FinTech

Article

Crowdfunding and Energy Efficiency Contracting: Exploring New Pathways for Private Investment in Building Renovations

Renan Magalhães [1,*], Federico Narracci [2] and Jens Lowitzsch [1,2]

1 Kelso Professorship of Comparative Law, East European Business Law and European Legal Policy, Europa-University Viadrina, 15230 Frankfurt (Oder), Germany; lowitzsch@europa-uni.de
2 Kelso Institute Europe, 10965 Berlin, Germany; narracci@kelso-institute-europe.de
* Correspondence: magalhaes@europa-uni.de

Abstract: Energy Efficiency Contracting (EEC) enables structural improvements in buildings by financing upgrades through the savings generated, eliminating the need for upfront investment by property owners. Although the model supports the energy transition and the reduction in GHG emissions, its adoption in the private sector faces relevant barriers such as the lack of information from the Energy Service Companies (ESCOs), distrust from clients in benefits with no upfront costs, and legal and behavioral barriers. To overcome these challenges, the FinSESCo platform, funded by Era-Net 2020 joint call, aims to channel private investments into building renovations and renewable energy installations via a crowdfunding portal. The platform allows individuals and organizations to finance small-scale renewable energy installations and energy efficiency measures for homeowners, tenants, and apartment owners. The new platform is likely to change the way EE investments are made and reach out to new audiences. A survey of 2585 German households sought to understand the drivers of EE investments, factors affecting the decisions, and their relationships with several demographic variables. Using a stepwise backward regression model, the study found significant differences between traditional investors in EE and those who would use the FinSESCo platform. Low- and medium-income households were more likely to take up the platform, and previous renewable energy ownership, experience with EEC models, and knowledge of crowdfunding further raised willingness to participate. The results point to the potential of the FinSESCo platform to expand EEC to new audiences, underlining its role of democratization and diversification of investments in building energy efficiency.

Keywords: energy efficiency contracting; crowdfunding; energy service companies; energy savings; private investment; investment diversification; demographic and socioeconomic profiles

JEL Classification: Q42; D14; O33

check for updates

Academic Editors: Valentina Vasile, Otilia Manta and Shigeyuki Hamori

Received: 19 December 2024
Revised: 20 January 2025
Accepted: 22 January 2025
Published: 4 February 2025

Citation: Magalhães, R.; Narracci, F.; Lowitzsch, J. Crowdfunding and Energy Efficiency Contracting: Exploring New Pathways for Private Investment in Building Renovations. *FinTech* **2025**, *4*, 6. https://doi.org/10.3390/fintech4010006

1. Introduction

Energy Efficiency (EE) investments are central to advancing energy transition, abating greenhouse gas emissions, and fostering sustainability. Improvement in energy use in buildings and industry can lead to significant reduction in energy consumption and general costs, contributing, then, to decarbonization efforts. However, despite their potential, EE investments remain limited due to financial barriers, lack of awareness, and limited access to appropriate financing mechanisms.

Among the possibilities of EE funding, one is Energy Performance Contracting (EPC). EPC is a method to implement structural improvements and upgrades in buildings through financing that is repaid using the savings generated from the improvements themselves. This approach allows energy upgrades to be carried out without requiring the initial financing costs to be borne by home, apartment, or building owners [1,2]. As an ally in the energy transition, the fight against greenhouse gas emissions and electricity saving, this model is currently popular in the public sector (intracting) but faces challenges in expanding to the private market [2–4]. Barriers include insufficient information available to Energy Service Companies (ESCOs) about potential projects and skepticism regarding the ease of gaining benefits without upfront investment from property owners [4]. Legal bureaucratic barriers and the ESCOs' inability to control user behavior regarding energy efficiency further limit acceptance of the model [4].

The most common contracting models for EPC are guaranteed savings and shared savings. The primary difference between these two models is the payment structure for the ESCO and which party assumes the credit risk. In the guaranteed savings EPC structure, the customer finances the project and therefore assumes the credit risk. The ESCO guarantees a predetermined level of energy savings, which provides an income stream in the form of avoided costs to repay the project investment. In the EPC shared savings structure, the project is fully financed by the ESCO, and the cost savings are shared between the customer and the ESCO for a predetermined period of time [5]. EPC or ESPC are very useful financial models for energy contracting because they connect interested customers with ESCOs that have the technical expertise to implement EE or RE projects [6]. An EPC or ESPC also provides a favorable cost structure for clients, as they repay project costs based on energy savings/profits rather than large initial investment burdens, which is typically a major barrier [4,6].

Regardless of the simple principle behind energy contracting, the uptake of EE retrofit projects, particularly in the building sector, has been slow [7,8]. Access to capital is a primary barrier for many interested buildings or facility owners. An EE project may require a large up-front investment to cover equipment, renovations, technology, expertise, labor, and other factors [9,10]. Many stakeholders interested in undertaking an EE project lack the capital to support a large-scale project. This may discourage many individuals from committing to an EE project because they cannot or will not take on the risk of debt [11,12]. Instead, they may cherry-pick a few short-term measures that result in small EE improvements instead of larger projects that have the potential to significantly reduce their energy demand [6,13]. An ESCO can help overcome this barrier by providing financing for the project, but they also have limitations. Only large ESCOs can financially support multiple projects simultaneously. Smaller ESCOs, on the other hand, must be more selective about the projects they take on because they do not have the capital backing of a larger company to continually launch projects. As a result, EE projects are often hampered by financing issues, even though their business case would be profitable. Against this background, the EPC and ESPC sector is in need of innovative financing solutions [6,11].

The FinSESCo—Fintech Platform Solution for Sustainable Energy System Intracting and Contracting, funded by the Era-Net 2020 joint call—aims to address these issues by streamlining investment processes, reducing transaction costs, and leveraging economies of scale to expand the pool of profitable investments. The mission of the project is to enable a wave of decarbonization projects by facilitating the establishment of Energy Performance and Energy Savings Performance Contracting EPCo/ESPCo through the end-to-end digitization of energy contracting (and the contracting process for public entities and larger companies) and enabling EE projects to take into place by crowdfunding investment. Using pre-existing data from building passports and energy audits, platform modules offer a gamified investment process with diversification options in an investor dashboard, smart contracts, a digitally encrypted meter-based repayment process, and machine learning-based fault detection during operation. A guidance tool allows potential portal developers to steer their projects in the right direction.

Potentially, the fintech environment will be able to reach a larger number of investors, democratizing and diversifying the field of energy efficiency and overcoming the above-mentioned barriers. This research, therefore, aims to outline a profile of key stakeholders interested in the platform, identify gaps in investment and interest, and link overlooked groups to the use of the platform, as we expect that the digital environment of investments can significantly change the profile of EE investments.

This paper is structured as follows: Section 2 provides the literature review. Section 3 introduces the material and methods underlying our analysis. Section 4 presents the results of the analysis and Section 5 delivers the corresponding discussion. Finally, Section 6 concludes and considers the policy implications of our results.

2. Theoretical Background

Literature identifies barriers that prevent users from engaging with EPCo and EE contracting measures. One of the most important barriers is a lack of awareness or information. Because the energy contracting and ESCO industries are still developing, many people, such as building owners, bankers, or lawyers, are not familiar with energy performance contracting and its financing method [4,14]. Therefore, it is not easy to convince clients to undertake a project as it is a foreign concept, and they may be reluctant to proceed. Also, the intuitions that support the project or the procurement process may not have the necessary information or awareness [15]. This circumstance greatly hinders project development. If parties are not properly informed about the EPC, or if access to information is associated with high barriers to entry due to the complexity of the topic, it creates unclear processes for all stakeholders. As a result, EPC models have a diminished potential to be used in practice, despite the unique idea for the ongoing decarbonization trend. Complex legal and contractual issues are another barrier that needs to be addressed to increase the uptake of EPC, as the legal documentation for EPC is complex and novel. The ESCO and potential customers often struggle to navigate the contractual landscape with its associated obligations, benefits, and risks. In addition, the lack of standardization of the energy performance process adds to the legal uncertainty [15].

The engagement, or lack thereof, of consumers in the energy transition is also significantly influenced by their perceived "ownership" of emerging energy systems. This ownership extends beyond legal definitions to include societal responsibility, behavioral change, and equitable distribution of benefits and burdens. Despite these broader implications, active participation in energy efficiency, prosumership, and energy system governance remain limited to a minority of financially capable early adopters and environmental activists [16,17]. Most citizens are excluded from these activities, highlighting the need for inclusive strategies that facilitate broader engagement.

