. In this dissertation, we explore the role of housing-related lifestyle in the context of energy-efficient retrofits in households.

Energy literacy as defined by DeWaters and Powers (2011) includes awareness, knowledge, attitudes, and values toward energy conservation as well as the corresponding behavior. To avoid conflating the dependent variable (energy efficient behavior of households) and the independent variable (energy literacy), we adhere to the narrower definition of energy literacy introduced by Blasch et al. (2019) consisting only of the awareness, knowledge, attitudes, and values concerning energy conservation. We expect that energy-literate individuals will correctly interpret the information available to them and make rational decisions. This determinant is studied in the context of energy-efficient real estate selection and cost-efficient appliance purchase.

Financial literacy is studied in the same setting as energy literacy and is defined as people's ability to process economic information and make informed decisions about financial planning, wealth accumulation, pensions, and debt (Lusardi & Mitchell, 2014). It refers to an individual's knowledge and correct application of concepts such as interest rate compounding, time value of money, inflation, and risk diversification, as well as life-cycle cost calculation. Higher levels of financial literacy imply that individuals will have the ability to perform and compare life-cycle cost calculations so that they make the optimal purchasing decision.

Energy performance certificates for buildings and energy labels for household appliances are informative measures implemented to overcome imperfect information and encourage energy-efficient choices in the residential sector. These measures aim to provide individuals with standardized and clearly presented information regarding the energy efficiency of buildings and appliances. By doing so, they facilitate decision-making processes and contribute to narrowing the energy efficiency gap. We study their effectiveness and test whether the provision of monetary information would improve the clarity and effectiveness of energy performance certificates and energy labels.

1.3 Research questions with a brief explanation, description of the research design and research methods

1.3.1 The role of social capital and housing-related lifestyle in performing energy-efficient retrofits

The main research questions studied in the first chapter are whether social capital and housing-related lifestyle have a significant role in household decisions to perform energy-efficient retrofits. There are many determinants of energy-efficient retrofits in households. Financial considerations are particularly discussed in the existing literature, as well as energy price expectations. Other factors include dwelling characteristics, information and advice seeking, policy measures, etc. We constructed a retrospective panel to study the roles of different drivers and barriers to energy-efficient retrofits, focusing on social capital and housing-related lifestyle (McIntosh et al., 2011).

To the best of our knowledge, social capital has been under-researched in the context of energy-efficient retrofit decision-making. Previous research in this area mostly includes only multiple-family dwellings. By observing both single-family and multiple-family dwellings, we were able to explore the different factors that influence energy-efficient decision-making between the two, leading to the next research question: whether there are differences between single-family and multi-family dwellings in this respect. The reasoning is straightforward in multiple-family dwellings: higher degrees of trust and stronger attachment to other residents should facilitate energy-efficient decision-making. On the other hand, the role of social capital in decision-making in single-family dwellings can be observed in a sense of family social capital: the ease of decision-making within a family, trust between family members, more active roles of certain family members in decision-making, as well as in a sense of a larger community: how attached respondents feel to their neighborhood, how active were they previously in community projects, etc. As defined by Putnam (1993) social capital facilitates spontaneous coordinated action. We show that households that exhibit higher levels of social capital have a higher likelihood of performing an energy-efficient retrofit.

Another contribution of this chapter is the inclusion of housing-related lifestyle variables. Lifestyle research originates from sociology, however, Thøgersen's research (2017) has asserted its importance in achieving energy savings and introduced the concept to energy efficiency literature. By including housing-related lifestyle in our research, we can provide targeted practical policy implications.

1.3.2 The impact of energy performance certificates and the display of monetary information in reducing the information barriers

The second chapter studies the role of energy performance certificates. We focus on their

effectiveness as an instrument for reducing the informational barrier to selecting energy-efficient real estate. Two initial research questions we cover in this chapter are whether energy performance certificates are effective in supporting energy-efficient decision-making and whether the display of monetary information facilitates decision making.

Existing literature on energy performance certificates mostly includes hedonic regression models. We designed a stated choice experiment which we analyzed using two separate probit models, the bivariate probit model, and recursive bivariate probit (Louviere et al., 2003). Respondents were given a choice between their current home and a more energy-efficient property, reflected in a better energy rating as measured by the energy performance certificate. The more energy-efficient home had a price premium, other characteristics kept equal (ceteris paribus). Information on the annual energy savings from selecting a more energy-efficient home was also provided. Half of the respondents received the treatment, which means that they received an experiment choice card displaying monetary information on the energy savings. The control group received the information provided on the energy performance certificate, which is displayed in physical units (kWh). This allowed us to explore whether energy performance certificates would benefit from the inclusion of monetary information, i.e. whether the inclusion of monetary information would improve their clarity and effectiveness as an informative measure of residential energy efficiency. However, the simple fact that information is available does not necessarily mean that the information will be correctly interpreted. The next research question we explored in the second chapter is whether financial literacy and energy literacy influence the likelihood of the decision to select a more energy-efficient real estate.

1.3.3 Addressing the role of information display and financial and energy literacy in household energy-efficient appliance purchasing decisions

In the third chapter, we study whether the display of monetary information affects the decision to purchase a more cost-efficient household appliance. Appliance labeling is another mechanism for reducing the informational barrier to residential energy efficiency. Energy labeling schemes rank and display the energy performance of different household appliances in a standardized way, often employing a color-coded scale. However, we argue that the simple provision of information is not enough to facilitate the selection of a more cost-efficient or more energy-efficient household appliance. This motivated our next research question: whether respondents' financial literacy and energy literacy impact the choice. The level of financial literacy was estimated based on responses to questions related to interest rate compounding, time value of money, inflation, and risk diversification, as well as the respondent's self-reported mathematical and economic knowledge. Energy literacy was similarly estimated and refers to the respondent's knowledge of energy consumption, such as electricity prices, average household energy consumption in kWh, as well the consumption of everyday household appliances.

We designed a choice experiment using stated preference. Respondents were required to choose between two models of washing machines and select the one with lower total life-cycle costs over a span of 15 years (Louviere et al., 2003; Train, 2009). The differences between the two appliances were only the price and the energy label, while the other features were kept the same. The treatment group received the annual energy consumption of the washing machine in euros, while the control group received the information in physical units - kWh. The choice experiment allowed us to additionally explore whether the energy label is used only as a visual heuristic device. Half of the sample received a stated experiment choice card where the appliance with the worse energy label is more cost-efficient. The results of a binary logit model show that the likelihood of correctly identifying the more cost-efficient appliance is lower if the respondent was presented with the choice card whereas the appliance with the worse energy rating pays off more in the long run.

1.4 Empirical data

To appropriately and comprehensively study all of the aspects of energy-efficient and environmentally friendly decision-making in Slovenian households, we acquired primary data. An online survey was conducted in Slovenia in August 2020 with the assistance of a market research agency to ensure the representativeness of the sample. The survey was conducted as a part of the EU-funded Care4Climate project (LIFE17 IPC/SI/000007). Before conducting the survey, we tested the questionnaire on a smaller sample of 100 respondents and made the appropriate adjustments.

The sample is representative of the population in Slovenia in terms of gender, region, and age, while there is a slight over-representation of respondents with higher levels of education. This is most likely because the survey was conducted online. The sample included representatives of 3,000 Slovenian households, who are economic decision-makers in their respective households. At the start of the survey, the role of an economic decision-maker was clearly explained (being in charge of main purchasing and investment decisions, paying the utility bills, choosing suppliers, etc.). We reasoned that economic decision-makers would be responsible for the tasks we analyzed to explore the determinants of residential energy efficiency in each household. These tasks include retrofit decisions, appliance purchasing decisions, and choice of real estate. Therefore, it was sensible to focus on the individuals responsible for these decisions and their characteristics.

The full sample included homeowners, co-owners, and tenants as well as family members of owners. The full sample included homeowners, co-owners, tenants, and family members of homeowners. 84.7% of respondents are either the homeowners, co-owners, or family members of the owner of their home. The remaining 15.3% of respondents are tenants, out of which 7.5% live in non-profit housing, and 7.8% in regular housing. 54.1% of households live in single-family houses (detached houses, terraced houses, or semi-detached houses), 12.4% in smaller multi-family dwellings, and the remaining 33.5% in larger apartment

buildings. The sample is comparable to the characteristics of the population of Slovenia. According to the Statistical Office of the Republic of Slovenia (SORS), at the beginning of 2021, almost 79% of the occupied dwellings were occupied by the owner or their family members. 9% of dwellings were occupied by tenants, and 12% were occupied by neither owners nor tenants. 60% of the occupied dwellings in Slovenia were located in single-family or two-family houses. The remaining 40% of occupied dwellings were in multi-apartment buildings (SORS, 2022). In the first and second chapters, we focused on homeowners, while the third chapter includes the whole sample: homeowners and renters. A more detailed overview of the subsamples can be found in each chapter.

There are certain limitations regarding the timing of our study. Namely, the first wave of the Covid-19 pandemic occurred in spring 2020, while the study was conducted in August 2020. However, we focused on performed retrofits, rather than planned retrofits in the first chapter of this dissertation. Already performed retrofits were not affected by the pandemic, as they happened in the past. In the second and third chapter we explore the concepts of energy literacy and financial literacy, which are not affected by Covid-19. We acknowledge, however, that the increase in energy prices has an implication on the total-life cycle cost calculations. However, it does not impact the ability to correctly perform the calculations.

Nevertheless, we asked the respondents to indicate whether they agree with three different statements about how they were affected by the pandemic, presented in **Table 1.** These variables were initially included in the models in the second and third chapter, but were not found to be statistically significant. Therefore, the variables are not included in the final models presented in this dissertation. Arguably, it was still too early for the full consequences of the pandemic to be felt.

Table 1: Agreement with statements about the Covid-19 pandemic (N=3000)

Statements about Covid-19[1]	**Mean**	**Std. Dev.**
I am very worried about the current situation regarding the Covid-19 pandemic.	3.124	1.258
The Covid-19 pandemic makes me feel uncertain about the future.	3.245	1.269
My financial situation has worsened due to the Covid-19 pandemic	2.824	1.385

Note: [1] - Measured on a scale from 1 (completely disagree) to 5 (completely agree)

Source: Own work.

1.5 Theoretical and practical contribution of the dissertation

By exploring the roles of relatively novel and under-researched concepts in the energy efficiency gap literature, this dissertation contributes to the discussion on barriers and drivers of residential energy efficiency.

In the first chapter, housing-related lifestyle is established, while social capital is confirmed as a driver of energy-efficient retrofits. This represents an important addition to the existing literature on energy-efficient household retrofits, which mostly includes variable groups such as socio-economic household and individual characteristics, building and location characteristics, information sources, policy impacts, and macroeconomic indicators. In the second chapter, we build upon the existing energy performance certificate literature by presenting a stated choice model, whilst mostly hedonic regression models are traditionally discussed in this context. We include the concepts of energy literacy, financial literacy, as well as environmental attitudes in our model, which are relatively novel in the domain of energy performance certificates. We find that energy literacy significantly and positively impacts the likelihood of relying on the energy performance certificates when making a decision, while financial literacy positively and significantly increases the likelihood of relying on the energy performance certificate and selecting a more energy-efficient home as a result. In the third chapter, the concepts of energy and financial literacy are confirmed as drivers of cost-efficient appliance selection. The provision of monetary information is also proven to significantly and positively impact the likelihood of selecting a more cost-efficient appliance.

These results provide implications for energy policy recommendations. The findings from the three chapters point to a need for a policy mix, essential for effectively addressing the energy efficiency gap in Slovenian households. This multifaceted approach should begin with educational and informational campaigns to address the identified low levels of energy literacy and financial literacy among the Slovenian population. We also show the need for informational campaigns about the existing informative measures i.e., energy labels and energy performance certificates. Concerning energy performance certificates, the public lacks knowledge of the benefits as well as the costs of obtaining them. We show that the labels would benefit from the simplification of their content to ensure better understanding, as they are mostly used visually as a heuristic device. The positive impact of the provision of monetary information indicates that energy labels would be improved by the inclusion of the annual energy costs in euros. Confirmation of the role of social capital as a driver of energy-efficient retrofits shows that community building should be encouraged to facilitate spontaneous cooperation, as well as that the formal organization of the building should be fostered. The establishment of the role of housing-related lifestyle allows for better-targeted energy policies. Incentives, such as subsidies and preferential loans should be provided for households to facilitate the decisions to undertake energy-efficient renovations. Implementing these policies would potentially lead to better decision making in Slovenian households and lessen the energy efficiency gap in the residential sector in Slovenia.

1.6 Structure of the dissertation

We introduced the main concepts and provided an overview of the chapters and the empirical data in this section. As explained, the main body of the dissertation is comprised of three chapters, whose titles are as follows:

I. The role of social capital and housing-related lifestyle in performing energy-efficient retrofits

II. The impact of energy performance certificates and the display of monetary information in reducing the information barriers

III. Addressing the role of information display and financial and energy literacy in household energy-efficient appliance purchasing decisions

By focusing on energy-efficient household retrofits, energy performance certificates for buildings, and energy labels for household appliances we wish to provide a comprehensive insight. Each chapter includes a more focused literature overview, a description of explanatory variables and the model, as well as a presentation and discussion of the results, and a brief discussion of the main findings. The combined conclusions of the three chapters are elaborated in the fifth section of the dissertation, along with policy recommendations that stem from them.

2 CHAPTER I: THE ROLE OF SOCIAL CAPITAL AND HOUSING-RELATED LIFESTYLE IN PERFORMING ENERGY-EFFICIENT RETROFITS[1]

2.1 Introduction

The European Commission's Joint Research Centre (JRC) report about achieving a cost-effective energy transformation of buildings in Europe (Filippidou & Jimenez Navarro, 2019) shows that almost three-quarters of buildings in the EU are energy inefficient according to current building standards. Retrofitting is recognized as a key instrument for improving the energy efficiency of the existing building stock in the EU (Ashrafian et al., 2016; Felius et al., 2020). However, only 0.4 to 1.2% of buildings in the EU are being retrofitted each year, with slight differences between member states (Filippidou & Jimenez Navarro, 2019). Combined with the statistics on final energy use and CO_2 emissions of EU households in **section 1.1**, it is clear that the yearly retrofit rates in EU member states must increase. However, despite the efforts, the retrofit rates are lagging. It was shown that at the current pace, the EU will not reach the goal of carbon-neutral buildings by 2050 (European Climate Foundation, 2020). This is why it is very important to understand the driving forces of energy-efficient household retrofits.

In Slovenia, the Integrated National Energy and Climate Plan (NECP) was adopted in

[1] The findings from this chapter have been published in an article in Energy Policy, titled 'Do social capital and housing-related lifestyle foster energy-efficient retrofits? Retrospective panel data evidence from Slovenia'

February 2020. Key energy efficiency targets include reducing final energy consumption in buildings by 20% by 2030 compared to 2005 and reducing GHG emissions in buildings by at least 70% by 2030 compared to 2005 (Government of the Republic of Slovenia, 2020). The National Long-term Energy Renovation Strategy for 2050 (Strategy) estimates that 7.264 million euros need to be invested to achieve the targets set in the NECP for the period 2021-2030 (Government of the Republic of Slovenia, 2021). The Strategy outlines the target annual renovation rates for single-apartment and multi-apartment buildings from 2020 to 2050. Specifically, it suggests a range of 3.5% to 4.0% for single-apartment buildings and 5.0% to 5.5% for multi-apartment buildings. It is worth noting that these rates reflect the percentage of integral renovations carried out per year. Unfortunately, as mentioned in the Strategy, progress toward achieving the residential energy efficiency targets by 2050 may be hindered due to the anticipated negative impact of the COVID-19 pandemic.

However, the residential sector in Slovenia had an increase in final energy savings in 2020 due to the implementation of energy efficiency and renewable energy source (RES) measures. Specifically, according to the Slovenian Environment Agency (2022), there was a cumulative reduction of 25% in final energy consumption and a decrease in CO_2 emissions by 2%. This surpasses the annual target set for 2020. Despite these positive outcomes, additional efforts are still required to meet both the targets for 2030 outlined by the NECP and the long-term goals for 2050 as specified under the Strategy.

According to the latest data on dwellings in Slovenia, 66% of the population lives in single-dwelling or double-dwelling houses. These types of dwellings represent 60% of the total number of occupied dwellings (SORS, 2022). 79% of the total number of occupied dwellings were owner-occupied, and 92.1% of dwellings are owned by private persons. This highlights an important characteristic of dwellings in Slovenia – the fact that the majority of the population are homeowners (SORS, 2022).

Commenting on the residential sector trends between the last two observed periods (2018 and 2021), there was an average increase in the total number of dwellings by approximately 1.4%, while the number of occupied dwellings increased by about 2.7% (SORS, 2019, 2022). Consequently, an increase in the dwelling size was recorded in the same period. The average useful floor area per person increased by 2.1%, as reported by SORS (2022). According to the preliminary data on building permits in 2022, there has been an 11% increase in the number of planned dwellings compared to the previous year (SORS, 2023). It is expected that with these approved permits, the total surface area of buildings in Slovenia will increase by 8%, with residential buildings accounting for 11% and non-residential buildings for 4%.

According to projections made in 2015, the population trends for Slovenia indicate that there would be a continuous increase in population until 2025, followed by a gradual decrease until 2080 (SORS, 2017). Eurostat reports that population growth has been slowing down across Europe over recent decades. Indeed, Slovenia had slight positive population growth rates until 2021, when similarly to the rest of the EU a decrease was recorded, most

likely due to the impact of COVID-19 (Eurostat, 2022a). Slovenia's population growth rate has generally been in line with or lower than the average for EU-27 since 2010 (Eurostat, 2022b). The exceptions were observed between 2018 and 2020 when net migrations significantly contributed to an increase in Slovenia's total population.

The projected long-term decrease in total population would most likely decrease emissions in the residential sector. On the other hand, since 2018 there is an increase in net migration mostly due to labor migrations. If labor migrations were to continue, combined with the recent building construction trends, this can lead to an increase in emissions. This means that energy efficiency in the residential sector is still a pressing topic in Slovenia.

More than 40% of the total number of single-family houses were built before the 1980s and classified in low energy-efficiency grades F and G, which means that they are inefficient according to current building standards (Government of the Republic of Slovenia, 2021), with associated high energy losses and costs, as well as other upkeep costs. Aside from this challenge, there is also the problem of joint ownership, especially in multi-dwelling buildings, where the majority of tenants must agree for the energy-efficient retrofit to take place. Through various aid schemes, financial incentives (such as subsidies and preferential loans), free energy counseling, and other actions and measures proposed in the Strategy to promote household energy efficiency, Slovenia aims to address the problem and achieve the targets set in the NECP in an attempt to bridge the energy efficiency gap in the residential sector.

The topic of energy-efficient household retrofits is not new in Slovenia and was already high on the political agenda even before the 2020 NECP. Over the past decade, several measures have been put in place to tackle the energy efficiency gap in the residential sector. As early as 1993, a specialized public fund named Eco fund was established to address energy efficiency issues. In 2008, with the help of the Eco fund, the country introduced a program of subsidies and preferential loans to promote energy-efficient retrofits. The program was more widely implemented since 2009. To improve the Eco fund's work, ENSVET, a network of energy counseling offices offering free-of-charge advice on energy-efficient retrofits, was also established. The consultants at ENSVET offer advice and one-on-one meetings to help select and plan energy-efficient retrofits and the use of renewable resources in residential buildings. The goal of the counseling is to increase citizen awareness of issues related to energy conservation, achieve energy savings and reduce GHG emissions by facilitating the implementation of certain energy policies and programs (ENSVET, 2022).

It should be noted that the effectiveness of the Slovenian subsidy program has been evaluated (Dolšak et al., 2020) and the role of information sources, including free-of-charge advice, has been explored in previous research (Hrovatin & Zorić, 2018). With this analysis, we aim to contribute to the discussion on the determinants of energy-efficient retrofits by providing evidence on additional aspects of retrofit decisions, that have not been addressed in previous studies.

Although there are reasons for cautious optimism, reflected in the facts that the energy-efficiency target until 2020 was met and that the Slovenian subsidy program proved to be effective (Dolšak et al., 2020), the road to achieving the ambitious goals of the NECP is still long. Therefore, unveiling the barriers and drivers to implementing energy-efficient retrofits in households is an important milestone on this road and a necessary tool for bridging the energy efficiency gap.

To this end, we will focus on relatively novel and under-researched concepts in the field of energy-efficient household retrofits, namely housing-related lifestyle (HRL) and social capital. In this way, we will explore the extent to which these additional factors, such as habits, behaviors, and community networks, help to explain energy-efficient retrofit decisions.

Social capital, more traditionally explored in sociology, refers to features of social organization that can ease coordinated action, such as trust, norms, and networks (Putnam, 1993). We expected to find that living in a well-connected and well-organized community, which can be reflected in harmonious relationships with your neighbors, knowing your neighbors, feeling attached to your neighborhood, but also the presence of a building manager or a renovation fund in place will positively influence energy-efficient retrofit decisions.

Housing-specific lifestyle refers to an integrated set of practices that individuals have related to that specific domain of their life (Giddens, 1991). Our premise is that individuals who score higher on certain dimensions of housing-related lifestyle, such as energy-efficient practices and having a do-it-yourself approach to home maintenance and repairs would also be more likely to decide on performing an energy-efficient retrofit. In exploring these concepts, we start in the second section by providing a literature review on the topics of energy-efficient retrofits, barriers, and drivers to energy-efficient retrofits, social capital, and domain-specific lifestyle research. We continue in the third section by presenting the method, model, and data. In the fourth section, we present the results of the retrospective panels, and in the fifth section, we discuss the main findings of these results.

2.2 Literature review

Considering that most of the final energy consumed in residential buildings is used for space heating and air-cooling, the focus of this chapter is solely on energy efficient retrofits, and upgrades of heating and ventilation systems. It should be noted that by energy-efficient retrofit, we mean substantive physical changes to a building made to improve the energy efficiency of the building (Dixon & Eames, 2013). More precisely defined, thermal insulation of the roof, thermal insulation of the façade, window replacement, and heating system or ventilation system upgrade or installation are considered energy-efficient retrofits.

A vast body of literature tackles the topic of energy-efficient retrofits, ranging from retrofit

policy rationale (Kerr et al., 2017), evaluating the economic potential of energy-efficient retrofits (Amstalden et al., 2007), assessing willingness to pay for energy-efficient retrofits (Achtnicht & Madlener, 2014; Banfi et al., 2008) and investigating numerous determinants of energy-efficient retrofits (Achtnicht & Madlener, 2014; Azizi et al., 2019; Broers et al., 2019; Camarasa et al., 2021; Curtis et al., 2018; Dolšak et al., 2020; Felius et al., 2020; Gamtessa, 2013; Gram-Hanssen et al., 2018; Hrovatin & Zorić, 2018; Michelsen & Madlener, 2012; Nair et al., 2010; Trotta, 2018a; Wilson et al., 2015).

A large number of these studies explore the impact of **socio-economic** characteristics on decisions to undertake a home retrofit, often with inconclusive results, in particular in connection to gender, age, and education. For instance, age is found to negatively influence retrofitting decisions in some studies (Achtnicht & Madlener, 2014; Hrovatin & Zorić, 2018) and to positively influence them in others (Cirman et al., 2013). While higher income often proves to be a driver for performing an energy-efficient retrofit or purchasing an energy-efficient appliance (Achtnicht & Madlener, 2014; Dolšak et al., 2020; Gamtessa, 2013; Mortensen et al., 2016), in turn, it has been shown that higher disposable income leads to household behavior being less environmentally friendly (Gamtessa, 2013; Trotta, 2018a). The rationale for this is that households with higher incomes do not have to strictly budget their living costs and therefore do not behave economically when it comes to reducing energy costs. On the other hand, households with lower disposable income have the incentive to avoid high energy costs and adjust their behavior accordingly.

Financial constraints are identified as a key barrier to energy-efficient retrofits (Felius et al., 2020). On the other hand, education is very often found to be a driver of energy-efficient retrofits (Broers et al., 2019; Mortensen et al., 2016; Nair et al., 2010), although some scholars consider it a barrier (Gamtessa, 2013). Environmental matters, including environmental awareness (Achtnicht & Madlener, 2014; Nauleau, 2014) and environmental benefits (Achtnicht, 2011) are another interesting consideration. These studies showed that environmental concerns generally have a positive effect on energy-efficient retrofits and the selection of a more energy-efficient heating system.

In addition, researchers also consider certain **building or dwelling characteristics**, such as the surface of the dwelling (Nauleau, 2014) and the age of the building, which often works as a driver of energy-efficient retrofits (Achtnicht & Madlener, 2014; Alberini et al., 2013; Dolšak et al., 2020), meaning that the older the building, the higher the probability of an energy-efficient retrofit. Location is often included as a variable. A significant impact of residing in certain regions is shown (Gamtessa, 2013), as well as an increased probability of retrofits when living in colder climates (Alberini et al., 2013). Apart from this, researchers identify the lack of clear retrofit regulations as a barrier to energy-efficient retrofits (Felius et al., 2020). In a mixed-tenure setting, some studies focus on governance issues and communication and consultation problems (Bright et al., 2019).

Notable research explores determinants such as the role of energy audits (Achtnicht &

Madlener, 2014; Murphy, 2014; Nair et al., 2010) and other (formal and informal) **information sources** and advice (Azizi et al., 2019; Hrovatin & Zorić, 2018). In these studies and other notable research, the lack of information and knowledge about energy-efficiency-related matters is often cited as a barrier to energy-efficient retrofits (Mortensen et al., 2016; Nair et al., 2010). In connection to the role of energy consultation and audits, one should also mention the endogeneity problem since causality can go in both directions, i.e., homeowners considering energy-efficient retrofits may be more likely to seek advice on energy savings in the first place, implying that the effect of consultation will be overestimated. This issue is not satisfactorily resolved in the reviewed literature, since finding suitable instrumental variables appears to be quite difficult.

It is also important to mention a body of literature that focuses on **policy impacts** on energy-efficient retrofits (Amstalden et al., 2007; Gram-Hanssen et al., 2018; Pettifor et al., 2015), as well as on evaluating the effectiveness of policy measures, most of which are examined in terms of the presence of the free-rider effect in either subsidy programs, rebate programs, or tax credits (Dolšak et al., 2020; Olsthoorn et al., 2017). Another important consideration is the impact of energy price expectations (Alberini et al., 2013; Amstalden et al., 2007) and certain macroeconomic indicators, such as GDP per capita and GDP growth (Dolšak et al., 2020).

From the literature review presented it follows that the determinants of energy-efficient retrofits can be broadly classified into several categories, namely socio-economic household and individual characteristics, building and location characteristics, information sources, policy impacts, and macroeconomic indicators. In addition, this chapter explores the role of certain novel concepts in explaining energy-efficient retrofits – social capital and housing-related lifestyle.

The topic of **social capital** is discussed more thoroughly in sociology and philosophy than in the energy efficiency gap literature. The term was first introduced by Glenn Loury, who defined it as the "consequences of social position in facilitating the acquisition of standard human capital characteristics" (Loury, 1976). Subsequently, social capital referred to "nontransferable advantages of birth that are conveyed by parental behaviors bearing on later-life productivity" (Loury, 1987). It is important to note that while expanding upon the latter definition, the author acknowledges that individuals and their families also belong to different social clusters, that he refers to as "communities". Communities serve as an additional source of social capital.

A well-known definition of social capital explains this concept as features of social organization, such as trust, norms, and networks, that can improve the efficiency of society by facilitating coordinated action (Putnam, 1993). Social capital plays a crucial role in fostering spontaneous cooperation, as highlighted by Putnam who draws upon Coleman's work on the topic. Coleman (1990) emphasizes the multifaceted nature of social capital, its distinction from human capital, and its productivity. He also acknowledges that social capital

enables individuals to achieve certain goals that would not be possible without it. Expanding upon this notion, we aim to show how social capital facilitates decision-making in the context of energy-efficient retrofits. Other studies investigate different aspects of social capital such as pro-social norms, organizational structures within buildings, and resident participation (Saegert et al., 2002).

A similar operationalization of social capital variables has been applied in research on renovations in Central and Eastern European countries (Cirman et al., 2013). The main findings suggest that both the sociocultural milieu, explained as the positive attitude of tenants towards their neighborhood and the ease of reaching an agreement, as well as the organizational ability of owners to act collectively, namely the existence of a collective building fund for renovations, both positively impact renovation decisions in multi-dwelling buildings. However, due to data availability issues, the study does not differentiate between retrofits carried out to improve the energy efficiency of the building and regular maintenance work and includes only multi-dwelling buildings in the sample. It should also be noted that social capital is recognized as an important information source in a study showing that, among other determinants, advice from relatives and friends positively influences the intention to implement energy-efficient retrofits (Hrovatin & Zorić, 2018).

The role of social capital has also been studied in terms of its effect on the adoption of energy-efficiency innovation in UK households (McMichael & Shipworth, 2013) and it was found that seeking information from personal contacts is generally associated with higher adoption rates of energy innovation. Social capital has also been explored in the context of environmental protection and carbon emissions reduction (Carattini et al., 2015; Marbuah et al., 2021; Yildirim et al., 2021).

Lifestyle research originates in sociology but has in recent years found its place in other fields as well. Giddens defined lifestyle as a more or less integrated set of practices that an individual embraces, not only because such practices fulfill utilitarian needs, but because they give material form to a particular narrative of self-identity (Giddens, 1991). The same author argues that similar to how individuals exist, interact, and move in different settings throughout their life, certain practices and actions might be desirable in one context while being unacceptable in another. Examples of this can be found in almost every aspect of life, the most obvious is the difference in behavior and habits in free time and during working hours. Researchers refer to this as a domain-specific lifestyle, which has been used primarily in areas such as marketing and consumer behavior, due to its applicability in better market segmentation (van Raaij & Verhallen, 1994). In this context, researchers refer to food-related lifestyle (Brunsø et al., 2004a; Grunert et al., 2001), transport-related lifestyle (Brand et al., 2019; Thøgersen, 2018), and other domain-related lifestyles. It bears to mention the place lifestyle has found in means-end chain theory, which observes lifestyle as distinct from value and places it in a hierarchy of constructs of different levels of abstraction (Grunert et al., 1993). Other researchers build on this model assigning lifestyle a role of a mediator of the relationship between values and behavior (Brunsø et al., 2004b).

