The influence of intermediaries' advice on energy-efficient retrofit decisions in private households

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Abstract

Even though energy efficiency (EE) refurbishment in the building sector is an important lever to reach the goal of a climate-neutral building stock, retrofit rates stagnate at a very low level. Since most house owners are laypeople in retrofitting, they consult intermediaries for planning the EE-retrofit. In our study, we therefore aimed for investigating the relative impact of these intermediaries on EE-retrofit decision-making in private households compared to other commonly known drivers and barriers for such decisions. An empirical two-step procedure was pursued: 1) Qualitative interviews were conducted to explore relevant factors in EE-retrofit decisions of private house owners (n = 6 intermediaries and n = 6 private house owners); 2) A choice-based conjoint study was run with n = 96 participants (n = 65 with retrofit experience), were the impact of "cost of the retrofit measure", "type of financing", "energy cost savings", "role/qualification of the intermediary" and "recommendation of the intermediary" on the retrofit decision was assessed. The recommendation of the intermediary had the highest impact, followed by the total cost of the retrofit measure and the type of financing. Energy cost savings and the qualification of the intermediary had the lowest impact on the retrofit decision. The influence of the intermediary, especially of craftsmen, on the retrofit decision, the relevance of energy cost savings and the qualification (certification) of the intermediary was higher for house owners with retrofit experience. Findings indicate that not only monetary aspects but particularly the intermediaries' advice affect retrofit decisions of house owners. Policy interventions should therefore target this stakeholder group to increase retrofit rates and depth in the residential sector.

Introduction

The building sector as the largest single energy consumer in the EU has an enormous potential for energy efficiency gains (European Commission, 2018). One important lever to reach climate protection targets are EE- refurbishments in the residential sector. Although political efforts have been made, the current retrofit rate stagnates at a low level. Extensive research activities focused on barriers and promoters of retrofit decisions (e.g., Stieß and Dunkelberg, 2013; for single-family home (SFH) retrofit), thereby taking an investor-centered perspective. We assume that these retrofit-decisions are, like other decisions, influenced by contextual factors (Ajzen, 1991). For decision-making in the context of retrofitting, intermediaries (external retrofit experts) can be such an influential factor (Maby & Owen 2015), as most house owners choose an expert to advise them on the planning of the refurbishment project due to the high complexity of the topic (Owen et al., 2014). The question of interest for the diffusion of EE-measures is therefore how important the advice of intermediaries is relative to other influential factors and if intermediaries therefore present a target group for policy-making. In this paper, the importance of the advice of the intermediary is thus empirically, quantitatively assessed in comparison to other decision-relevant attributes in a choice-experiment.

In the following, the current EE-retrofitting situation in the German residential sector is described, followed by an overview of impact factors on retrofit decisions and an introduction of intermediaries and their role in retrofitting. The empirical approach of the study is described and results with regard to the impact of intermediaries on retrofit decisions are presented. The paper closes with a discussion of the interaction between intermediaries and house owners as well as implications targeting at the intermediaries.

ENERGY EFFICIENT RETROFITTING IN PRIVATE HOUSEHOLDS IN GERMANY

The buildings sector plays a central role in the energy transition in Germany. The total energy consumption in buildings for space heating, space cooling, and warm water supply was 35.4 in 2016, with private households accounting for the majority of energy consumption: their share of final energy consumption was 22.1 % (BMWi, 2018a). Around 63 % of buildings in Germany were erected before the first German Thermal Insulation Ordinance ("Wärmeschutzverordnung") was introduced in 1977 (dena, 2018). Compared to new buildings, especially the existing building stock in Germany, offers a high energy saving potential due to the high-energy consumption per square meter (dena, 2018).

The range of EE-retrofit measures, which contribute to a reduction of CO_2-emissions, encompass EE-measures to reduce the energy demand through higher efficiency (e.g., insulation, window or boiler replacement), by microgeneration of heat (e.g., solar thermal systems) or microgeneration of electricity (e.g. PV cells) (Owen and Mitchell, 2015). In our paper, we focus on and define EE-retrofit activities in SFH as the installation of EE-measures to the building envelope (e.g., windows, insulation of the roof, facade, or basement) or the heating system (Wilson et al., 2015) with the aim of reducing energy consumption.

Policy measures in the field of EE were not sufficient so far to achieve climate protection targets in the building sector (dena, 2018). In Germany, the renovation rate is currently around 1 % (dena, 2018), although a renovation rate of 1.4 % would be required to achieve national climate protection targets (dena, 2018). In addition, the renovation depth, i.e. the quality of the thermal insulation and technical efficiency measures, must also be increased (Henger, 2016). The development of heat consumption in the residential sector shows that the dynamics of refurbishment in Germany is too low. Although final energy consumption was reduced by 20 % between 2002–2010, it was not further reduced from 2010 on (dena, 2018).

From the perspective of policy-makers, one of the main barriers to invest in energy-efficient refurbishment is the lack of effective incentives. Numerous programs for the buildings sector were expanded in recent years and new measures were initiated, mainly focusing on funding instruments in order to increase the attractiveness of investments (e.g., BMWi, 2018a). However, financial support is not the only effective leverage point and refurbishments are not always carried out on the basis of economic considerations (e.g., Michelsen and Madlener, 2013). Besides financial incentives, personal motivation and knowledge about options are essential, so that communication and marketing also play an important role as instruments for an increased retrofit rate (Projektverbund ENEF Haus, 2010). Especially in the residential sector, a large number of non-monetary factors, which are described in more detail in the following chapter, influence the decision to install EE-measures.