An examination of green investment opportunities highlights the disparity in participation. Only a few can afford to invest in photovoltaic systems for their roofs, while tenants who cannot modify their rented properties face even greater challenges [18]. This results in a renovation rate in Germany that is significantly lower than its potential [6,19,20]. The commercial sector, despite the potential for high energy ROI, struggles with external financing constraints and limited resources for design and procurement [6,20,21]. Energy Service Companies (ESCOs) and Energy Performance Contracting Companies (EPCos) play a critical role in bridging this gap by providing expertise in design, implementation, and financing. However, these entities require a high ROI to cover the risks, adding another layer of complexity.

Digital platforms through fintech initiatives could be viewed as an alternative to facilitate investment in energy efficiency measures. The new fintech solutions, including mobile payments, blockchain, and crowdfunding, reduce the costs of financial service delivery and improve access, especially to underserved areas, since fintech investments have shown to improve environmental efficiency and promote sustainable development goals [22]. Digital platforms afford unique opportunities to surmount the barriers present in traditional investment methods, such as access to capital and long decision-making processes, by lowering costs of delivering financial services and expanding their accessibility [23]. In addition, the introduction of ECF platforms further illustrates how disruptive technologies with social and environmental value propositions can attract investors to support sustainable initiatives [24]. Their digital nature, added to the focus on sustainability and innovation, is expected to drive significant differences in how investments are made compared to traditional financial mechanisms, fostering quicker adoption and greater inclusiveness in EE measures.

Considering only the research for traditional EE investment, we see a complex interplay between a variety of motivational drivers, what we call in this paper controllers and socioeconomic factors, that seem to present a vast possibility of combinations that influence energy efficiency investments and behavioral changes. Previous research shows that investment in EE appliances, as well as the willingness to change behavior, is associated with environmental behaviors and the motivation to limit individual environmental impact [25–28], although it can be constrained by costs. That is, low-cost investments are more strongly associated with environmental consciousness, while high-cost investments are not primarily driven by it [29]. Knowledge about the methods also positively influences and serves as a driver for investment [30]. In some contexts, however, financial considerations appear to be the major factor leading to EE spending [31]. This driver also varies according to the income group an individual belongs to, as financial savings do not act as the main motivator for high-income households but are a key factor for low-income ones [30].

Controllers may also redirect the willingness of investment in EE. There is a positive association between renewable energy (co-)ownership and the willingness to invest in EE [32] although it can vary depending on the type of prosumership (the ones that produce energy for self-consumption, just to sell excess and the fully fledged—the ones that do both) [32]. Homeownership (combined with higher income) also seems to play a role in increasing the willingness to invest [30,33,34]. Considering the equity crowdfunding functionality of the platform, we must consider what can lead to the investment. Past research shows that willingness to undertake crowdfunding investments in green energy is increased by past experiences utilizing the concept while moderated by the knowledge of environmental questions [35]. In stronger markets, the concept of crowdfunding is more consolidated and, therefore, more spread in the society, increasing the possibility of users having past experiences, and it also increases the willingness to support projects [36,37]. At the same time, past EE investment can boost the willingness of future EE investments [38], showing that knowledge of different EE investment models can lead to a cycle of what triggers more EE investment.

Regarding the socioeconomic profiles, previous research has shown that age plays a positive role in increasing the willingness to invest in energy efficiency measures [34], with older and middle-aged individuals more likely to invest than younger ones. Gender does not appear to significantly influence energy efficiency investments [33,34], while education level may vary in its influence, sometimes affecting certain types of energy efficiency investments. The level and complexity of investments tends to increase with higher education levels [33].

However, we assume that the order of importance and the interaction of these drivers, controllers, and socioeconomic factors and their influence on the willingness to invest may shift or be differently impacted by the digital factor. Aiming to fill this research gap, to compare both models, and to guide the FinSESCo consortium to understand the profile of investors of EE measures via fintech while comparing to the ones in a traditional environment, a survey with German households was conducted in 2023. The resulting dataset allows us to correlate interest in the platform, knowledge of energy efficiency contracting models, and previous experience with crowdfunding investments in energy efficiency behavior. We translated our interests into four main research questions, trying to predict which groups would be interested in using the platform by interacting with the different groups of variables (controllers and drivers), socioeconomic factors, and the willingness to invest in EE and to invest in the FinSESCo platform:

1. What are the main drivers for investment in energy efficiency measures?
2. What are the main barriers for investment in energy efficiency measures?
3. Given the availability of options such as the FinSESCo platform, is it a determining factor for investing in energy efficiency?
4. Which groups are most likely to use the platform based on different socioeconomic demographics, real estate ownership, and experience in renewables?

3. Materials and Methods

This section presents the methods applied in this paper, discussing the process of data collection, the sample, and the measurement, describing the models used.

3.1. Deliberations on the Data Collection

The questionnaire used for the data collection process was inspired by previous questionnaires developed by Roth et al. [32,39]. At the time, Roth et al. [39] conducted data collection among users of a real estate portal in Germany, focusing on reaching the largest possible number of people who (co-)own renewable energy production facilities. This process served as the foundation for structuring our own survey, with a focus on measuring the energy efficiency behaviors and demand-side flexibility of renewable energy prosumers. The databases collected by Roth et al. were also used for similar investigations, such as in [32], where they examined which types of (co-)ownership were associated with the willingness to adopt and invest in energy efficiency measures. These studies share clear similarities with our research interests. Consequently, we adopted similar questions or adapted them to suit the context of our study.

Following this new survey and data collection effort, the resulting database targets a broader range of prosumers and ensures a more balanced distribution across gender and income levels, reaching a larger number of low-income prosumers, non-prosumers, and female prosumers.

It was conducted by the survey company Norstat between 28 August 2023 and 23 November 2023, utilizing its pool of respondents and filters established by its team to target prosumers within it. Thus, the questionnaire may not be representative of the demographics of German prosumers—how they are distributed across different societal strata, the main sectors they represent, or how to infer the percentage of prosumers in the country; data related to these factors are still unknown [40]. The questionnaire initially aimed to be representative of German society, aligning with the distributions in relation to the population of the states, age groups, and gender. Small adjustments were made during the data collection, with invitations sent to groups where a higher concentration of prosumers was observed without the use of filters. In the final phase of the collection, to achieve the expected numbers, internal questionnaire filters were used to exclude non-prosumers, and at the last moment, all those who were not female prosumers were excluded.

The data were collected to address the interests of FinSESCo, aiming to outline a profile of the main stakeholders interested in the platform, identify investment and interest gaps, and match overlooked groups with the platform's usage. Possible relationships between potential platform usage and prosumership were translated into questions on the platform to utilize the data as broadly as possible. The data allow for the correlation of interest in the platform, knowledge of energy efficiency contracting models, and past experiences in crowdfunding investing in energy efficiency behavior, enabling a series of possible analyses for consumption habits to be tested. A summary overview of the data can be found in Appendix B.

3.2. Deliberation on the Sample

The total sample of the database consists of 2585 complete questionnaires. We have selected the main demographic and control variables for prosumership to briefly summarize the data characteristics. It is important to note that our database includes a high number of prosumers—a total of 925, with 464 of them being females. This is a robust database for understanding prosumer behavior, comparing it with non-prosumers, and conducting internal comparisons between genders and types of prosumership.

Our database initially aimed to be representative of the German demographic. Therefore, we sought to mirror the distribution by age groups according to the country data. However, as we tried to boost the number (co-)owners of the data, the invitations for the questionnaire focused on groups with a higher likelihood of encountering prosumers. Therefore, the data cannot be used to infer the number of prosumers in Germany.

To ensure the quality of the dataset, we conducted an outliers test, *t*-test, and Wilcoxon test to examine differences in the samples of regular respondents and those who completed the survey after an interruption; this was in the form of syntax analysis searching for unusual values and characters. Additionally, we investigated the cooperation required to respond properly to matrix questions and the estimated time to complete the questionnaire. From the initial sample of 2585, we removed 31 questionnaires due to potential issues regarding their quality.

Income levels are defined based on thresholds derived from the median income. Specifically, incomes below 60% of the median are classified as low, those between 60% and 150% of the median as medium, and incomes above 150% of the median as high, using the main thresholds used for countries in the European Union [41].

3.3. Deliberation on the Measurement

In our questionnaire, we have designed specific questions to understand the level of understanding of German households regarding energy efficiency contracting, their willingness to invest in models like FinSESCo, and their willingness to invest in energy efficiency in general.