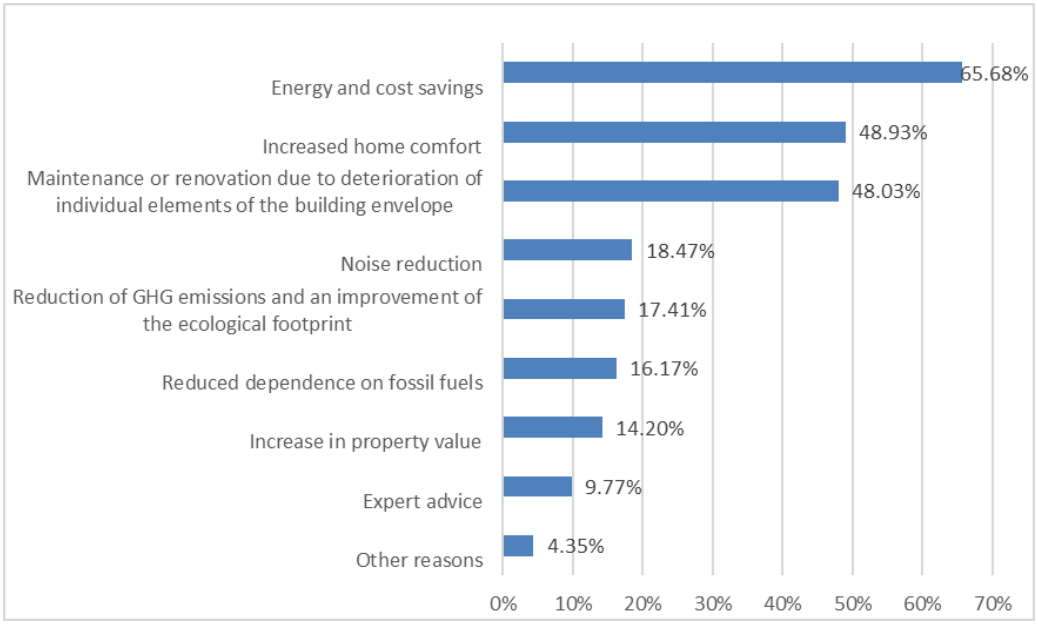
Recently, domain-specific lifestyle research has found its place also in energy-efficiency literature, as in the case of interesting research by Thøgersen, who has, drawing on the means-end chain theory, operationalized housing-related lifestyle and asserted its importance in achieving energy savings (Thøgersen, 2017). His research has shown that housing-related lifestyle segmentation can be used for better-targeted energy-saving campaigns. The findings of this study suggest that variations in housing-related lifestyle account for substantial variations in energy-saving behavior and innovativeness. Thøgersen's research also shows that a person's level of engagement in their own home affects their energy-saving efforts. The same author notes a gap in research regarding the definition of housing-related lifestyle and its impact on energy consumption. In our attempt to confirm the link between lifestyle and energy-efficient retrofits, we follow Thøgersen's (2017) operationalization of housing-related lifestyle, while using a modified and reduced instrument. A detailed description of the instrument is provided in the following section.

2.3 Method, model, and data

The data was collected from an online survey conducted in Slovenia in August 2020 with the assistance of a market research agency. The full sample included homeowners, co-owners, and tenants, as well as family members of owners, and was representative of the population in Slovenia. As it is often the case that tenants cannot opt for retrofits of any kind as they are not the proprietors of their homes, we chose to focus on the subsample of homeowners, co-owners, and their family members comprising 2,537 respondents. This decision was also made based on the characteristics of dwellings in Slovenia. We have included both multi-family and single-family dwellings in the subsample.

To gain a better understanding of the driving forces and barriers of retrofits in households, we asked the respondents who performed an energy-efficient retrofit to list the main reasons for doing so. It should be noted that it was possible to select multiple options, as well as that the order of options was randomized. The majority of homeowners who performed energy-efficient retrofits, more precisely 65.68% of them, chose to do so because of the energy and cost savings, as shown in **Figure 1**. This is followed by the increase in the comfort of the home (48.93%) and the necessity for maintenance or retrofitting due to the deterioration of the building envelope (48.03%). 4.35% of respondents performed the retrofit due to other reasons (including advice from the building manager, increase in operating costs of the existing heating system, existing heating system malfunction, etc.). Only 9.77% chose to do so based on expert advice. 14.2% of respondents chose to perform a retrofit because of an increase in the property value.

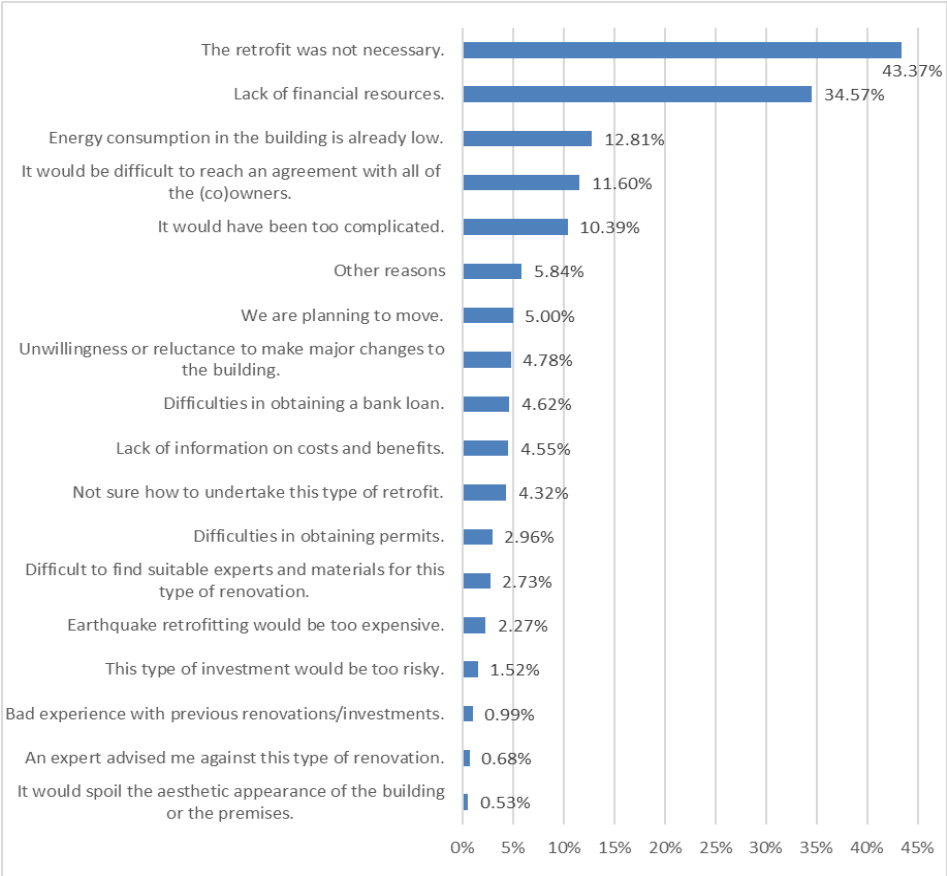
Figure 1: Reasons for performing energy-efficient retrofits (n=1,218)



Source: Own work.

On the other hand, we observed the reasons against performing an energy efficient retrofit. It was also possible to select multiple options, and the order of options was randomized. The majority of respondents who have not performed an energy-efficient retrofit in their home claim that the retrofit was not necessary (43.37%). However, as witnessed by the characteristics of the building stock in Slovenia, the average dwelling age in our dataset, and the lack of knowledge about energy performance certificates (more details in section 3.2.3) this could point to a lack of information on the necessity and benefits of energy-efficient retrofits. Unsurprisingly, the lack of financial resources is the second most selected reason against performing an energy-efficient retrofit. 34.57% of respondents who have not performed an energy-efficient retrofit in their homes claimed that this is why they decided against it. Other reasons include low energy consumption in the building (12.81%), the difficulty of reaching an agreement with all of the owners or coowners (11.6%), and the complexity of energy-efficient retrofits (10.39%). Aesthetic considerations (0.53%), as well as expert advice against the renovation (0.68%), represent the two least selected reasons against an energy-efficient retrofit. A more detailed overview is provided in **Figure 2.**

Figure 2: Reasons against performing energy-efficient retrofits (n=1,319)



Source: Own work.

As mentioned in the literature review, we chose to include explanatory variables that can be divided into several categories: socio-economic household and individual characteristics, building and location characteristics, social capital, housing-related lifestyle, and other variables, including information sources, policy effects, and macroeconomic variables. **Table 2** shows the descriptive statistics of the employed explanatory variables. It should be noted that the age of the respondents and the building were adjusted to the panel data.

Table 2: Descriptive statistics of explanatory variables (n=2,357)

Explanatory variables	**Mean**	**Std. Dev.**	**Min**	**Max**
Socio-economic individual and household characteristics				
The respondent is male (1-Yes, 0-No)	0.484	0.500	0	1
Education level (1 – elementary school or lower to 3 – University degree or higher)	2.472	0.534	1	3
Age of respondents (in years)	46.989	13.445	18	86
Monthly income (in EUR)	1956.63	858.959	500	3500

To be continued

Table 2: Descriptive statistics of explanatory variables (n=2,357) (cont.)

Explanatory variables	**Mean**	**Std. Dev.**	**Min**	**Max**
Socio-economic individual and household characteristics				
Monthly income not reported (1-Yes, 0-No)	0.158	0.364	0	1
Loan (1-Yes, 0-No)	0.557	0.497	0	1
Respondent is the first owner of their home (1-Yes, 0-No)	0.496	0.500	0	11
Pro-environmental awareness (scale from 1 to 7)	5.470	1.050	1	7
Number of household members	3.130	1.370	1	10
Renovations performed before the year 2000 (1-Yes, 0-No)	0.047	0.210	0	1
Building and location characteristics				
How old is the building (years)	42.078	19.523	4	75
Multi-apartment building (1-Yes, 0-No)	0.379	0.485	0	1
The surface of the dwelling (in square meters)	120.174	74.149	25	500
Urban settlement (1-Yes, 0-No)	0.586	0.492	0	1
The region with the highest average temperature in Slovenia (1-Yes, 0-No)	0.048	0.215	0	1
Social capital				
Ease of agreement (1-Yes, 0-No)	0.504	0.500	0	1
Respondent knows their neighbors (on a scale from 1 – one of them to 3 – almost all of them)	2.715	0.477	1	3
Respondent finds the presence of a building manager helpful (1-Yes, 0-No)	0.265	0.441	0	1
No reserve (1-Yes, 0-No)	0.056	0.230	0	1
Neighbors participated in a project (1-Yes, 0-No)	0.543	0.498	0	1
Explanatory variables	**Mean**	**Std. Dev.**	**Min**	**Max**
Housing-related lifestyle[1]				
PC1 – Privacy	0	1.683	-9.497	3
PC2 – DIY identity	0	1.615	-7.171	3.147
PC3 – Energy-saving behavior	0	1.537	-5.814	3.795
PC4 – Functionality and quality	0	1.461	-5.624	3.098
PC5 – Participation	0	1.379	-4.406	3.718
PC6 – Social life	0	1.343	-5.439	3.297
PC7 – Spaciousness	0	1.256	-5.244	3.747

To be continued

Table 2: Descriptive statistics of explanatory variables (n=2,357) (cont.)

Explanatory variables	Mean	Std. Dev.	Min	Max
Information sources, policy effects, and macroeconomic variables				
Negative GDP growth (1-Yes, 0-No)	0.142	0.349	0	1
GDP per capita (in EUR)	17270	3348	11076	23165
Subsidy program in place (1-Yes, 0-No)	0.619	0.485	0	1
The importance attached to free-of-charge public counseling (scale from 1 to 4)	3.296	0.656	1	4

Note: [1] – Normalized values of principal components (PCs) are reported.

Source: Own work.

We decided to include socio-economic individual and household characteristics such as gender, age, education, and income, as well as building and location characteristics because they appear as determinants in several papers covered in the literature review (Achtnicht & Madlener, 2014; Azizi et al., 2019; Wilson et al., 2015). In particular, financial constraints are seen as an important barrier to energy-efficient retrofits (Felius et al., 2020). We accounted for the number of household members, even though this variable has mostly appeared as insignificant, or even as a barrier in certain studies. However, since we are focusing on social capital, it seemed reasonable to consider it.

It bears to mention that the rationale behind the inclusion of the dummy variable for residing in the region with the highest average temperature in Slovenia comes from the fact that the climate in Slovenia is quite regionally varied with exposure to Mediterranean, continental, and Alpine climate influences. The average mean temperature in the period 1991-2020 was 9.68°C in the entire country, 12.16°C in the warmest region, which is the Obalno-kraška region with the Mediterranean climate, and 8.45°C in the coldest region, which is the Gorenjska region (World Bank Group, 2021). In addition to the type of climate, temperature conditions are strongly influenced by the altitude, so the average annual temperature in Slovenia decreases on average by 1°C for every 180 meters of increase in altitude (Slovenian Environment Agency, 2017).

We also found it important to include pro-environmental awareness, which we operationalized as a composite variable comprised of five variables with a scale reliability coefficient of 0.82. We observed pro-environmental awareness in the context of residential energy-efficient retrofits, motivating our focus on climate change and associated energy use concerns. Similarly, environmental concerns are considered a determinant of energy-efficient retrofits and observed in terms of climate change, pollution, and renewable energy-related issues in a study focusing on insulation retrofit measures (Nauleau, 2014).

Of course, pro-environmental awareness is a broad term and could include awareness and attitudes about many issues, such as efficient and environmentally-friendly use of water and

other resources, recycling, transportation choices, mobility, clothing, etc. Given the expected positive correlations between different environmental concerns, climate change concerns can be taken as a good proxy for environmental awareness. The respondents reported how much they agree with statements related to environmental concerns on a scale from 1 – not at all to 7 – completely agree. Statements included whether it is important for the respondent's home to have a low carbon footprint, whether climate change, global warming, and pollution are serious threats to the future, whether the respondent feels morally responsible to reduce energy consumption, as well as whether the respondent would sacrifice some money to reduce their energy consumption. A more detailed overview is provided in **Table 3.**

Table 3: Variables used to construct the composite pro-environmental awareness variable

Variable	**Mean**	**Std.Dev.**	**Min**	**Max**
Climate change, global warming, and pollution pose a serious threat to future generations.	5.870	1.399	1	7
I feel morally responsible to reduce my energy consumption.	5.283	1.479	1	7
I try to use as little energy as possible in my home.	5.724	1.245	1	7
It is important to me that my home has a low carbon footprint.	5.077	1.471	1	7
I do not regret sacrificing a little money to reduce energy consumption in my home.	5.433	1.329	1	7

Source: Own work.

Given the characteristics of the building stock in Slovenia, in particular the age, we have found it important to account for previously performed renovations. Here, we did not differentiate between energy-efficient retrofits and other maintenance work. We assumed that if respondents had a positive experience with a past retrofit (regardless of its type), they would be more inclined to undertake an energy-efficient retrofit.

We operationalized social capital by observing how connected respondents feel to their neighborhood and neighbors (whether they know and talk to their neighbors), how actively they used to participate in community projects, how easy the decision-making in the building was as well as by exploring the existing infrastructure that facilitates coordinated decision making, such as the presence of a renovation fund, a building manager and the building manager's helpfulness. To clarify, the renovation fund is a collective fund to which homeowners monthly contribute a certain amount of funds and as such is an instrument for ensuring the maintenance of multi-apartment buildings by distributing the financial burden of necessary repairs and maintenance over time.

However, it could be argued that the prevalence of an attitude that is not pro-environmental in a community could influence the respondents to do otherwise. Nevertheless, only 9.38%

of homeowners expressed a negative attitude towards energy conservation, indicating that they strongly or completely agree with the statement that they are not willing to reduce their energy consumption if others don't do the same. We can therefore assume that the general attitude towards the environment is positive in the homeowner subsample.

While social capital is more often studied in multi-family dwellings, we also include single-family dwellings in the sample. This is motivated by the characteristics of the building stock in Slovenia, as well as by the fact that a certain level of coordination and agreement is necessary even in a single-family dwelling for a retrofit to take place. Namely, an energy-efficient retrofit is a disruption to the household's daily routine and has an impact on a household's finances, requiring an agreement between the family members. Further, even in a single-family household there are often multiple co-owners that inherited the same property, and an agreement needs to be reached for a retrofit to take place.

The inclusion of housing-related lifestyle variables is an important addition to this study. Following Thøgersen (2017), we asked the respondents about various aspects of housing-related lifestyle, such as, how important is the aesthetics of their home, if they have a 'do-it-yourself' (DIY) attitude towards home repairs and maintenance, how much they value the privacy of their home, whether all family members participate in household chores and decoration, as well as about their behavior related to energy conservation (see **Appendix, Table A.1**: Descriptive statistics of variables used for the PCA).

To reduce the dimensionality of our dataset, we performed a principal component analysis (PCA) with varimax rotation. Based on the obtained test statistics for the KMO test of sampling adequacy and Bartlett's test of sphericity we concluded that the data were suitable for PCA analysis (Jollife & Cadima, 2016). Employing the Kaiser criterion identified seven principal components (PCs) that pertain to different dimensions of housing-related lifestyle. **Table 4** presents different component loadings with a cut-off limit of 0.3. Cronbach's alphas were also satisfactory, as shown in **Table 5.**

In comparison to Thøgersen (2017), we use a modified and reduced set of variables. As our research focuses on various aspects of energy-efficient retrofits with HRL potentially being one of the influential factors, operationalization of the HRL instrument as originally presented by Thøgersen would make the questionnaire too long and overwhelming for the respondent. In this respect, we have put more emphasis on dimensions relevant to the domain of energy-efficient retrofits (home improvement, quality aspects, living situation, etc.) than certain other dimensions (such as ways of shopping), even though all dimensions have been considered. Reassuringly, a comparison of our PCA analysis with Thøgersen's reveals that we obtained very similar components even with a reduced set of statements. As an example, variables that load on two dimensions of Thøgersen's HRL instrument (4.1 'DIY identity' and 4.4 'Handyman') load on one of the principal components that we found: PC2 'DIY identity'.

We identified the components as follows:

- *Privacy (PC1),* which explains the extent to which the respondent values the privacy of their home and their family. Individuals who score high on this dimension regard their home as a safe haven for their family and set the rules in their own homes.

- *DIY identity (PC2),* which encompasses the proclivity that a respondent has towards do-it-yourself maintenance and repairs. These individuals might also look for decorating and maintenance inspiration online or in magazines and have a more hands-on approach to maintaining and repairing their homes.

- *Energy-saving behavior (PC3),* which includes energy-efficient practices that an individual engages in, such as turning off the lights to save electricity and using household appliances properly (turning them off when they are not being used and using the dishwasher or the washing machine only when they are full).

- *Functionality and quality (PC4),* which explains how much the participants value the functionality and quality of their homes. Individuals who score high in this category would place more value on the functionality of their home rather than aesthetics, as well as value the quality of their home over the home's size and cost.

- *Participation (PC5),* which refers to the decision-making in the family in terms of whether all family members decide on home decoration, as well as do family members participate in household chores.

- *Social life (PC6),* which explains the extent to which visits from friends make up the respondent's social life, as well as whether housing-related matters are a topic of conversation between the respondent and their friends. These individuals also find that their home reflects their social status.

- *Spaciousness (PC7),* which indicates how much the respondent cares about the size as well as the spaciousness of their home.

Table 4: Principal component loadings

Description	PC1 (Privacy)	PC2 (DIY identity)	PC3 (Energy-saving behavior)	PC4 (Function-ality and quality)	PC5 (Partici-pation)	PC6 (Social life)	PC7 (Spacious-ness)	Unexplained
The spaciousness of my home is very important.							0.497	0.406
The bigger the apartment, the better.							0.680	0.280
It is important that my housing costs are as low as possible.								0.625
The proximity of green areas is very important.								0.640
The functionality of my home is very important.				0.477				0.402
The functionality of a home is more important than its aesthetics.				0.596				0.389
The quality of my home is more important than its size and cost.				0.456				0.497
Our home is an ideal place to spend quality family time.	0.386							0.417
My home is the first and most important haven for my family.	0.467							0.338
I value the privacy of my home.	0.473							0.374
My home is my mansion, where I set the rules.	0.472							0.454
My friends' visits to my home are an important aspect of my social life.						0.520		0.445
My friends and I often talk about our homes.						0.553		0.390

To be continued

Table 4: Principal component loadings (cont.)

Description	PC1 (Privacy)	PC2 (DIY identity)	PC3 (Energy-saving behavior)	PC4 (Function-ality and quality)	PC5 (Partici-pation)	PC6 (Social life)	PC7 (Spacious-ness)	Unexplained
It is important to me that my home reflects my social status.						0.302		0.474
When I buy things for my home, I compare prices to get the most value for my money.								0.057
It is important to me that everything in my home is of the highest quality.		0.379						0.554
I read magazines and articles in which I get inspiration for future purchases and improvements to my home.		0.308						0.532
In our family, we do housework together.					0.606			0.332
All members of the family have a say in furnishing the home.					0.606			0.346
I routinely do the necessary repairs and maintenance, as well as gardening according to the time of the year.		0.371						0.435
I routinely check to see if anything in my home needs repair.		0.474						0.448
My home is equipped with tools for necessary repairs.		0.310						0.501
I think that maintaining a home is a man’s job.		0.457						0.580
I use the washing machine or dishwasher only when it is full.			0.351					0.651

To be continued

Table 4: Principal component loadings (cont.)

Description	PC1 (Privacy)	PC2 (DIY identity)	PC3 (Energy-saving behavior)	PC4 (Function-ality and quality)	PC5 (Partici-pation)	PC6 (Social life)	PC7 (Spacious-ness)	Unexplained
I turn off the lights when I leave the room.			0.410					0.562
I switch off electrical appliances (TV, PC, etc.) when I am not using them.			0.432					0.592
I turn off the air conditioning when I'm not in the room (in summer).			0.393					0.667
I have a lower temperature setting during the night or periods of absence (heating season).			0.427					0.612
I use household appliances (e.g., washing machine, dryer, dishwasher) in the lower tariff periods.			0.381					0.068

Source: Own work.

Table 5: Explained variance and Cronbach's alphas of PCs

	PC1 Privacy	PC2 DIY identity	PC3 Energy-saving behavior	PC4 Function-ality and quality	PC5 Partici-pation	PC6 Social life	PC7 Spacious-ness
Explained variance (%)	10.2%	7.67%	7.58%	7.16%	6.56%	6.42%	5.45%
Cronbach's alpha	0.715	0.675	0.628	0.654	0.676	0.624	0.611

Source: Own work.

In modeling the households' energy-efficient retrofit decisions, we employed random utility theory and the method of revealed preference, where the revealed preference refers to the decision to implement energy-efficient retrofit in the respondent's home in the past. According to random utility theory, the utility of an individual *n* in the case of an energy-efficient retrofit *j* can be represented in the following way (Train, 2009):

$$U_{nj} = V_{nj} + \varepsilon_{nj}, \qquad (1)$$

where U_{nj} is the individual's utility obtained from alternative *j*, V_{nj} is the component of utility we are attempting to estimate, and ε_{nj} represents the random error term. The $V_{nj} = \beta' X_n$ is assumed to be linear in parameters and includes different variables covered in the literature review and further discussed in this section (socioeconomic household and individual characteristics, building and location characteristics, information sources, policy effects and macroeconomic indicators, social capital, and HRL). The probability that an individual *n* opts for an energy-efficient retrofit (*EEREN*) can be modeled through its utility, that is, the individual will choose to perform an energy-efficient retrofit *j* only if the choice increases their underlying utility:

$$Prob\ (EEREN_n) = Prob\ (U_{nj} \geq U_{nk}) = Prob\ (V_{nj} + \varepsilon_{nj} \geq V_{nk} + \varepsilon_{nk}), \quad (2)$$

where the alternative *k* represents a decision not to undertake an energy-efficient retrofit.

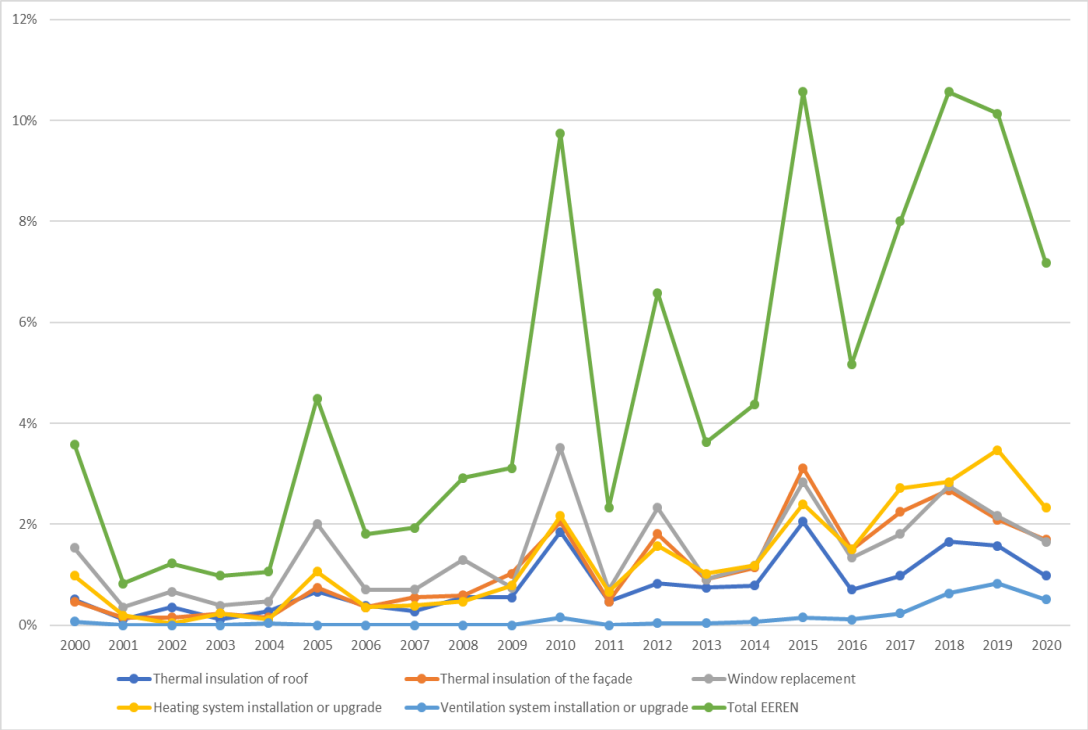
If we assume that the random error term ε_{nt} in equation (2) has a logistic normal distribution, we can express the model as follows:

$$Prob(EEREN_n|X_n) = \frac{e^{\beta' X_n}}{1+e^{\beta' X_n}}. \quad (3)$$

The dependent variable *EEREN* is thus dichotomous and takes the value of one in the year when the energy-efficient retrofit has taken place and zero otherwise.

To get a better sense of the dependent variable, **Figure 3** shows the yearly share of performed *EEREN* by type of retrofit (calculated using the survey data as the share of the total number of homeowners). The upward trend after 2009 is noticeable, indicating the positive effect of subsidies, which were introduced at the end of 2008.

Figure 3: Yearly energy-efficient retrofit rates per type of retrofit



Source: Own work.

Table 6 shows a comparison between average yearly retrofit rates and the average yearly subsidized retrofit rates per type of retrofit. We observe retrofit rates in the period from 2000 to 2020, and after the introduction of the subsidy program, from 2008 to 2020. It should be noted that the baseline retrofit rates for the period 2020–2050, as defined in the 2050 Strategy are 3.5 to 4.0% for single-family dwellings and 5.0 to 5.5% for multi-family dwellings and refer to integral energy-efficient retrofits.

Table 6: Comparison of average yearly retrofit rates and subsidized retrofit rates by type of retrofit

	Average yearly retrofit rates in % (2000 to 2020)	**Average yearly retrofit rates in % (2008 to 2020)**	**Average yearly subsidized retrofit rates in % (2008 to 2020)**	**Average yearly subsidized retrofit rates – share of completed retrofits in % (2008 to 2020)**
All retrofit types	4.77%	6.48%	3.05%	43.71%

To be continued

Table 6: Comparison of average yearly retrofit rates and subsidized retrofit rates by type of retrofit (cont.)

	Average yearly retrofit rates in % (2000 to 2020)	**Average yearly retrofit rates in % (2008 to 2020)**	**Average yearly subsidized retrofit rates in % (2008 to 2020)**	**Average yearly subsidized retrofit rates – share of completed retrofits in % (2008 to 2020)**
Thermal insulation of the roof	0.78%	1.06%	0.46%	37.56%
Thermal insulation of the facade	1.15%	1.64%	1.09%	59.45%
Window replacement	1.43%	1.79%	0.57%	32.34%
Heating system installation or upgrade	1.26%	1.78%	0.79%	41.08%
Ventilation system installation or upgrade	0.14%	0.22%	0.14%	34.26%

Source: Own work.

The observed rates presented in **Table 6** refer to any type of energy-efficient retrofit and are calculated using the survey data. Window replacement is the most common energy-efficient retrofit, possibly related to the relatively low cost and complexity of the construction work necessary to perform it compared to more demanding types of retrofits. There is also an obvious positive effect of subsidies, reflected in the fact that the average yearly retrofit rates per type of retrofit increased after the introduction of subsidies (2008 to 2020). Thermal insulation of the façade is the most frequently subsidized type of retrofit.

For more details and a comparison of average yearly retrofit rates for both periods and average yearly subsidized retrofit rates (2008 to 2020) in multi-family and single-family dwellings, see **Table 7.** It should be noted that similar results are obtained in multi-family dwellings and single-family dwellings.