DRIVERS AND BARRIERS TO ENERGY RETROFITTING FROM THE HOUSE OWNERS' PERSPECTIVE

On the basis of extensive empirical surveys in the national and international context, main influencing factors despite of different socio-technical-economic systems have been identified which promote or impede the implementation of EE-measures in private households (e.g., Jafari and Valentin, 2017; Stieß and Dunkelberg, 2013; Wilson et al., 2015). House owners' retrofit decision, i.e. the reasoned decision to conduct an EE-retrofit and to implement EE-measures in their house, can be regarded as a trade-off between the costs (investment costs but also restrictions in living comfort during construction work) and benefits (economic benefits by reducing the operating costs of a property, ecological benefits such as reducing CO_2 emissions or social benefits such as increased living comfort) (Jafari and Valentin, 2017).

In many studies, financial factors were in the focus of the analysis of EE-retrofit decisions, such as the financial situation of the owners, the access to credits of funding, investment costs, expected energy (cost) savings and economic viability (Wilson et al., 2015). Beyond financial factors, contextual factors also contribute to the EE-retrofit decision of house owners (Stieß and Dunkelberg, 2013). Michelsen and Madlener (2013) show that living comfort has a greater influence on the perceived relative advantage of an EE-retrofit measure than the cost savings from reduced energy consumption. Nair et al. (2010) reveal that several economic factors, such as previous investments or perceived energy costs, together with other contextual factors influence the retrofit decision. Aesthetic considerations can act as, but also as barriers (in the case of listed buildings) in the decision to refurbish a house (Galvin and Sunikka-Blank, 2014). In addition, attitudinal factors influence the retrofit-decision of households. EE-renovators are more likely to have an environmentally conscious lifestyle (Long et al., 2015) and greater interest, awareness, and knowledge in EE-technologies (Axsen et al., 2012). Especially for highly ambitioned EE-renovators, which strive for high levels (>60 %) of CO_2 emission reductions in their EE-retrofit, environmental benefits (e.g., energy saving, taking action of climate change) act as drivers in EE-retrofit decisions (Fawcett & Kilipp, 2014).

House owners use various sources in searching for information on EE-measures prior to a retrofit project (Nair et al., 2010), with the Internet as the most important source (Risholt and Berker, 2013). Also significant is the influence of social peers, i.e. friends, neighbours or family, especially in the case of house owners with a low awareness and knowledge level on EE-measures (Stieß et al., 2010). As lay investors generally have (too) little knowledge about EE-technologies, accurate and decision-supporting information from experts is a relevant feature (Duah and Syal, 2016). At this point, the influence of EE-experts as advisory actors in retrofit decision processes becomes relevant. So far, research has been rather investor-centered and the impact of intermediaries on retrofit decisions in households was either regarded on the level of information sources (Stieß and Dunkelberg, 2013) or was qualitatively conceptualized (e.g., Maneschi, 2013; Owen and Mitchell, 2015).

Since intermediaries might represent an important leverage point for influencing the rate and quality of EE-retrofits, their impact on retrofit decisions in households should be investigated in more detail.

IMPACT OF INTERMEDIARIES ON RETROFIT DECISIONS IN HOUSEHOLDS

Intermediaries play an essential and innovative role in the transformation of energy systems. They can raise public awareness and create a new perspective for alternative ways of energy consumption. They are "actors and institutions who enable the exchange of knowledge, skills development and perform connecting and mediating functions" to support the adoption of an innovation (Bush et al., 2017, p. 138). Intermediaries are characterized by their "in-between-ness" (Moss et al., 2009) between policy-makers, energy- and technology providers and energy consumers. They can strategically position themselves between these actors, act as a connecting element between them and serve as credible actors on the basis of their independence (Backhaus, 2010).

A variety of intermediaries in the building sector was identified, ranging from architects, building managers, and regulators to building innovation organizations (Kivimaa and Martiskainen, 2018). In the following, we focus on intermediaries being active in retrofit decisions in households rather than examining EE-building innovations in general. In the context of residential building refurbishment, different types of intermediaries exist, which can be broadly categorized into "advisory intermediaries", who advise house owners, design or specify EE-measures and develop a refurbishment plan; and "implementing intermediaries", i.e. craftsmen who install the EE-measures, procure material and technology, introduce house owners to their usage and perform maintenance work (Owen and Mitchell, 2015). The group of advising intermediaries includes energy advisors who advise house owners on the need and possibilities of an EE-refurbishment (Feser and Runst, 2016). Architects or civil engineers also belong to the group of advisory intermediaries, even if they are usually consulted in the course of other construction measures requiring building permits. The group of "implementing intermediaries" mainly consists of craftsmen such as installers, roofers, and painters, who professionally install the chosen EE-measures. This requires not only technical knowledge but also practical skills (Owen and Mitchell, 2015).

Especially in residential retrofitting, installers also become active as advising intermediaries in the preceding planning stage, when no other planning expert was consulted. This is a further reason, why intermediaries – and here especially craftsmen – should move into the focus of attention. Installers do not only have to have specific technical background knowledge on EE-measures but must also be able to advise homeowners individually and competently. Major deficits in the advisory performance of installers include that relevant retrofit options are not identified, or suboptimal solutions are offered due to a lack of experience with innovations (e.g., Risholt and Berker, 2013). The influence of craftsmen on the quality of EE-retrofit is not only influenced by their advice but above all by their practical skills in implementing the EE-measures. A lack of qualification and practical skills among craftsmen might reduce the quality of EE-retrofit work, leading to e.g., poor finishes causing thermal bridges in windows and walls (Beillan et al., 2011).

To sum up, the decision of house owners to invest in EE-retrofitting is shaped by a multitude of decision-relevant factors. The present study analyses and integrates the relative impact of intermediaries on the EE-retrofit decision of house owners compared to other drivers and barriers. In contrast to preceding studies, which explored the impact of intermediaries in qualitative studies (e.g., Maby & Owen 2015), we pursued a quantitative approach to investigate the interaction and to determine the decision impact of this actor group on retrofit decisions. Therefore, the present paper addresses the following research questions:

- To what extent is the EE-retrofit decision of house owners influenced by intermediaries? Do financial factors (investment cost, energy cost savings, financing) outweigh the influence of the intermediary (his qualification and recommendation) in the EE-retrofit decision of house owners?
- Which type of intermediary is relevant in residential EE-retrofitting?
- Are there differences in EE-retrofit decisions of house owners with differing EE-retrofit experience?