To calculate their willingness to invest in EE measures, we have asked if they have already invested in energy efficiency measures to reduce electricity consumption or investment in measures to reduce requirements for heating. The respondents could also select which of the following types of investments they have made:

- v_33_1: Replacing lighting with energy-efficient LED lamps;
- v_33_2: Replacing household appliances;
- v_33_3: Replacement of other electronic entertainment devices;
- v_33_4: Other;

- v_39_1: Replacement of windows;
- v_39_2: Renovation of the insulation of the house;
- v_39_3: Technical devices for heating management purchased;
- v_39_4: Replacing the circulation pump;
- v_39_5: Installation of a heat pump;
- v_39_6: Other.

They were also asked if they are planning on performing these following measures:

- v_36_1: Replacing lighting with energy-efficient LED lamps;
- v_36_2: Replacing household appliances;
- v_36_3: Replacement of other electronic entertainment devices;
- v_36_4: Other;
- v_44_3: Technical devices for heating management purchased;
- v_44_4: Replacing the circulation pump;
- v_44_5: Installation of a heat pump;
- v_44_6: Other.

For each question, the respondent could opt for 0 (no), or 1 (yes), meaning that they had invested or are planning to invest for each specific measure. Afterwards, after being briefly introduced to the models and how the platform will work, we asked the following questions:

- v_63_1: Are you familiar with “Energy Savings Performance Contracting” or “Energy Savings Contracting”?
- v_64_1: Would you use an Energy Savings Performance Contracting Service via FinSESCo?
- v_65_1: Have you ever used crowdfunding to fund your own project?
- v_66_1: Have you ever invested money through crowdfunding to finance a third-party project?

Afterward, respondents were asked to rate on a scale from −3 to +3, representing “Not familiar at all” to “Very familiar” for the first question, and “I wouldn’t use it under any circumstances” to “I would definitely use it” for the second. We transformed the scale from −3 to 0 as 0, meaning individuals who were not familiar and/or “people who would not use the FinSESCo model”, and from +1 to +3 as individuals who were familiar and would use the FinSESCo platform.

Respondents were are also asked what were their main drivers to invest or plan to invest in EE measures:

- v_40_1: Financial motivation;
- v_40_2: Environmental protection motivation;
- v_40_3: Previous knowledge motivation;
- v_40_4: Climate change motivation;
- v_40_5: Energy autonomy motivation;
- v_40_6: To sell excess energy motivation.

For each answer, respondents could opt on a Likert scale from 1 (strongly disagree) up to 5 (strongly disagree). Details of the questionnaire are found in Appendix A.

3.4. Deliberations on the Model Specification

Our analysis is based on backward stepwise regressions. Backward stepwise regression is a statistical method used for building regression models. In this approach, all independent variables are initially included in the model, and then, step by step, variables are removed based on their statistical significance until only the most significant variables remain [42]. The backward stepwise regression starts with a full model containing all independent variables and gradually removes variables that contribute the least to the model's predictive power [43,44]. This process continues until no further variables can be removed without significantly affecting the model's fit. Overall, backward stepwise regression is a valuable tool for identifying the most influential variables and building a predictive [45] model that accurately captures the relationship between independent and dependent variables in our analysis. In our analysis, the significance level of α is < 0.05, as per [46].

For this, we have created four different models. The models have as independent variables either an index to calculate the willingness to invest in EE measures using the FinSESCo prototype platform (index_finsesco) or the willingness to invest in EE measures in general (index_ee).

The "index_finsesco" quantifies the willingness of respondents to use the FinSESCo platform, converting responses to the question "Are you familiar with 'Energy Savings Performance Contracting' or 'Energy Savings Contracting'?" (v_63_1) from a scale of −3 to +3, representing "Not familiar at all" to "Very familiar" for the first question, and "I wouldn't use it under any circumstances" to "I would definitely use it" for the second. (a.) The value of the variable v_63_1, here named y1, contains values on scale of 1 to 6; (b.) subsequently, we perform a log transformation. Log transformation is used to normalize skewed data, reduce the impact of extreme values, and make the data more normally distributed [47] as many behaviors and perceptions follow a skewed distribution, where a few individuals exhibit extreme behaviors or attitudes [48]. Log transformation helps in stabilizing the variance and making the data [47]; (c.) to this value, we add a constant of 1. Adding a constant (in this case, 1) before applying log transformation is a common practice to handle zero or negative values, since the log of zero is undefined; adding a constant ensures that all values are positive and, hence, their logarithms can be computed; (d.) we normalize the value by dividing it by the mean of the values. (e.) Finally, we take the square root of the total. Normalizing by the mean value of the transformed variables helps in standardizing the scores and making them comparable. This step ensures that the index is not biased by the scale of the original variables and is interpreted on a common scale.

Considering γ_1 as the variable v_64_1, the value of index_finsesco can be seen in the following operation:

$$indexfinsesco = \frac{\sqrt{log(\gamma_1) + 1}}{\left(\sqrt{log(\gamma_1) + 1}\right)} \quad (1)$$

Subsequently, *index_ee* is calculated. Considering V, the group of variables, V = {v33,1,v33,2, ...,v44,6}, with 18 variables in total; Xi is the sum of valid (non-NA) values for row i and variable j:

$$X_i = \sum_{j \in V} vi, j, \ where \ vi, j \neq NA. \quad (2)$$

Then, a log transformation is applied to the sum of valid values for row i, adding 1 to avoid log of 0, with a square root transformation to the log-transformed sum:

$$Z_i = \sqrt{Y_i} = \sqrt{\log(X_i + 1)} \quad (3)$$

Finally, the value is normalized by computing the average of the square root-transformed values for all rows, I, and dividing the square root value by the mean, μ_Z:

$$\mu_Z = \frac{1}{n}\sum_{i=1}^{n} Z_i, \ where \ Z_i \neq NA \quad (4)$$

The value for index_ee is then:

$$index\_ee_i = \frac{Z_i}{\mu_Z} \tag{5}$$

After creating the independent variables, we divide the independent variables into three groups: drivers, controllers, and demographics. The following is the list of variables used in the four models calculated in this analysis [Table 1].

Table 1. Variables of the models.

Variable	Description
	Indexes:
Y_1	index willingness to invest in energy efficiency
Y_2	index willingness to invest via FinSESCo
	Drivers:
X_1	v_40_1: Financial motivation [25–28]
X_2	v_40_2: environmental protection motivation [29]
X_3	v_40_3: previous knowledge motivation [30,38]
X_4	v_40_4: climate change motivation [29]
X_5	v_40_5: energy autonomy motivation [32]
X_6	v_40_6: to sell excess energy motivation [32]
	Controllers:
X_7	Home Ownership [30,33,34]
X_8	Previous experience in crowdfunding [35]
X_9	Previous knowledge in energy efficiency contracting [38]
X_{10}	Prosumer [32]
	Demographics:
X_{11}	Income: Low [30]
X_{12}	Income: Medium [30]
X_{13}	Income: High [30]
X_{14}	Age [34]
X_{15}	Gender [33,34]
X_{16}	Education [33]

Source: Own elaboration.

In our analysis, we employed bootstrapping to enhance the robustness and reliability of our regression models' coefficients [49]. Bootstrapping involves repeatedly resampling the original dataset with replacement and estimating the model on each resampled dataset. This process mitigates the influence of outliers, providing more accurate confidence intervals [50,51]. Specifically, the data were resampled 10,000 times to ensure a comprehensive and reliable estimation of the model parameters, where each sample had the same size as the original dataset.

We then calculated Cook's distance to identify influential points in the dataset [52] and remove the ones exceeding 4/n, where n is the number of observations. A new regression model was fitted to the dataset without the influential points, again, performing a backward stepwise regression. The results of Cook's distance analysis are present in Appendix C.