Table 7: Comparison of average yearly retrofit rates between multi-family and single-family dwellings per type of retrofit

	Multi-family dwellings				**Single-family dwellings**			
	Average yearly retrofit rates in % (2000 to 2020)	**Average yearly retrofit rates in % (2008 to 2020)**	**Average yearly subsidized retrofit rates in % (2008 to 2020)**	**Average yearly subsidized retrofit rates – share of completed retrofits in % (2008 to 2020)**	**Average yearly retrofit rates in % (2000 to 2020)**	**Average yearly retrofit rates in % (2008 to 2020)**	**Average yearly subsidized retrofit rates in % (2008 to 2020)**	**Average yearly subsidized retrofit rates – share of completed retrofits in % (2008 to 2020)**
All retrofit types	4.69%	6.63%	3,03%	43.36%	4.82%	6.39%	1,89%	28.17%
Thermal insulation of the roof	0.83%	1,22%	0,63%	49.39%	1.23%	1,56%	0,12%	11.97%
Thermal insulation of the facade	1.38%	2,14%	1,47%	62.05%	1.64%	2,18%	0,39%	27.66%
Window replacement	1.47%	1,89%	0,51%	27.52%	2.31%	2,82%	0,41%	23.94%
Heating system installation or upgrade	0.89%	1,21%	0,32%	27.55%	2.44%	3,47%	0,83%	35.38%
Ventilation system installation or upgrade	0.11%	0,17%	0,10%	24.62%	0.25%	0,40%	0,14%	31.89%

Source: Own work

While performing analysis on different types of models to check the robustness, we opted for a random-effects logit model employed on a retrospective panel data set. The model is estimated using the maximum likelihood (ML) estimation method. A retrospective panel data model was constructed to explicitly account for the timing of implemented retrofits and also to be able to account for the effect of the Slovenian subsidy program introduced in 2009. Retrospective panels are typically constructed around fundamental events, which are discrete, unforgettable, and important indicators of household welfare (Dolšak et al., 2020; McIntosh et al., 2011). A discrete event is such an event that has either taken place, or has not. It is also important that the event has been memorable in a way that it has created an impact on the household. In our case, it is easy to see that an energy-efficient retrofit in the household is such a fundamental event. An energy-efficient retrofit either did or did not occur, thus satisfying the condition of being a discrete event. It is also memorable because it impacts the household's daily life and welfare. A retrospective panel allows the inclusion of both time-variant and time-invariant variables.

What is often considered a disadvantage of retrospective panels is the problem of inaccuracy in creating retrospective panel datasets (McIntosh et al., 2011). However, due to the discrete and memorable nature of the event, respondents are unlikely to be in the dark about whether the energy-efficient retrofit occurred. Respondents were asked to list the year when the energy-efficient retrofit took place, per type of retrofit. The main motivation for using a retrospective panel was to account for the effects of the subsidy program and general macroeconomic conditions. Although certain errors could be present in terms of correctly remembering and 'rounding up' the years when the retrofit took place, our results are well in line with a similar study (Dolšak et al., 2020), where retrofit data collected by the Statistical Office of the Republic of Slovenia were used.

Conducting energy-efficient home retrofits requires retrofit planning, searching for and concluding contracts with constructors, and finally lifestyle adjustments associated with decreased comfort during renovations. Combined with the fact that 35% of respondents (co)financed the retrofits with subsidies or preferential loans, and 25% with commercial bank loans, which requires additional efforts, these events are even more memorable time-wise. Furthermore, estimating the model on a longer and shorter panel is another robustness check, where in the latter case we excluded observations too far in the past to assure better data accuracy. These lead us to believe that the inaccuracies in reporting the year of retrofit were not substantial.

Another drawback is that certain variables in our model (such as education and income) are assumed to be time-invariant, whereas they may change over time. While similar levels of explanatory variables are expected in shorter panels, adequately capturing the retrofit activity of households typically requires longer panels. For this reason, we have constructed a longer panel data set, spanning from 2000 to 2020, and a shorter panel, spanning from 2006 to 2020. This in turn allows for checking the robustness of the obtained results.

With panel data, researchers can typically choose to use a fixed-effects estimator or a random-effects estimator. The former is praised for its ability to control for all stable characteristics of the individuals, thereby eliminating bias and addressing the problem of omitted variables (Allison, 2006). At the same time, there is a disadvantage related to the fact that fixed effects methods cannot estimate coefficients for variables that have no within-subject variation. However, it should be noted that the fixed effects method can still control for the variables that have no within-subject variation without estimating the coefficients. Since there are very few variables in our dataset with within-subject variation, the fixed effects estimator appears less appealing. At this point, the random effects method can come in handy to produce coefficient estimates for time-invariant variables. In a fixed-effects model the intercept α_n would be a set of fixed parameters, whereas in a random-effects model, individual-specific effect α_n is a random variable with a specified probability distribution, which is typically a normal distribution and is further assumed to be independent of the residuals ε_{nt} and the covariates X_{nt}. The assumption of independence between α_n and X_{nt} is on the other hand not imposed by the fixed effects model, which is one of the biggest differences between the two and may result in biased estimates of the random-effects model.

The random-effects model can be represented as follows:

$$EEREN_{nt}^{*} = X_{nt}'\beta + \alpha_n + \varepsilon_{nt}, \quad (4)$$

where:

$EEREN_{nt}$=1 if $EEREN_{nt}^{*}$>0, (5)

$EEREN_{nt}$=0 if $EEREN_{nt}^{*} \leq 0$, (6)

$EEREN_{nt}$ is the observed investment decision, whereas $EEREN_{nt}^{*}$ is a latent or index variable, which is not observed and needs to be estimated and where *n* refers to each respondent so that $n = 1, \ldots 2{,}537$ and *t* corresponds to the year $t = 2006, \ldots 2020$ for the shorter panel and $t = 2000, \ldots 2020$ for the longer panel.

An alternative approach would be a mixed model or a hybrid model, which combines the positives of fixed effects and random effects methods by estimating coefficients that are equivalent to those obtained with a fixed-effects method, with possibly different standard errors and test statistics (Allison, 2006). This method allows the researcher to observe both between-person and within-person variations. However, this model is more applicable in a setting that involves clustered data (Schunck & Perales, 2017). Keeping in mind that the only clustering in our dataset is at the individual level, after estimation and further consideration, we have not found the hybrid model to be appropriate in our research setting. Due to the hybrid model not being appropriate in our research setting, and because the fixed effects model cannot produce coefficient estimates for time-invariant variables, we attempted to find a solution better suitable for our data. After performing the appropriate

diagnostic test, which comprises of computing the panel-level average of our time-variant covariates (participant and building age, respectively), adding them as regressors, and testing if their coefficients are jointly zero, we have opted for random effects logistic regression with Mundlak correction (Mundlak, 1978). This allows for some correlation between individual-specific effects and regressors in the random-effects model.

2.4 Results

In **Table 8** we present the results of the random-effects logit model. For interpretation purposes, we estimated the average marginal effects for continuous variables, whereas for dummy variables marginal effects denote a change in the probability of energy-efficient retrofit when the dummy value is changed from 0 to 1.

When observing **socio-economic individual and household characteristics**, we identified a positive effect of gender, age of respondents, and certain higher income categories, which is in line with other studies (Cirman et al., 2013; Dolšak et al., 2020; Gamtessa, 2013; Mortensen et al., 2016). The fact that we focused on performed retrofits may explain why age appears as a driver, while other studies identify it as a barrier (Achtnicht & Madlener, 2014; Hrovatin & Zorić, 2018). In our research setting, the older the participant is, the higher the probability that they have already performed an energy-efficient retrofit in the past. The focus of our study was on economic decision-makers within the family and arguably, younger respondents have just recently taken over this role within their household. High income works as a driver of energy-efficient retrofits, which is not surprising, as financial constraints have been cited by numerous scholars as an important barrier to energy-efficient retrofits. Further, respondents who took out a loan to purchase their home are more likely to perform energy-efficient retrofits. This is possibly due to the characteristics of the building stock. As mentioned before, the building stock in Slovenia is rather old on average, therefore it is often the case that purchase is accompanied by a retrofit. This is consistent with the fact that we have identified a negative effect of being the first owner. Namely, if a respondent is the first owner, at the time of acquisition, their home was probably newly constructed and more in accordance with the recent building standards and thus not in need of a retrofit.

Focusing on **building and location characteristics**, the dwelling surface appears to be a driver of energy-efficient retrofits in both panels, consistent with other research (Nauleau, 2014). In the shorter panel, previous renovations appear as a driver of energy-efficient retrofits. This may appear counterintuitive at first. However, it can be explained by the fact that a positive experience with a previously performed retrofit could encourage the respondent to perform another type of energy-efficient retrofit. Moreover, residing in the region with the highest average temperature in Slovenia lowers the probability of performing an energy-efficient retrofit, which is consistent with studies showing a significant influence of residing in colder climates (Alberini & Ramseier, 2013)

Table 8: Results of the random-effects logit model and estimated marginal effects (M.E.)

	Retrospective panel 2006-2020				**Retrospective panel 2000-2020**			
Explanatory variables	**Coef.**	**St.Err**	**M.E.**	**St.Err**	**Coef.**	**St.Err**	**M.E.**	**St.Err**
Gender	0.181***	0.064	0.008***	0.003	0.182***	0.060	0.006***	0.002
Education	0.047	0.058	0.002	0.002	0.050	0.054	0.002	0.002
Respondent's age	0.153***	0.057	0.006***	0.002	0.077**	0.031	0.003**	0.002
Income base: Below minimal wage						.		
Between 751 EUR and 1700 EUR	0.218	0.153	0.007	0.005	0.196	0.141	0.005	0.004
Between 1701 EUR and 2500 EUR	0.420***	0.157	0.015***	0.005	0.370**	0.144	0.011**	0.004
2501 EUR and above	0.491***	0.163	0.019***	0.005	0.433***	0.151	0.013***	0.004
Income not reported	0.479***	0.163	0.018***	0.006	0.428***	0.150	0.013***	0.004
First owner dummy	-0.150**	0.066	-0.006**	0.003	-0.157**	0.062	-0.005**	0.002
Loan dummy	0.125**	0.061	0.005**	0.003	0.087	0.056	0.003	0.002
Pro-environmental awareness	-0.048	0.041	-0.002	0.002	-0.046	0.039	-0.002	0.001
Number of household members	-0.003	0.025	-0.000	0.001	0.008	0.023	0.001	0.001
Renovations performed before the year 2000	0.185**	0.087	0.008**	0.004	0.193	0.118	0.007	0.004
Panel-average age (Mundlak correction)	-0.149***	0.057	-0.006***	0.002	-0.068**	0.031	-0.002**	0.001
Building age (adjusted for the panel)	-0.090	0.057	-0.004	0.002	-0.015	0.028	-0.001	0.001
Multi-apartment building (dummy)	0.045	0.127	0.002	0.005	0.022	0.118	0.001	0.004
The surface of the apartment (in logarithms)	0.246***	0.072	0.010***	0.003	0.218***	0.067	0.008***	0.002
Urban settlement (dummy)	0.059	0.067	0.002	0.003	0.057	0.062	0.002	0.002
Highest temperature region	-0.355**	0.154	-0.015**	0.006	-0.395***	0.145	-0.014***	0.005
Panel-average building age (Mundlak correction)	0.103**	0.057	0.004**	0.002	0.029*	0.028	0.001*	0.001
Ease of agreement	0.321***	0.063	0.013***	0.003	0.281***	0.058	0.009***	0.002

To be continued

Table 8: Results of the random-effects logit model and estimated marginal effects (M.E.) (cont.)

	Retrospective panel 2006-2020				Retrospective panel 2000-2020			
Explanatory variables	**Coef.**	**St.Err**	**M.E.**	**St.Err**	**Coef.**	**St.Err**	**M.E.**	**St.Err**
Neighbor projects	0.006	0.063	0.000	0.003	0.000	0.058	0.000	0.000
Respondent talks to their neighbors	0.109	0.128	0.005	0.005	0.142	0.121	0.005	0.004
The presence of a building manager is helpful	0.379***	0.114	0.016***	0.005	0.333***	0.105	0.011***	0.004
No renovation fund (dummy)	-0.623***	0.160	-0.026***	0.007	-0.436***	0.142	-0.015***	0.004
PC1 - Privacy	0.001	0.022	0.000	0.001	0.012	0.021	0.001	0.001
PC2 – DIY identity	0.035	0.024	0.001	0.001	0.043*	0.022	0.001*	0.001
PC3 – Energy-saving behavior	0.065***	0.025	0.003***	0.001	0.061***	0.023	0.002***	0.001
PC4 – Functionality and quality	-0.021	0.025	-0.001	0.001	-0.016	0.024	-0.001	0.001
PC5 – Participation	0.024	0.026	0.001	0.001	0.008	0.024	0.001	0.001
PC6 – Social life	0.021	0.027	0.001	0.001	0.022	0.025	0.001	0.001
PC7 - Spaciousness	-0.037	0.027	-0.002	0.001	-0.048*	0.025	-0.002*	0.001
Importance of public counseling	-0.114**	0.047	-0.005**	0.002	-0.093**	0.044	-0.003**	0.001
Negative GDP growth (dummy)	-0.294***	0.061	-0.012***	0.003	-0.280***	0.076	-0.01***	0.002
GDP per capita (yearly)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Subsidy program in place (dummy)	0.877***	0.138	0.037***	0.006	0.685***	0.108	0.023***	0.004
Constant	-6.392***	0.744			-5.974***	0.666		
lnsig2u	-0.868	0.148			-0.988	0.146		
Mean dependent var	0.045				0.037			
Number of obs	38055				53277			
Prob > chi2	0.000				0.000			

*Note: *** p<0.01, ** p<0.05, * p<0*

Source: Own work.

In terms of **social capital**, the ease of agreement within the dwelling and the importance attached to the helpfulness of the building manager are significant drivers of energy-efficient retrofits in both panels. Another barrier is the lack of a renovation fund in the building. To clarify, allocating certain funds for building maintenance and repairs would tackle the problem of unexpected additional expenses of energy-efficient retrofits and facilitate planning. This confirms that social capital plays an important role in the decision-making process about energy-efficient retrofits, which is in line with existing research. Our results also speak in favor of the sociocultural milieu and organizational ability of owners impacting retrofit decisions, consistent with the findings and conclusions of Cirman et al. (2013). However, whereas Cirman et al. (2013) include all types of maintenance and retrofit works, without distinguishing between them, and analyze solely multi-family dwellings, our research is focusing on energy-efficient retrofits, which also allows for suggestions for energy policy measures to be drawn. Including both multi-family and single-family dwellings represents another contribution of this dissertation. As mentioned earlier, in Slovenia the majority of the population lives in single or double-dwellings and there is an issue of split ownership, with, for instance, multiple distant family members inheriting a part of the same dwelling. In this regard, a certain level of intra-household coordination and agreement is required for retrofitting to occur even in a single-family house, as the co-owners need to agree on the retrofit decision, thus raising the issues of trust, norms, and relationships also at the level of a single-family dwelling.

Another important contribution of our study is the inclusion of **housing-related lifestyle**, not considered in the study by Cirman et al. (2013).

When it comes to housing-related lifestyle, scoring high on the energy-saving behavior component is another driver of energy-efficient retrofits in both panels. This is in line with previous research, which shows that the combination of behavior, retrofit, and appliance purchases provide the best results when it comes to energy savings (Trotta, 2018b). Pro-environmental awareness did not appear as significant. A possible explanation suggested by the means-end chain theory of lifestyle is that the impact of values on behavior is mediated through lifestyle (Brunsø et al., 2004b; Thøgersen, 2017) so that the effect of this variable is captured by the energy-saving behavior component of HRL. Even though the pro-environmental awareness variable and the energy-saving behavior component of HRL are, as expected, positively correlated, the obtained correlation coefficient is not very high (0.39). In this respect and also motivated by the existing energy economics literature treating pro-environmental awareness as a separate determinant of energy-efficient retrofits, as seen in several studies (Achtnicht & Madlener, 2014; Alberini et al., 2013; Nauleau, 2014), we opted to keep the pro-environmental awareness variable in our model.

Finally, higher scores on the DIY component of housing-related lifestyle are another driver of energy-efficient retrofits in the longer panel. It stands to reason that those respondents who have a more hands-on approach to home maintenance and repairs are also those who are more likely to be willing, prepared, or able to take on a large and demanding retrofit

project, which is often the case with energy-efficient retrofits. In the longer panel, scoring high on the spaciousness component of housing-related lifestyle appears to be a barrier to energy-efficient retrofits. This can be explained by the fact that spacious homes are also more difficult to retrofit and are likely to be less energy-efficient, due to a larger area that requires heating. Therefore, respondents who value spaciousness are more likely to trade off energy efficiency for spaciousness.

Commenting on **information sources, policy effects, and macroeconomic variables,** we found a positive effect of subsidies in both panels. Namely, the dummy variable we introduced for the years following the introduction of the subsidy program appears significant in both panels, confirming **Figure 3,** which plots the yearly rate of retrofits per type of retrofit and which clearly shows an increasing trend in the yearly retrofit rates after the introduction of the subsidy program. As shown in another study (Dolšak et al., 2020), the subsidy program was an effective instrument for reducing the energy efficiency gap in the residential sector. Although this is encouraging, we cannot exclude the presence of free riders, as argued by the same authors. Even though the issue of free ridership is beyond the scope of this dissertation, it should be noted that 69.5% of respondents that received the subsidy reported they would have performed the energy-efficient retrofit even without it, which indicates that free riders were present in our sample.

As expected, negative GDP growth appears to be a barrier to energy-efficient retrofits. Surprisingly, the results also suggest that the probability of having performed an energy-efficient retrofit is lower when more importance is given to free-of-charge advice on energy-efficient retrofits. One explanation for this could be that those who are less informed in the first place would place more value on getting the advice or would appreciate this type of advice more than those individuals already possessing a certain knowledge on the subject. This could be because households that do not have experience with energy-efficient retrofits perceive the advice offered free-of-charge at ENSVET as more important due to the greater need to acquire information, implying that lack of information also works as a barrier to retrofits.

It should be noted that among those respondents who performed the retrofit, only 11.33% indicated that they searched for advice at ENSVET, while 38.41% of respondents who have not performed an energy-efficient retrofit remarked that they would seek their advice at ENSVET, supporting our argument. Another possible explanation is that respondents that have completed the energy-efficient retrofit looked for a more qualified and specialized information source, such as contractors, equipment suppliers, architects, engineers, or energy consultants. Thus, we conclude that the importance attached to free-of-charge advice was not enough of an impetus to decide on performing an energy-efficient retrofit. Except for certain dimensions of housing-related lifestyle, we have not found larger discrepancies between the shorter and the longer retrospective panel, thus showing the robustness of the obtained results.

To summarize, in addition to identifying drivers of energy-efficient retrofits belonging to a group of socio-economic characteristics (gender, age, income, and loan), building and location characteristics (the surface of the dwelling, and previously performed renovations) and the availability of subsidy program, we have also confirmed the importance of certain social capital and housing-related lifestyle variables in fostering energy-efficient retrofits.

In terms of social capital, it can be said that the ease of agreement among residents and within the household increases the probability of a retrofit because strong networks, harmonious relationships, and established norms within a community facilitate coordinated action within the same community. The importance attached to the presence and helpfulness of a building manager suggests that the building's formal organization also contributes to the achievement of community goals. In the social capital group of variables, we found the lack of a renovation fund to be an important barrier. This also speaks to the building's formal organization (the building manager and the presence of a renovation fund) as a determinant of energy-efficient retrofits.

When it comes to housing-related lifestyle, individuals with pronounced energy-saving behavior and DIY proclivity are those that are more likely to perform an energy-efficient retrofit. It is not surprising that these individuals would be more inclined to undertake this type of household project as they are concerned about the energy cost and environmental impact of their home and have a hands-on approach to home maintenance and repairs. In contrast, the identified barriers to energy-efficient retrofits include negative GDP growth, lack of information, residing in the region with the highest average temperature, and being the first owner of the real estate, as well as certain social capital and housing-related lifestyle variables. Concerning housing-related lifestyle, attaching a high value to spaciousness is also found to negatively impact energy-efficient retrofits. The result is not surprising because, given the budget constraint, such individuals would more likely trade off energy efficiency for more space.

In conclusion, both social capital and housing-related lifestyle are found to be relevant additions to the standard model, which may help better explain different aspects of household behavior related to energy-efficient retrofits.

Finally, there are certain limitations to interpreting the results of our study. As already stated, inaccuracies may arise when constructing retrospective panel datasets, often stemming from the respondents wrongly remembering the year a certain event has taken place or whether the event has occurred at all. However, because the work required to perform an energy-efficient retrofit can disrupt the daily life of the household, it is unlikely that respondents would forget such an event.

Another possible limitation is the timing of our study, as it was performed amid the COVID-19 pandemic. However, we focused our research on performed retrofits. which have not been affected by the pandemic.

It should also be noted that causalities in the model can run in both directions and one should speak of correlates with energy-efficient retrofits. The issue of the generalisability of results can often be raised in country-specific studies. This can be due to differences in local contexts, the determinants, and the timeframe when the research was conducted, as noted by other researchers (Dolšak, 2023). Also, differences may occur when analyzing revealed as opposed to stated preferences and carried out as opposed to planned retrofits.

Nevertheless, our results are found to be in line with other similar studies in connection to the 'core' concepts we explored (HRL and social capital) as well as the role of other factors such as income, the surface of the apartment, subsidy program, climate conditions, and GDP growth rate, to name just a few of the most important variables.

2.5 Discussion of the main findings

This study has confirmed the role of social capital and several dimensions of housing-related lifestyle as determinants of energy-efficient retrofits. We aimed to show that social capital facilitates the achievement of certain goals, that would be unattainable in its absence. Fostering good relationships and trust within a dwelling is the first step, as it leads to easier agreement and facilitates coordinated action of residents. In the context of energy-efficient retrofits, which are quite often challenging and complex undertakings, better relationships among residents in the dwelling and with the building manager facilitate decision-making. This argues for community-building as a tool for achieving better outcomes in residential energy-efficiency measures. Community building can be achieved through, among other means, more frequent tenant meetings and by encouraging smaller-scale joint projects, particularly for tenants in multi-dwelling settings. Positive experiences with a smaller project, such as a gardening project, can help create a sense of community and encourage tenants to later pursue more ambitious projects. In addition, community-building can also be encouraged at the neighborhood level. As shown in other research (Cirman et al., 2013), feeling attached to the neighborhood would increase the likelihood of retrofits. Many projects of this type can be envisioned at a municipality level. A problem could arise if the prevalent opinion in the community on topics related to energy conservation and protection of the environment is negative, however, this problem can be addressed through further education and information campaigns.

Aside from norms and trust within a community, the building's formal organization is the next thing to consider. The lack of a renovation fund lowers the likelihood of retrofitting, demonstrating that a lack of formal organization within a building negatively impacts energy-efficient retrofits. The presence of a building manager has a positive impact. This suggests that the existence of a formal and functioning organization within a building could encourage energy-efficient retrofits. In this way, the presence of a renovation fund would tackle the financial barrier to energy-efficient retrofits, as (at least) some of the required funds could be collected over time and in a way that is not perceived as a serious constraint

to the family budget at the moment when the expenses occur. The appropriate choice of a building manager could also help overcome the information barrier, as the manager could help not only to coordinate the retrofits but also to provide relevant hands-on information on the retrofits to the less-informed tenants. We also found that attaching more importance to free-of-charge energy counseling negatively impacts energy-efficient retrofits. This leads us to believe that there is an information barrier, as it is primarily those who do not have the appropriate and relevant information who would value free-of-charge energy counseling.

In the area of housing-related lifestyle, energy-saving behavior appears to increase the probability of energy-efficient retrofits. The goal of increased residential energy efficiency can only be achieved through a synergy of energy-efficient retrofits, the purchase of energy-efficient appliances, and energy-saving behavior. It is encouraging to note that respondents who scored high on the energy-saving dimension of the housing-related lifestyle instrument also performed energy-efficient retrofits. This leads us to believe that promoting and encouraging energy-saving behavior through certain education and information measures and activities could lead to an increase in energy-saving habits which in turn would have a positive impact on energy-efficient retrofits. Researchers refer to this as the spillover effect, showing that pro-environmental behavior in the past increases the likelihood of engaging in other or more challenging pro-environmental behavior in the future, with self-efficacy having the mediator role in this relationship (Lauren et al., 2016). Another interesting dimension of housing-related lifestyle is the DIY identity. The availability of demonstration projects may pique the interest of individuals with such preferences and facilitate their decision to undertake an energy-efficient retrofit.

Although social capital and housing-related lifestyle are significant determinants of energy-efficient retrofits, other barriers and determinants must also be considered to provide a more complete and clearer picture. We showed a positive effect of a respondent's age, gender, higher income categories, the fact that the respondent has taken out a loan, and the dwelling surface. What was also shown was a very important positive effect of the Slovenian subsidy program, which is in line with the previous research on this topic (Dolšak et al., 2020). We confirmed the negative effect of being the first owner of a dwelling; in addition and as expected, negative GDP growth and residing in a region with high temperatures significantly decrease the likelihood of retrofits.

The topics of energy literacy and financial literacy are important considerations for further research into determinants of energy-efficient retrofits. Since in our sample we did not obtain significant results for the impact of financial and energy literacy on performed retrofits, we decided to include only education in the final model, which can serve as a proxy. Furthermore, in the context of a retrospective panel data study, these factors were not taken into consideration due to the fact that they are not time-invariant.

Results of this research point toward a need for a policy mix to tackle different aspects of energy-efficient retrofits. This policy mix should tackle all relevant barriers in the process

of deciding to perform energy-efficient retrofits and include further education and information campaigns on the topics of residential energy efficiency, subsidies, preferential loans, tax rebates, and measures that concern the building's formal organization and foster community building.

3 CHAPTER II: THE IMPACT OF ENERGY PERFORMANCE CERTIFICATES AND THE DISPLAY OF MONETARY INFORMATION IN REDUCING THE INFORMATION BARRIER

3.1 Introduction

Energy performance certificates, also referred to as energy labels, are an informative measure that provides standardized information on the energy efficiency of buildings (or their parts). The energy performance is usually rated on a scale from A (most energy-efficient) to G (least energy-efficient). It can be argued that energy performance certificates offer more comprehensive information to the consumer, when compared to energy labels for electrical appliances. Namely, energy labels for household appliances provide details about the energy use of a specific appliance and its energy efficiency ranking. However, they do not include measures and recommendations to reduce energy consumption. On the other hand, aside from information on the building's average yearly energy consumption for heating (expressed in physical units i.e., kilowatt hours (kWh) per square meter), energy performance certificates also include recommendations for potential cost-effective measures that can be taken to minimize the building's energy consumption. These recommendations are tailor-made, and do not necessarily involve a significant investment.

Energy performance certification of buildings in the EU was introduced by the Energy Performance of Buildings Directive (EPBD), adopted in December 2002 by the European Parliament and the Council (2002/91/EC). This directive stipulated, among other measures, that EU member states must implement the necessary laws, regulations, and administrative provisions to comply with the directive by 2006, with the option to extend the deadline to 2009 if there was a shortage of qualified or accredited experts. The directive was later recast for the sake of clarity in 2010 (Directive 2010/31/EU) and revised in 2018 (Directive 2018/844/EU). Currently, the directive is under revision again.

A comparative analysis of progress in the implementation of energy certification of buildings across the EU was performed (Andaloro et al., 2010), considering the varying circumstances of different member states and using two indicators: uniformity and excellence. The uniformity measure assesses how closely each EU member state adheres to the parameters set by the EPBD. The excellence measure identifies the top performers in energy certification of buildings and allows for the appraisal of each member state's efforts. The findings of this study show that there is a significant discrepancy between EU member states

when it comes to the practical implementation of various aspects of energy certification of buildings. It should be mentioned that Slovenia scored high on both indicators, obtaining a grade of four out of four in excellence, and five out of six in uniformity (Andaloro et al., 2010).

Researchers exploring residential energy efficiency have often focused on retrofitting as a particularly important measure in improving the energy efficiency of the building stock. Although important, retrofitting is not the only tool – namely, improvements in residential energy efficiency can also be achieved through other means, such as purchasing (or rental) decisions and energy-efficient behavior. This means that information barriers to residential energy efficiency and measures to tackle them also merit attention. The effectiveness of energy performance certificates as a means of reducing information barriers and thus improving residential energy efficiency has been under-researched, especially in terms of the financial and energy literacy of respondents.

The objective of this chapter is to explore the roles of financial and energy literacy, as well as the potential benefits of displaying monetary information on energy performance certificates, by exploring survey data and choice experiment evidence from an EU member state of Slovenia. After introducing the topic in the first section, we present the literature review and the Slovenian context in the second section. The literature review includes relevant literature on energy performance certificates and energy and financial literacy. Method, models, and data are discussed in the third section, and the obtained results in the fourth. A summary of the main findings is provided in the fifth and final section of this chapter.

3.2 Literature review and the Slovenian context

3.2.1 Literature on energy performance certificates

Initial research focusing on energy performance certificates mostly explored the progress in the implementation or adoption of energy performance certification programs, identifying a significant discrepancy between EU member states (Andaloro et al. 2010). More recently, energy performance certification in the EU has been researched in terms of suggestions for future improvements (Li et al. 2019). The suggestions include integrating building information modeling to speed up and improve the energy performance certificate generation process, establishing a reliable database to boost transparency and energy policy planning, smart home considerations, as well as providing tailor-made recommendations for retrofitting. The inclusion of these recommendations would lead to a new generation of energy performance certificates as comprehensive information and decision-supporting tools for prospective buyers and tenants.

Another recent study explores the recommended list of measures on the energy performance certificates (Gonzalez-Caceres et al. 2020), identifying these recommendations not just as an important informative measure, but also highlighting the role that recommendations on the energy performance certificates have in encouraging homeowners to pursue energy-efficient retrofits. As noted by the authors, this field is under-researched.

Brounen and Kok (2011) were the first to explore the implementation of energy performance certificates in the Netherlands, finding that the adoption rates were decreasing in the Dutch housing market at the time. The authors explain it partially due to the possibility to 'opt out' of the certification by signing a waiver, but also through negative media portrayal. An important contribution of this paper is establishing evidence that household- and dwelling-related characteristics influence the probability that the respondents' home has an energy performance certificate. Another important finding is that home purchasers are willing to pay a premium for real estate with a better energy rating as measured by the energy performance certificate, as well as that the price premium is dependent on the energy rating on the energy performance certificates – namely, that respondents are willing to pay a larger premium for better energy rating.