Methodology and Research Design

In order to investigate the aforementioned questions, a two-level empirical research-approach was chosen: First, in a pre-study, relevant factors in retrofit decisions were identified based on qualitative interviews with house owners and intermediaries (see "selection of attributes"). Second, a survey was conducted which focused on the interaction between house owners and intermediaries and determined the relative impact of the intermediaries' advice and financial factors on house owners' retrofit decisions in a conjoint study.

CHOICE-BASED CONJOINT ANALYSIS

For studying the impact of intermediaries on retrofit decisions, the conjoint measurement approach (also referred to as conjoint analysis (CA)) was applied. CA is a quantitative empirical research method for analyzing individual preferences for products or scenarios, determining trade-offs, segmenting groups, and simulating preferences for novel products or scenarios (Rao, 2014). Applying CA allows decomposing a product or scenario into its individual components to determine which of these components influence preference decisions the most. Furthermore, trade-offs in terms of weighting criteria against each other can be analysed. CA assumes that the individual preference for a hypothetical product or scenario, i.e., its "utility", is additively composed by specific explanatory variables (Arning, 2017). In a conjoint study, different scenarios which consist of combinations of these variables (attributes and levels) are presented. The scenarios presented here referred to the choice of a preferred retrofit scenario. This way it is possible to determine the most and least attractive scenario, identify the most decision-relevant criterion, and investigate where trade-offs are made between decision criteria. Thus, CA are optimally suited for studying complex decision scenarios, where multiple criteria influence decisions. In the present study, a choice-based conjoint (CBC) analysis approach was chosen. The CBC also assumes that respondents maximize benefits in their decisions

Table 1. Attributes and levels in the CBC study.

Attributes	Levels				
Total cost of the EE-retrofit measure	€10,000	€20,000	€30,000	€50,000	
Type of financing	Personal savings	Personal savings + bank loan	Personal savings + state subsidies	Bank loan	State subsidies
Energy cost savings	25 %	50 %	75 %		
Type/qualification of the intermediary	EE-certified craftsman	Non-EE-certified craftsman	Certified energy advisor	Non-certified energy advisor	
Recommendation of the intermediary	Recommends measure	Neutral attitude	Advises against measure		

and select the scenario with the highest utility value (Sawtooth Software, 2013). CBC studies closely mimic complex decision scenarios in competitive contexts and are therefore especially suited for simulating EE-retrofitting decisions.

SELECTION OF ATTRIBUTES

In order to identify characteristics of the refurbishment situation, which are relevant for the retrofit decision of house owners, a pre-study was conducted. Relevant characteristics were extracted from an interview study and transferred into attributes and levels for the conjoint study. The sample consisted of six renovators and six intermediaries (craftsmen and architects). They were asked about perceived benefits and barriers of EE-renovation projects, the influence of intermediaries on renovation decisions, other relevant decision criteria (e.g. finances) and trust-building characteristics of intermediaries.

In the interviews, renovators reported that they had little expertise in the topic of EE-retrofitting and had therefore relied on the advice of the intermediaries involved in their EE renovation project. The saving of costs related to energy consumption was named as one of the main reasons for refurbishing, while costs of the refurbishment measures were mentioned by renovators and intermediaries as a major drawback. In relation to the costs, different types of financing were found, but mainly personal savings, bank loans, and state subsidies had been used to pay for the measures. For the choice of an intermediary, trust was important, and this was built by recommendations of the intermediary through others and the technical competence, indicated by qualification with regard to EE-measures.

According to these findings, the factors total cost of the retrofit measure, types of financing, energy cost savings, the recommendation of the intermediary and type/qualification of the intermediary were defined as attributes for the CBC study and operationalized with varying levels (Table 1).

The attributes total cost of the retrofit measure, type of financing and energy cost savings were chosen to represent financial aspects in the context of EE-retrofit decisions. The attribute "type of financing" did not include all combinations possible in order to keep the number of levels similar across the attributes for design efficiency purposes. Therefore, only those options which had been identified as most common from the interviews have been included.

The influence of the intermediary was operationalized by two attributes: the *recommendation of the intermediary* with the levels "recommends", "neutral attitude" or "advises against", in order to model different types of advice and to find out in how far a recommendation makes retrofit scenarios more or less attractive to renovators. Since results of the interview study indicated, that the *type/qualification of the intermediary* was also of relevance to the renovators, the attribute was designed by integrating different types of intermediaries (craftsmen and energy advisors) and a "certification" as an official label for trustworthiness and good quality of work.

QUESTIONNAIRE

For the design of the online-questionnaire, SSI Web Software was used (SSI Web, HB, SMRT) (Sawtooth Software, 2013). After a short introduction into the aim and background of the study, respondents were filtered according to owning a (self-occupied) house and experience in EE-refurbishment (in the last 10 years). Respondents, who fulfilled these specifications, were transferred to the questionnaire. The first block assessed sociodemographic data (age, gender, family status, education, and income) and data on the residential property and the EE-retrofit project (cost, type of EE-measures). The second block comprised self-ratings of awareness, interest, and knowledge about EE-retrofit. Further, the type of intermediary chosen and evaluations of the interaction between the house owner and the intermediary were assessed. In the third block, the choice tasks of the CBC study were presented (Figure 1). After an introduction into the scenario and the attributes and levels of the conjoint study, respondents answered 12 choice tasks by indicating their preferred retrofit scenario. Self-ratings and evaluations were measured by using 6-point Likert-scales (1 = "do not agree at all" to 6 = "fully agree").