To answer our research questions, we created four different regression models: (i) considering as the independent variable the index to calculate the willingness to invest in EE and the interactions of the drivers and the demographic variables; (ii) the index to calculate the willingness to invest in EE and the interactions of the controllers and the demographic variables; (iii) considering as the independent variable the index to calculate the willingness to invest via FinSESCo and the interactions of the drivers and the demographic variables; and (iv) the willingness to invest via FinSESCo and the interactions of the controllers and the demographic variables. The following are the models:

Model I:

$$Y_1 = \beta_0 + \sum_{i=11}^{13} \beta_i X_i + \sum_{j=14}^{16} \beta_j X_j + \sum_{k=1}^{6} \beta_k X_k + \sum_{i=11}^{16} \sum_{k=1}^{13} \beta_{ik} X_i X_k + \epsilon$$

Model II:

$$Y_1 = \beta_0 + \sum_{i=11}^{13} \beta_i X_i + \sum_{j=14}^{16} \beta_j X_j + \sum_{m=7}^{10} \beta_m X_m + \sum_{i=11}^{16} \sum_{m=7}^{10} \beta_{im} X_i X_m + \epsilon$$

Model III:

$$Y_2 = \beta_0 + \sum_{i=11}^{13} \beta_i X_i + \sum_{j=14}^{16} \beta_j X_j + \sum_{k=1}^{6} \beta_k X_k + \sum_{i=11}^{16} \sum_{k=1}^{13} \beta_{ik} X_i X_k + \epsilon$$

Model IV:

$$Y_2 = \beta_0 + \sum_{i=11}^{13} \beta_i X_i + \sum_{j=14}^{16} \beta_j X_j + \sum_{m=7}^{10} \beta_m X_m + \sum_{i=11}^{16} \sum_{m=7}^{10} \beta_{im} X_i X_m + \epsilon$$

For all models, coefficients $\beta_0, \beta_i,\ \beta_j,\ \beta_k,\ \beta_m,\ \beta_{ik},\ \beta_{im}$ are estimated using resampled datasets from 10,000 bootstrap iterations. Each model includes the interaction terms between demographic variables and either drivers or controllers, and ε accounts for the unexplained variance or error in the models. Each model is used to answer the four different research questions proposed after the analysis presented in the previous section. All calculations were performed using RStudio with R version 4.4.0.

4. Results

The following paragraphs outline the results of the stepwise regression models that were developed to answer the research questions. The regression tables highlight the significance and impact of the most relevant predictors on the dependent variables. In a stepwise approach, only the most influential variables are kept, enhancing interpretability [Table 2].

For our model I, we see that environmental protection motivation (v_40_2) and energy autonomy motivation (v_40_5) are the main drivers to increase the willingness to invest in EE. The increase in the age variable seems to play a positive effect, although it is on the border of being a statistically significant predictor. The low-income variable has a negative direction of the estimate, while the high-income variable has a positive one, although the interaction of low-income with a previous knowledge driver (v_40_3) results in a positive direction [Table 3].

Table 2. Interaction of Drivers and Demographics on the willingness to invest in EE.

Term	Estimate	Std. Error	p Value	
(Intercept)	1.038972	0.06088	$<2 \times 10^{-16}$	*
Income: Low	−0.08131	0.030025	0.006845	*
Income: Medium	0.002593	0.0413	0.949952	
Income: High	0.103556	0.04175	0.013233	*
Age	0.001921	0.00099	0.052436	
Academic	−0.03643	0.027474	0.185067	
v_40_2	0.029971	0.007847	0.000139	*
v_40_3	0.007181	0.004154	0.084071	
v_40_4	−0.01126	0.007328	0.1246	
v_40_5	0.051021	0.014993	0.000684	*
v_40_6	−0.02234	0.00717	0.001871	*
Income: Low: v_40_3	0.01879	0.009117	0.039489	*
Income: Medium: v_40_5	−0.02027	0.009041	0.02509	*
Income: Medium: v_40_6	0.028237	0.009232	0.002263	*
Income: High: v_40_4	0.024179	0.012454	0.052399	
Income: High: v_40_5	−0.01504	0.009223	0.103066	
Age: v_40_5	−0.00049	0.000272	0.071738	
Academic: v_40_6	0.015923	0.008699	0.067391	

Source: Own elaboration. * indicates statistical significance at $p < 0.05$. Residual standard error: 0.1712 on 1510 degrees of freedom; Multiple R-squared: 0.06525, Adjusted R-squared: 0.05906; F-statistic: 10.54 on 10 and 1510 DF, p-value: $<2.2 \times 10^{-16}$.

Table 3. Interaction of Controllers and Demographics on the willingness to invest in EE.

Term	Estimate	Std. Error	p Value	
(Intercept)	1.235	0.02028	$<2 \times 10^{-16}$	*
Income: Low	−0.04087	0.01309	0.001824	*
Income: High	0.01623	0.0102	0.111989	
Age	−0.000079	0.000381	0.836263	
Academic	−0.003209	0.01036	0.756673	
Home Ownership	0.04979	0.00972	3.41×10^{-7}	*
Crowdfunding Experience	0.03687	0.01116	0.000977	*
EPCo Experience	−0.136	0.05655	0.01629	*
Income: Low: EPCo Knowledge	0.1222	0.0422	0.003841	*
Age: EPCo Knowledge	0.002372	0.00119	0.046356	*
Academic: EPCo Knowledge	0.08161	0.02842	0.004142	*

Source: Own elaboration. * indicates statistical significance at $p < 0.05$. Residual standard error: 0.1712 on 1510 degrees of freedom; Multiple R-squared: 0.06525, Adjusted R-squared: 0.05906; F-statistic: 10.54 on 10 and 1510 DF, p-value: $<2.2 \times 10^{-16}$.

In our model II, only low-income households appear to have a statistically significant coefficient to predict the willingness to invest in EE, playing a negative factor, although the interaction with familiarity with energy efficiency contracting inverts the direction. Previous experience with crowdfunding and especially home ownership seems to have a statistically significant impact on the increase in index_ee. Prior knowledge about energy efficiency contracting has a negative coefficient; however, its interactions with the academic (people with a high education degree) variable and age both have a positive effect [Table 4].

Table 4. Interaction of Drivers and Demographics on the willingness to invest using the FinSESCo platform.

Term	Estimate	Std. Error	p Value	
(Intercept)	1.384391	0.108056	$<2 \times 10^{-16}$	*
Income: Low	0.077879	0.100578	0.438824	
Income: Medium	−0.07522	0.085317	0.378087	
Income: High	−0.02557	0.082289	0.756056	
Gender	0.169004	0.084368	0.045276	*
Age	−0.00136	0.000811	0.09443	
Academic	−0.09107	0.063354	0.150698	
v_40_1	−0.04571	0.011734	0.000101	*
v_40_3	0.003849	0.013521	0.775919	
v_40_4	0.026997	0.017248	0.117676	
v_40_5	−0.07627	0.013109	6.78×10^{-9}	*
v_40_6	−0.01456	0.016307	0.372144	
Income: Low: v_40_1	−0.03836	0.025142	0.127252	
Income: Medium: v_40_6	0.050084	0.026072	0.054855	
Income: High: v_40_5	0.054662	0.020287	0.007101	*
Gender: v_40_4	−0.05572	0.021245	0.008783	*
Academic: v_40_3	0.047107	0.02005	0.018885	*

Source: Own elaboration. * indicates statistical significance at $p < 0.05$. Residual standard error: 0.4988 on 2275 degrees of freedom; Multiple R-squared: 0.07522, Adjusted R-squared: 0.06871; F-statistic: 11.56 on 16 and 2275 DF, p-value: $<2.2 \times 10^{-16}$.

In our model III, although not statistically significant, we see for the first time the low-income variable being associated with a positive effect in the dependent variable. The variable gender has a positive and statistically significant effect on the willingness to invest in EE via the FinSESCo platform. This index also increases with the interaction of the high-income variable and the driver for energy autonomy [Table 5].

Table 5. Interaction of Controllers and Demographics on the willingness to invest using the FinSESCo platform.

Term	Estimate	Std. Error	p Value	
(Intercept)	4.127004	0.168481	$<2 \times 10^{-16}$	*
Income: Low	0.292901	0.116232	0.01181	*
Income: Medium	0.206155	0.095596	0.03115	*
Income: High	0.37052	0.113093	0.00107	*
Gender	−0.015558	0.06387	0.80758	
Age	−0.01805	0.003026	2.83×10^{-9}	*
Academic	0.119923	0.061975	0.05311	
Home Ownership	−0.248104	0.2126	0.24334	
Crowdfunding Experience	0.133435	0.109454	0.22293	
Prosumership Experience	0.207034	0.080738	0.0104	*
EPCo Knowledge	0.866511	0.141527	1.08×10^{-9}	*
Income: Low: Home Ownership	−0.320667	0.164468	0.05133	
Income: High:Prosumership Experience	−0.178546	0.125641	0.15543	
Gender: Crowdfunding Experience	0.269898	0.146185	0.06498	
Gender: EPCo Knowledge	−0.306526	0.190073	0.10695	
Age: Home Ownership	0.006661	0.004337	0.12477	

Source: Own elaboration. * indicates statistical significance at $p < 0.05$. Residual standard error: 1.322 on 2265 degrees of freedom; Multiple R-squared: 0.09531, Adjusted R-squared: 0.08932; F-statistic: 15.91 on 15 and 2265 DF, p-value: $<2.2 \times 10^{-16}$.