However, other studies of energy performance certificate implementation in the same country arrived at contradictory findings, showing a weak impact of energy performance certificates on the adoption of energy efficiency measures both pre- and post-purchase, and concluding that more sophisticated mechanisms are needed to enhance the effect of energy performance certificates (Murphy 2014).

It was similarly shown in a study employing a hedonic pricing model in a different context, providing empirical evidence from Norway (Olaussen et al. 2017), that energy performance certificates have a negligible or no effect on the price premium of real estate. This is explained to be due to omitted variables correlated to the energy performance certificate rating, such as the expected energy consumption, aesthetic appearance of the dwelling, micro-location, etc. The same authors highlight the issue of timing and explain that homeowners at the moment of home purchase transaction are not focusing on the matter of energy consumption and energy savings, but rather on different expenses more pressing at that time. Regardless of the finding that energy performance certificates have a negligible effect on the price, these authors find that further research on the topic of energy performance certificates in different countries or contexts should be encouraged rather than discouraged.

Other authors employing hedonic pricing found price premiums for buildings with better ratings in Portugal (Evangelista et al. 2020), England (Fuerst et al. 2015), Ireland (Hyland et al. 2013), and Sweden (Cerin et al. 2014). In recent years, discrete choice experiments have become more present in the energy performance certificate literature. A stated preference choice experiment was used to explore whether energy performance certificates matter in the residential market in Barcelona (Marmolejo-Duarte & Bravi 2017). Authors find that the energy performance certificates do matter, and so do the individual's education level and

preference for owning, rather than renting the home. This paper also includes an interesting observation that the use of financial units (monthly energy savings), rather than physical ones (kWh per m^2) may play a role. A stated choice experiment in Slovenia provided the same conclusion about the display of information in monetary terms (Lakić et al. 2021).

3.2.2 Literature on energy and financial literacy

Energy literacy as defined by DeWaters and Powers (2011) includes awareness, knowledge, attitudes, and values toward energy conservation as well as the corresponding behavior. To avoid confounding the dependent variable (energy efficient behavior of households) and the independent variable (energy literacy), we adhere to the narrower definition of energy literacy introduced by Blasch et al. (2019) comprising only the awareness, knowledge, attitudes, and values concerning energy conservation. An early study of energy literacy and awareness in the context of energy conservation behavior in Dutch households found that the levels of energy literacy are low and that it is rather sociodemographic characteristics and attitudes toward energy conservation that affect energy conservation behavior (Brounen et al. 2013). However, more recent studies found that energy-literate individuals are more likely to correctly identify cost-effective appliances in a discrete choice experiment conducted in Switzerland (Blasch et al. 2019), as well as that high energy and investment literacy is associated with lower electricity consumption in the same country (Blasch et al. 2017). Even though the information on the energy label is readily available, some individuals do not possess the knowledge necessary to correctly interpret the information and make good choices when it comes to the energy efficiency of their homes. We expect to find that energy-literate individuals correctly interpret the information on the energy label and can select a more energy-efficient housing option.

Financial literacy is defined as people's ability to process economic information and make informed decisions about financial planning, wealth accumulation, pensions, and debt (Lusardi & Mitchell 2014). It refers to an individual's knowledge and correct application of concepts such as interest rate compounding, time value of money, inflation, and risk diversification, as well as life-cycle cost calculation. The latter is particularly important in the context of our research. Being able to calculate life-cycle costs based on the provided information on the energy performance certificate drives energy-efficient decision-making. In residential energy efficiency literature, financial literacy was found to be a determinant of investment in energy efficiency in the context of hot water system purchases (Brent & Ward 2018).

More recently, energy-related financial literacy was introduced as an integrated concept that combines both energy cost-specific knowledge and skills needed to process this information (Blasch et al. 2021). Empirical evidence from Italy and Switzerland presented in this study suggests that higher levels of energy-related financial literacy significantly and positively impact the adoption of energy-efficient light bulbs. In another study conducted in Finland,

it was found that respondents with higher levels of energy-related financial literacy tend to consume less electricity when controlling for dwelling and household characteristics (Kalmi et al. 2021).

Although energy and financial literacy have been discussed and researched in the context of appliance labeling (He et al. 2022; Stadelmann & Schubert 2018), the concepts have been under-researched in the domain of energy performance certificates for buildings. In the context of appliance labeling, energy, and financial literacy were found to be drivers of residential energy efficiency, as better-informed individuals are empowered to make better choices about their energy consumption. We expect to find similar results for energy and financial literacy in the context of energy performance certificates, that is, that individuals with high levels of energy and financial literacy make better decisions regarding their housing.

3.2.3 Energy performance certificates in Slovenia and the local context

Energy performance certificates have been issued in Slovenia since 2013 and are valid for ten years. The appraisal of a building's energy efficiency is performed by independent licensed experts using a defined methodology, and based on it, energy performance certificates are issued by legal entities authorized by the competent Ministry. Energy performance certificates are mandatory for public buildings exceeding 250 m^2 and for all buildings (regardless of whether public or privately owned) with frequent public use and a usable floor surface area of more than 500 m^2 (Official Journal of the Republic of Slovenia no. 158/20). The same applies in the case of a real-estate sale, as well as a real-estate rental if the rental period is one year or longer. Energy performance certificates are not compulsory for detached buildings with a total usable floor area of less than 50 m^2. Additionally, property rental for less than one year does not require the provision of an energy performance certificate unless several successive contracts whose rental period is longer than one year are signed with the same tenant. There are also other exceptions, including the sale of buildings unfit for use or habitation, non-residential agricultural buildings, unsophisticated buildings, etc.

Energy performance certificates in Slovenia show the energy ratings of residential and non-residential buildings on a scale from A (most energy-efficient) to G (least energy-efficient). It should be noted that there are seven energy ratings, as ratings A and B are divided into two subcategories (A1 and A2, and B1 and B2). Aside from the information about the building and its energy performance, the certificate also includes information on the issuer, as well as a more detailed overview of the energy use in the building, and possible additional comments and recommendations. Recommendations for cost-effective energy efficiency improvements may include measures to improve the quality of the building envelope and the energy efficiency of heating and ventilation systems, measures to increase the use of

renewable energy sources in the buildings, and other measures. For an example of a Slovenian energy performance certificate, see **Appendix, Figure A.1.**

By providing information to the public in a standardized way, individuals are empowered to make more cost-efficient and/or energy-efficient real estate purchase or rental decisions. An essential component of an energy performance certificate is not just the information on the energy consumption of the building, but also the recommendations for cost-effective energy efficiency improvements. These provide an incentive to implement the most important measures to improve the energy efficiency of the dwelling. An important feature of these recommendations is that they are not general, but specific to the building for which the energy performance certificate is produced. This is, in particular, significant in the case of Slovenia, where 79% of occupied dwellings were constructed before the year 1990 (SORS 2022), which means that they were not built following the current building standards and require retrofitting to improve their energy efficiency.

The Republic of Slovenia's Long-term energy renovation strategy for 2050 (Government of the Republic of Slovenia, 2021) highlights the issue of the worst-performing building stock- 40% of single-family dwellings were estimated to have the lowest energy ratings of F and G. Slovenia intends to narrow the energy efficiency gap in the residential sector by implementing a range of aid schemes, financial incentives (including subsidies and preferential loans), offering consultations and advice to the public free of charge and taking other steps and initiatives to promote residential energy efficiency. Energy performance certificates are another mechanism of improving household energy efficiency.

When observing the building stock in Slovenia, it is important to note that the majority of the population are homeowners (SORS 2022). Our research focus on the residential, rather than industrial or public sector was also motivated by the fact that 92.1% of dwellings in Slovenia are owned by natural persons, rather than legal entities.

The role of monetary information in energy performance certificates in Slovenia has already been researched by Lakić et al. (2021). This study shows that when information about energy savings on the energy performance certificate is provided in monetary terms, respondents are willing to pay a 47% larger premium for an improvement in the energy rating. However, Lakić et al. (2021) focus on real-estate-specific characteristics (such as location, condition, and proximity to important infrastructure) and don't consider individual-specific determinants such as energy and financial literacy, energy-efficient behavior, and attitude toward energy conservation. The inclusion of these variables, and in particular the inclusion of energy literacy and financial literacy is an important contribution of our study.

3.3 Method, model, and data

The empirical data was collected from an online household survey conducted in August 2020. We focused on the subsample of homeowners, as they represent the majority of the

population in Slovenia, and would be able to relate to the hypothetical situation in the stated choice experiment. After removing certain mischievous responders, there were 2,484 individuals left in the subsample. Our choice of explanatory variables was motivated by the relevant energy performance certificate literature, as well as the literature on energy and financial literacy presented in sections 2.1 and 2.2. Descriptive statistics of explanatory variables are presented in **Table 9.**

Table 9: Descriptive statistics of explanatory variables (n=2,484)

Variable	**Mean**	**Std.Dev.**	**Min**	**Max**
Socio-economic and individual-specific variables				
The respondent is male (0–No, 1–Yes)	0.483	0.5	0	1
Age (in years)	47.113	13.388	18	86
University education or higher (0–No, 1–Yes)	0.493	0.5	0	1
Respondent's net monthly income is larger than the median of 1,900 EUR (0–No, 1–Yes)	0.356	0.478	1	5
Energy literacy (score 0 to 5 depending on the number of correct answers)	1.093	1.244	0	5
Financial literacy (score 0 to 5 depending on the number of correct answers)	3.371	1.338	0	5
Correct total life-cycle cost calculation (0–No, 1–Yes)	0.596	0.491	0	1
Positive attitude towards energy conservation (0–No, 1–Yes)	0.491	0.5	0	1
Free-riding attitude towards energy conservation (0–No, 1–Yes)	0.092	0.289	0	1
Energy-efficient behavior (scale 1-Never to 5-Always)	3.833	0.587	1	5
The respondent would take the EPC into account in their future real estate purchase or rental decisions (0-No, 1-Yes)	0.564	0.495	0	1
Building and location-specific variables				
The surface of the apartment (logarithm of the surface in square meters)	4.633	0.535	3.401	5.991
Age of the building (in years)	41.989	19.542	4	75
Respondent lives in a single-family house (0–No, 1–Yes)	0.62	0.485	0	1
Respondent lives in a city (0–No, 1–Yes)	0.587	0.492	0	1

To be continued

Table 9: Descriptive statistics of explanatory variables (n=2,484) (cont.)

Variable	Mean	Std.Dev.	Min	Max
Energy performance certificate-related variables				
Treatment variable: respondent received monetary information on the annual energy savings (0–No, 1–Yes)	0.482	0.5	0	1
The respondent's home has an energy rating of D or worse (0–No, 1–Yes)	0.817	0.387	0	1
Change in energy rating showed in the choice experiment (1 to 5 energy 'grades')	2.762	.795	1	5
Price premium (in %)	7.069	3.541	1	20

Source: Own work.

We consider *socio-economic characteristics*, such as gender, age, education, and income. We introduced dummy variables for individuals with higher formal education (university degree or higher) and individuals whose net monthly income is higher than the reported median income in our sample. We also account for pro-environmental awareness, i.e., having a positive attitude towards issues such as energy conservation and climate change mitigation, which we operationalized as a dummy variable. Another consideration is a free-riding approach to energy consumption, namely, whether respondents indicated that they are not willing to reduce their energy consumption unless others do the same. We expected that having a free-riding approach would negatively impact the choice.

We observe the effect of energy-efficient behavior, which we operationalized as a composite variable comprised of nine variables with a scale reliability coefficient of 0.68. The respondents reviewed a set of statements listing energy-efficient and environmentally friendly practices and reported how frequently they behave in this way on a scale from 1 (never) to 5 (always). This included statements about household appliance use, for instance, whether respondents use the washing machine or dishwasher only when they are fully loaded, whether they switch off small electrical appliances (TV, PC, etc.) when they are not being used, and whether they use larger household appliances (washing machine, dryer, dishwasher) during the lower tariff (off-peak) periods. The respondents also reported if they turn off the lights when they leave the room, as well as whether they turn off the air conditioning when they are not in the room in the summertime and have a lower temperature setting during the night or periods of absence during the heating season. They also indicated how frequently they monitor the consumption of electricity and heating fuels in their home, opt for public transportation, bicycle, or going on foot instead of driving, and avoid using disposable and environmentally unfriendly products. The descriptive statistics of variables used for constructing the composite energy-efficient behavior variable are presented in **Table 10**: Descriptive statistics of variables used to construct the composite energy-efficient behavior variable

Table 10: Descriptive statistics of variables used to construct the composite energy-efficient behavior variable

Variable	Mean	Std.Dev.	Min	Max
I use the washing machine or dishwasher only when it is full.	4.352	0.806	1	5
I turn off the lights when I leave the room.	4.557	0.692	1	5
I switch off electrical appliances (TV, PC, etc.) when I am not using them.	3.717	1.201	1	5
I turn off the air conditioning when I'm not in the room (summer).	3.857	1.461	1	5
I have a lower temperature setting during the night or periods of absence (heating season).	3.881	1.259	1	5
I use household appliances (ex. washing machine, dryer, dishwasher) during the lower tariff periods.	3.628	1.160	1	5
I monitor the consumption of electricity and heating fuels in my home.	3.350	1.199	1	5
When traveling shorter distances, I usually use public transportation, ride a bicycle or go on foot.	3.537	1.086	1	5
I avoid using disposable products and environmentally unfriendly products.	3.616	0.868	1	5

Note: Variables are measured on a scale from 1 – Never to 5 – Always

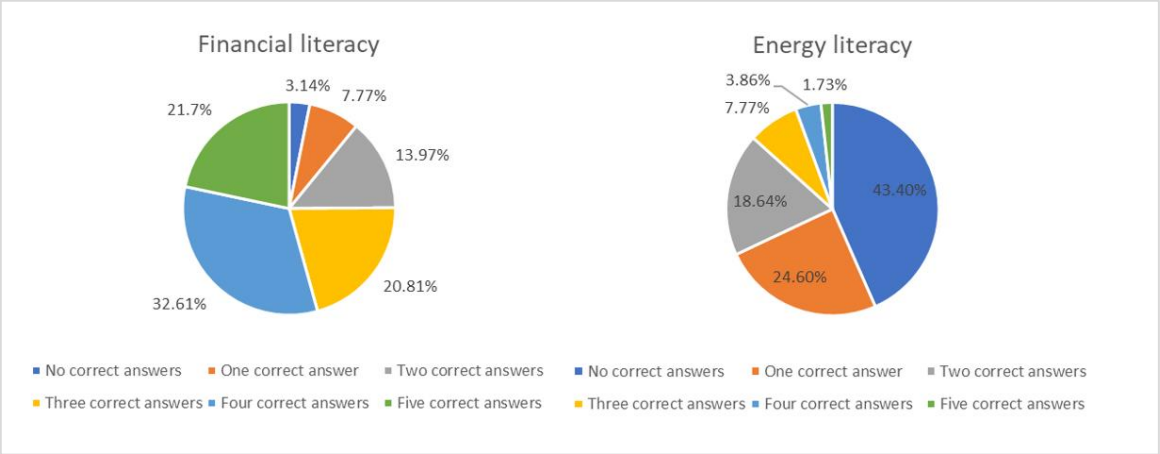
Source: Own work.

We also account for the energy and financial literacy of the respondent, which we measure on a scale from 0 to 5, depending on the correct number of answers to two sets of questions respectively. When assessing the financial literacy of respondents, we observed whether they understand concepts such as risk diversification and time-value of money, and can perform basic interest return calculations. We asked the respondents to self-report their mathematical knowledge compared to the general population (whether it is better, comparable, or worse) and whether they have taken economic classes during their formal education.

For the energy literacy assessment, we asked respondents to list the price of electricity in Slovenia and the average monthly electricity household consumption in kWh. We also inquired about electricity costs for one round of laundry, electricity consumption in kWh required to run a laptop for an hour, and the percentage of energy savings obtained by switching from halogen to LED lightbulbs, while maintaining the same brightness. It bears to mention that we found energy literacy to be low in our sample, while results obtained for financial literacy were better, implying that further education and information campaigns on the topics of residential energy efficiency are needed. Respondents were also asked to calculate the total life-cycle costs of an appliance, and a dummy variable was introduced for those that performed the calculation correctly.

Similar to many other studies researching financial and energy literacy, we have found low levels of energy literacy in our sample, as observed in **Figure 4**. Namely, 43.4% of respondents incorrectly answered all of the energy literacy-related questions, while only 1.73% gave correct answers to all of the questions. Better results are obtained for financial literacy, as over 70% of respondents provided correct answers to three or more questions, and only 3.14% of respondents wrongly answered all of the questions. We also find that almost 60% of respondents correctly calculated the total life-cycle costs of an appliance. For a more detailed overview see **Appendix**, **Table A.2.**

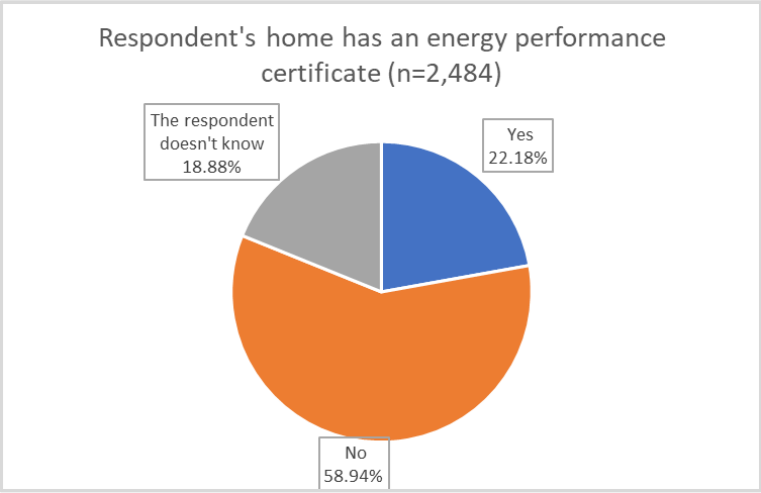
Figure 4: Obtained levels of financial and energy literacy



Source: Own work.

Aside from the identified low levels of energy literacy, we also found that 58.94% of the respondents stated that their home does not have an energy performance certificate, while 18.88% do not know if their home has an energy performance certificate. **Figure 5** shows the presence of energy performance certificates.

Figure 5: Presence of energy performance certificates

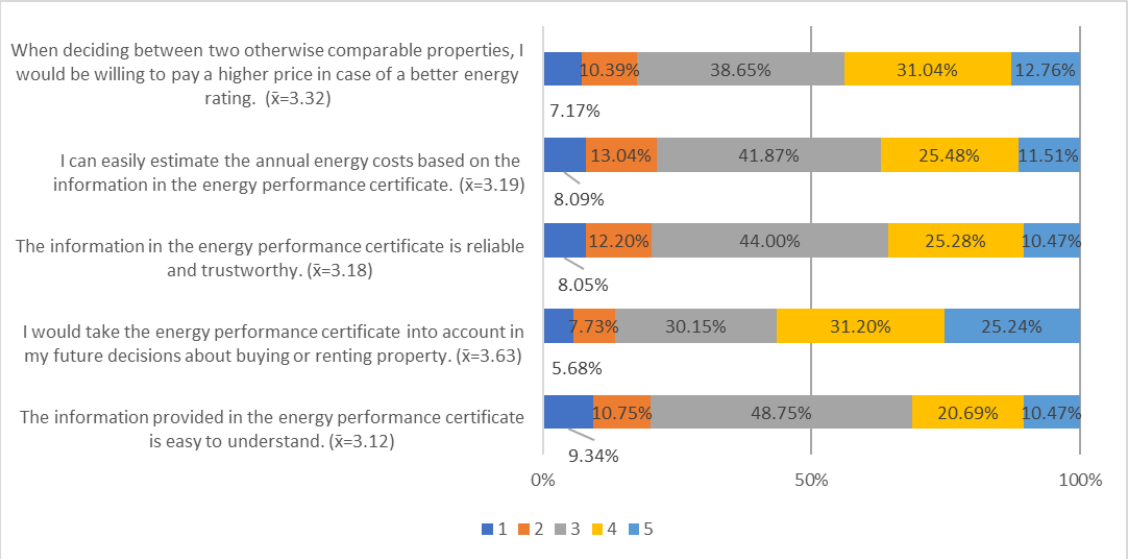


Source: Own work.

The large share of homes without energy performance certificates can be explained by the fact that under Slovenian legislation, homeowners don't need to obtain an energy performance certificate for their real estate, except in the case of a sale or long-term rental, meaning that there is no incentive for homeowners to obtain them. For this purpose, to make the choice experiment as realistic as possible, we approximated the energy rating for buildings of those respondents who indicated that they do not know the energy rating of the home they reside in by taking into account the age of the building and previously performed energy-efficient retrofits. Respondents who are familiar with the energy rating of their home are mostly those who have purchased their property recently, predominantly in newly constructed buildings.

Interestingly, the attitudes expressed towards energy performance certificates were generally positive. The respondents were asked to indicate on a 5-point Likert scale from (1 - completely disagree to 5 - completely agree) how much they agree with certain statements regarding energy performance certificates and an overview of responses is shown in **Figure 6.** More than 56% of homeowners agree with the statement that they would rely on the energy performance certificate in their purchasing decisions.

Figure 6: Attitudes about energy performance certificates



Source: Own work.

The next set of explanatory variables we consider are *building and location-specific variables*. Here we explore how the surface of the apartment (logarithm of the surface expressed in m^2), the age of the building (in years), as well as the type of housing (dummy variable for single-family dwellings), affect the choice. In Slovenia, single-family dwellings account for 60% of occupied dwellings, which motivated our choice to control for this important characteristic of the building stock. We additionally controlled for the location, introducing a dummy for dwellings located in the cities.

Finally, the third set of variables is related to the *energy-performance certificates*. We explore whether residing in a home with a poor energy rating would work as an incentive. An important matter to consider is how the price premium would affect the choice. We vary the price premium from 1% to 20%. It is also important to account for the improvement in rating. Namely, we expected that a more drastic improvement in the energy rating (for instance, an improvement from G to B2) would serve more as an impetus compared to a slight rating change (for instance, an improvement from G to E). Finally, the treatment variable has a value of 1 if the respondent received monetary information (in EUR) on the annual energy savings, rather than information on quantity, e.g. in kWh available on the energy label.

As we are interested in exploring the roles of financial and energy literacy in making energy-efficient real estate choices, we estimated two probit models. We first estimated how different socio-economic factors, energy literacy, financial literacy, and moral attitudes towards energy conservation influence the respondents' decision to rely on the energy performance certificate when making decisions. Our motivation is to provide insight into the usefulness of energy performance certificates as information measures, namely, whether individuals perceive them as a useful tool in energy-efficient decision-making. The

dependent variable in the first probit model is dichotomous and takes the value of one if the respondent has indicated that they would take the energy performance certificate into account in their future real estate purchase or rental decisions.

We followed up with a discrete choice experiment with stated preference to establish whether a better rating on the energy performance certificate would encourage respondents to accept paying a price premium, with all other elements kept constant. Different discrete choice methods were employed to estimate the specified model. In the choice experiment, we asked the respondents to select between two apartments: the current home they are residing in and a home with a better energy rating, for which they would be required to pay a price premium. All other apartment characteristics remained unchanged (location, size, age, etc.).

The treatment group received information on both the monthly level of energy savings expressed in monetary terms (in EUR) and the energy performance certificate, while the control group had information only on the energy performance certificate. For examples of choice cards shown in the stated choice experiment, see **Appendix**, **Figure A.2** for the control group and **Figure A.3** for the treatment group**.**

We then estimated the second probit model, observing how different factors impact the real estate choice. The dependent variable in the second probit model is dichotomous and takes the value of one if the respondent has accepted to pay a price premium for real estate with a better energy rating as measured by the energy performance certificate.

To gain a better understanding of the dependent variable, **Table 11** shows the average price premium in the full sample, treatment group, and control group. As expected, respondents residing in a home with a low energy efficiency rating as measured by the energy performance certificate are willing to accept a larger premium compared to respondents residing in homes with a better energy rating.

Table 11: Overview of the average price premium

Price premium (in %)	Full sample	Treatment group	Control group
Average price premium	4.58%	4.49%	4.65%
Average price premium per one unit improvement in the energy rating	1.64%	1.69%	1.59%
Average price premium if the current home has a rating of D or worse	5.07%	5.01%	5.14%
Average price premium if the current home has a rating of C or better	2.36%	2.30%	2.43%
Average price premium if residing in a single-family house	4.64%	4.41%	4.86%
Average price premium if residing in a multi-dwelling building	4.47%	4.63%	4.32%

Source: Own work

In modeling the individual's choice to either take into consideration the energy performance certificate when reaching the decision or accept paying a price premium for real estate with a better energy rating, we use the stated preference method. Random utility theory postulates that the utility an individual *n* gets from selecting the alternative *i* can be expressed in the following way:

$$U_{ni} = V_{ni} + \varepsilon_{ni} \quad (7)$$

where U_{ni} denotes the utility obtained from alternative *i*, which can be decomposed into the observable part of utility, V_{ni}, and the unobservable part, also referred to as a random error term, ε_{ni}. $V_{ni} = x_n'\beta$ is assumed to be linear in parameters and includes socio-economic and individual-specific variables, building and location-specific variables, as well as energy performance certificate-specific variables. It should be noted that *i=(1,2)*. In the setting of our first probit model, *1* denotes taking into account the energy performance certificate when making future real estate purchase decisions, and *2* denotes not taking into account the energy performance certificate when making future real estate purchase decisions. In the context of the second model, *1* denotes accepting to pay a price premium for real estate with a better energy rating, and *2* denotes otherwise.

To continue, the probability that an individual will select one of the alternatives is related to the underlying utility of that alternative. Therefore, alternative *1* will be selected if its underlying utility is higher than the utility of alternative *2*.

$$Prob\ (Alternative\ 1\ is\ selected) = Prob\ (U_{n1} \geq U_{n2}) = Prob\ (V_{n1} + \varepsilon_{n1} \geq V_{n2} + \varepsilon_{n2}), \quad (8)$$

Assuming the standard normal distribution, we can express the probit model as:

Prob (Alternative 1 is selected|x) = $\Phi(x_n'\beta)$, (9)

where Φ(x) denotes standard normal distribution.

Finally, we estimated a bivariate probit model and a recursive bivariate probit model. The bivariate probit model allows for modeling the joint determination of two variables. With a bivariate probit model, it is possible to jointly analyze two binary outcomes with correlated disturbances. In the case of a zero correlation, the model consists of two independent probit equations, which can be estimated separately.

A specification of a bivariate probit model can be represented in the following way:

$y_1^* = x_1'\beta_1 + \varepsilon_1, y_1 = 1\ if\ y_1^* > 0$, 0 otherwise (10)
$y_2^* = x_2'\beta_2 + \varepsilon_2, y_2 = 1\ if\ y_2^* > 0$, 0 otherwise (11)

where y_1^* denotes the latent variable in the first probit model, and y_1 is the observable dichotomous variable, taking the value of one if the respondent stated that they would rely on the energy performance certificate when making the real estate purchase or rental decisions, and zero otherwise. On the other hand y_2^* denotes the latent variable in the second probit model, and y_2 is the observable dichotomous variable, taking the value of one if the respondent accepted paying a price premium for the real estate with a better energy rating.
A recursive bivariate probit is an extension of the bivariate probit model allowing for the observable dichotomous variable from equation (12) to be used as an endogenous variable in equation (13):

$y_1^* = x_1'\beta_1 + \varepsilon_1, y_1 = 1\ if\ y_1^* > 0$, 0 otherwise (12)
$y_2^* = x_2'\beta_2 + \gamma y_1 + \varepsilon_2, y_2 = 1\ if\ y_2^* > 0$, 0 otherwise (13)

3.4 Results

Even though we estimated two separate probit models, a bivariate probit model, and a recursive bivariate probit, we report the findings of the two separate probit models and the bivariate probit model in **Table 12**, as the correlation coefficient of the recursive bivariate probit model was not significant. The difference between a probit model and a bivariate probit model is that the two binary outcomes are jointly determined in the context of the bivariate probit model. Having obtained a statistically significant correlation coefficient rho for the bivariate probit model (as shown in **Table 12**), the decision to rely on the energy performance certificate and the decision to select a more energy-efficient apartment have correlated disturbances and should be analyzed jointly, rather than separately.

It was found that higher levels of financial literacy, energy literacy, energy-efficient behavior, and pronounced moral values about energy conservation and climate-change

mitigation significantly and positively impact the respondent in claiming that they would rely their purchasing decisions on the energy performance certificate, ceteris paribus.

However, when it comes to actually making the choice, financial literacy, and energy-efficient behavior significantly and positively impact the decision to rely on the energy performance certificate and select a more energy-efficient real estate. We also found a significant and positive effect of the correct total life-cycle cost calculation. This can be explained by the fact that the knowledge required to perform a correct investment calculation is translated into both an awareness of energy performance certificates and energy-efficient decision making, reflected in the selection of a more energy-efficient home.

A larger premium and a 'free-rider' attitude towards energy conservation negatively impacts the decision to rely on the energy performance certificate and accept the price premium for a more energy-efficient home.

There is also a pronounced positive effect of residing in a home that is not energy-efficient, which can be an additional incentive for the respondents to improve their living conditions. Certain socio-economic characteristics, such as income appear as a driver, while age has a negative impact. Given that financial concerns are often recognized as a barrier to energy-efficient decision making in households, these results are expected.

Interestingly, we did not find the treatment variable to have a significant influence on the likelihood of energy-efficient real estate selection, meaning that in our sample, it did not matter whether the respondents received both monetary information on energy savings and the information on the energy performance certificate, or just the information on the energy performance certificate. One explanation can be found in the low energy literacy scores. In this setting, the display of information might not have been as relevant to the decision making as the respondent lacked the knowledge to adequately interpret the information. Another explanation is that the achieved energy savings might have been considered too low compared to the price premium. The price premium varied from 1% to 20%. The 2022 and 2023 increases in energy prices might have led to different conclusions were the choice experiment repeated.