DATA ANALYSIS

Conjoint data was analysed by using Sawtooth Software (Sawtooth Software, 2013). On the basis of Hierarchical Bayes estimations, importance scores and part-worth utilities were calculated. Relative importance scores indicate the decision impact of an attribute compared to all other attributes. Part-worth utilities are interval-scaled data scaled to an arbitrary additive constant within each attribute. By using zero-cantered differential part-worth utilities, which are scaled to sum to zero within each attribute, it is possible to compare differences between attribute levels (Arning, 2017). Likert ratings in the questionnaire were descriptively analysed (M = mean value, SD = standard deviation); for testing group differences t-Tests were applied.

SAMPLE

Originally, 132 participants volunteered to take part in the online survey (self-selected sample). A mixture of recruiting via social networks and leaflets was used. After a data screening procedure, in which participants classified as "speeder" (completion of the questionnaire in less than 15 minutes) and "cheater" (persons who had not answered truthfully and attentively) were eliminated, datasets of 96 participants remained for analysis. The specification for participating in the survey was that participants had either conducted an EE-refurbishment at their house or were at least interested in doing so in the future.

35 (36.5 %) participants were female, 61 (63.5 %) male. The majority of the sample held a university degree (47.9 %) or had completed vocational training (20.8 %). The mean age was 49.4 years (SD=11.3, range 25–81 years). Regarding the average monthly household income, 15.6 % reported an income of €7,000 and above, 8.3 % between €6,001 and €7,000, and 10.4 % between €5,001 and €6,000. The majority lived in a household of 2 persons (35.4 %), 22.9 % lived in a household with 3 persons and 20.8 % in one with 4 persons. 13.5 % lived in the countryside, 34.4 % in suburban areas, 25.0 % in a small town and 27.1 % in a larger town.

Regarding the characteristics of the properties, all of the participants owned the house they lived in. 53.1 % were detached homes, 24.0 % semi-detached houses and 22.9 % terraced houses. One-quarter of the houses (25.0 %) were built between 1970 and 1990, so before the first regulations on energy efficiency for buildings had been replaced by the forerunner of today's energy saving decree. Around 12 % of the houses were built before 1920, further 13.5 % between 1920 and 1945 and 21.9 % between 1945 and 1970. 18.8 % were built between 1990 and 2010, and only a minority of 8.3 % was built after 2010. The majority of the sample had bought their house (65.6 %), around a quarter had built it themselves (24.0 %) and 10.4 % had inherited it.

Concerning the characteristics of the EE-retrofit, 65 (67.7 %) reported to have completed EE-refurbishments on their house or were currently doing so. These participants were classified as "renovators". To control for a correct understanding of the term "EE-retrofit", they were additionally asked to indicate the specific EE-measures they had conducted from a predefined list: The majority of renovators had renewed their heating system (46.9 %) or insulated the roof or ceilings (42.7 %) (multiple answers possible). 37.5 % had insulated the facade of their house, 17.7 % had insulated the basement. 33.3 % had built in double-glazed windows and 28.1 % triple-glazed windows. Other measures were, e.g., the installation of solar panels on the roof. The majority of retrofit measures (70.8 %) had been conducted after 2010.

31 (32.3 %) could imagine refurbishing their house energetically in the future; these respondents were classified as "non-renovators". Further analyses of more sophisticated subgroups were not conducted due to the limited sample size. The renovators had spent an average of €54,263 on their renovation, with costs ranging from several hundred euros to €180,000. The majority of the renovators (55.2 %) had used personal savings to finance the retrofit measures, 16.7 % had profited from subsidies and 21.9 % had financed the measures through a bank loan (multiple answers possible). Other financing options that were taken included, e.g., building loan contracts.

Results

First, results will be reported on the general attitude towards EE-retrofit measures and an evaluation of the personal retrofit experience. Afterwards, the evaluation of involved intermediaries will be analysed. Finally, results on the influence of intermediaries on the refurbishment decision are presented.

GENERAL ATTITUDE TOWARDS EE-MEASURES AND EVALUATION OF PERSONAL RETROFIT EXPERIENCE

To gain insights on the overall opinion of respondents, renovators and non-renovators indicated their general attitude towards and interest in EE- measures (Figure 2). Overall, a

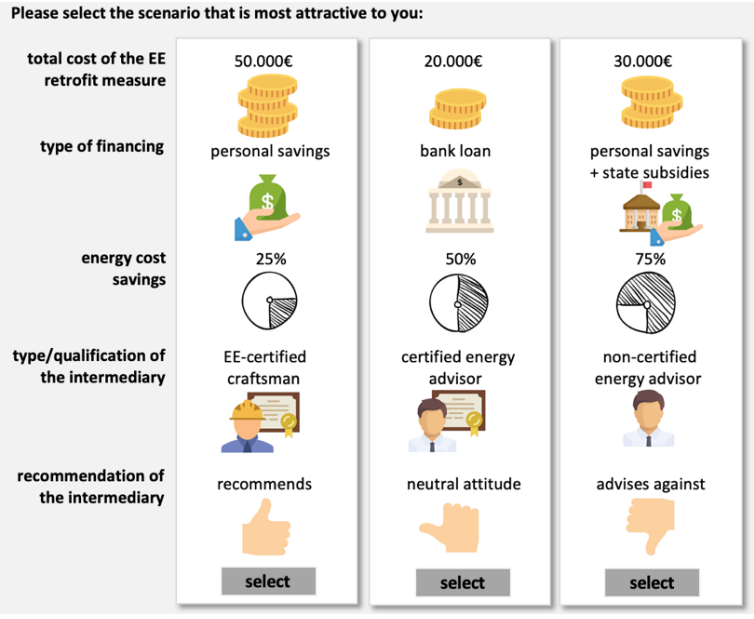

Figure 1. Screenshot of a choice task in the CBC study.