Finally, in our model IV, although the high-income variable plays a positive effect in the willingness to invest in EE via the FinSESCo platform, the low-income variable seems to have a higher effect than the medium-income one. In this model, the increase in the age variable is associated with a negative effect on the dependent variable, and its value is highly statistically significant, as is the previous knowledge of EPC, but this time it is a positive effect. Past experiences with prosumership also have a positive effect on the index finsesco.

5. Discussion

In this section, we discuss the results in the context of existing literature and the theoretical framework.

Discussion of the Results

For model I, with HIHs having the largest propensity to invest, previous research indicating that the lack of financial means is an obstacle to EE investments is corroborated. Within the groups that have a higher propensity to invest, i.e., HIHs and MIHs, positive drivers appears to be "counteracting climate change" for HIHs and the drive to "sell excess energy" for MIHs. On the other hand, with regard to LIHs, we observe that previous knowledge motivation is an incentive.

Thus, these results confirm previous research, showing that HIHs and MIHs, motivated by counteracting climate change, have a strong willingness to invest in EE. The emphasis on pro-environmental attitudes as drivers supports the point on social motivations for investment [53]. This result is also supported by [54]. The option to receive monetary returns from surplus energy motivates MIHs to invest, highlighting how financial incentives can bolster demand flexibility [53,55]. In the context of Renewable Energy Communities, the literature shows that financial means among consumer-sellers (who are typically from HIHs) support demand flexibility for EE investments, specifically in household appliance use. This aligns with the point that financial resources enable HIHs to engage in EE [32]. However, only households with both consumption and selling options have a higher propensity to invest in energy-efficient technologies [32]. The financial incentives associated with selling excess energy motivate households to invest in energy-efficient technologies, optimizing their utility and aligning with the economic drivers highlighted in our results. In the literature, the counteracting climate change driver is also associated with community energy membership rather than financial gains, while financial limitations are a key barrier, particularly for LIHs [54]. This supports the point on financial constraints being an obstacle and aligns with the socio-ecological drivers of HIHs and MIHs [53].

For our model II, controlling for home ownership, previous experience in crowdfunding, or EE contracting and prosumership, we observe the same general picture, i.e., the propensity to invest increases with income. Interestingly, the strongest interacting element is homeownership followed by experience in crowdfunding. With both moderating elements stemming from experience, we surmise that they reflect the financial barrier mentioned earlier—richer HHs are more likely to be homeowners, while poorer HHs may have experience in crowdfunding precisely to overcome the financial barriers. Unsurprisingly, home ownership as a co-factor is positively only relevant for HIHs and MIHs (who are the ones most likely to own), while having a negative interaction with LIHs. On the other hand, the interaction between previous knowledge of EPC and LIHs converts the effect to be a positive co-factor.

Community experience, including previous involvement in collective prosumership, increases trust and belief in citizen participation, independently from the income. However, if on the one hand higher-income participants show lower impact on behavioral changes, they are additionally driven by the possibility of financial returns. This confirms that previous experience in collective prosumership has a positive influence on the willingness to invest, but the focus on financial returns lead wealthy households to an higher propensity to participate as prosumers [53,56,57]. At the same time, RE ownership is linked with higher flexibility. According to the literature, this effect is more frequent in rural areas, where more frequent prosumership opportunities arise. [58]. Results show us that previous prosumership and crowdfunding experience increase investment propensity. Furthermore, emphasizing the role of social mechanisms in linking ownership and behavior, LIHs and MIHs can overcome financial barriers through community-based prosumership [39,59,60]. Finally, experience in energy-related activities significantly boosts flexibility and willingness to invest in EE [39].

However, if, on the one hand, literature shows that financial barriers for LIHs limit their involvement in EE behaviors, emphasizing the need for policy interventions to ensure equitable participation [17,61], the obtained results show that prosumership experience generally increases energy-efficient behaviors and interacts positively with investment propensity [39,58].

Considering platform-moderated vis à vis conventional investments, in our model III, the general observation is that the former lends itself to households with limited disposable income whereas the latter is more attractive to richer households. In this light unsurprisingly, we see that the possibility to receive monetary returns from the sale of excess production—as a generally strong motivator for HIHs—converts into a negative driver as monetary returns under crowdfunding mechanisms are burdened or wiped out by transaction costs and costs of financing (which independently of the crowdfunding scheme is essentially an investment on borrowed money).

Conventional investment models with fixed returns are attractive to HIHs, as they provide financial stability. In contrast, digital ones make it more appealing for LIHs, due to lower financial barriers. Limited financial resources hinder LIHs from participating in renewable energy initiatives and the access to economic benefits, such as avoided energy costs [32,61]. The results show that in the case of a digital environment, financial drivers may not always encourage energy-conscious behaviors, as seen in [53].

Finally, in model IV, we see that prosumership has the highest positive interaction, in particular for LIHs. As expected, increasing age is a generally disincentivizing factor, since crowdfunding and the use of digital platforms appears to be strongly correlated with digital literacy [62]. This effect, however, turns around when coupled with home ownership (although not statistically significant) with the explanation most likely being that with increasing age, HH income decreases and, in particular, LIH and MIH homeowners seek to revert to alternative financing sources.

6. Conclusions

This paper conducts an analysis of the most important engagement-determining factors in the Energy Efficiency investment platform FinSESCo, particularly demographic characteristics, previous experience with EEC, and renewable co-ownership-related dynamics. The built and tested models shed light on diverse factors that shape interest in EE investment via a fintech platform. The findings revealed a complex interplay among socioeconomic and demographic factors and household dynamics that influence attitudes toward energy efficiency investments. The positive associations between lower income levels and platform engagement do confirm that the FinSECCo model attracts a public that is economically heterogeneous—those looking for cost-efficient energy solutions. Gender dynamics and RE ownership continue to condition engagement, emphasizing the importance of inclusivity integrating these variables. The characteristics of the platform could potentially widen participation in energy efficiency projects by attracting non-homeowners, particularly renters, who have shown interest on the platform, which could help wider involvement and overcome the traditionally strong barriers of financing. Among the most important factors is the strong relationship between experience with RE installations and a much higher likelihood of engagement within the platform. Surely, this suggests that those with the experience do realize the benefit attached to the reinvestment in renewable energy.

We identified several key differences and similarities between engagement with the FinSESCo platform and more traditional forms of energy efficiency investment. The FinSECo platform makes the market more accessible to lower-income groups and renters, mostly excluding from traditional energy efficiency investments, lowering the barriers to participation. Regarding motivational drivers, a wider scope comes with this platform, appealing to people who seek positive environmental impact opposed to traditional investments with an individual financial focus, especially those in the medium- and high-income households.

Both models, however, attract those with experience or knowledge relating to energy efficiency investments. Familiarity with crowdfunding or renewable energy systems is one of the most critical drivers of engagement in both models. Financial savings are a key driver for both the platform and traditional methods, particularly among lower-income participants. The economic incentives to invest in energy efficiency are fairly well accepted across a wide demographic base. These findings underline the potential of the FinSESCo platform for increasing energy efficiency participation and filling in some of the gaps from traditional approaches that cannot easily reach economically or socially disadvantaged groups.

The results of this study suggest important policy implications to diversify the profile of energy efficiency investment. We recognize that efforts should mainly target systemic barriers to participation, especially among low-income households, women, and other underrepresented minority groups. In that sense, specifically designed financial support to these groups, including specific subsidies for RE and EE project initiatives, is essential. Hanke and Lowitzsch (2020) underline that participation in energy projects must bring tangible benefits immediately, especially through well-designed financial incentives [63]. In the case of EE, simplified legal frameworks and incentives can promote social inclusion while reducing administrative burdens to encourage participation in projects and to increase the willingness to invest in EE measures. The empowerment of vulnerable consumers to better access energy-sharing schemes is crucial for ensuring more equitable energy systems [64] and for that, the FinSESCo platform can help to make EE investment opportunities more economically inclusive to those who often cannot participate in traditional EE investments.