Table 12: Results of separate probit models and the bivariate probit model

	First equation				Second equation			
Explanatory variables	**Separate probit model**		**Bivariate probit model**		**Separate probit model**		**Bivariate probit model**	
Socio-economic and individual-specific variables								
	Coef.	St.Err.	Coef.	St.Err.	Coef.	St.Err.	Coef.	St.Err.
Gender	-0.077	0.055	-0.076	0.055	0.001	0.058	-0.014	0.057
Age	0.001	0.002	0.001	0.002	-0.006***	0.002	-0.006***	0.002
Education	-0.013	0.055	-0.013	0.055	0.093	0.058	0.088	0.057
High-income dummy	-0.009	0.057	-0.010	0.057	0.134**	0.062	0.127**	0.061
Energy literacy	0.039*	0.023	0.039*	0.023	0.000	0.024	0.008	0.024
Financial literacy	0.104***	0.023	0.103***	0.023	0.085***	0.024	0.103***	0.024
Life-cycle cost calculation	0.097	0.059	0.100*	0.059	0.172***	0.062	0.186***	0.061
Positive attitude toward energy conservation	0.368***	0.055	0.369***	0.055	0.118**	0.058	0.190***	0.057
Free-riding attitude toward energy conservation	-0.001	0.090	0.001	0.089	-0.233**	0.091	-0.225**	0.090
Energy-efficient behavior	0.219***	0.047	0.221***	0.048	0.170***	0.049	0.210***	0.049
Relying on EPC in future real estate purchase decisions	/	/	/	/	0.540***	0.056	/	/
Building and location-specific variables								
Surface	/	/	/	/	0.137**	0.069	0.132**	0.067
Age	/	/	/	/	0.002	0.002	0.002	0.002
Single-family home	-0.024	0.054	-0.023	0.054	-0.047	0.078	-0.050	0.076
City dummy	/	/			-0.097	0.062	-0.094	0.060

To be continued

Table 12: Results of separate probit models and the bivariate probit model (cont.)

	First equation				**Second equation**			
Explanatory variables	**Separate probit model**		**Bivariate probit model**		**Separate probit model**		**Bivariate probit model**	
Energy performance certificate-specific variables								
Treatment variable	/	/	/	/	-0.055	0.054	-0.053	0.052
Current home with an energy rating of D or worse	/	/	/	/	0.233***	0.087	0.226***	0.084
Grade change	/	/	/	/	0.024	0.050	0.027	0.049
Price premium	/	/	/	/	-0.034***	0.012	-0.033**	0.012
Constant	-1.291***	0.204	-1.296***	0.205	-1.351***	0.385	-1.311***	0.374
Rho							0.337***	0.035

*Note: *** p<0.01, ** p<0.05, * p<0.1*

Source: Own work.

We report the marginal effects calculated for the bivariate probit model, shown in **Table 13.** We find that having a positive attitude toward energy conservation has the strongest effect, and increases the probability of relying on the energy performance certificate in decision-making and accepting a price premium for real estate with a better energy rating by 13.1 percentage points. This is followed by energy-efficient behavior, which increases the likelihood by 9.6%. Correctly calculating life-cycle costs increases the likelihood by 6 percentage points, while a one-unit increase in financial literacy increases it by 4.6 percentage points. We found the negative impact of the price premium, whose one-unit increase decreases the probability by 0.6 percentage points. If the respondent's current home has a low energy efficiency rating (D or less), the likelihood is increased by 4.3% points.

Table 13: Average marginal effects calculated for the bivariate probit model

Variables	**M.E.**	**St.Err.**
Gender	-0.023	0.019
Age	-0.001	0.001
Education	0.013	0.019
High-income dummy	0.020	0.020
Energy literacy	0.012	0.008
Financial literacy	0.046***	0.008
Life-cycle cost calculation	0.060***	0.021
Positive attitude toward energy conservation	0.131***	0.019
Free-riding attitude toward energy conservation	-0.043	0.030
Energy-efficient behavior	0.096***	0.017
Surface	0.024**	0.012
Dwelling age	0.000	0.000
Single-family home	-0.015	0.021
City dummy	-0.017	0.011
Treatment	-0.010	0.010
Current home with an energy rating of D or worse	0.043**	0.017
Grade change	0.005	0.009
Price premium	-0.006***	0.002

*Note: *** $p<0.01$, ** $p<0.05$, * $p<0.1$*

Source: Own work.

3.5 Discussion of the main findings

Although energy performance certificates have been present in EU member states since the early 2010s, more research is required to assess whether they are effective as a means of reducing the information barrier to achieving residential energy efficiency. In our sample, we did not find that providing information in monetary terms, as opposed to physical units leads to respondents accepting a price premium for a better energy rating of their home. While energy literacy significantly and positively increased the likelihood of relying on the

energy performance certificate in real estate purchase decisions, its marginal effect in the bivariate probit model was insignificant.

We find that financial literacy and the ability to correctly perform life-cycle cost calculations are drivers of better energy-efficient decision-making. Sociodemographic characteristics, such as income and age significantly influence the likelihood of relying on the energy performance certificate and the acceptance of a premium for an apartment with a better energy rating. Unsurprisingly, income is a driver, while age was found to negatively impact the choice.

Dwelling characteristics, such as the surface and condition of the dwelling, reflected in the low energy rating both appear as drivers, while as expected, the price premium has a negative impact. Other important drivers we identified are the positive attitude towards energy conservation and energy-efficient behavior. The occurrence when past energy-efficient behavior, or energy-efficient behavior in one domain (such as the use of household appliances or transportation choices) positively impacts energy-efficient behavior in other contexts (in our example, the real estate choice) is defined as the spillover effect (Lauren et al., 2016).

On the other hand, having a free-riding attitude towards energy conservation is a barrier. This leads us to believe that while energy performance certificates can visually serve as a heuristic device, the respondents still do not possess the knowledge necessary to make an informed choice. Combined with the fact that 40% of respondents incorrectly conducted the life-cycle cost calculation, it can be concluded that in this case, the savings might have seemed too low compared to the price premium, regardless of the fact whether these savings were expressed in monetary terms or physical units.

In addition to identifying low levels of energy literacy in our sample, we found that the majority of respondents did not know whether their home has an energy performance certificate. Out of those who stated that their home has an energy performance certificate, 50.83% did not know the energy rating of their home. More than 40% wrongly estimated the costs of acquiring an energy performance certificate. A similar lack of incentive and information was identified in other countries, due to the possibility to opt out of energy certification and negative media portrayal (Brounen & Kok, 2011). While there hasn't been negative media portrayal of energy performance certification programs in Slovenia, the lack of incentive and information is clearly present. Both of these issues can be improved by better informing homeowners on both the prices and the benefits of energy performance certificates, thus motivating them to get an energy performance certificate.

It should be noted that 47.97% of respondents indicated that they are neutral toward the statement that the information provided in the energy performance certificate is easily understandable. Keeping this in mind, a simplification of the energy performance certificate would be a mechanism of improving its effectiveness as an information measure.

A potentially useful feature of energy performance certificates for homeowners is the recommendations provided for cost-effective retrofits and other measures to reduce energy consumption. On one hand, by enhancing and better promoting this feature, the homeowners would be motivated to obtain the energy performance certificate and consequently, to implement the recommended measures. In the context of energy literacy and financial literacy and based on the results we obtained, we find that continued education and information campaigns that raise awareness of energy efficiency are still required, especially in the area of energy literacy. Combined with a better promotion and clarification of information on the energy performance certificates, this policy mix can tackle the information barriers to achieving residential energy efficiency, and improve the effectiveness of energy performance certificates.

4 CHAPTER III: ADDRESSING THE ROLE OF INFORMATION DISPLAY AND FINANCIAL AND ENERGY LITERACY IN HOUSEHOLD ENERGY-EFFICIENT APPLIANCE PURCHASING DECISIONS

4.1 Introduction and background on appliance labeling

Appliance labels are an informative measure that attempts to bridge the residential energy efficiency gap by ranking the energy performance of various household appliances. The ranking makes it very easy for the consumer to compare the energy efficiency of household appliances of the same type. Energy labels also display different types of detailed information about the appliance, such as capacity, noise levels, or water consumption, depending on the type of appliance. The energy label also includes information on the yearly energy consumption, usually displayed in physical units – kWh. By using an energy-efficiency rating scale for household appliances, energy labels provide information on energy performance in a straightforward and standardized way. Different appliance energy-efficiency labeling schemes have been implemented globally since as early as the 1990s.

These schemes can be broadly divided into voluntary energy label schemes and mandatory energy label schemes. The well-known Energy Star program administered by the United States Environmental Protection Agency is an example of a voluntary appliance labeling scheme. Under this scheme, the energy efficiency of an appliance is evaluated by an independent body. The manufacturers and retailers can then choose whether to display this information on the appliance. The EU energy label is an example of a mandatory appliance labeling scheme, also referred to as a comparative labeling scheme. In this case, the manufacturers must display information on the energy performance of the appliances.

The EU energy label was initially introduced in 1994 for various household appliance types. Since 2004 the EU energy label included a scale ranging from A (most efficient) to G (least efficient). For easier understanding and clarity, the categories were color-coded, so that the

best energy-efficiency rating was depicted in green, midrange energy-efficiency ratings in yellow, and the worst in red. From 2010 until 2021 the EU energy label design featured three subcategories (A+, A++, A+++) for the most energy-efficient rating. The scale thus, went from A+++ (most efficient) to G (least efficient). This is referred to in practice and the residential energy efficiency literature as the 'beyond A' scale.

Starting from March 1, 2021, the new simpler A to G scale was applied to refrigerators, dishwashers, washing machines, and televisions. The updated scale did not contain the subcategories (A+, A+++, and A+++) like the previous scale. The update also includes stricter requirements for qualifying for a certain energy rating, meaning that the cut-off values for achieving a higher energy rating were changed. The rescaling improved the clarity of the energy label by providing a clearer distinction between products in terms of energy efficiency. It also eliminated consumers' confusion about the differences between the subcategories of the highest energy-efficiency rating A. Energy labels for light sources, such as light bulbs, were rescaled as of September 1, 2021. Gradually, the rescaled EU energy label will include also other product groups. To allow room for further innovation and the development of even more energy-efficient models of household appliances in the future, the A rating for each product group will initially remain empty. Only the most energy-efficient products will be given the highest available rating. This removes the issue of overcrowding, which was present in the previous version of the EU energy label. By simplifying the scale and creating space for technological advancements, the EU aims to promote energy efficiency and encourage manufacturers to continue improving the energy performance of their products. These modifications are implemented as per European regulation, ensuring consistency and compulsory adherence across all EU member states. Since June 2002, Slovenia has enforced mandatory labeling for nearly all household appliances (refrigerators, freezers, washing machines, tumble dryers, dishwashers, ovens, heaters and hot water storage tanks, household lighting, televisions, air conditioners, etc.), and has used the renewed label design since 2021.

Even though the information on the energy label is available, and there have been improvements in the clarity of the EU energy label, we argue that being informed on the energy rating and the energy consumption in physical units alone is not enough to facilitate the decision to purchase the most cost-efficient household appliance. We aim to confirm that the degree of energy literacy and financial literacy of the consumer, as well as the display of monetary information on the energy label also have an important impact on the appliance purchasing decision. The role of these drivers is estimated with the use of a discrete choice model.

The choice experiment we designed using stated preference required respondents to select the washing machine with the lowest total life-cycle costs over the period of fifteen years. Respondents chose between two models of washing machines, differing solely in the price and the energy label, while all other elements are kept constant (such as capacity, noise level, and size). The control group received information on the yearly energy consumption in

physical units, and the lower price of the machine, while the treatment group received monetary information on the yearly energy costs of operation expressed in euros. This will enable us to assess whether the customers can more easily identify the more cost-efficient appliance when provided with monetary information, as well as whether concepts such as energy literacy and financial literacy play a role in facilitating rational choice. To the best of our knowledge, the provision of monetary information on the energy label for household appliances has not been studied in Slovenia up to this date. After introducing the topic, we provide a literature review on energy and financial literacy and appliance labeling in the second section. Data description, method, and model specification are provided in the third, while results are discussed in the fourth, and the main findings are summarized in the fifth section.

4.2 Literature review and the rescaled energy label

Several studies have been conducted on the impact of appliance labeling on consumer choices of energy-efficient appliances. An early study of appliance labeling awareness and purchase propensity in Germany found that socio-economic characteristics have little impact on the choice of appliance, while regional electricity prices and dwelling characteristics have a more important influence (Mills & Schleich, 2010). The authors, however, found merit in future research on appliance labeling exploring individual-related concepts, suggesting the potential inclusion of determinants such as environmental attitudes, beliefs, psychological factors, and social norms. Concepts such as financial literacy and energy literacy are logical candidates for bridging this research gap.

Energy literacy, along with energy awareness and energy-efficient behavior was explored as a determinant of residential energy expenditures (Brounen et al., 2013). Brounen et al. (2013) identified very low levels of energy literacy in the Netherlands and found that it is rather the energy awareness that impacts residential energy conservation. It should be noted that many studies exploring energy literacy in different contexts found the reported energy literacy scores to be very low in different European countries (Blasch et al., 2017, 2019, 2021; Brounen et al., 2013; He et al., 2022; Kalmi et al., 2021). Brounen et al. (2013), however, find that the careful use of behavioral nudges can improve residential energy efficiency. An example is the use of home energy scorecards.

Indeed, a randomized field experiment in the US showed that electricity savings were achieved by providing social norm information on a home energy scorecard, communicating to households how their electricity consumption compares to their neighbors, and rating their home efficiency accordingly as 'great', 'good' and 'below average' (Allcott, 2011). More recently, the role of digital nudging has been researched in the context of smart home functionalities of different household appliances (Stieglitz et al., 2023). These non-price interventions are important for consideration, even though the behavioral component often gets disregarded when discussing residential energy efficiency, as also highlighted by

Brounen et al. (2012). Energy labels are another example of a non-price intervention that can improve residential energy efficiency and can thus be seen as another potential field of research.

Although the fact that early studies have not found energy literacy to be a determinant of residential energy conservation might have discouraged further exploration of this concept as a determinant of residential energy efficiency, other researchers included this relatively novel score of respondents' knowledge of energy-related matters in their research. Providing empirical evidence from Switzerland, a study by Blasch et al. (2019) explored the impact of energy and investment literacy and the display of information on household appliance labels on the correct identification of the more cost-effective household appliances, when given a choice of two appliances. They showed that more than two-thirds of the respondents in their sample do not perform an investment calculation when selecting a more cost-effective household appliance. Instead of choosing a rational investment calculation decision strategy, consumers opt for heuristic decision-making, relying visually on the energy label when selecting a more energy-efficient household appliance. Based on these findings Blasch et al. (2019) concluded that consumers are boundedly rational. A boundedly rational consumer takes ‘shortcuts’ when making decisions, rather than using both the available information and their knowledge on energy-related matters to make the rational choice for the energy efficiency of their home. The shortcut we refer to is the simple comparison of energy ratings of two products as shown on the energy label. This is followed by the selection of the product with the better energy efficiency rating, depicted usually as the deeper shade of green on the energy label. Blasch et al. (2019) show that energy and investment literacy, as well as the display of monetary information significantly and positively impact rational decision-making. Rational decision-making is based on an investment calculation decision-making strategy, rather than a heuristic decision-making strategy, which is reflected in relying visually on the energy label when making the selection. This established the role of energy literacy as a determinant of energy-efficient household appliance purchasing decisions.

The exploration of energy literacy in the sphere of appliance labeling was continued by He et al., (2022), finding that general energy-related knowledge does not directly impact the consumer’s choice. On the other hand, energy-saving attitudes and knowledge of energy policy and household energy use were found to positively influence the choice of a more efficient appliance. More recently, studies include an integrated concept of energy-related financial literacy rather than observing energy literacy as a separate concept. Similar operationalization of energy-related financial literacy can be found in Blasch et al. (2021). A study from Finland showed that higher scores of energy-related financial literacy are associated with lower residential electricity consumption (Kalmi et al., 2021).

An interesting strain of appliance labeling literature focuses on the impact of different label design choices as well as the inclusion of different information on the energy label. There is evidence as early as 2009 showing that the use of a simplified scale (A to G scale, similar to the updated EU scale in use since 2021), rather than the ‘beyond A scale’ (A+++, A++, A+

to G scale used since 2010 until 2021) has a stronger impact on consumers' decisions and willingness to pay for a better energy rating (Heinzle & Wüstenhagen, 2009). These findings are presented in a working paper employing conjoint analysis to observe the effect that different energy label designs have on television sales in Germany. Subsequently, it was found in the same research setting (i.e., television sales in Germany) that the provision of lifetime operating costs on the energy label is preferred to both the provision of annual operating costs in monetary terms and in physical units (Heinzle, 2012).

More recently Stadelmann & Schubert (2018) explored how different designs of energy labels influence appliance purchases in Switzerland. An important contribution of their study was that the empirical evidence they provide comes from field data, whereas the majority of studies on these topics use stated preference models. In their work, the EU Energy label is compared both to an absence of a label, and the energy label using a simplified scale (A to G scale). The updated energy label also included monetary information about energy consumption as well as lifetime-oriented information. Although it was found that the presence of the label is preferable to its absence, they find that the provision of monetary and lifetime-oriented information does not impact the consumers' choice. This is an important conclusion highlighting the need to improve the energy literacy of consumers. Namely, if energy literacy and financial literacy scores are very low, it is arguable whether the provision of more energy and finance-related information plays a role in decision-making. Stadelmann & Schubert (2018) also support the use of the simplified scale on the EU energy label.

Interestingly, Bjerregaard & Møller (2019) had the opposite conclusion based on empirical evidence from the Danish market for cold appliances. Their research employed a cointegrated vector-auto-regressive model to assess the quantitative impact of the energy label in the period from 2005 to 2017, accounting for the fact that from 2010 until the end of the research period, the EU energy label used the 'beyond A' scale. They found that the label change increased sales of high-efficiency appliances both at the announcement of the label change and after implementation, while the sales of low-efficiency appliances decreased.

It should be mentioned that our literature review focuses more on papers researching the EU energy label, its effectiveness, implementations, and different aspects. There are, of course, influential papers researching similar matters in the framework of other labeling schemes. A particularly interesting study provides choice experiment evidence from the USA where two energy labels are combined: Energy Star and EnergyGuide (Newell & Siikamäki, 2014). These researchers include a design similar to the EU energy label (including a standardized scale depicting the energy rating of the appliance) in their stated choice experiment. The findings of this study are that standardized ratings of appliances encourage substantially higher energy efficiency, reflected in the selection of a more energy-efficient appliance. This speaks in favor of the EU energy label design. The same authors, however, find that the inclusion of operating costs is another determinant of household energy efficiency. Min et

al. (2014) find that providing monetary information on the energy label leads to lower implicit discount rates and increases the adoption of energy-efficient lightbulbs. Also, researchers focus on other mandatory labeling systems, such as the one employed in Korea (Park, 2017), and China (He et al., 2022). However, as our research focus was on Slovenia, which is an EU member state, the studies exploring the EU energy label were the ones we focused on more in-depth.

4.2.1 The rescaled EU energy label

As of March 2021, the renewed label design using a simplified A to G scale without the A+, A++, and A+++ subcategories has become compulsory in the EU. According to the Eurobarometer survey and report on Europeans' attitude toward EU energy policy (European Commission, 2019), the energy label was recognized by 93% of EU consumers. It was also found that 79% of EU consumers relied on the EU energy label as a decision tool when purchasing energy-efficient household appliances. The importance that consumers attach to the energy label motivated the manufacturers to produce appliances whose performance places them in the highest possible energy-efficiency rating category when compared to their competitors. Consequently, manufacturers producing appliances with lower energy-efficiency ratings strived to enhance their ratings to better position their products in the market. For instance, more than 90% of refrigerators and washing machines sold in 2017 were classified as A+, A++, or A+++ (European Commission, n.d.).

Therefore, the consistent efforts of the manufacturers to improve the energy efficiency of their products resulted in the overcrowding of products with high energy-efficiency ratings. As products became more energy-efficient, it became very difficult for consumers to distinguish between subcategories of the highest energy-efficiency rating (A). This means that the difference between A+++, A++, and A+ was not sufficiently clear to the consumer. The consequence was a lower willingness to pay for an improvement in the energy rating when compared to a more simplified energy-efficiency scale, also shown by Heinzle & Wüstenhagen (2009) and Heinzle (2012). While product overcrowding happened in the higher energy-efficiency rating categories, very few products had the lowest available energy-efficiency rating. The rating system was ultimately unsuccessful in providing information on the energy efficiency of household appliances. This warranted a renewed and improved rating system, that conveyed clearer information to consumers.

Apart from the re-scaled energy-efficiency ratings, there are additional elements incorporated into the label, such as the manufacturer’s brand name and the model of the appliance, pictograms for selected features and characteristics of the appliance, typical operating characteristics of the appliance (e.g. centrifuge speed, capacity, noise level, etc.), annual energy consumption expressed in kWh and information on the durability of the appliance. One notable addition to the new EU energy label is the QR code situated in the top right corner, enabling consumers to access supplementary product information beyond

what is provided on the label itself. An example of the new energy label can be found in **Appendix, Figure A.4**

4.3 Data, method, and model specification

Primary data were collected from an online household survey conducted in August 2020 as a part of the EU-funded Care4Climate project with a help of a market research agency. We obtained a representative sample of 3,000 economic decision-makers from Slovenia. A summary of the data and the motivation to focus on economic-decision makers is provided in the section **Empirical data**. While it is true that homeowners represent the majority of the population in Slovenia (SORS, 2022), the combined subsample analyzed in this chapter includes both homeowners and tenants. The reasoning behind this is the fact that we are studying appliance purchases, which is a topic that concerns both homeowners and tenants. After removing certain mischievous responders, the final combined subsample consists of 2,963 respondents. Descriptive statistics of explanatory variables we used in our analysis are presented in **Table 14.**

Table 14: Descriptive statistics of explanatory variables

Explanatory variables	**Mean**	**Std.Dev.**	**Min**	**Max**
Male respondent (1-Yes, 0-No)	0.477	0.499	0	1
Age (in years)	46.19	13.415	18	86
Income higher than EUR 2,700 per month (1-Yes, 0-No)	0.208	0.406	0	1
University education (1-Yes, 0-No)	0.479	0.5	0	1
Respondent is a tenant (1-Yes, 0-No)	0.153	0.36	0	1
Treatment: information on the energy label was shown in EUR (1-Yes, 0-No)	0.506	0.5	0	1
Energy literacy (score from 0 to 5)	1.068	1.227	0	5
Financial literacy (score from 0 to 5)	3.302	1.353	0	5
Moral obligation to reduce energy consumption (scale from 1– completely disagree to 7–completely agree)	5.279	1.487	1	7
Energy efficient behavior (scale from 1– never to 5 – always)	3.785	0.762	1	5
Free-rider attitude towards energy consumption (scale from 1– completely disagree to 7 – completely agree)	3.007	1.762	1	7
More than half of appliances in the respondent's home are energy efficient (1-Yes, 0-No)	0.69	0.463	0	1
Number of appliances in the respondent's home	7.333	3.291	0	20
Number of appliances in the respondent's home	7.333	3.291	0	20
Heuristic decision-making strategy (1-Yes, 0-No)	0.644	0.479	0	1
In the experiment, respondent received the choice card where the appliance with the worse energy label pays off (1-Yes, 0-No)	0.493	0.5	0	1

Source: Own work.

Socioeconomic and individual-related characteristics are not always found to be drivers of energy-efficient decision-making in the appliance labeling literature, and in general, in residential energy-efficiency literature (Mills & Schleich, 2010). However, due to other influential studies identifying them as relevant, we decided to include them as explanatory variables in our research (Blasch et al., 2019).

We control for the gender, age, income, and education of the respondent. It should be noted that income and education are included as dummy variables in our analysis. Individuals whose combined household income is higher than EUR 2,700 per month are represented with a variable that takes the value of one, and zero otherwise. We account similarly for education. The education level of at least a university degree or higher is recorded by a corresponding variable that takes a value of one, and zero otherwise.

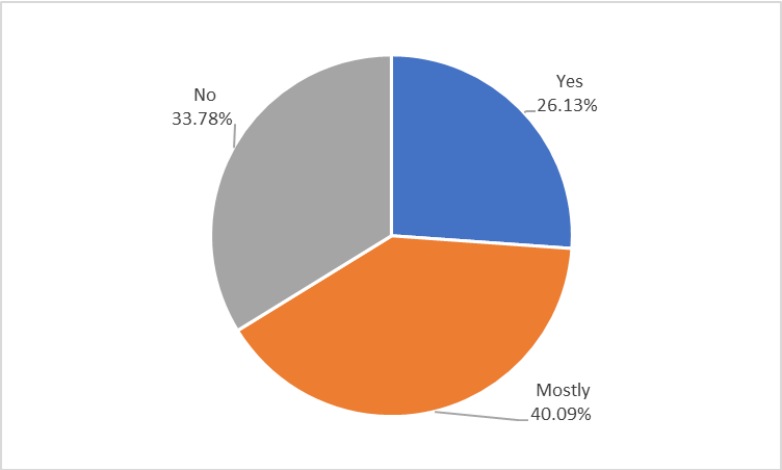
We also consider financial literacy, estimated based on responses to questions related to interest rate compounding, time value of money, inflation, and risk diversification, as well as the respondents' self-reported mathematical and economic knowledge. The level of energy literacy was measured based on the respondent's knowledge of energy consumption, such as prices of electricity and average household energy consumption, as well as the electricity use of everyday household appliances (washing machine, lighting, computer).

For more background and a more detailed literature review on financial literacy-related and energy-literacy-related matters, see section **3.2.2**. It should be noted that we identified very low levels of energy literacy in the combined subsample, similar to the subsample of homeowners. Respondents achieved an average score of 1.068 out of 5 on energy literacy. The score corresponds to the number of correct answers to energy-literacy-related questions. The average financial literacy score was 3.302 out of 5, also measured as the number of correct answers to financial literacy-related questions. Better financial literacy scores are possibly related to the fact that throughout their formal education, respondents could familiarize themselves with many finance-related matters, either through mathematics or through specialized economics and business classes. A detailed overview of energy literacy and financial literacy-related questions and the frequency of correct and wrong answers to them can be found in the **Appendix, Table A.3** and **Table A.4.**

Another consideration is whether the respondent is a homeowner or a tenant. There could exist split incentives between landlords and tenants when it comes to purchasing energy-efficient appliances. Namely, landlords generally do not reside in the tenants' apartments. As a result, landlords are not as mindful of the household appliance energy efficiency when equipping the apartment for rent, as they are not using the appliance. On the other hand, tenants actively use appliances and pay the associated electricity and other costs. Naturally, the tenants prefer to minimize energy costs, and consequently, prefer to have energy-efficient appliances in their homes. When asked about landlord purchasing decisions, 33.78% of tenants responded that their landlord does not purchase energy-efficient appliances (**Figure 7**). This suggests the existence of split incentives between landlords and

tenants when it comes to the purchase of energy-efficient appliances. Namely, only 26.13% of tenants confirm that their landlords do so.

Figure 7: Split incentives between landlords and tenants - do landlords purchase energy-efficient appliances?



Source: Own work.

An important addition to this study is the consideration of environmental attitudes and energy-efficient behavior. We explored both a positive environmental attitude and a negative environmental attitude. On a scale of 1 (completely disagree) to 7 (completely agree), respondents reported a high average score of 5.279 when asked whether they feel a moral obligation to reduce their energy consumption. Commenting on the negative environmental attitude, we take into account the free-rider effect. Using the same scale to measure their agreement with the statement that they are not willing to reduce their energy consumption unless others do the same, the respondents reported an average score of 3.007. This shows that while free-riding (i.e. negative environmental attitude) is present, the positive attitude towards the environment is more prevalent in our subsample, reflected in feeling a moral obligation to reduce energy consumption. Considerations of energy-efficient behavior are also important for improving residential energy efficiency (Trotta, 2018a). Namely, energy-efficient behavior complements the other, more time-consuming or financially demanding ways of reaching residential energy efficiency, such as retrofitting to reduce energy consumption for heating, purchasing energy-efficient appliances, or selecting an energy-efficient home. Respondents were surveyed on different ways of energy-efficient household appliance use and asked to rate the frequency of performing certain practices on a scale ranging from 1 (never) to 5 (always). The energy-efficient behavior variable was then constructed as a composite variable.

We additionally consider the number of appliances in a respondent's home. It is expected that individuals possessing a larger number of household appliances, with associated higher energy and maintenance costs, are also more mindful of the energy consumption of their homes. This means, that in the current setting of relatively higher electricity bills due to the

possession of a large number of appliances, respondents are motivated to select additional appliances that do not significantly increase their existing electricity costs. leading us to believe that they would be more likely to opt for energy-efficient appliances. It should be noted that electricity and energy costs were not particularly high in Slovenia at the time when this study was conducted. In present-day terms, namely, after the 2022 and 2023 increase in energy prices in the EU, the inclusion of this variable can be deemed even more necessary and relevant. We additionally included a dummy variable, taking the value of one if more than half of household appliances in the respondent's home are energy-efficient appliances, and zero otherwise. We assumed that an already existing positive experience with energy-efficient appliances would encourage future purchases of energy-efficient appliances.

In the choice experiment, respondents were presented with a choice card containing two energy labels for a washing machine. Examples of choice cards for the treatment group and the control group are presented in the **Appendix, Figure A.5** and **Figure A.6.** The two washing machines differed solely in the price, energy label, and annual electricity consumption, while all other characteristics, such as the capacity and noise level were the same. The respondents were asked to choose the appliance that would have the lowest total life-cycle costs over a span of fifteen years. It should be noted that these costs include not only the purchasing price but also the operating and maintenance costs over the entire lifespan of the appliance. In all of the choice cards, the more energy-efficient appliance was also more expensive.

To identify the appliances with lower total life-cycle costs, the respondents had to correctly perform the investment calculation. Half of the respondents received the treatment. The treatment group was shown a choice card with energy labels containing monetary information on the annual electricity consumption of the appliance. The non-treated (control) group received information on the annual electricity consumption expressed in physical units (kWh). Of course, if the monetary information was provided, the total life-cycle cost calculation was somewhat easier, as it required the respondent to simply multiply the annual costs provided in the energy label by the number of years, and add the operating costs. The calculation was more demanding for the control group, who received information on the annual energy consumption in physical units (kWh) and had to know the electricity price per kWh to correctly calculate the total life-cycle costs. The total life-cycle costs are calculated as a multiplication of the number of years (fifteen), annual energy consumption (provided in the energy label in kWhs), and the electricity price (euro cents/kWh). Operating costs per year are also added to the total life-cycle cost calculation.