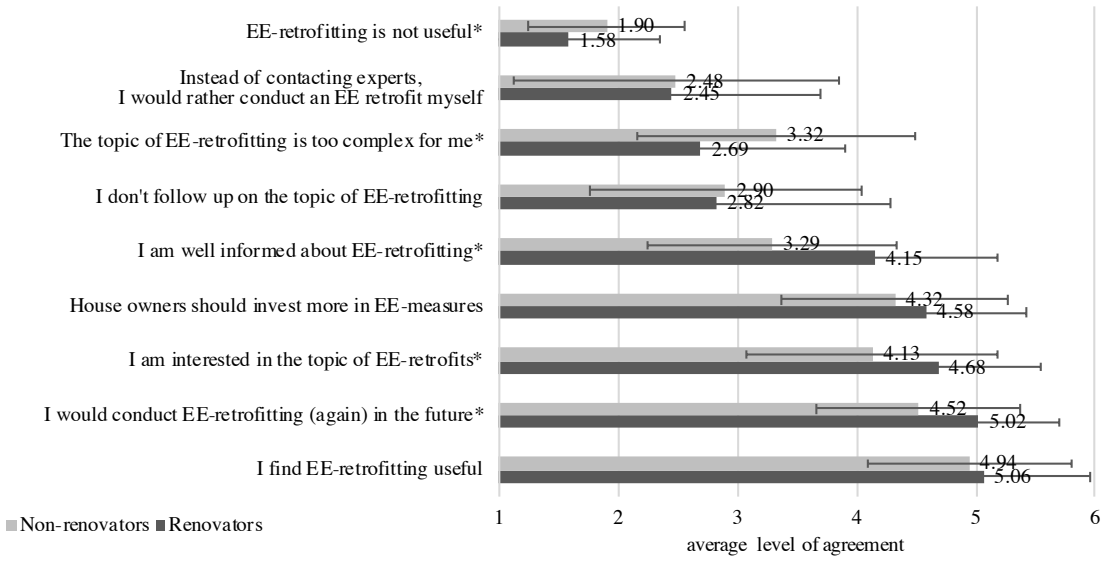

*Figure 2. Attitude towards and interest in EE-retrofitting (n=96) (1= do not agree at all, 6=fully agree, mean values at top of the bar, error bars indicate standard deviation), * significant group differences (p < 0.05).*

positive attitude towards EE-measures was found, as the respondents agreed to the positively formulated items: They found that retrofitting is useful, would conduct EE-measures (again) in the future and that house owners should invest more in EE-measures in future.

Significant differences between the groups of renovators and non-renovators were found for the statements on non-usefulness and intention to conduct retrofitting (again) in the future, as well as knowledge, interest and perceived complexity of the topic. Non-renovators were significantly more critical towards EE- measures, they agreed significantly more to the statement that EE-retrofitting is not useful ($t(68.87)=-2.11$, $p\leq0.05$, corrected for equality of variances), and significantly less to the statement that they would conduct EE-measures (again) in the future ($t(48.53)=2.87$, $p\leq0.05$, corrected for equality of variances). Non-renovators felt significantly less well-informed ($t(94)=3.82$, $p \leq0.05$), found the topic significantly more complex ($t(94)=-2.41$, $p\leq0.05$) and were also less interested in EE-retrofitting ($t(94)=2.69$, $p\leq0.05$) than renovators.

Main drivers for the refurbishment were energy cost savings (M=4.92, SD=0.81), increased thermal comfort (M=4.69, SD=1.13), or repair or maintenance reasons (M=4.65, SD=1.23). To a lesser extent, renovators had been motivated by the advice of others (M=2.60, SD=1.38), by a defect (M=2.57, SD=1.70) or legal requirements (M=2.49, SD=1.26) (Figure 3).

Furthermore, the group of the renovators (n=65) was asked about the evaluation of their personal retrofitting experience. On average, they reported to be satisfied with the result of the refurbishment (M=5.05, SD=0.80) and the specific refurbishment measures installed (M=5.11, SD=0.69). Therefore, they also disagreed to the statement that the refurbishment was not worthwhile (M=2.08, SD=1.27). Nevertheless, overall participants were undecided whether to conduct the same measure the same way again (M=3.51, SD=1.49). Here, the standard deviation was particularly high, so it can be assumed that answers diverged in this point due to different experiences in the refurbishment process.

INTERACTION WITH INTERMEDIARIES IN THE EE-REFURBISHMENT PROCESS

Renovators were specifically asked for their experience with intermediaries involved in the refurbishment process. Of the 65 renovators, 61 (93.8 %) answered that intermediaries had been involved in their refurbishment activities. In 93.5 % of those cases, craftsmen were involved, in 41.0 % energy advisors and 19.7 % reported that one or more architects were involved (multiple answers possible) (cf. Figure 4).

For the following questions on the evaluation of the intermediary, the participants were asked to refer to the intermediary they had worked with most intensely. 77 % of the renovators had spent the most time with a craftsman during the refurbishment process (cf. Figure 4). In general, renovators were satisfied with the collaboration with the intermediary during the retrofit project (M=4.78, SD=1.04). They correspondingly disagreed to choose (M=2.26, SD=1.18) or work with (M=2.49, SD=1.23) another intermediary next time. More specifically, the renovators perceived the intermediary as competent (M=4.84, SD=0.78), reliable (M=4.64, SD=1.03), and would choose the same intermediary again (M=4.82, SD=1.20) and also recommend him to others (M=4.79, SD=1.16). Interestingly, participants clearly disagreed that they could have done the EE-refurbishment without talking to the intermediary (M=2.00, SD=1.10), which indicates that he played an important role in the refurbishment process (Figure 4).

INFLUENCE OF THE INTERMEDIARY ON RETROFIT DECISIONS

The influence of the craftsman on the EE-retrofit decision of house owners was measured by two different approaches in the study. First, renovators estimated the impact of their intermediary on their basic decision to EE-retrofit as well as the influence on the specific design of the EE-retrofit project (Figure 4). Second, renovators and non-renovators participated in the CBC-study in which the influence of the craftsman was analyzed in comparison to other impact factors on the refurbishment decision (Figures 5 and 6).