The results also highlight possible pathways for the consolidation of a more inclusive energy system, one that include a greater diversification of the profiles involved in decision making. Heldeweg and Saintier (2020) point to the need to go beyond the state-versus-market dualism in governance models and recognize the thriving role of civil society [65], which would require a coordinated governance approach to avoid dominance by any single group. Collective prosumership, together with digital solutions like FinSESCo, may allow LIHs and MIHs to overcome financial constraints and boost EE measures adoption, as prior experience with RE prosumership is an important driver for the platform acceptance. This points out to the direction that the platforms such as FinSESCo need to act also as an enabler of collective action, aiming to the advancement of socio-economic and environmental goals, aligned with the community approaches to the investment in EE.

Finally, further research is needed to identify precisely which strategies will enhance initial engagement and to consider the longer-term effects of knowledge and information in EE investment via fintech platforms. Our findings point out that the FinSESCo platform can be scaled up with great potential for investment in energy efficiency measures; still, it has to tackle the informational and motivational barriers by capitalizing on its strengths while navigating in the fintech sector. By fostering inclusivity and accessibility, the fintech environment can tackle traditional barriers associated with EE investment, creating a more inclusive and accessible scenario, hence driving wider participation in the transition toward energy efficiency.

Author Contributions: Conceptualization, R.M. and J.L.; methodology, R.M.; software, R.M.; validation, R.M. and F.N.; formal analysis, J.L.; investigation, R.M., F.N. and J.L.; resources, J.L.; data curation, R.M.; writing—original draft preparation, R.M., F.N. and J.L.; writing—review and editing, J.L.; visualization, R.M.; supervision, J.L.; project administration, J.L.; funding acquisition, J.L. All authors have read and agreed to the published version of the manuscript.

Funding: The research for this publication has been co-funded by the Bundesministerium für Wirtschaft und Klimaschutz der Bundesrepublik Deutschland (BMWK) project FKZ: 03EI6072A 'FinSESCo—Fintech-Plattformlösung fur das Intracting und Contracting von nachhaltigen Energiesystemen zur Förderung von Energieeinsparungen und erneuerbaren Energien'.

Data Availability Statement: The dataset presented in this article is not readily available because the data are part of an ongoing study. Requests to access the datasets should be directed to magalhaes@europa-uni.de.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

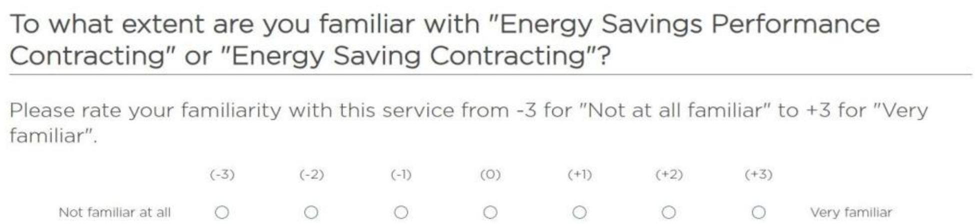

Figure A1. Question v_63_1.

Figure A2. Question v_64_1 explanation pop-up.

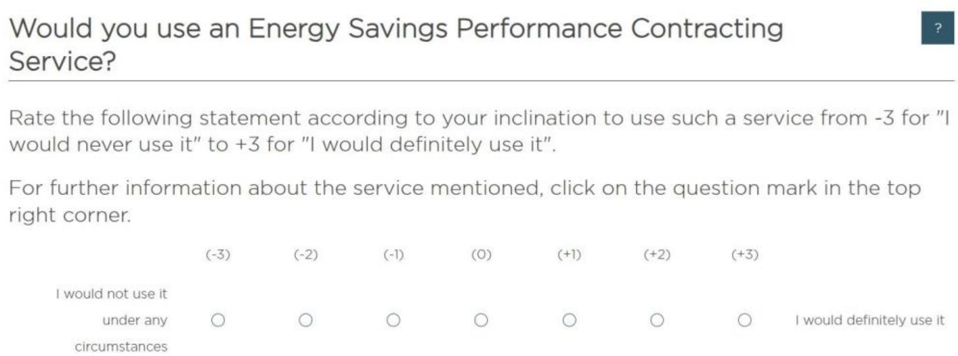

Figure A3. Questionv_64_1.

Figure A4. Question v_65_1.

Figure A5. Question v_636_1.

Appendix B

Table A1. Data Summary.

Variable	Obs.	Mean	Std. Dev.	Min	Max
Ownership	2585	0.3578337	0.4794556	0	1
Co-Ownership	2585	0.1748549	0.3799165	0	1
Age	2585	46.82901	13.13504	21.5	68
Gender	2585	0.5415861	0.498364	0	1
Academic	2585	0.35822205	0.4795702	0	1
Income	2278	2.114135	0.7533631	1	3

Appendix C

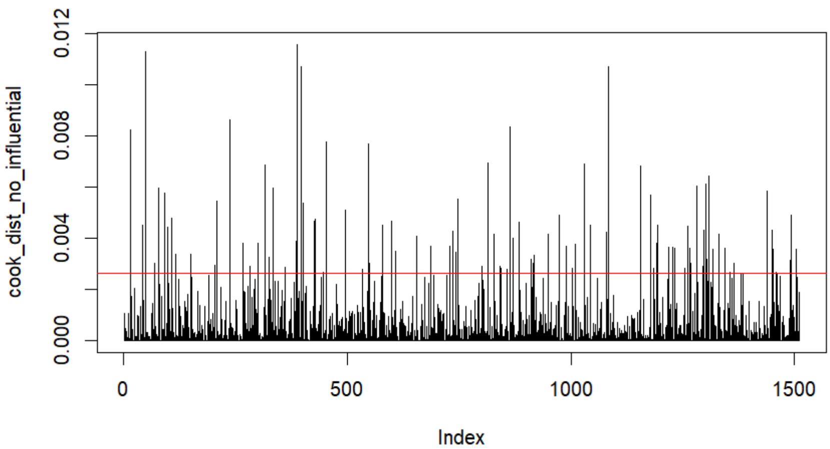

Figure A6. Model 1 Cook's distance not influential points.

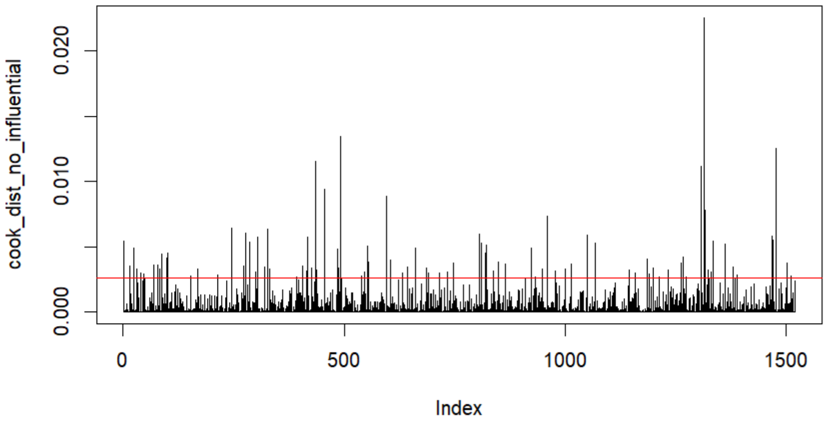

Figure A7. Model 2 Cook's distance not influential points.

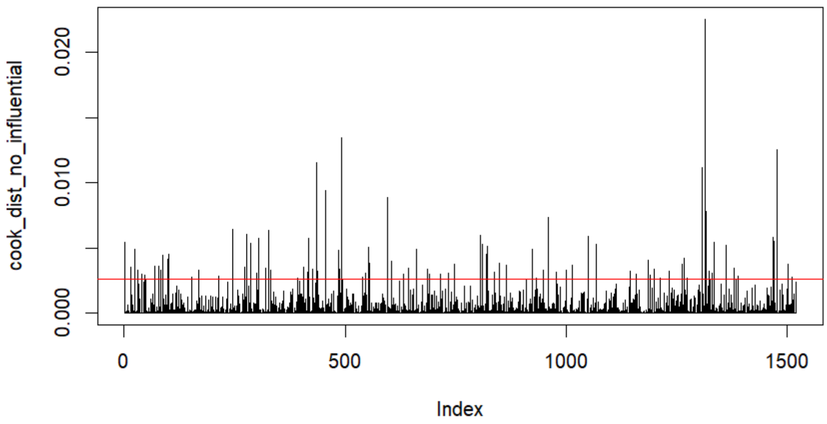

Figure A8. Model 3 Cook's distance not influential points.