Anticipating low scores for financial and energy literacy based on the test survey we conducted, we did not require the respondents to use discounting when performing total life-cycle cost calculation. The same is true for future energy price anticipation. It is also worth mentioning the timing of our study, which was conducted during the first onset of the COVID-19 pandemic. At this time individuals were faced with a lot of uncertainty about the future, which made the anticipation of future energy prices more demanding for the

respondent. Taking into consideration the low energy literacy scores obtained in the sample before conducting the analysis, we expected the treatment group to have better success in correctly identifying the more energy-efficient appliance.

It should be noted, that the EU energy label has so far not included energy consumption information expressed in monetary terms. There are, of course, practical reasons for this: electricity prices are different between member states, and change over time, and it would be difficult to provide an energy cost estimate that would be valid in different contexts and different timeframes. Nevertheless, we wanted to explore whether the provision of monetary information would facilitate better decision-making.

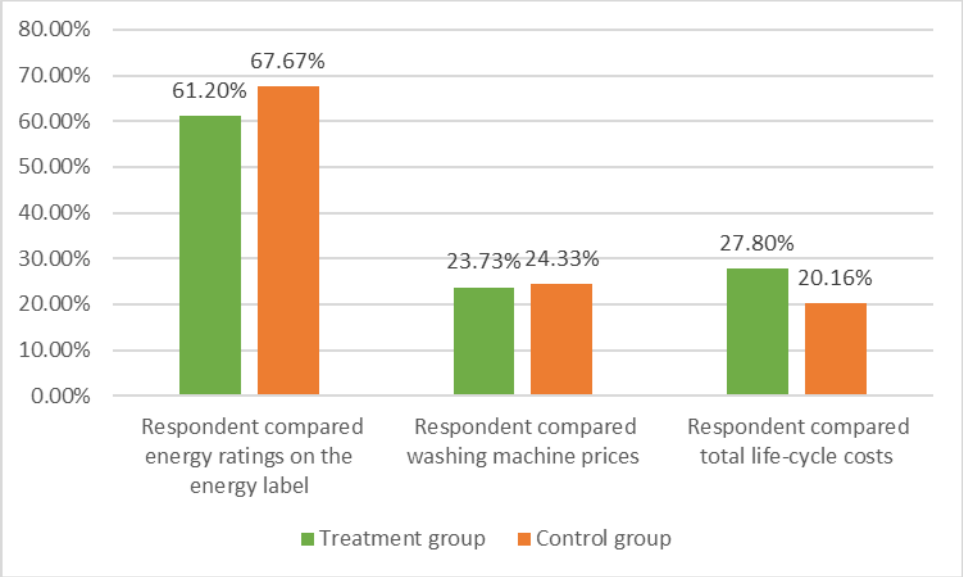
As we were additionally interested in exploring whether the appliance energy label serves as a heuristic device, we designed the choice experiment in a way that half of the respondents would receive a choice card where the appliance with the worse energy label pays off in the longer run. The logic behind this type of choice experiment design was the following: if the respondents are using the energy label simply as a shortcut, then they would select the appliance with the 'better' energy rating as measured by the energy label, rather than performing a life-cycle cost calculation to determine which appliance would pay off in the longer run. After the experiment, the respondents were asked to select which decision-making strategies they used. Possible decision-making strategies investment calculation, price comparison, energy-rating comparison, etc.

Interested to explore how much heuristic decision-making impacted the correct energy-efficient appliance choice, and motivated by the fact that 64.4% of the respondents selected energy-rating comparison as their decision strategy, we included a dummy variable, taking the value of one if the respondent stated that this was the strategy they used, and zero otherwise. A comparison of the decision-making strategies in the treatment group and the control group can be found in **Figure 8**. It should be noted that respondents had the option to select multiple decision-making strategies. Nevertheless, relying on the energy label was the most widely selected strategy.

Additionally, two more strategies were available for selection after the choice experiment. The treatment group received the option to state that they compared the annual costs of electricity, and 20.4% of respondents in the treatment group claimed to do so. The control group had the option of selecting the comparison of annual electricity consumption in kWh as their decision-making strategy, selected by 28.71% of the control group. However, even when presented with these additional decision-making strategies, both in the treatment group and the control group the comparison of energy ratings on the energy labels remains the most frequently selected strategy. Interestingly, more respondents in the control group (67.67%) opted for a heuristic decision-making strategy than in the treatment group (61.2%). This implies that providing monetary information leads to a better understanding of the problem and lessens the necessity to resort to heuristic decision-making, i.e., taking "shortcuts" rather than correctly performing the total life-cycle cost calculation to determine the more cost-

efficient appliance.

Figure 8: Comparison of decision-making strategies in the treatment group and the control group



Source: Own work.

The dependent variable *EEAPP* is dichotomous and takes the value of one if the respondent correctly selected the appliance with the lowest total life-cycle costs, and zero otherwise. Let us emphasize again, that some respondents received the choice card where the appliance with the 'worse' energy label paid off in the long run, so it wasn't always the appliance with the best energy-efficiency rating as measured by the EU energy label that had the lowest total life-cycle costs.

In modeling the respondents' appliance choice, we employed random utility theory and the method of stated preference, where the stated preference refers to the choice of the more cost-efficient appliance in terms of total life-cycle costs of operation. The use of the stated preference method was motivated by multiple factors. Namely, stated preference models allow the researcher the flexibility in including hypothetical situations in the choice experiment, as well as the existing situations, while revealed preference models can only have existing alternatives as observables (Louviere et al., 2003).

The logistics behind conducting a field experiment concerning energy-efficient appliance labeling should also be considered – with limited research funds, it is difficult to obtain a representative sample. When it comes to the choice of household appliances, field experiments concerning energy labels could also be more affected by financial considerations when compared to a stated preference choice experiment. It should also be noted that one of our research questions refers to a hypothetical situation. Namely, we are exploring the effect of displaying monetary information on the energy label, which is not included in the current EU energy label design. Because of this, the stated preference model

was the best fit for our research focus. According to the random utility theory, the utility of an individual *n* in the case of the energy-efficient appliance choice can be represented in the following way (Train, 2009):

$$U_{nj} = V_{nj} + \varepsilon_{nj}, \qquad (14)$$

where U_{nj} is the individual's utility obtained from alternative *j*, $V_{nj} = \beta' X_n$ is assumed to be linear in parameters and includes different variables denoted as X_n covered in the literature review and further discussed in this section (socioeconomic and individual characteristics, energy literacy, financial literacy, pro-environmental attitude, free-riding attitude, energy-efficient behavior, etc.), and ε_{nj} is the random error term. The probability that an individual *n* opts for the more energy-efficient appliance *j* (*EEAPP*) can be modeled through its utility, that is, the individual will select the appliance, only if the choice increases their underlying utility:

$$\text{Prob}\,(EEAPP_{\text{n}}) = \text{Prob}\,(U_{nj} \geq U_{nk}) = \text{Prob}\,(V_{nj} + \varepsilon_{nj} \geq V_{nk} + \varepsilon_{nk}), \quad (15)$$

where the alternative *k* represents the less energy-efficient appliance.

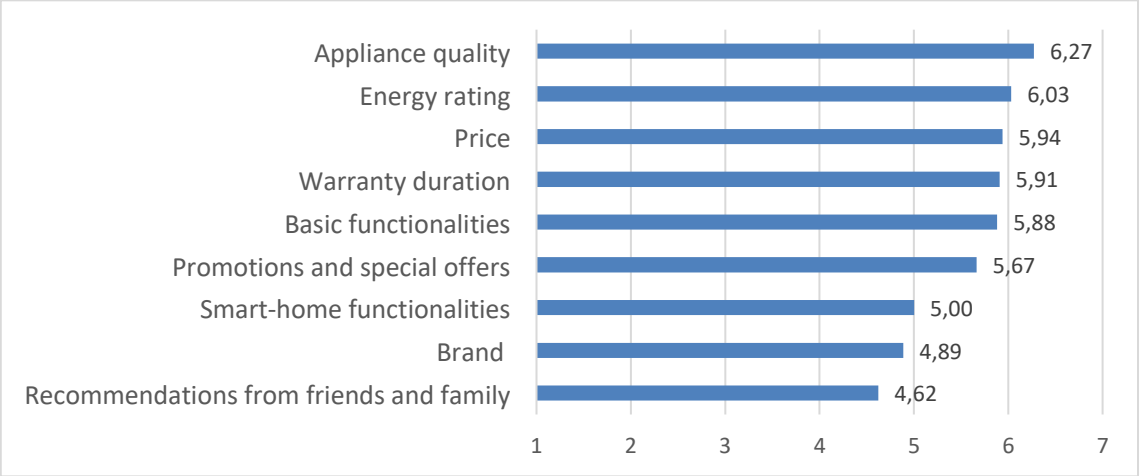
If we assume that the random error term ε_{nj} in equation (1) has a logistic normal distribution, we can express the model as follows:

$$Prob(EEAPP|X_n) = \frac{e^{\beta' X_n}}{1+e^{\beta' X_n}}. \quad (16)$$

Of course, there are many different appliance characteristics that individuals can take into consideration when making appliance-purchasing decisions. An overview of the importance of different household appliance attributes can be found in **Figure 9**. Respondents ranked the characteristics on a scale from 1 – not important at all, to 7 – very important. It can be noticed that the energy rating is the second most important attribute of household appliances, ranking higher than the price of appliances. As expected, appliance quality is the most important characteristic. On the other hand, recommendations from friends and family are given the least importance.

It is therefore warranted that the research focus of this chapter is the energy label and its effectiveness in conveying clear and relevant information to empower consumers to make good decisions for the increased energy efficiency of their homes. For this reason, the choice experiment did not include varying different attributes of energy-efficient appliances (such as the brand name, aesthetic, functionality, capacity, quality, etc.). We recognize, however, that important conclusions and policy recommendations can be also drawn from exploring the valuation of different attributes.

Figure 9: Importance of appliance characteristics (n=2,963)



Source: Own work.

Particularly relevant and interesting for future considerations are smart-home functionalities of appliances, that can enhance the appliance's energy efficiency. Even in early studies of residential energy conservation, smart-home functionalities (especially when it comes to energy consumption monitoring and thermostat options) have been identified as a behavioral nudge that can improve residential energy efficiency without requiring substantial efforts from the consumer (Brounen et al., 2013). The valuation of smart-home functionalities has already been studied in Slovenia, revealing that the market prices of smart-home appliances at the time of research were higher than the willingness to pay for smart-home functionalities (Rihar et al., 2015). For future research, it is possible to combine this research problem with energy appliance labeling and concepts of financial and energy literacy. This is especially relevant keeping in mind the increase in energy prices after 2022. The price increase can motivate households to look for ways to decrease their energy costs without considerably changing habits, increasing efforts, and reducing their thermal comfort or quality of life.

4.4 Results

The results are presented in **Table 15**. Similar to other studies in this area, we find that socio-economic variables, such as gender, age, and income of the respondent don't influence the correct selection of the appliance with the lower lifetime costs. University education increases the likelihood of correctly selecting the more cost-efficient appliance. As expected, both energy literacy and financial literacy have a positive and statistically significant effect on cost-efficient appliance purchasing. This suggests that individuals with higher levels of energy and financial knowledge are more likely to correctly identify and purchase appliances with the lowest total life-cycle costs.

Having a positive attitude towards the environment expressed as a moral obligation to reduce the energy consumption of your household positively and significantly increases the

likelihood of correctly selecting the appliance with the lowest lifetime costs. On the other hand, energy-efficient behavior has a negative and significant effect on the likelihood of correct cost-efficient appliance selection. This result implies that individuals who engage in energy-efficient behaviors may not necessarily correctly identify the appliance with the lowest total life-cycle costs. This may seem counter-intuitive, however, it should be taken into account that we obtained very low energy literacy scores in the combined subsample. Also, it should be noted that we did not elicit customer preferences, but rather asked which appliance has lower total life-cycle costs. This requires performing a correct investment calculation. It appears that energy-efficient habits and behavior don't necessarily translate into the knowledge necessary to correctly perform this task. Although early definitions of energy literacy include also the behavioral component, next to the knowledge component, the definition to which we adhere distinguishes between the two, as already mentioned.

Being a tenant is associated with a lower likelihood of correctly selecting the more cost-efficient appliance. A compelling argument could be that tenants have different financial considerations compared to homeowners. This way, different financial circumstances lead to selecting the cheapest possible option in the short term. Also, we required the respondents to select the appliance which would minimize the total life-cycle costs over a period of fifteen years. It is possible, that while not actively planning to relocate, tenants aspire to do so within a period shorter than the timeframe requested by the total life-cycle cost calculation. If planning to use the appliance for a defined period, tenants might focus on the short-term costs and would rather invest in energy-efficient appliances once they acquire their own home. This way, they could purchase appliances that are compatible with the layout and fit in their own future home. This might also have been their motivation to focus on the short-term costs.

Respondents who were provided with monetary information on the appliance's annual electricity consumption have a higher likelihood of correctly selecting the appliance with the lowest total life-cycle costs. This confirms that providing information in monetary terms supports energy-efficient decision making, similar to the findings of other studies. The confirmed role of the provision of monetary information is also an important contribution due to its practical implications for policy recommendations. The inclusion of monetary information on the annual energy costs can be an important tool to improve the effectiveness of the energy label as an informative measure.

Further, we identified a negative effect of being shown the experiment choice card where the appliance with the worse energy rating minimizes total life-cycle costs. This implies that when respondents were presented with a choice where the washing machine with the lower energy rating pays off in the long term, they used the energy label visually as a heuristic device. As a consequence, they were less likely to correctly identify the more cost-efficient appliance. The lack of knowledge on energy-related matters thus translated into a suboptimal choice of appliance. This also supports the claim that the energy label could benefit from simplification. Namely, if the energy label is predominantly used as a heuristic device, then

improving the visual features and simplifying the energy rating scale would result in individuals making better choices. Hopefully, the renewed EU energy label addressed these problems by eliminating the subcategories within the highest energy rating, which can be an interesting consideration for future research.

If respondents reported that their decision-making strategy was to compare the energy labels, there is a significant negative effect on the likelihood of correctly identifying the more cost-efficient appliance. This finding suggests that comparing energy labels, i.e. a heuristic decision-making strategy does not result in the correct selection of appliance that minimizes lifetime costs.

Table 15: Results of the logistic regression (n=2,963)

Explanatory variables	**Coef.**	**St.Err.**	**t-value**	**p-value**	**[95% Conf**	**Interval]**
Gender	0.143	0.124	1.15	0.251	-0.101	0.387
Age	-0.001	0.004	-0.19	0.851	-0.010	0.008
Income	-0.067	0.150	-0.45	0.656	-0.362	0.228
Education	0.213*	0.124	1.72	0.085	-0.029	0.455
Energy literacy	0.108**	0.051	2.14	0.033	0.009	0.207
Financial literacy	0.098**	0.048	2.06	0.039	0.005	0.191
Energy-efficient behavior	-0.162*	0.083	-1.96	0.050	-0.324	0.000
Pro-environmental	0.078*	0.043	1.81	0.070	-0.006	0.162
Free-rider	0.044	0.034	1.28	0.201	-0.023	0.111
Energy-efficient appliance	-0.045	0.129	-0.35	0.729	-0.297	0.208
Number of appliances	-0.023	0.019	-1.24	0.215	-0.059	0.013
Treatment	0.291**	0.116	2.50	0.012	0.063	0.520
Comparing labels	-0.955***	0.127	-7.53	0.000	-1.204	-0.706
The worse label pays off	-4.310***	0.131	-32.99	0.000	-4.566	-4.054
Tenant	-0.347**	0.166	-2.09	0.037	-0.672	-0.022
Constant	2.842***	0.475	5.98	0.000	1.911	3.774

Mean dependent var	0.551	SD dependent var	0.497
Pseudo r-squared	0.496	Number of obs	2963.000
Chi-square	2023.307	Prob > chi2	0.000
Akaike crit. (AIC)	2084.832	Bayesian crit. (BIC)	2180.735

*Note: *** p<0.01, ** p<0.05, * p<0.1*

Source: Own work.

Table 16 shows the marginal effects at means when controlling for the display of information and cost-effectiveness of the less energy-efficient appliance as measured by the energy label rating. As expected, when the information is provided in monetary terms, and the appliance with the worse energy label is also less cost-efficient, the choice of a heuristic decision-making strategy has a lower impact on the correct selection of the more cost-efficient appliance, decreasing the likelihood by 5.9%. On the other hand, when the treatment group was presented with the choice card where the appliance with the worse energy rating

was more cost-efficient, the heuristic decision-making strategy decreased the likelihood of correct choice by 13.9%.

In the treatment group, a one-unit increase in energy literacy increases the likelihood of correct cost-efficient appliance selection by 1.6% if the respondent was shown the choice card where the appliance with the worse energy rating pays off. However, if a respondent from the treatment group was shown the choice card where the appliance with the worse energy label is also the less cost-efficient appliance, a one-unit increase in energy literacy increased the likelihood of correct cost-efficient appliance selection by 0.7%. This is comparable to the marginal effects of financial literacy, whose one unit increase corresponds to a 1.4% and 0.6% increase in the likelihood of correct cost-efficient appliance selection, respectively.

Table 16: Marginal effects: treatment group

	Appliance with the worse energy rating is more cost-efficient		**Appliance with the worse energy rating is less cost-efficient**	
Variable	**Marginal effect**	**Std. error**	**Marginal effect**	**Std. error**
Gender	-0.021	0.018	-0.009	0.008
Age	-0.000	0.001	-0.000	0.000
Income	-0.010	0.022	-0.004	0.009
Education	0.031*	0.018	0.013*	0.008
Energy literacy	0.016**	0.007	0.007**	0.003
Financial literacy	0.014**	0.007	0.006**	0.003
Energy-efficient behavior	-0.024**	0.012	-0.010*	0.005
Pro-environmental	0.011*	0.006	0.005*	0.003
Free-rider	0.006	0.005	0.003	0.002
Energy-efficient appliance	-0.006	0.019	-0.003	0.008
Number of appliances	-0.003	0.003	-0.001	0.001
Comparing labels	-0.139***	0.018	-0.059***	0.010
Tenant	-0.050**	0.024	-0.021**	0.010

*Note: *** p<0.01, ** p<0.05, * p<0.1*

Source: Own work.

In the control group, in the context where the appliance with the worse energy label is less cost-efficient, the choice of a heuristic decision-making strategy decreases the likelihood of correct cost-efficient appliance selection by 7.5% (which is higher than the treatment group). On the other hand, in the control group, when presented with the choice card where the less efficient appliance pays off in the long run, the heuristic decision-making strategy decreased the likelihood of correct choice by 11.6%. As expected, a one-unit increase in energy literacy increases the likelihood of correct cost-efficient appliance selection by 1.3% if the respondent was shown the choice card where the appliance with the worse energy rating pays off. The effect of energy literacy is thus weaker than in the treatment group. Unsurprisingly, if a respondent from the control group was shown the choice card where the appliance with the worse energy label is also the less cost-efficient appliance, a one-unit increase in energy literacy increased the likelihood of correct cost-efficient appliance selection by 0.8%. Similar conclusions can be drawn for financial literacy, whose one unit increase corresponds to a 1.2% and 0.8% increase in the likelihood of correct cost-efficient appliance selection, respectively. The marginal effects are presented in **Table 17.**

Table 17: Marginal effects: control group

	Appliance with the worse energy rating is more cost-efficient		**Appliance with the worse energy rating is less cost-efficient**	
Variable	**Marginal effect**	**Std.error**	**Marginal effect**	**Std.error**
Gender	-0.017	0.015	-0.011	0.010
Age	-0.000	0.001	-0.000	0.000
Income	-0.008	0.018	-0.005	0.012
Education	0.026*	0.015	0.017*	0.010
Energy literacy	0.013**	0.006	0.008**	0.004
Financial literacy	0.012**	0.006	0.008**	0.004
Energy-efficient behavior	-0.020**	0.010	-0.013*	0.007
Pro-environmental	0.009*	0.005	0.006*	0.003
Free-rider	0.005	0.004	0.003	0.003
Energy-efficient appliance	-0.005	0.016	-0.004	0.010
Number of appliances	-0.003	0.002	-0.002	0.001
Comparing labels	-0.116***	0.016	-0.075***	0.012
Tenant	-0.042**	0.020	-0.027**	0.013

*Note: *** p<0.01, ** p<0.05, * p<0.1*

Source: Own work.

These findings show that the energy label would benefit from the provision of monetary information, as it would improve its effectiveness as an informative measure. Additionally, the 'beyond A' EU energy label design would be improved through its simplification. Namely, even if respondents relied on heuristic decision-making, in a setting where information was presented more clearly and understandably, they would be able to make better, rational choices.

4.4.1 Limitations

There are certain limitations to interpreting the results of this study. Namely, the survey and stated choice experiment were performed in August 2020. At the time, the EU energy label included three subcategories for the highest energy-efficiency rating (A+, A++, A+++). To make our choice experiment as realistic as possible, we used this label design. This kind of label is also what the customers would actually see when deciding to purchase an appliance in a store, or on a website. They were also familiar with this label. In 2021, the label was redesigned, and the template used in our choice experiment no longer exists in the EU market for household appliances, as the 'beyond A' label has been replaced by the simplified label. Nevertheless, the findings of this study are still valid, as we confirm that the simplification of energy labels should facilitate decision-making. Therefore, it is not expected that the use of simplified labeling would lead to significantly different results. In addition, providing that the energy label redesign still does not include monetary information, our findings are relevant in showing the importance of this kind of information

Also, we consider the effect of the financial and energy literacy of respondents, which does not depend on the specific label design. Namely, our obtained scores for financial and energy literacy would not have changed if the energy labels were different. Further, our choice experiment design includes energy ratings of A++ and A+++, and these subcategories appear to be particularly confusing for the consumers, who struggle to clearly understand the differences between the two. The already highlighted issue of product overcrowding in these categories was a clear signal for policymakers that the energy labels were not an effective informative tool in their previous form, hence the 2021 redesign of the label. Another limitation is that the total life-cycle cost calculations rely on the electricity prices at the time of the survey. Considering the increase in electricity prices in 2022 and 2023, the life-cycle cost calculations would lead to different results if the investment calculation was performed at a different time.

4.5 Discussion of the main findings

We attempted to explore the effectiveness of the EU energy label providing stated choice experiment evidence from Slovenia. We researched whether the energy label would benefit from the provision of monetary information, and observed whether the label was used visually as a heuristic device in appliance purchasing decisions. Further, we studied the roles

of energy and financial literacy in the selection of energy-efficient appliances. We included other variables, such as energy-efficient behavior, and both positive and negative environmental attitudes to have a more comprehensive overview of different barriers and drivers to residential energy efficiency purchasing decisions.

Although some socioeconomic variables do not significantly influence the correct selection of cost-efficient appliances, university education does and acts as a driver. Other individual-related characteristics, such as energy literacy, and financial literacy positively impact the likelihood of the correct choice of a more cost-efficient appliance. A positive attitude towards the environment increases the likelihood of correct selection, while energy-efficient behavior has a negative effect. Being a tenant is associated with a lower likelihood of correctly selecting the more cost-efficient appliance, which can also be explained by split incentives and financial and timeframe considerations. Presenting the experiment choice card in which the appliance with a worse energy label pays off in the long run leads to a lower likelihood of correctly identifying cost-efficient appliances. The same is true for having a heuristic decision-making strategy, namely, comparing energy labels instead of performing investment calculations to identify the more cost-efficient appliance.

In terms of policy recommendations, the results of this chapter suggest that investing in energy and financial literacy programs would be a necessary tool for bridging the energy efficiency gap in the residential sector. Keeping in mind the low energy literacy scores recorded in our sample, as well as the fact that energy-related knowledge is not a part of primary and secondary school formal education in Slovenia, the need for informational and educational campaigns is amplified. These campaigns, aimed towards increasing awareness and knowledge of energy-related matters would empower the public to make better choices. Consequently, residential energy efficiency would improve. Our finding that energy-efficient behavior does not necessarily translate into knowledge necessary for correctly identifying cost-efficient appliances also highlights the need for such campaigns.

Although it is encouraging that steps have already been taken to improve the effectiveness of the EU energy label by simplifying it, there are more possibilities to further improve consumer understanding and facilitate decision-making. One example is the provision of monetary information on energy costs, shown in this chapter to influence the correct identification of the more cost-efficient appliance. The updated energy label design may provide opportunities for improving the effectiveness of the EU energy label as an informative measure. One feature of the updated label design that can be leveraged for this purpose is the QR code, included in the top right part of the renewed EU energy label. These recommendations aim at improving consumer decision-making, increasing the adoption of cost-efficient and energy-efficient appliances, and ultimately contributing to achieving energy efficiency and sustainability goals in the residential sector.

We acknowledge certain limitations, among others, the use of the previous EU energy label format in the design of choice experiment cards. Nevertheless, the results emphasizing the

importance of displaying monetary information about electricity costs on the energy label are pertinent because the revised EU energy label design still lacks monetary information. In addition, the established roles of financial and energy literacy are also highly relevant as these characteristics do not rely on the energy label design. Of course, for future research, it would be interesting to explore whether the change in the design affects the impact of the various control variables included in the choice experiments in a meaningful way. As already mentioned, smart-home functionalities are another interesting aspect of energy-efficient household appliance purchases.

5 CONCLUSIONS AND POLICY IMPLICATIONS

This dissertation investigated various factors that influence energy-efficient and pro-environmental decision-making in Slovenian households. The key elements that were explored include social capital, housing-related lifestyle, informative measures such as energy performance certificates for buildings and energy labels for household appliances, as well as financial and energy literacy. By analyzing these concepts comprehensively, a thorough understanding of the drivers behind households' energy-efficient decision process can be gained. Establishing and confirming the roles of the determinants studied in this dissertation represents its theoretical contribution to energy efficiency gap literature. The identification of relevant determinants provides valuable insights for policymakers regarding potential strategies for bridging the existing residential energy efficiency gap. The proposed policy measures aim to encourage and support sustainable choices within households and represent a practical contribution of this dissertation.

The results of our study indicate that solely considering socio-demographic factors is insufficient to fully and thoroughly understand the barriers and drivers of the decision-making process in the context of performing energy-efficient retrofits, purchasing an energy-efficient home, or a cost-efficient appliance. The same applies to dwelling and location characteristics. Therefore, novel concepts need to be included and considered to better understand energy-efficient and environmentally friendly decision-making and behavior in households.

The first chapter highlights a statistically significant positive relationship between housing-related lifestyle and social capital on one side and energy-efficient home retrofits on the other. Social capital has not been researched in the context of energy-efficient home retrofits, which represents an important theoretical contribution of this dissertation. Other drivers of energy-efficient home retrofits include income, respondents’ age, the surface of their home, experience with retrofits, and subsidies, while high regional temperatures and negative GDP growth rates are barriers. The assertion of the role of social capital in this process suggests that measures aimed at enhancing the organizational infrastructure within dwellings and fostering community development are important strategies required to address the barriers to residential energy efficiency.

An important conclusion is that energy-saving behavior as a component of housing-related lifestyle is associated with a higher likelihood of performing energy-efficient retrofits. This indicates that promoting and encouraging energy-saving behavior through educational measures and other campaigns may increase energy-saving habits. This, in turn, could have a spillover effect on the adoption of energy-efficient retrofits and other energy-efficient behavior. Another interesting dimension of housing-related lifestyle is the DIY identity, found to significantly and positively impact the likelihood of retrofits. Individuals with such inclination are likely to be attracted by demonstration projects and subsequently feel motivated towards implementing energy-efficient retrofits in their own homes.

More than a third of respondents that have not performed an energy-efficient retrofit in their home explained that the reason for this was a lack of finances. While it is evident that financial incentives, such as subsidies, are an important tool for improving residential energy efficiency, they are not the only solution. This is supported by the fact that 69.5% of respondents who received a subsidy reported, that they would have performed the retrofit regardless, showing a presence of a free-rider effect.

Acknowledging the above-mentioned statements, addressing the issue of energy-efficient retrofits requires a policy mix of subsidies, informational and educational campaigns, demonstration projects, as well as measures that support community building and promote a better formal organization inside a dwelling.

Furthermore, the results of the second and third chapter prove our initial claims regarding the significance of financial literacy and pro-environmental awareness when selecting an energy-efficient home or a cost-efficient household appliance. Energy literacy is identified as a driver of cost-efficient appliance purchases.

We also find that while energy labels and energy performance certificates are useful, they serve mainly as a heuristic device. The respondents do not seem to have sufficient knowledge to correctly interpret the information provided to them on the energy labels and energy performance certificates. We showed that providing monetary information about the energy consumption of household appliances on the energy label improves its effectiveness in informing the public about the most cost-effective appliance.

An important recommendation for improving the effectiveness of the energy label for household appliances is both to include monetary information and to simplify the energy rating scale. While understanding the logistical and practical difficulties of including monetary information on the energy label, perhaps the new QR code feature of the redesigned EU energy label can include a calculator or a similar tool that provides the consumer with the monetary information on energy consumption, with each member state inputting and updating energy prices. Almost 87% of respondents reported that it would be useful to have an online calculator that would allow them to calculate the total lifetime cost of an appliance in euros and compare appliances.

Surprisingly, our research findings do not support the notion that including monetary information on energy performance certificates for buildings would enhance their effectiveness as an informative measure. While attitudes towards energy performance certificates are generally positive, various factors contribute to homeowners' lack of motivation to obtain an energy performance certificate. Keeping in mind the possibility of exemption from certification it is easy to see that homeowners have no incentive to get an energy performance certificate. There are no legal requirements for certification of existing dwellings, except in the case of sale, or long-term rental.