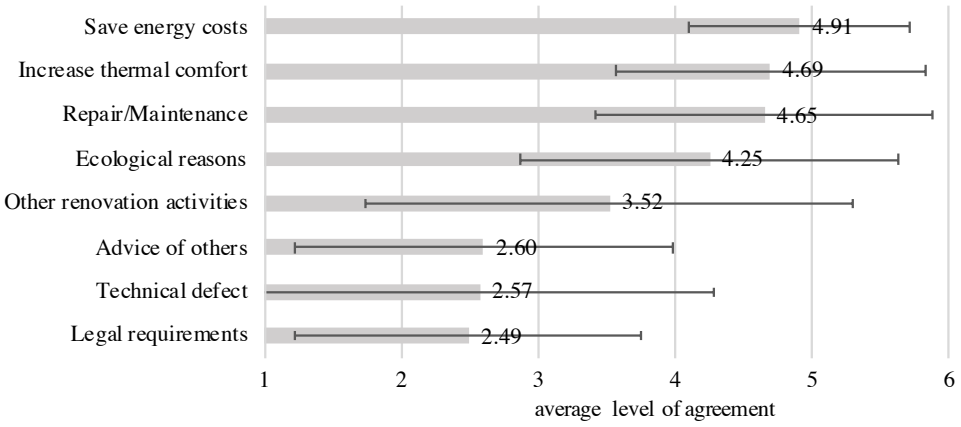

Figure 3. Reasons for EE-retrofitting of renovators (n=65) (1= do not agree at all, 6=fully agree, mean values at top of the bar, error bars indicate standard deviation).

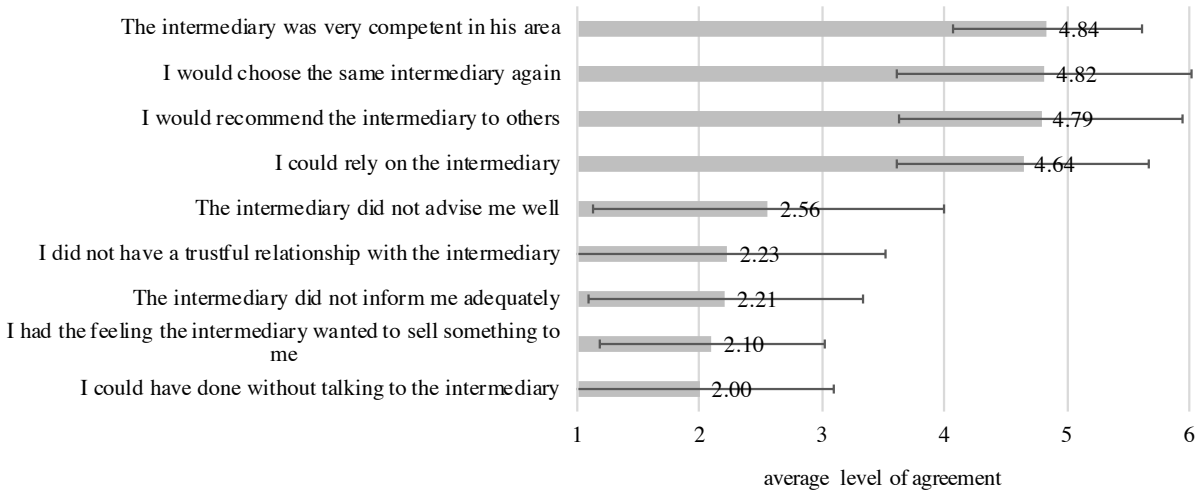

Figure 4. Evaluation of intermediary the renovators worked with most intensely (n=61, 1 = do not agree at all, 6 = fully agree, mean values at top of the bar, error bars indicate standard deviation).

Asked about which intermediary influenced the basic EE-refurbishment decision the most, 44.3 % reported the craftsmen involved, 22.6 % reported "other" (e.g., renovators themselves, friends, media), 19.7 % reported the architect, and 9.8 % named the energy advisor (Figure 4). Interestingly, a significantly higher proportion (55.7 %) reported that the craftsman had the greatest influence on the design of the EE-measure, whereas the proportion of cases, where architects (19.7 %) or energy advisors (8.2 %) influenced the design of the EE-project, remained on the same level. This means that in almost all cases in which architects or energy advisors had been involved, they were attributed the greatest influence on the EE-retrofit decision. The craftsman, in contrast, was not only the type of intermediary who was involved in almost all retrofit projects and the intermediary most renovators collaborated most intensely with, but also for the majority of the renovators the intermediary who had the greatest influence on EE retrofit decisions. Thus, in absolute terms, the craftsmen are the intermediaries with the greatest influence, since they reach the larger share of renovators. In relative terms, once architects or energy advisors are involved, they have a more influential role in the specific EE-refurbishment project.

In addition, the influence of the intermediary's advice on the EE-retrofit decision was analysed in a *choice-based conjoint study*. Renovators and non-renovators were presented with a set of refurbishment scenarios, which were defined by the attributes *total costs, type of financing, energy cost savings, the role of intermediary* and *recommendation of the intermediary*. Participants were asked to choose their preferred EE-retrofit scenario.