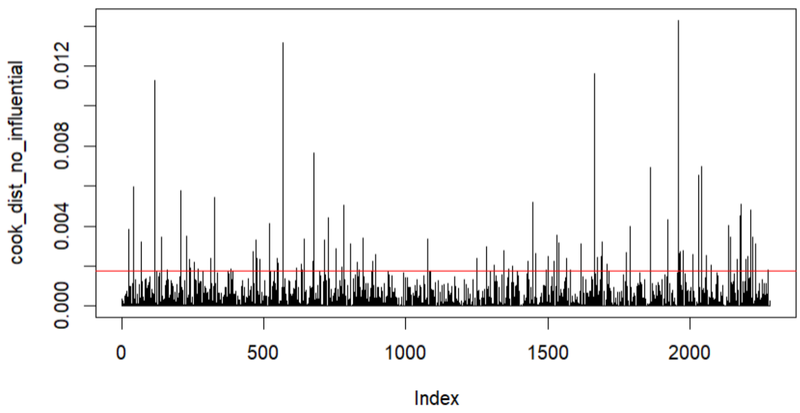

Figure A9. Model 4 Cook's distance not influential points.

References

1. Sorrell, S. The economics of energy service contracts. *Energy Policy* **2006**, *35*, 507–521. [CrossRef]
2. Hoyle, J.W. *Performance-Based Potential for Residential Energy Efficiency*; Technical Report; CICERO: Oslo, Norway, 2013.
3. Vine, E. An international survey of the energy service company (ESCO) industry. *Energy Policy* **2003**, *33*, 691–704. [CrossRef]
4. Labanca, N.; Suerkemper, F.; Bertoldi, P.; Irrek, W.; Duplessis, B. Energy efficiency services for residential buildings: Market situation and existing potentials in the European Union. *J. Clean. Prod.* **2015**, *109*, 284–295. [CrossRef]
5. Guo, L.; Vargo, C.J.; Pan, Z.; Ding, W.; Ishwar, P. Big Social Data Analytics in Journalism and Mass Communication: Comparing Dictionary-Based Text Analysis and Unsupervised Topic Modeling. *J. Mass Commun. Q.* **2016**, *93*, 332–359. [CrossRef]
6. Bertoldi, P.; Boza-Kiss, B. Analysis of barriers and drivers for the development of the ESCO markets in Europe. *Energy Policy* **2017**, *107*, 345–355. [CrossRef]

7. Kangas, H.-L.; Lazarevic, D.; Kivimaa, P. Technical skills, disinterest and non-functional regulation: Barriers to building energy efficiency in Finland viewed by energy service companies. *Energy Policy* **2018**, *114*, 63–76. [CrossRef]
8. Jenkins, K.E.H.; Hopkins, D. (Eds.) *Transitions in Energy Efficiency and Demand: The Emergence, Diffusion and Impact of Low-Carbon Innovation*; Routledge: London, UK, 2020.
9. Sorrell, S.; O'Malley, E.J.; Schleich, J.; Scott, S. (Eds.) *The Economics of Energy Efficiency: Barrieres to Cost-Effective Investment*; Elgar: Cheltenham, UK, 2004; 349p.
10. Schleich, J. *The Economics of Energy Efficiency: Barriers to Profitable Investments*; European Investment Bank (EIB): Luxembourg, 2007.
11. Gouldson, A.; Kerr, N.; Millward-Hopkins, J.; Freeman, M.C.; Topi, C.; Sullivan, R. Innovative financing models for low carbon transitions: Exploring the case for revolving funds for domestic energy efficiency programmes. *Energy Policy* **2015**, *86*, 739–748. [CrossRef]
12. Fylan, F.; Glew, D.; Smith, M.; Johnston, D.; Brooke-Peat, M.; Miles-Shenton, D.; Fletcher, M.; Aloise-Young, P.; Gorse, C. Reflections on retrofits: Overcoming barriers to energy efficiency among the fuel poor in the United Kingdom. *Energy Res. Soc. Sci.* **2016**, *21*, 190–198. [CrossRef]
13. Borgeson, M.; Zimring, M.; Goldman, C. *The Limits of Financing for Energy Efficiency*; Lawrence Berkeley National Laboratory: Berkeley, CA, USA, 2012.
14. Winther, T.; Gurigard, K. Energy performance contracting (EPC): A suitable mechanism for achieving energy savings in housing cooperatives? Results from a Norwegian pilot project. *Energy Effic.* **2016**, *10*, 577–596. [CrossRef]
15. Bertone, E.; Stewart, R.A.; Sahin, O.; Alam, M.; Zou, P.X.; Buntine, C.; Marshall, C. Guidelines, barriers and strategies for energy and water retrofits of public buildings. *J. Clean. Prod.* **2018**, *174*, 1064–1078. [CrossRef]
16. European Environment Agency. Energy Prosumers in Europe: Citizen Participation in the Energy Transition. LU: Publications Office. 2022. Available online: https://data.europa.eu/doi/10.2800/030218 (accessed on 2 August 2024).
17. Hanke, F.; Grossmann, K.; Sandmann, L. Excluded despite their support—The perspectives of energy-poor households on their participation in the German energy transition narrative. *Energy Res. Soc. Sci.* **2023**, *104*, 103259. [CrossRef]
18. Heller, R. Financing Rooftop Solar for Single-Family Rental Properties. In *Sustainable Real Estate*; Walker, T., Krosinsky, C., Hasan, L.N., Kibsey, S.D., Eds.; Palgrave Studies in Sustainable Business in Association with Future Earth Series; Springer International Publishing: Cham, Switzerland, 2019; pp. 313–327. Available online: https://link.springer.com/10.1007/978-3-319-94565-1_12 (accessed on 12 December 2024).
19. Bleyl-Androschin, J.W.; Seefeldt, F.; Eikmeier, B. *How Much Energy Efficiency Can Energy Contracting Deliver to the Residential Sector in Germany?* European Council for an Energy-Efficient Economy: Stockholm, Sweden, 2009.
20. Polzin, F.; von Flotow, P.; Nolden, C. What encourages local authorities to engage with energy performance contracting for retrofitting? Evidence from German municipalities. *Energy Policy* **2016**, *94*, 317–330. [CrossRef]
21. Sesana, M.M.; Salvalai, G.; Della Valle, N.; Melica, G.; Bertoldi, P. Towards harmonising Energy Performance Certificate Indicators in Europe. *J. Build. Eng.* **2024**, *95*, 110323. [CrossRef]
22. Uddin, M.; Siddik, A.B.; Yuhuan, Z.; Naeem, M.A. Fintech and environmental efficiency: The dual role of foreign direct investment in G20 nations. *J. Environ. Manag.* **2024**, *360*, 121211. [CrossRef]
23. Ebirim, G.U.; Odonkor, B. Enhancing global economic inclusion with Fintech innovations and accessibility. *Financ. Account. Res. J.* **2024**, *6*, 648–673. [CrossRef]
24. Yáñez-Valdés, C.; Guerrero, M. Equity crowdfunding platforms and sustainable impacts: Encountering investors and technological initiatives for tackling social and environmental challenges. *Eur. J. Innov. Manag.* **2024**, *27*, 2326–2350. [CrossRef]
25. Poortinga, W.; Steg, L.; Vlek, C.; Wiersma, G. Household preferences for energy-saving measures: A conjoint analysis. *J. Econ. Psychol.* **2003**, *24*, 49–64. [CrossRef]
26. Steg, L.; Vlek, C. Encouraging pro-environmental behaviour: An integrative review and research agenda. *J. Environ. Psychol.* **2009**, *29*, 309–317. [CrossRef]
27. Ek, K.; Söderholm, P. The devil is in the details: Household electricity saving behavior and the role of information. *Energy Policy* **2009**, *38*, 1578–1587. [CrossRef]
28. Gadenne, D.; Sharma, B.; Kerr, D.; Smith, T. The influence of consumers' environmental beliefs and attitudes on energy saving behaviours. *Energy Policy* **2011**, *39*, 7684–7694. [CrossRef]
29. Ramos, A.; Labandeira, X.; Löschel, A. Pro-environmental Households and Energy Efficiency in Spain. *Environ. Resour. Econ.* **2015**, *63*, 367–393. [CrossRef]
30. Trotta, G. Factors affecting energy-saving behaviours and energy efficiency investments in British households. *Energy Policy* **2018**, *114*, 529–539. [CrossRef]
31. Caird, S.; Roy, R.; Herring, H. Improving the energy performance of UK households: Results from surveys of consumer adoption and use of low- and zero-carbon technologies. *Energy Effic.* **2008**, *1*, 149–166. [CrossRef]