Consequently, nearly 58.9% of the homeowner sample reported not having an energy performance certificate altogether. 42.4% of respondents overestimated the costs associated with acquiring the energy performance certificate. This shows a significant knowledge gap among homeowners regarding both energy performance certificate prices and benefits from acquiring them. A valuable asset to homeowners could be the recommendations provided on the performance certificates, including cost-effective retrofit suggestions and other energy conservation measures. Enhancing this feature and increasing awareness about it may encourage homeowners to pursue the option of energy performance certification. This could consequently also lead to the implementation of the recommended measures, thus multiplying the positive effect.

An important policy implication from the results of the second and third chapter is the necessity of continuous educational and informational campaigns to improve the energy literacy and financial literacy of households in Slovenia. Similar to previous research on financial and energy literacy in different countries and contexts, our findings indicate that there is a low level of knowledge regarding energy matters among households. Specifically, 43.4% of respondents provided incorrect answers to all questions related to energy literacy while only 1.7% answered all questions correctly. This suggests that households generally lack knowledge about household appliance electricity consumption, average household electricity consumption as well as electricity prices. When it comes to financial literacy, a higher level of understanding was observed with over 70% of participants answering three or more questions accurately and only 3.1% providing incorrect responses to every question asked.

We observed that over 40% of respondents face difficulties in accurately estimating the total life-cycle cost of household appliances, even when provided with information regarding prices and energy consumption. We highlight two main factors contributing to this issue: insufficient access to necessary information and a lack of cognitive abilities required for assessing energy efficiency investments. Consequently, there is an undeniable necessity to enhance existing measures aimed at providing relevant information and tools, such as awareness campaigns, brochures, and calculators that facilitate comparisons between different investment options. The introduction and continuous implementation of these measures would provide households with access to reliable tools and crucial insights

concerning energy-related matters. They would be empowered to make better-informed and rational choices, and consequently achieve cost and energy savings.

It is worth noting that households place significant importance on information measures in addition to subsidies when it comes to energy policy measures. These information measures include free energy advice, digital online platforms for searching and comparing offers, contacting energy experts, and the opportunity for demonstration projects and turnkey energy efficiency projects. To further improve the residential energy efficiency potential, future efforts should also focus on smart homes. However, for these new technologies and concepts to be successfully implemented and accepted by end-users, they must understand and acknowledge the potential benefits they offer. Investigating the role of smart home functionalities in improving the energy efficiency of homes is beyond the scope of this dissertation and is left to be addressed in future research. Time preferences and future energy price expectations are another interesting consideration for further research. However, in the first chapter we focus on already performed retrofits and therefore we did not find time preferences and future energy price expectations to be applicable in this research setting. In the second chapter, we explore factors influencing the decision to purchase a more energy-efficient home and provide monetary information on the annual cost savings for the treatment group. This makes it easier for the respondents to understand that while they will pay a premium for their housing, they will also enjoy future monetary savings as a consequence of this decision. The third chapter studies how different factors influence the selection of a more cost-efficient household appliance. Due to the timing of our study and the uncertainty about future energy prices, we did not expand our research agenda to include this concept. However, we recognize the importance of both time preferences and future energy price expectations and would take them into account in a different research context.

The results presented in the three chapters consistently suggest that a policy mix approach is necessary to address the energy efficiency gap in the residential sector. This approach should focus on enhancing the promotion and clarity of information regarding energy certificates and labels and streamlining their content for improved understanding. Other elements of this policy mix include incorporating monetary details on the energy label and conducting educational campaigns to improve both energy literacy and financial literacy among individuals. Finally, providing incentives such as subsidies and preferential loans for undertaking energy-efficient retrofits in households, as well as implementing measures aimed at fostering community engagement and optimizing the formal organization of dwellings would increase energy-efficient retrofit rates. By implementing these recommended strategies, decision-making processes can be enhanced while simultaneously contributing to the attainment of household sustainability goals through improved levels of energy efficiency.

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APPENDICES

Appendix 1: Daljši povzetek v slovenščini (extended Summary in Slovene)

Naslov doktorske disertacije: Vloga ukrepov informiranja, socialnega kapitala ter finančne in energetske pismenosti za sprejemanje energetsko učinkovitih odločitev gospodinjstev

Pričujoča disertacija raziskuje vlogo socialnega kapitala, z domovanjem povezanega življenjskega sloga, ukrepov informiranja (v obliki energetskih izkaznic stavb in energijskih nalepk za gospodinjske aparate), ter finančne in energetske pismenosti pri pojasnjevanju energetsko učinkovitega in okolju prijaznega odločanja slovenskih gospodinjstev.

Osredotočenost naše raziskave na energetsko učinkovitost gospodinjstev je posledica vpliva, ki ga rezidenčni sektor ima na končno porabo energije v EU. Leta 2021 so gospodinjstva prispevala 27% h končni porabi energije v EU, od tega je bila večina (64.4%) porabljena za ogrevanje prostorov (Eurostat, 2022c). Kot spodbudno se sicer kaže dejstvo, da so gospodinjstva v EU zmanjšala emisije toplogrednih plinov za skoraj 114 milijonov ton ekvivalenta CO_2, kar pomeni 13-odstotno zmanjšanje med letoma 2008 in 2021 (Eurostat, 2022b). Kljub temu je bil stanovanjski sektor leta 2021 odgovoren za 20.5% emisij toplogrednih plinov v EU in 21.3% emisij toplogrednih plinov v Sloveniji (Eurostat, 2022b).

V večini študij je ugotovljen velik potencial za stroškovno učinkovite prihranke energije v gospodinjstvih (Held et al., 2014), ki ga je mogoče doseči z energetsko učinkovitimi prenovami, ustrezno izbiro energetsko učinkovitih naprav in nepremičnin ter energetsko učinkovitim vedenjem in drugimi ukrepi. Kljub temu pa je še vedno veliko neizkoriščenega potenciala za varčevanje z energijo. Raziskovalci to neskladje med optimalno in dejansko porabo energije imenujejo vrzel v energetski učinkovitosti (Allcott in Greenstone, 2012; Jaffe in Stavins, 1994). Za dosego cilja podnebno nevtralne EU do leta 2050 je treba ugotovljeno vrzel v energetski učinkovitosti v rezidenčnem sektorju odpraviti, kar predstavlja precejšen izziv.

Ta disertacija prispeva k literaturi o vrzeli v energetski učinkovitosti s proučevanjem novih vplivnih dejavnikov odločanja in energetsko učinkovitega obnašanja gospodinjstev, in sicer: socialnega kapitala, življenjskega sloga, povezanega z bivanjem v domu, energetske pismenosti, finančne pismenosti in ukrepov informiranja (energetske izkaznice in energijske nalepke).

Socialni kapital je opredeljen kot značilnosti družbene organizacije, kot so zaupanje, norme in mreže, ki lahko izboljšajo učinkovitost družbe, saj omogočajo usklajeno delovanje članov organizacije (Putnam, 1993). Pomembna značilnost socialnega kapitala je, da omogoča spontano sodelovanje. Putnam se pri tem sklicuje na Colemanovo delo, v katerem poudarja večplastnost socialnega kapitala, njegovo produktivnost, razlike in podobnosti med človeškim in socialnim kapitalom ter dejstvo, da socialni kapital omogoča doseganje določenih ciljev, ki jih brez tega ne bi bilo mogoče doseči (Coleman, 1990). Skladno s tem

smo v delu izpeljali in preverili trditev, da socialni kapital olajšuje sprejemanje odločitev na področju energetsko učinkovitih prenov doma.

Življenjski slog je opredeljen kot bolj ali manj celovit niz praks, ki jih posameznik izvaja ne le zato, ker te prakse zadovoljujejo utilitarne potrebe, ampak ker dajejo materialno obliko njegovi lastni identiteti (Giddens, 1991). Isti avtor trdi, da podobno kot posamezniki obstajajo, sodelujejo in se obnašajo v različnih okoljih skozi svoje življenje, so lahko določene prakse in dejanja zaželena v nekem kontekstu, medtem ko so v drugem nesprejemljiva. To se imenuje življenjski slog na določenem področju. Življenjski slog na področju bivanja v domu se nanaša na niz praks, ki jih posamezniki izvajajo v povezavi s svojim domom in bivanjem v njem. Raziskave o življenjskem slogu, povezanim z bivanjem v domu, so našle svoje mesto tudi v literaturi o energetski učinkovitosti. Thøgersen (2017) je na podlagi teorije verige med sredstvi in ciljem operacionaliziral življenjski slog, povezan z bivanjem v domu, in potrdil njegov pomen pri doseganju prihrankov energije. Poleg tega z domovanjem povezan življenjski slog omogoča priporočila za ukrepe spodbujanja energetske učinkovitosti gospodinjstev, prilagojene glede na odnos, ki ga imajo posamezniki do svojega doma.

Energetska pismenost, kot sta jo opredelila DeWaters in Powers (2011), vključuje ozaveščenost, znanje, stališča in vrednote glede varčevanja z energijo ter ustrezno vedenje. Da bi se izognili zamenjavi odvisne spremenljivke (energetsko učinkovito vedenje gospodinjstev) in neodvisne spremenljivke (energetska pismenost), se držimo ožje opredelitve energetske pismenosti, ki so jo v svojem delu uvedli Blasch et al. (2019). Ta opredelitev vključuje le ozaveščenost, znanje, stališča in vrednote glede varčevanja z energijo. Pričakujemo, da bodo posamezniki, ki izkazujejo višjo raven energetske pismenosti, pri odločanju pravilno interpretirali informacije, ki so jim na voljo.

Finančna pismenost je opredeljena kot sposobnost ljudi, da obdelujejo ekonomske informacije in sprejemajo informirane odločitve o finančnem načrtovanju, kopičenju premoženja, pokojninah in dolgovih (Lusardi in Mitchell 2014). Nanaša se na posameznikovo poznavanje in pravilno uporabo konceptov, kot so obrestne mere, časovna vrednost denarja, inflacija in razpršitev tveganja ter izračun stroškov življenjskega cikla. Višja raven finančne pismenosti pomeni, da bodo posamezniki znali izvesti in primerjati izračune stroškov življenjskega cikla naprav, in bodo posledično lahko sprejeli optimalno odločitev o nakupu ali investiciji.

Energetske izkaznice za stavbe in energijske nalepke za gospodinjske aparate odpravljajo informacijske ovire pri sprejemanju odločitev o energetski učinkovitosti, s čimer olajšujejo postopek odločanja in pomagajo zmanjšati vrzel v energetski učinkovitosti v stanovanjskem sektorju. V delu proučujemo njuno učinkovitost in preverimo, ali bi dodatna vključitev monetarnih informacij na energetske izkaznice in energijske nalepke izboljšala jasnost in učinkovitost teh pomembnih ukrepov informiranja.

Za celovit pregled teh dejavnikov odločanja in njihovem vplivu na energetsko učinkovitost gospodinjstev smo disertacijo razdelili na tri vsebinska poglavja z naslednjimi naslovi:

I. Vloga socialnega kapitala in življenjskega sloga, povezanega z bivanjem v domu, pri izvajanju energetsko učinkovitih prenov doma;
II. Vpliv energetskih izkaznic stavb in prikazovanja denarnih informacij na zmanjšanje informacijskih ovir;
III. Vloga prikazovanja denarnih informacij, ter finančne in energetske pismenosti pri odločanju gospodinjstev za nakup energijsko učinkovitih naprav.

Spletno raziskavo na reprezentativnem vzorcu 3.000 slovenskih gospodinjstev smo izvedli avgusta 2020 s pomočjo tržno-raziskovalne agencije. Raziskava je bila izvedena v okviru projekta LIFE IP CARE4CLIMATE (LIFE17 IPC/SI/000007), ki ga financira EU. Pred izvedbo raziskave smo vprašalnik preizkusili na manjšem vzorcu 100 anketirancev, se posvetovali s strokovnjaki in izvedli potrebne prilagoditve. V končnem vzorcu je z vidika reprezentativnosti razmeroma dobro zastopano slovensko prebivalstvo glede na spol, statistično regijo in starost, medtem ko je v vzorcu nekoliko prevelika zastopanost posameznikov z višjo stopnjo izobrazbe. To je najverjetneje posledica dejstva, da je bila anketa izvedena prek spleta.

Anketiranci so v svojih gospodinjstvih zadolženi za sprejemanje ekonomskih odločitev. Na začetku raziskave je bila anketirancem jasno pojasnjeno, kaj to pomeni. Ta vloga vključuje odgovornosti, kot so nadzor nad glavnimi nakupnimi in naložbenimi odločitvami, plačevanje položnic, izbira dobaviteljev itd. Odločitev, da se osredotočimo na osebe zadolžene za sprejemanje ekonomskih odločitev v svojih gospodinjstvih, je utemeljena z dejstvom, da bodo ti posamezniki odgovorni za odločitev o izvedbi energetsko učinkovite prenove, nakupu gospodinjskjega aparata, ali izbiri stanovanja. Zato se je bilo smiselno osredotočiti na te posameznike in njihove značilnosti.

Celoten vzorec je vključeval lastnike stanovanj, solastnike in najemnike ter družinske člane lastnikov. V vzorec smo vključili tako večdružinska kot enodružinska stanovanja. 84,7% anketirancev je lastnikov doma, v katerem živijo, ali so lastniki njihovi družinski člani. Preostalih 15.3% anketirancev najema svoje domovanje, od tega 7.8% predstavlja profitni najem, 7.5% pa jih živi v neprofitnih stanovanjih. 54.1% gospodinjstev živi v enodružinskih hišah (samostoječih hišah, vrstnih hišah ali dvojčkih), 12.4% v večstanovanjskih hišah in preostalih 33.5% v večstanovanjskih stavbah oziroma blokih. Vzorčne vrednosti so primerljive s populacijskimi vrednosti. Statistični urad Republike Slovenije (2022) poroča, da so na začetku leta 2021 v skoraj 79 % naseljenih stanovanjih živeli lastniki teh stanovanj in njihovi družinski člani. Najemnih stanovanj je bilo 9%, v 12% pa so živeli uporabniki, ki niso bili ne lastniki ne najemniki. 60% naseljenih stanovanj v Sloveniji se je nahajalo v eno- ali dvostanovanjskih hišah. Preostalih 40% naseljenih stanovanj je bilo v tro- ali večstanovanjskih in drugih stavbah (SURS, 2022). V prvem in drugem poglavju smo se

osredotočili na lastnike stanovanj, tretje poglavje pa vključuje celoten vzorec: lastnike stanovanj in najemnike.

Prvo poglavje obravnava vlogo socialnega kapitala in z bivanjem v domu povezanega življenjskega sloga pri spodbujanju energetsko učinkovitih prenov ter raziskuje druge morebitne ovire in dejavnike energetsko učinkovitih prenov v gospodinjstvih. V tehničnem poročilu Evropske komisije (Filippidou in Jimenez Navarro, 2019) o doseganju stroškovno učinkovite energetske preobrazbe stavb v Evropski uniji je poudarjeno, da je skoraj 75 % stavb v EU energetsko neučinkovitih v skladu z veljavnimi gradbenimi standardi. Vsako leto se v povprečju prenovi le od 0.4 do 1.2% stavbnega fonda, pri čemer so prisotne razlike med državami članicami. Energetsko učinkovite prenove so bistveno orodje za povečanje energetske učinkovitosti evropskega stavbnega fonda (Ashrafian et al., 2016; Felius et al., 2020). Vprašanje energetsko učinkovitih prenov v gospodinjstvih je pomembno zaradi njihovega vpliva na porabo energije za ogrevanje prostorov, ki predstavlja prevladujoči delež porabe energije v gospodinjstvih v EU.

Ob upoštevanju relevantne literature smo se odločili vključiti pojasnjevalne spremenljivke, ki jih lahko razdelimo v več kategorij, in sicer: socialno-ekonomske značilnosti gospodinjstev in posameznikov, značilnosti stavb in lokacije, socialni kapital, z bivanjem v domu povezan življenski slog, ter druge spremenljivke, vključno z informacijskimi viri, učinki politik in makroekonomskimi spremenljivkami. Vključitev socialnega kapitala in z bivanjem v domu povezanega življenjskega sloga je najpomembnejši prispevek tega poglavja k obstoječi literaturi.

Socialni kapital smo operacionalizirali z opazovanjem, kako povezani se anketiranci počutijo s svojo sosesko in sosedi (ali poznajo svoje sosede in se z njimi pogovarjajo), kako aktivno sodelujejo pri projektih skupnosti, kako enostavno je sprejemanje odločitev v stavbi, pa tudi s preko opazovanja obstoječe infrastrukture, ki olajšuje usklajeno sprejemanje odločitev, kot je prisotnost rezervnega sklada, upravitelja stavbe in njegove ustrežljivosti.

Z bivanjem v domu povezan življenjski slog je bil operacionaliziran po Thøgersenu (2017), pri čemer smo uporabili nekoliko spremenjeno in zmanjšano število instrumentov, da ne bi anketiranca preobremenili s prevelikim naborom vprašanj. Anketirance smo spraševali o različnih vidikih življenjskega sloga, povezanega z bivanjem v domu, na primer, kako pomembna je estetika njihovega doma, ali imajo odnos "naredi sam" do popravil in vzdrževanja doma, ali cenijo zasebnost svojega doma, ali vsi družinski člani sodelujejo pri gospodinjskih opravilih in urejanju doma, pa tudi o njihovem vedenju v povezavi z varčevanjem z energijo. Za zmanjšanje dimenzionalnosti našega nabora podatkov smo nato izvedli analizo glavnih komponent z rotacijo varimax. Po uporabi Kaiserjevega merila smo določili sedem glavnih komponent, ki se nanašajo na različne vidike življenjskega sloga, povezanega s stanovanjem. Komponente smo opredelili na naslednji način: zasebnost (PC1), identiteta "naredi sam" (PC2), energetsko varčno vedenje (PC3), funkcionalnost in kakovost (PC4), sodelovanje (PC5), družabno življenje (PC6) in prostornost (PC7).

Na podlagi podatkov iz spletne ankete, izvedene avgusta 2020, je sestavljen retrospektivni vzorec panelnih podatkov, ki obsega predstavnike 2,537 gospodinjstev iz Slovenije. Retrospektivni panel je primeren za tovrstno analizo, saj omogoča vključitev tako časovno spremenljivih kot tudi časovno nespremenljivih spremenljivk in omogoča raziskovanje učinka sheme subvencioniranja, ki je bila vpeljana konec leta 2008, dejansko pa je zaživela v letu 2009. Pomanjkljivost omenjenega pristopa je v potencialnem problemu netočnosti pri oblikovanju vzorca retrospektivnih panelnih podatkov (McIntosh et al., 2011). Vendar je zaradi pomembnosti tovrstnega dogodka in dejstva, da energetsko učinkovite prenove motijo vsakdanje življenje gospodinjstva, v katerem se izvajajo, malo verjetno, da anketiranci ne bi vedeli, ali pa se ne spomnijo, ali je bila izvedena energetsko učinkovita prenova. Druga pomanjkljivost je, da za nekatere spremenljivke v našem modelu (kot sta izobrazba in dohodek) predpostavljamo, da so časovno nespremenljive, medtem ko se lahko v času spreminjajo. Medtem ko se pri krajših panelih pričakujejo podobne ravni pojasnjevalnih spremenljivk, pa je za ustrezno zajetje dejavnosti gospodinjstev v zvezi z prenovami običajno potrebno daljše časovno obdobje. Zato smo sestavili daljši vzorec panelnih podatkov, ki zajema obdobje od leta 2000 do leta 2020, in krajši panel, ki zajema obdobje od leta 2006 do leta 2020. To pa hkrati tudi omogoča preverjanje robustnosti dobljenih rezultatov.

Pri modeliranju odločitev gospodinjstev za energetsko učinkovito prenovo uporabljamo teorijo naključne koristnosti in metodo razkritih preferenc, pri čemer se razkrite preference nanašajo na dejansko obnašanje, torej na odločitev o izvedbi energetsko učinkovite prenove v anketirančevem domu v preteklosti. Verjetnost, da se posameznik odloči za energetsko učinkovito prenovo, je mogoče modelirati z njegovo koristnostjo, kar pomeni, da se bo posameznik odločil za izvedbo energetsko učinkovite prenove le, če bo ta odločitev povečala njegovo koristnost. Odvisna spremenljivka je torej dihotomna in ima vrednost ena v letu, ko je bila izvedena energetsko učinkovita prenova, in vrednost nič v nasprotnem primeru.

Rezultati logit modela z naključnimi učinki kažejo, da so dohodek, starost anketiranca, velikost stanovanja, predhodno izvedene prenove in razpoložljivost subvencij spodbujevalci, medtem ko predstavljajo visoke regionalne temperature in negativna stopnja rasti BDP ovire za energetsko učinkovite prenove. Iz anketnih odgovorov lahko tudi sklenemo, da pomanjkanje sredstev pomeni najpomembnejšo oviro pri izvajanju energetsko učinkovitih ukrepov gospodinjstev, prav tako pa so potencialni prihranki energije in stroškov najpomembnejši spodbujevalec teh investicij. Rezultati tako utemeljujejo pomen vpeljanih ukrepov subvencioniranja pri spodbujanju energetske učinkovitosti gospodinjstev. Nadalje na podlagi rezultatov modela ugotavljamo, da sta tudi socialni kapital in življenjski slog, povezan z bivanjem v domu, pomembna dejavnika energetsko učinkovitih prenov. Nekateri vidiki življenjskega sloga, povezanega z domom, kot sta varčno ravnanje z energijo in nagnjenost k vzdrževanju in popravilom doma po načelu "naredi sam", predstavljajo spodbujevalce energetsko učinkovitih prenov. Enako velja za spremenljivke, povezane s

socialnim kapitalom, in sicer za enostavnost dogovarjanja med stanovalci in vzpostavljeno in delujočo formalno organizacijo stavbe.

Drugo poglavje se osredotoča na energetske izkaznice stavb. Energetske izkaznice, (v literaturi včasih imenovane tudi energijske nalepke za stavbe), so informativni ukrep, ki zagotavlja standardizirane informacije o energetski učinkovitosti stavb (ali njihovih delov) in jih običajno ocenjuje na lestvici od A (najbolj energetsko učinkovite) do G (najmanj energetsko učinkovite). Lestvica je pogosto barvno označena, tako da zelena barva ustreza najbolj energetsko učinkovitem, rdeča pa najmanj energetsko učinkovitem razredu. Energetske izkaznice vključujejo tudi informacije o povprečni letni porabi energije za ogrevanje stavbe (navedene v fizičnih enotah – kWh) ter priporočila za stroškovno učinkovite izboljšave stanovanja.

Certificiranje energetske učinkovitosti stavb v EU je bilo uvedeno z Direktivo o energetski učinkovitosti stavb (EPBD), ki sta jo decembra 2002 sprejela Evropski parlament in Svet Evrope (2002/91/ES). Ta direktiva je med drugim določala, da morajo države članice EU do leta 2006 sprejeti potrebne zakone, predpise in upravne določbe za uskladitev z direktivo, pri čemer so lahko rok podaljšale do leta 2009, če je primanjkovalo usposobljenih ali akreditiranih strokovnjakov. Direktiva je bila pozneje zaradi jasnosti leta 2010 prenovljena (Direktiva 2010/31/EU), leta 2018 pa revidirana (Direktiva 2018/844/EU).

Energetske izkaznice se v Sloveniji izdajajo od leta 2013 in veljajo deset let. Energetske izkaznice so obvezne za javne stavbe, večje od 250 m^2, in za vse stavbe (ne glede na to, ali so v javni ali zasebni lasti) s pogosto javno rabo in uporabno tlorisno površino večjo od 500 m^2. Enako velja v primeru prodaje nepremičnine in v primeru najema nepremičnine za obdobje enega leta ali več. Energetske izkaznice v Sloveniji prikazujejo energetske razrede stanovanjskih in nestanovanjskih stavb na lestvici od A (najbolj energijsko učinkovite) do G (najmanj energijsko učinkovite). Opozoriti je treba, da je energetskih razredov sedem, saj sta razreda A in B razdeljena na dve podrazreda (A1 in A2 ter B1 in B2). Poleg podatkov o stavbi in njeni energetski učinkovitosti so v izkaznici navedeni tudi podatki o izdajatelju ter podrobnejši pregled rabe energije v stavbi in morebitne dodatne pripombe in priporočila. Priporočila za stroškovno učinkovite izboljšave energetske učinkovitosti lahko vključujejo ukrepe za izboljšanje kakovosti ovoja stavbe ter energetske učinkovitosti ogrevalnih in prezračevalnih sistemov, ukrepe za povečanje uporabe obnovljivih virov energije v stavbah in druge ukrepe.

Čeprav so bile objavljene vplivne študije o energetskih izkaznicah je njihova učinkovitost pri izboljšanju energetske učinkovitosti gospodinjstev z zmanjšanjem informacijskih ovir premalo raziskana. To poglavje zapolnjuje ugotovljeno vrzel. Na reprezentativnem vzorcu lastnikov stanovanj najprej analiziramo, kako različni socialno-ekonomski dejavniki, finančna in energetska pismenost ter pozitiven odnos do varčevanja z energijo vplivajo na odločitev, da se pri odločanju o nakupu nepremičnine zanesejo na energetsko izkaznico.

V oblikovanem modelu smo upoštevali socio-ekonomske značilnosti anketirancev, kot so spol, starost, izobrazba in dohodek. Vključili smo tudi okoljsko ozaveščenost, tj. pozitiven odnos do vprašanj, kot sta varčevanje z energijo in blaženje podnebnih sprememb, in zastonjkarski pristop k porabi energije, ugotovljen na podlagi strinjanja s trditvijo, da anketiranci niso pripravljeni zmanjšati svoje porabe energije, če tega ne storijo tudi drugi. Poleg tega smo upoštevali tudi učinek energetsko učinkovitega obnašanja, ki smo ga opredelili kot sestavljeno spremenljivko, sestavljeno iz devetih spremenljivk. Anketiranci so prejeli niz izjav, ki so naštevale energetsko učinkovite in okolju prijazne prakse, ter na lestvici od 1 (nikoli) do 5 (vedno) poročali, kako pogosto se tako obnašajo.

V model smo kot pojasnjevalni spremenljivki vključili tudi energetsko in finančno pismenost anketirancev, ki ju merimo na lestvici od 0 do 5 glede na število pravilnih odgovorov na dva sklopa vprašanj. Pri ocenjevanju finančne pismenosti anketirancev smo opazovali, ali razumejo pojme, kot sta razpršitev tveganja in časovna vrednost denarja, ter ali lahko izvedejo osnovne izračune upoštevajoč obrestno obrestni račun. Anketirance smo prosili, naj ocenijo svoje matematično znanje v primerjavi s splošno populacijo (ali je boljše, primerljivo ali slabše) in navedejo, ali so v času formalnega izobraževanja obiskovali ekonomske predmete. Pri ocenjevanju energetske pismenosti smo anketirance prosili, naj navedejo povprečno ceno električne energije v EUR/kWh (brez omrežnine, DDV in prispevkov), ki jo plačujejo gospodinjstva, in povprečno mesečno porabo električne energije v povprečnem gospodinjstvu v kWh. Zanimali so nas tudi stroški električne energije za eno pranje perila, poraba električne energije v kWh, potrebna za enourno delovanje osebnega računalnika, in odstotek prihranka energije, ki ga dosežemo s prehodom s halogenskih na LED-žarnice, pri čemer ohranimo enako svetilnost. Omeniti velja, da je bila energetska pismenost v našem vzorcu nizka, medtem ko so bili rezultati, dobljeni za finančno pismenost, boljši, kar pomeni, da so potrebne nadaljnje izobraževalne in informacijske kampanje na temo energetske učinkovitosti stanovanj. Anketirance smo prosili tudi, naj izračunajo skupne stroške življenjskega cikla naprave.

Nadalje smo v modelu upoštevali spremenljivke, značilne za stavbo in lokacijo. Tu smo raziskali, kako na izbiro vplivajo površina stanovanja, starost stavbe, vrsta stanovanja in lokacija.

Izveden je bil poskus izbire, ki je od anketirancev zahteval, da izbirajo med svojim sedanjim domom in domom z boljšim energetskim razredom, za katerega bi morali plačati cenovno premijo, ob enakih drugih pogojih (ceteris paribus). Eksperimentalna skupina je prejela denarne informacije o mesečni ravni prihrankov energije in o energetskem razredu na energetski izkaznici, medtem ko je kontrolna skupina prejela informacije samo o energetski izkaznici. Cenovno premijo za bolj učinkovit dom smo spreminjali od 1% do 20%, med drugim tudi v odvisnosti od izboljšanja energetske učinkovitosti doma, merjene z uvrstitvijo v višji energetski razred.

Podatke smo analizirali z dvema ločenima probit modeloma, bivariatnim probit modelom in rekurzivnim bivariatnim probit modelom. Poročamo o ugotovitvah bivariatnega probitnega modela, saj se korelacijski koeficient v rekurzivnem bivariatnem probitnem modelu ni izkazal za statistično značilnega. V našem vzorcu presenetljivo nismo ugotovili, da zagotavljanje monetarnih informacij namesto izraženih prihrankov energije v fizičnih enotah vodi k temu, da se anketiranci pri odločanju o nakupu zanašajo na energetsko izkaznico in se z večjo verjetnostjo odločajo za izbiro energetsko učinkovitejšega doma. Ugotovili smo, da sta finančna pismenost in sposobnost pravilnega izračuna stroškov življenjskega cikla dejavniki, ki pozitivno vplivata na izbiro energetsko bolj učinkovite alternative. Tudi sociodemografske značilnosti, kot sta visoka izobrazba in višina dohodka, pozitivno vplivajo na izbiro nepremičnine z boljšim energetskim razredom, medtem ko je bilo ugotovljeno, da starost anketiranca negativno vpliva na izbiro. Značilnosti stanovanja, kot sta večja površina in slab energetski razred, ki se odražata v večji porabi energije v gospodinjstvu, pozitivno vplivata na odločitev za energetsko bolj učinkovit dom, medtem ko ima višina cenovne premije po pričakovanjih negativen vpliv. Drugi pomembni dejavniki, ki smo jih ugotovili, so pozitiven odnos do okolja in energetsko učinkovito obnašanje, po drugi strani pa se kot ovira kaže zastonjkarski odnos do varčevanja z energijo. Na podlagi rezultatov analize lahko sklenemo, da čeprav lahko energetske izkaznice vizualno služijo kot hevristični pripomoček, anketiranci še vedno nimajo potrebnega znanja za informirano in racionalno izbiro.