The analysis of average *importance* for renovators and non-renovators (Figure 6) revealed that for both groups the recommendation of the intermediary was most important for the choice of a refurbishment scenario, followed by the type of financing and the total costs. The role of the intermediary and the energy cost savings were of lesser importance. Both

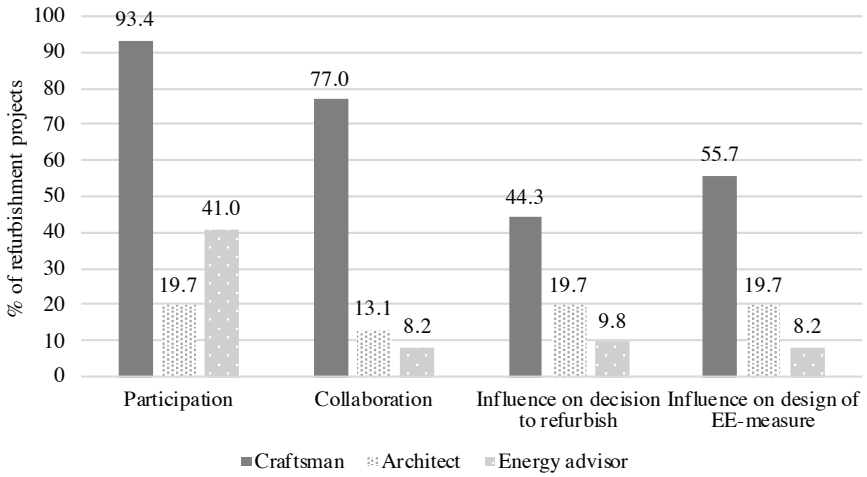

Figure 5. Participation and influence of different intermediaries on EE- refurbishment projects (n=61).

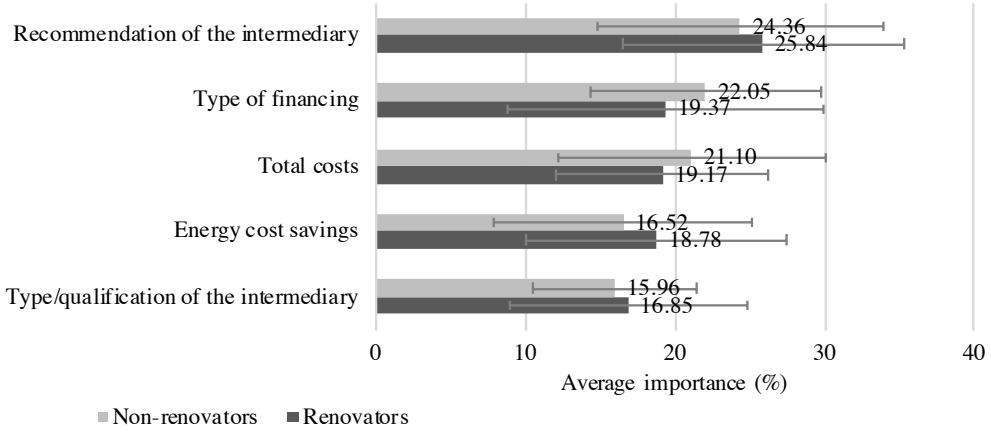

Figure 6. Average importance of attributes for EE-retrofit scenarios for renovators (n=65) and non-renovators (n=31).

groups did not differ significantly with regard to their importance scores (n.s.).

Concerning the *part-worth utilities*, renovators' and non-renovators' preferences did not differ significantly for the levels of the attributes "recommendation of the intermediary", "energy cost savings" and "total costs" (cf. Figure 7, n.s.). Regarding the "*recommendation of the intermediary*" it had the most positive effect on the overall preference for a scenario when the intermediary recommended the measure, followed by a neutral attitude. When the intermediary advised against the measure, this had a strong negative effect on the overall preferability of the scenario. Both groups preferred the highest share of *energy cost savings* as a result of the refurbishment measure (75 %), followed by 50 % savings, and least preferred, with a comparably large difference to the second-most preferred level, were savings of 25 %. Regarding the *total costs* of the measure, it had a positive impact on the overall preference of a scenario when costs were low, therefore, costs of €10,000 were the most preferred option for both groups, followed by €20,000 for renovators and €30,000 for non-renovators. Both groups least preferred costs of €50,000. Again, like for energy cost savings, the preference did not decline linearly from the lowest to the highest costs. Instead, a large change in the utility values can be seen between the levels €30,000 and €50,000.

Significant group different in level utilities were found for two attributes, the type/qualification of intermediary and type of financing. Concerning the *type of the intermediary*, the EE-certified craftsman was most preferred by renovators, while this represented only the third most preferred option for the non-renovators, consequently, the utility value for this level was significantly higher for renovators than for non-renovators ($T(94)=2.08$, $p\leq0.05$). A non-EE-certified craftsman was the most rejected option for renovators, while it presented the most preferred option for non-renovators. Accordingly, the utility value for this level was significantly higher for non-renovators than for renovators ($T(94)=-2.56$, $p\leq0.05$). The groups did not differ significantly in their preference for EE-certified or non-EE-certified energy advisors. The non-certified energy advisor was strongly rejected by both groups, while the certified energy advisor was the second-most preferred option for both groups. For the *type of financing*, the two groups differed in the ranking of the preference of the financing options, but the only level for which difference between the groups was significant was the preference of the

combination of personal savings and a bank loan. This option was significantly more preferred by renovators than by non-renovators (T(94)=2.19, p≤0.05). Generally, the pattern emerged that for renovators, all options, apart from an entire financing through a bank loan, had a positive effect on the overall preference for a scenario. For non-renovators, only personal savings and personal saving in combination with state subsidies had this positive effect. Especially the options in which a bank loan was involved were not preferred.

To sum up, the influence of intermediaries on EE-retrofit decisions can be described as follows: Renovators were satisfied with the collaboration with their intermediary during their EE-retrofit projects, whose advice influenced the decision to refurbish and – to a greater extent – the design of the EE-retrofit project. The conjoint analysis revealed that the (positive) recommendation of the intermediary had the greatest influence on the decision for or against an EE-retrofit scenario. Among the intermediaries, craftsmen were especially important, as they were involved in almost all refurbishment projects, thus reaching a larger share of renovators than architects and energy advisors. Nevertheless, architects and energy advisors, as soon as they were involved, became more influential for the EE-retrofit decisions.