32. Roth, L.; Lowitzsch, J.; Yildiz, Ö. Which (co-)ownership types in renewables are associated with the willingness to adopt energy-efficient technologies and energy-conscious behaviour? Data from German households. *Energy Policy* **2023**, *180*, 113683. [CrossRef]
33. Nair, G.; Gustavsson, L.; Mahapatra, K. Factors influencing energy efficiency investments in existing Swedish residential buildings. *Energy Policy* **2010**, *38*, 2956–2963. [CrossRef]
34. Ameli, N.; Brandt, N. What Impedes Household Investment in Energy Efficiency and Renewable Energy? *Int. Rev. Environ. Resour. Econ.* **2015**, *8*, 101–138. [CrossRef]
35. Wasiuzzaman, S.; Pungut, N.N.H.; Don, M.K.S.M. Crowdfunding green projects in Brunei: Awareness and investing preferences. *Manag. Environ. Qual. Int. J.* **2021**, *32*, 1383–1400. [CrossRef]
36. Appiah-Otoo, I.; Song, N.; Acheampong, A.O.; Yao, X. Crowdfunding and renewable energy development: What does the data say? *Int. J. Energy Res.* **2022**, *46*, 1837–1852. [CrossRef]
37. Cicchiello, A.F.; Gatto, A.; Salerno, D. At the nexus of circular economy, equity crowdfunding and renewable energy sources: Are enterprises from green countries more performant? *J. Clean. Prod.* **2023**, *410*, 136932. [CrossRef]
38. Hrovatin, N.; Cagno, E.; Dolšak, J.; Zorić, J. How important are perceived barriers and drivers versus other contextual factors for the adoption of energy efficiency measures: An empirical investigation in manufacturing SMEs. *J. Clean. Prod.* **2021**, *323*, 129123. [CrossRef]
39. Roth, L.; Lowitzsch, J.; Yildiz, Ö.; Hashani, A. Does (Co-)ownership in renewables matter for an electricity consumer's demand flexibility? Empirical evidence from Germany. *Energy Res. Soc. Sci.* **2018**, *46*, 169–182. [CrossRef]
40. Flaute, M.; Großmann, A.; Lutz, C.; Nieters, A. Macroeconomic Effects of Prosumer Households in Germany. *Int. J. Energy Econ. Policy* **2017**, *7*, 146–155.
41. Hirsch, D.; Padley, M.; Stone, J.; Valadez-Martinez, L. The Low Income Gap: A New Indicator Based on a Minimum Income Standard. *Soc. Indic. Res.* **2020**, *149*, 67–85. [CrossRef]
42. Thayer, J.D. *Stepwise Regression as an Exploratory Data Analysis Procedure*; American Educational Research Association: Washington, DC, USA, 2002.
43. Hong, X.; Mitchell, R.J. Backward elimination model construction for regression and classification using leave-one-out criteria. *Int. J. Syst. Sci.* **2007**, *38*, 101–113. [CrossRef]
44. Ruengvirayudh, P.; Brooks, G.P. Comparing Stepwise Regression Models to the Best-Subsets Models, or, the Art of Stepwise. *Gen. Linear Model J.* **2016**, *42*, 1–14.
45. Agostinelli, C. Robust stepwise regression. *J. Appl. Stat.* **2002**, *29*, 825–840. [CrossRef]
46. Wang, Q.; Koval, J.J.; Mills, C.A.; Lee, K.-I.D. Determination of the Selection Statistics and Best Significance Level in Backward Stepwise Logistic Regression. *Commun. Stat.-Simul. Comput.* **2007**, *37*, 62–72. [CrossRef]
47. Feng, C.; Wang, H.; Lu, N.; Chen, T.; He, H.; Lu, Y.; Tu, X.M. Log-transformation and its implications for data analysis. *Shanghai Arch. Psychiatry* **2014**, *26*, 105–109. [CrossRef]
48. Hammouri, H.M.; Sabo, R.T.; Alsaadawi, R.; Kheirallah, K.A. Handling Skewed Data: A Comparison of Two Popular Methods. *Appl. Sci.* **2020**, *10*, 6247. [CrossRef]
49. Sahinler, S.; Topuz, D. Bootstrap and jackknife resampling algorithms for estimation of regression parameters. *J. Appl. Quant. Methods* **2007**, *2*, 188–199.
50. Cribari-Neto, F.; Zarkos, S.G. Bootstrap methods for heteroskedastic regression models: Evidence on estimation and testing. *Econ. Rev.* **1999**, *18*, 211–228. [CrossRef]
51. Streukens, S.; Leroi-Werelds, S. Bootstrapping and PLS-SEM: A step-by-step guide to get more out of your bootstrap results. *Eur. Manag. J.* **2016**, *34*, 618–632. [CrossRef]
52. Filho, D.F.; Silva, L.; Pires, A.; Malaquias, C. *Living with Outliers: How to Detect Extreme Observations in Data Analysis*; BIB—Revista Brasileira De Informação Bibliográfica Em Ciências Sociais: São Paulo, Brazil, 2023.
53. Radtke, J.; Yildiz, Ö.; Roth, L. Does Energy Community Membership Change Sustainable Attitudes and Behavioral Patterns? Empirical Evidence from Community Wind Energy in Germany. *Energies* **2022**, *15*, 822. [CrossRef]
54. Bauwens, T. Explaining the diversity of motivations behind community renewable energy. *Energy Policy* **2016**, *93*, 278–290. [CrossRef]
55. Bauwens, T.; Eyre, N. Exploring the links between community-based governance and sustainable energy use: Quantitative evidence from Flanders. *Ecol. Econ.* **2017**, *137*, 163–172. [CrossRef]
56. Hossain, M. Grassroots innovation: The state of the art and future perspectives. *Technol. Soc.* **2018**, *55*, 63–69. [CrossRef]
57. Bauwens, T.; Schraven, D.; Drewing, E.; Radtke, J.; Holstenkamp, L.; Gotchev, B.; Yildiz, Ö. Conceptualizing community in energy systems: A systematic review of 183 definitions. *Renew. Sustain. Energy Rev.* **2021**, *156*, 111999. [CrossRef]
58. Roth, L.; Yildiz, Ö.; Lowitzsch, J. An Empirical Approach to Differences in Flexible Electricity Consumption Behaviour of Urban and Rural Populations—Lessons Learned in Germany. *Sustainability* **2021**, *13*, 9028. [CrossRef]

59. Goulden, M.; Bedwell, B.; Rennick-Egglestone, S.; Rodden, T.; Spence, A. Smart grids, smart users? The role of the user in demand side management. *Energy Res. Soc. Sci.* **2014**, *2*, 21–29. [CrossRef]
60. Rommel, J.; Radtke, J.; von Jorck, G.; Mey, F.; Yildiz, Ö. Community renewable energy at a crossroads: A think piece on degrowth, technology, and the democratization of the German energy system. *J. Clean. Prod.* **2018**, *197*, 1746–1753. [CrossRef]
61. Hanke, F.; Guyet, R.; Feenstra, M. Do renewable energy communities deliver energy justice? Exploring insights from 71 European cases. *Energy Res. Soc. Sci.* **2021**, *80*, 102244. [CrossRef]
62. Krupa, D.; Buszko, M. Age-dependent differences in using FinTech products and services—Young customers versus other adults. *PLoS ONE* **2023**, *18*, e0293470. [CrossRef] [PubMed]
63. Hanke, F.; Lowitzsch, J. Empowering Vulnerable Consumers to Join Renewable Energy Communities—Towards an Inclusive Design of the Clean Energy Package. *Energies* **2020**, *13*, 1615. [CrossRef]
64. European Commission. Directorate-General for Energy. State of the Energy Union Report 2023 (Pursuant to Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action) (COM/2023/650 Final). Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions. 2023. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52023DC0650 (accessed on 31 January 2025).
65. Heldeweg, M.A.; Séverine, S. Renewable energy communities as 'socio-legal institutions': A normative frame for energy decentralization? *Renew. Sustain. Energy Rev.* **2020**, *119*, 109518. [CrossRef]