Tretje poglavje se osredotoča na raziskovanje vloge finančne pismenosti, energetske pismenosti in prikaza denarnih informacij na energijski nalepki pri izbiri stroškovno učinkovitejšega aparata. Energijska nalepka ima pomembno vlogo pri odpravljanju vrzeli v energetski učinkovitosti gospodinjstev, saj zagotavlja standardizirane informacije o energetski učinkovitosti gospodinjskih aparatov. Energijska nalepka EU je primer obveznega sistema označevanja aparatov. Takšen sistem se imenuje tudi sistem primerjalnega označevanja. V tem primeru morajo proizvajalci obvezno prikazati informacije o energetski učinkovitosti gospodinjskih aparatov in drugih naprav.

Energijska nalepka je bila v EU uvedena leta 1994 za različne gospodinjske aparate. Od leta 2004 je energijska nalepka vključevala lestvico od A (najučinkovitejši) do G (najmanj učinkovit). Zaradi lažjega razumevanja in jasnosti so bile kategorije barvno označene, tako da je bila najboljša ocena energetske učinkovitosti prikazana z zeleno barvo, srednja ocena energetske učinkovitosti z rumeno, najslabša pa z rdečo. Od leta 2010 do leta 2021 je energijska nalepka EU vključevala tri podkategorije za najbolj energijsko učinkovito oceno (A+, A++, A+++). V praksi in literaturi o energetski učinkovitosti gospodinjstev se to imenuje lestvica "nad A". Od 1. marca 2021 se je za hladilnike, pomivalne stroje, pralne stroje in televizorje začela uporabljati nova, preprostejša lestvica od A do G. Posodobljena lestvica ne vsebuje več podkategorij (A+, A+++ in A+++) ter hkrati zaostruje pogoje glede porabe energije, ki omogoča uvrstitev aparata v višji energijski razred. Ta sprememba je zagotovila jasnejše razlikovanje med izdelki glede na energetsko učinkovitost, da bi odpravila zmedo pri kupcih in izboljšala jasnost glede razlik med kategorijami visoke

stopnje energetske učinkovitosti. Slovenija od junija 2002 uveljavlja obvezno označevanje skoraj vseh gospodinjskih aparatov, od leta 2021 pa uporablja prenovljeno obliko nalepke.

Pri poskusu izbire so anketiranci prejeli kartico z dvema energijskima nalepkama za pralni stroj. Izbirali so med dvema pralnima strojema, ki sta se razlikovala le po ceni, energijski nalepki in letni porabi energije, medtem ko so bile vse druge lastnosti, kot sta kakovost in raven hrupa, enake. Anketiranci so morali izbrati napravo, ki bi imela najnižje skupne stroške v življenjskem ciklu v petnajstih letih. Odvisna spremenljivka je dihotomna in ima vrednost ena, če je anketiranec pravilno izbral aparat z najnižjimi skupnimi stroški življenjskega cikla, v nasprotnem primeru pa vrednost nič. Opozoriti je treba, da ti stroški vključujejo nakupno ceno in tudi stroške obratovanja. V vseh izbirnih karticah je bil energijsko učinkovitejši aparat, kot ga meri energijska nalepka, tudi dražji. Da bi anketiranci pravilno določili aparate z nižjimi skupnimi stroški življenjskega cikla, so morali pravilno izvesti izračun naložbe. Skupni stroški življenjskega cikla se izračunajo kot zmnožek števila let (petnajst), letne porabe energije (navedene na energijski nalepki v kWh) in cene električne energije (eurocent/kWh). Izračunu skupnih stroškov življenjskega cikla so dodani tudi letni obratovalni stroški. Ker smo na podlagi izvedene testne ankete predvideli nizke rezultate na področju finančne in energetske pismenosti, od anketirancev nismo zahtevali, da pri izračunu skupnih stroškov življenjskega cikla uporabijo diskontiranje. Enako velja za predvidevanje prihodnjih cen energije.

Eksperimentalni skupini je bila prikazana izbirna kartica z energijskimi nalepkami, ki je vsebovala informacije o letni porabi energije aparata v denarju (evrih), kontrolna skupina pa je prejela informacije o letni porabi energije v fizičnih enotah (kWh).

Poleg tega nas je zanimalo, ali energijska nalepka služi kot hevristični pripomoček in kakšno vlogo imata pri izbiri varčnejšega aparata energetska in finančna pismenost. Poskus izbire smo zasnovali tako, da bi polovica anketirancev prejela kartico z izbiro, na kateri bi se dolgoročno izplačal aparat s slabšo energijsko nalepko, za polovico anketirancev pa bi se dolgoročno bolj izplačal energetsko učinkovitejši aparat. Logika v ozadju takšnega oblikovanja poskusa je bila, da bodo anketiranci v primeru uporabe energijske nalepko zgolj kot bližnjice izbrali aparat z boljšim energetskim razredom, namesto da bi opravili izračun stroškov življenjskega cikla, da bi ugotovili, kateri aparat se bo dolgoročno izplačal. Pojasnjevalne spremenljivke, ki smo jih uporabili, so bile socio-demografske značilnosti posameznika, energetska pismenost, finančna pismenost, energetsko učinkovito vedenje, pozitiven ali zastonjkarski odnos do okoljskih vprašanj, število gospodinjskih aparatov in izkušnje z lastništvom energetsko učinkovitih aparatov. Anketiranci so po koncu eksperimenta izbrali, katere strategije odločanja so uporabili: izračun naložbe, primerjava cen, primerjava energetskih razredov itd.

Na reprezentativnem vzorcu 2,963 lastnikov stanovanj in najemnikov, ki smo ga analizirali z logit modelom, smo ugotovili, da finančna pismenost, energetska pismenost in pozitiven odnos do okolja pozitivno vplivajo na verjetnost informirane in racionalne odločitve o

nakupu energetsko učinkovitega gospodinjskega aparata, kar se kaže v nakupu stroškovno učinkovitejšega aparata. Ta študija tudi ugotavlja, da hevristična strategija odločanja, ki temelji le na primerjavi energetskih razredov na energijski nalepki, z večjo verjetnostjo vodi k napačni izbiri v primeru dveh aparatov s podobno ravnjo energetske učinkovitosti. Poleg tega je odsotnost denarnih informacij na energijskih nalepkah ugotovljena kot ovira za sprejemanje racionalnih odločitev. Z izjemo pozitivnega vpliva izobrazbe večina socio-ekonomskih značilnosti ne vpliva bistveno na pravilno izbiro stroškovno učinkovitih naprav. Status najemnika je povezan z manjšo verjetnostjo pravilne izbire stroškovno učinkovitejšega aparata, kar je mogoče razložiti tudi z deljenimi spodbudami ter finančnimi in časovnimi vidiki. Poskus izbire, v katerem se izplača izbrati aparat s slabšo energijsko nalepko, vodi k manjši verjetnosti pravilnega prepoznavanja stroškovno učinkovitih aparatov. Enako velja za hevristično strategijo odločanja, in sicer primerjanje energijskih nalepk namesto izvajanja naložbenih izračunov za določitev stroškovno učinkovitejšega aparata.

Zaključki, ki izhajajo iz rezultatov naše raziskave, kažejo, da samo sociodemografske značilnosti in značilnosti stanovanja in lokacije ne zadostujejo za pojasnitev odločitev o izvedenih energetsko učinkovitih prenovah v slovenskih gospodinjstvih. V disertaciji je ugotovljena tudi statistično značilna vloga življenjskega sloga, povezanega z bivanjem v domu, in socialnega kapitala kot dejavnikov, ki pozitivno vplivajo na energetsko učinkovite prenove doma. Prvo poglavje tudi pokaže, da so subvencije in ukrepi, ki vplivajo na organizacijsko infrastrukturo stavbe in spodbujajo oblikovanje skupnosti, pomembni ukrepi, potrebni za odpravo različnih ovir pri energetsko učinkovitih prenovah. V drugem in tretjem poglavju nadalje potrjujemo vlogo finančne pismenosti in okoljske ozaveščenosti pri izbiri energetsko učinkovite nepremičnine in izbiri stroškovno učinkovitih gospodinjskih aparatov. Pri izbiri stroškovno učinkovitih gospodinjskih aparatov je značilna tudi energetska pismenost.

Prav tako ugotavljamo, da so energijske nalepke in energetske izkaznice sicer koristne, vendar služijo predvsem kot hevristični pripomoček, saj anketiranci nimajo dovolj znanja za pravilno interpretacijo informacij na energijski nalepki, oziroma energetski izkaznici. V disertaciji tudi pokažemo, da zagotavljanje denarnih informacij o prihrankih energije na energijskih nalepkah za gospodinjske aparate izboljša njihovo učinkovitost pri obveščanju javnosti o stroškovno najučinkovitejšem aparatu. Pomembno priporočilo za izboljšanje učinkovitosti energijske nalepke za gospodinjske aparate je tako vključitev denarnih informacij in poenostavitev lestvice energijskih ocen.

Po drugi strani v disertaciji nismo ugotovili, da bi zagotavljanje denarnih informacij na energetskih izkaznicah povečalo njihovo učinkovitost kot informativnega ukrepa. Čeprav je odnos do energetskih izkaznic na splošno pozitiven, pa zaradi možnosti, da se izvzamejo iz certificiranja, in odsotnosti zakonske zahteve lastniki stanovanj nimajo dovolj spodbud za pridobitev energetske izkaznice. V proučevanem vzorcu gospodinjstev je tako 58.9 % anketirancev navedlo, da njihov dom nima energetske izkaznice. 42.4 % anketirancev je tudi

precenilo stroške pridobitve energetske izkaznice. To kaže na pomanjkanje znanja o energetskih izkaznicah, ki ga je mogoče izboljšati z boljšim obveščanjem lastnikov stanovanj o cenah in prednostih tega pomembnega informacijskega ukrepa. Potencialno koristna lastnost energetskih izkaznic za lastnike stanovanj so priporočila za stroškovno učinkovite prenove in druge ukrepe za zmanjšanje porabe energije. Z izboljšanjem in boljšo promocijo te lastnosti bi bili lastniki stanovanj motivirani za pridobitev energetske izkaznice in posledično za izvajanje priporočenih ukrepov.

V okviru energetske in finančne pismenosti ter na podlagi dobljenih rezultatov ugotavljamo, da so potrebne stalne izobraževalne in informacijske kampanje, ki povečujejo ozaveščenost o energetski učinkovitosti, zlasti na področju energetske pismenosti. Podobno kot v številnih drugih študijah, ki so raziskovale finančno in energetsko pismenost, smo tudi v našem vzorcu ugotovili nizko raven energetske pismenosti. 43.4 % anketirancev je namreč napačno odgovorilo na vsa vprašanja, povezana z energetsko pismenostjo, in le 1.7 % jih je pravilno odgovorilo na vsa vprašanja. Gospodinjstva torej v povprečju ne poznajo porabe elektrike posameznih naprav, ne poznajo svoje skupne porabe elektrike ali cen električne energije. Boljše rezultate smo dobili pri finančni pismenosti, saj je več kot 70 % anketirancev pravilno odgovorilo na tri ali več vprašanj, le 3.1 % anketirancev pa je napačno odgovorilo na vsa vprašanja. Poleg tega ob podanih informacijah o cenah in porabi energije več kot 40 % gospodinjstev ni znalo pravilno oceniti skupnih stroškov življenjskega cikla gospodinjskega aparata, kar omogoča sprejemanje racionalnih odločitev.

Težave so pomanjkanje informacij in pa lahko tudi kognitivne sposobnosti, ki jih presojanje upravičenosti investicij v energetsko učinkovitost zahteva. To kaže na potrebo po okrepitvi ukrepov informiranja, kot so ozaveščevalne kampanje, brošure in kalkulatorji za primerjavo alternativnih investicij, ki bi omogočili pridobitev tehtnih orodij in informacij o energetskih in stroškovnih prihrankih. To lahko podkrepimo tudi z ugotovitvijo, da gospodinjstva poleg subvencij, ki so med vsemi ukrepi energetske politike na prvem mestu, zelo visok pomen pripisujejo ravno ukrepom informiranja, kot so brezplačno energetsko svetovanje, digitalna spletna okolja (platforme) za iskanje, primerjavo ponudb in kontaktiranje energetskih strokovnjakov ter možnost izdelave energetsko učinkovitih projektov na ključ. V prihodnje bi veljalo več pozornosti nameniti tudi pametnim domovom, ki so dodaten potencial za izboljšanje energetske učinkovitosti v rezidenčnih stavbah. Pri tem je za uspešno vpeljavo novih tehnologij in konceptov pomembno, da končni odjemalci razumejo potencialne koristi in jih sprejmejo.

Skupne ugotovitve treh poglavij kažejo na potrebo po mešanici politik, ki bi temeljila na boljši promociji in pojasnjevanju informacij o energetskih izkaznicah in energijskih nalepkah, poenostavitvi energijskih nalepk in izkaznic, prikazu denarnih informacij na energijski nalepki, izobraževalnih in informacijskih kampanjah za povečanje energetske in finančne pismenosti, subvencijah za energetsko učinkovite prenove, ter ukrepih, ki spodbujajo gradnjo skupnosti in boljšo formalno organizacijo stavb. Izvajanje teh priporočil

bi izboljšalo sprejemanje odločitev ter prispevalo k doseganju ciljev energetske učinkovitosti in trajnosti v gospodinjstvih.

Appendix 2: Tables and figures

Table A.1: Descriptive statistics of variables used for the PCA

Variable	Mean	Std.Dev.	Min	Max
The spaciousness of my home is very important.[1]	5.564	1.279	1	7
The bigger the apartment, the better.[1]	4.072	1.631	1	7
It is important that my housing costs are as low as possible.[1]	6.131	1.133	1	7
The proximity of green areas is very important. [1]	6.242	1.037	1	7
The functionality of my home is very important. [1]	5.986	1.030	1	7
The functionality of a home is more important than its aesthetics. [1]	5.448	1.274	1	7
The quality of my home is more important than its size and cost. [1]	5.537	1.240	1	7
Our home is an ideal place to spend quality family time. [1]	5.843	1.193	1	7
My home is the first and most important haven for my family. [1]	6.277	1.015	1	7
I value the privacy of my home. [1]	6.380	0.896	1	7
My home is my mansion, where I set the rules. [1]	5.629	1.403	1	7
My friends' visits to my home are an important aspect of my social life. [1]	4.567	1.654	1	7
My friends and I often talk about our homes. [1]	4.066	1.594	1	7
It is important to me that my home reflects my social status. [1]	3.748	1.703	1	7
When I buy things for my home, I compare prices to get the most value for my money. [1]	5.982	1.106	1	7
It is important to me that everything in my home is of the highest quality. [1]	4.510	1.431	1	7
I read magazines and articles in which I get inspiration for future purchases and improvements to my home. [1]	4.203	1.794	1	7
All members of the family have a say in furnishing the home. [1]	5.548	1.434	1	7
In our family, we do housework together. [1]	5.222	1.530	1	7
I routinely do the necessary repairs and maintenance, as well as gardening according to the time of the year. [1]	5.354	1.396	1	7
I routinely check to see if anything in my home needs repair. [1]	4.743	1.599	1	7
My home is equipped with tools for necessary repairs. [1]	5.542	1.367	1	7
I think that maintaining a home is a man’s job. [1]	4.064	1.841	1	7
I use the washing machine or dishwasher only when it is full.[2]	4.352	0.806	1	5
I turn off the lights when I leave the room. [2]	4.557	0.692	1	5

To be continued

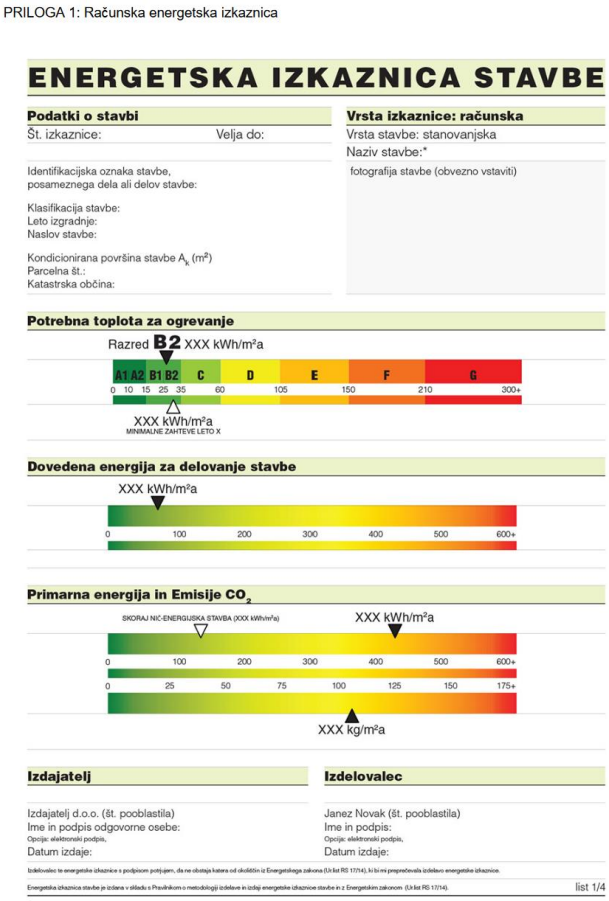
Table A.1: Descriptive statistics of variables used for the PCA (cont.)

Variable	Mean	Std.Dev.	Min	Max
I switch off electrical appliances (TV, PC, etc.) when I am not using them. [2]	3.717	1.201	1	5
I turn off the air conditioning when I'm not in the room (summer). [2]	3.857	1.461	1	5
I have a lower temperature setting during the night or periods of absence (heating season). [2]	3.881	1.259	1	5
I use household appliances (ex. washing machine, dryer, dishwasher) during the lower tariff periods. [2]	3.628	1.160	1	5

Notes: [1] Measured on a scale from 1 (completely disagree) to 7 (completely agree). [2] Measured on a scale from 1 (never) to 5 (always).

Source: Own work.

Figure A.1: Example of the first page of EPC


PRILOGA 1: Računska energetska izkaznica

ENERGETSKA IZKAZNICA STAVBE

Podatki o stavbi

Št. izkaznice: Velja do:

Identifikacijska oznaka stavbe, posameznega dela ali delov stavbe:

Klasifikacija stavbe:
Leto izgradnje:
Naslov stavbe:

Kondicionirana površina stavbe A_k (m²)
Parcelna št.:
Katastrska občina:

Vrsta izkaznice: računska

Vrsta stavbe: stanovanjska

Naziv stavbe:*

fotografija stavbe (obvezno vstaviti)

Potrebna toplota za ogrevanje

Razred B2 XXX kWh/m²a

A1 A2 B1 B2 C D E F G

0 10 15 25 35 60 105 150 210 300+

XXX kWh/m²a
MINIMALNE ZAHTEVE LETO X

Dovedena energija za delovanje stavbe

XXX kWh/m²a

0 100 200 300 400 500 600+

Primarna energija in Emisije CO_2

SKORAJ NIČ-ENERGIJSKA STAVBA (XXX kWh/m²a)

XXX kWh/m²a

0 100 200 300 400 500 600+

0 25 50 75 100 125 150 175+

XXX kg/m²a

Izdajatelj

Izdajatelj d.o.o. (št. pooblastila)
Ime in podpis odgovorne osebe:
Opcija: elektronski podpis,
Datum izdaje:

Izdelovalec

Janez Novak (št. pooblastila)
Ime in podpis:
Opcija: elektronski podpis,
Datum izdaje:

Izdelovalec te energetske izkaznice s podpisom potrjujem, da ne obstaja katera od okoliščin iz Energetskega zakona (Ur.list RS 17/14), ki bi mi preprečevala izdelavo energetske izkaznice.

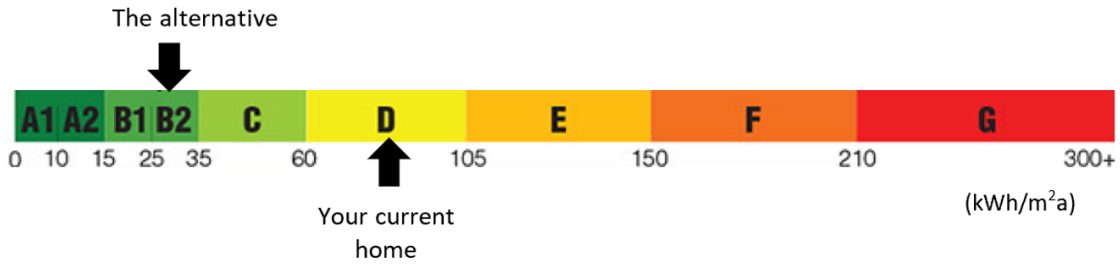
Energetska izkaznica stavbe je izdana v skladu s Pravilnikom o metodologiji izdelave in izdaji energetske izkaznice stavbe in z Energetskim zakonom (Ur.list RS 17/14).

list 1/4

Source: Ministry of Environment, Climate and Energy

Figure A.2: Example of a stated choice experiment card (control group)

Assume that you could choose between your current home and a property that has a better energy rating as measured by the energy performance certificate, but is otherwise comparable to your current home (e.g., location, size, furnishings, year of construction, etc.). A comparison of the information provided in the energy performance certificate for the two properties is given below. **Would you be willing to pay 4% more for a more energy-efficient home**?

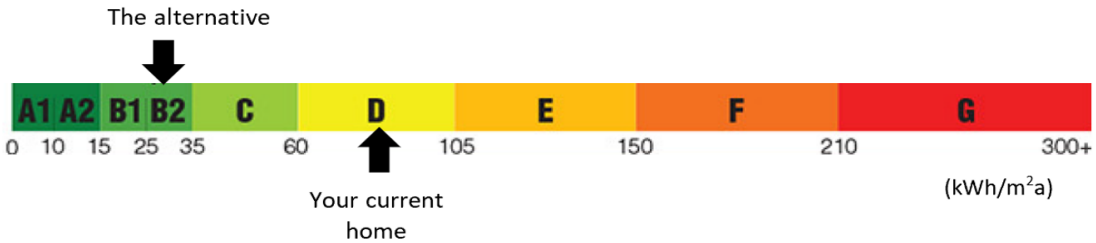


☐ YES
☐ NO

Source: Own work.

Figure A.3: Example of a stated choice experiment card (treatment group)

Assume that you could choose between your current home and a property that has a better energy rating as measured by the energy performance certificate, but is otherwise comparable to your current home (e.g., location, size, furnishings, year of construction, etc.). A comparison of the information provided in the energy performance certificate for the two properties is given below. The more energy-efficient property offers annual savings in energy costs of €489. **Would you be willing to pay 4% more for a more energy-efficient property**?



☐ YES
☐ NO

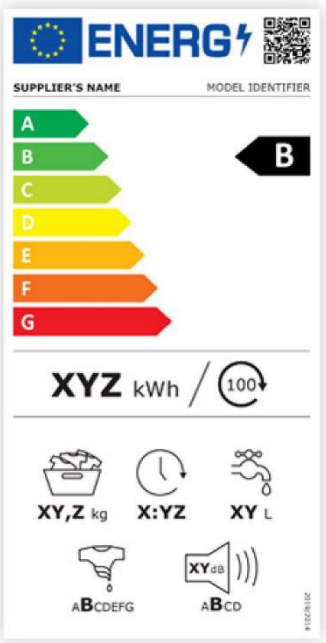
Source: Own work.

Table A.2: Share of correct and incorrect responses to questions related to financial literacy, energy literacy, and life-cycle cost calculation in the homeowner subsample (n=2,484)

Answers to questions related to financial and energy literacy	**Correct**	**Incorrect**
Financial literacy: interest rate and inflation	66.55%	33.45%
Financial literacy: time value of money	70.29%	29.71%
Financial literacy: risk diversification	72.42%	27.58%
Financial literacy: mathematical knowledge	84.10%	15.90%
Financial literacy: economics classes	43.72%	56.28%
Life-cycle cost calculation	59.66%	40.34%
Energy literacy: electricity price	11.39%	88.61%
Energy literacy: average monthly electricity consumption	12.96%	87.04%
Energy literacy: electricity costs of running a washing machine	26.77%	73.23%
Energy literacy: computer electricity consumption	37.64%	62.36%
Energy literacy: energy savings from using LED lightbulbs	17.51%	82.49%

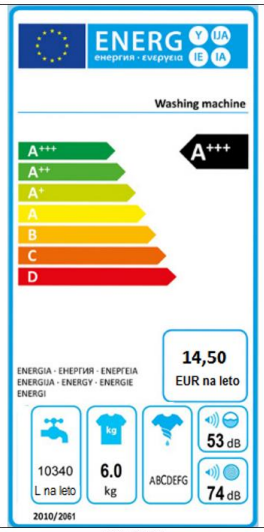
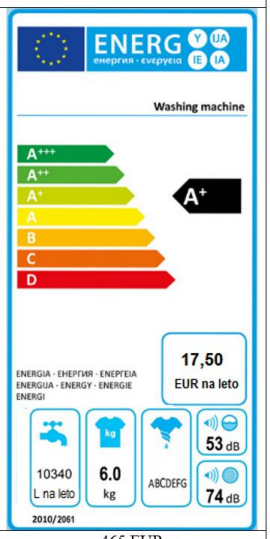
Source: Own work.

Figure A.4: Rescaled energy label for a washing machine



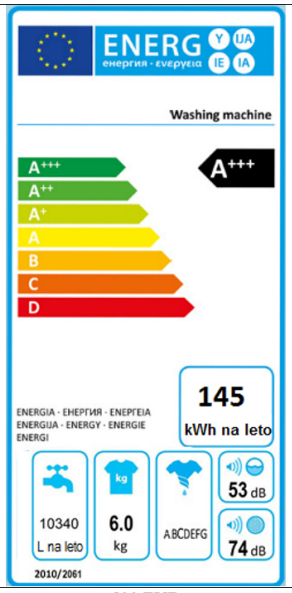
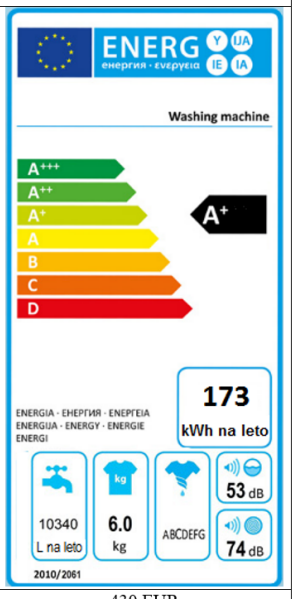
Source: European Commission's press release on new energy labels

Figure A.5: Example of a choice experiment card (treatment group)

Assume that your washing machine broke down and needs to be replaced. You can choose between two washing machines that are identical in size, design, and quality. Also consider that the useful life of a machine is 15 years and that €1 today is worth the same as €1 in 15 years. Which of the two washing machines do you think has lower overall costs over its lifetime?		
Energy label		
Price	500 EUR	465 EUR
Select one	☐	☐

Source: Own work.

Figure A.6: Example of a choice experiment card (control group)

Assume that your washing machine broke down and needs to be replaced. You can choose between two washing machines that are identical in size, design, and quality. Also consider that the useful life of a machine is 15 years and that €1 today is worth the same as €1 in 15 years. Which of the two washing machines do you think has lower overall costs over its lifetime?		
Energy label		
Price	500 EUR	430 EUR
Select one	☐	☐

Source: Own work.

Table A.3: Overview of financial literacy-related questions and responses (n=2,963)

Questions and responses	Freq.	Percent
Assume you have €100 in a savings account and the annual interest rate is 2%. Other than that, you do not intend to carry out any other transaction involving a deposit or withdrawal of money. How much money will you have in your account in 2 years?		
More than EUR 102 (correct answer)	1937	65.37
Exactly EUR 102 EUR	498	16.81
Exactly EUR 100 EUR	89	3.00
I don't know	439	14.82
Assume that the annual interest rate for your savings account is 1% and the annual inflation rate is 2%. How much will you be able to buy with the money in your account in one year?		
Less than today (correct answer)	2026	68.38
More than today	177	5.97
Same as today	241	8.13
I do not know	519	17.52
Please indicate whether the following statement is incorrect or correct: "Buying shares of one company is usually a safer investment than buying shares in several companies."		
Wrong (correct answer)	2093	70.64
Correct	173	5.84
I do not know	697	23.52
How do you rate your knowledge of mathematics?		
Better than most of the population	541	18.26
Comparable to the majority of the population	1934	65.27
Worse than most of the population	237	8.00
I do not know	251	8.47
Did you take a course in economics or business during your formal education?		
Yes	1252	42.25
No	1452	49.00
I don't remember	259	8.74

Source: Own work

Table A.4: Overview of energy literacy-related questions and responses (n=2,963)

Questions and responses	Freq.	Percent
Do you know how much you are currently paying on average for the price of electricity in EUR/kWh (excluding network charges, VAT, and other fees)?		
Correct answer	359	12.12
Wrong answer	307	10.36
I don't know	2,297	77.52

To be continued

Table A.4: Overview of energy literacy-related questions and responses (n=2,963) (cont.)

Questions and responses	Freq.	Percent
In your opinion, what is the average monthly electricity consumption per household in Slovenia, expressed in kWh?		
Correct answer	412	13.90
Wrong answer	304	10.27
I don't know	2,247	75.83
How much do you think it costs to run a washing machine for one wash?		
0 – 39 (euro) cents (correct answer)	794	26.80
40 – 59 cents	330	11.14
60 – 79 cents	187	6.31
80 – 100 cents	182	6.14
More than a 100 cents	236	7.96
I don't know	1,234	41.65
How much electricity in kWh do you think a personal computer uses in one hour?		
0 – 0.5 kWh (correct answer)	1,104	37.26
0.6 – 0.9 kWh	262	8.84
1 – 2 kWh	115	3.88
3 – 4 kWh	47	1.59
More than 5 kWh	23	0.78
I don't know	1,412	47.65
What % of energy do you think can be saved by using LED lamps instead of halogen lamps with the same luminosity?		
Up to 30%	559	18.87
31 to 50%	460	15.52
50 to 70%	621	20.96
More than 70% (correct answer)	493	16.64
I don't know	830	28.01

Source: Own work.