Discussion and conclusion

In order to reach climate targets, more house owners must be convinced to renovate their houses energetically. So far, house owners behave rather reluctantly; they doubt the effectiveness of EE- renovation or reject retrofits primarily for financial reasons. However, retrofit decisions are not only made on the basis of financial factors. Further contextual factors, such as the impact of intermediaries, might also influence EE-retrofit decisions.

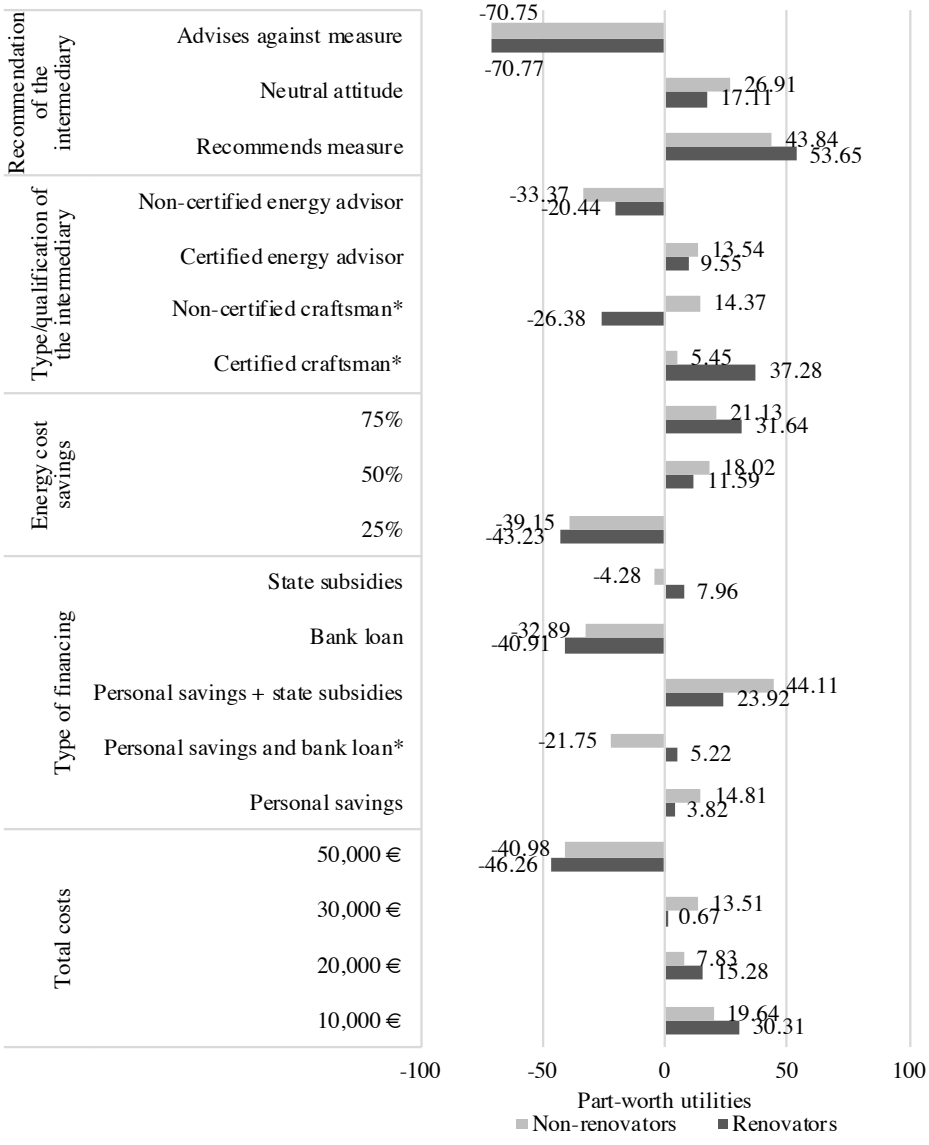

*Figure 7. Part-worth utilities of levels for energy-efficiency retrofit scenarios for renovators (n=65) and non-renovators (n=31), * significant group differences (p<0.05).*

INTERACTION BETWEEN HOUSE OWNERS AND RELEVANT INTERMEDIARIES

EE-retrofits are perceived as a relevant and important topic by house owners who had conducted them or were planning to do so. In general, house owners are satisfied with the outcome of the EE-retrofit project and they recommend EE-refurbishments, even though post-decisional dissonance reduction (Faiers et al., 2007) might have positively affected these ratings.

However, even for homeowners with EE-retrofit experience, the topic is still complex. This refers not only to the EE-retrofit itself but also to the choice of an intermediary. Intermediaries were involved in most of the refurbishments in the study. Renovators and intermediaries interact and cooperate closely during the EE-retrofit project. In general, this cooperation is positively perceived, house owners especially appreciate the advisory role of the intermediary. The intermediary thus plays an important role as a knowledge mediator in the diffusion of EE-measures, as he can translate technical information into understandable facts for laypersons (Darby, 2006).

Renovators especially appreciate EE-certified craftsmen and reject non-EE-certified craftsmen for EE-retrofit. Apparently, the awareness of qualification and certification grows with increasing renovation experience. This can be explained by the fact that not only the evaluation of the content of the advice but also the evaluation of the intermediary himself is complex for laypersons, so a situation of twofold insecurity emerges (Feser and Runst, 2016). To evade this insecurity, renovators rely on recommendation principles for their choice of intermediaries, either through their peers (Feser and Runst, 2016) or, as the results of the conjoint analysis showed, on an external, "objective" certification.

It also became obvious, that the starting point of EE-retrofit activities are not always a technical defect. In line with the findings on trigger points of EE-retrofit or windows of opportunities (EST, 2011), non-technical enablers such as energy cost savings, thermal comfort, and ecological reasons should be addressed in interventions and communication strategies for promoting EE-retrofit activities.

IMPACT OF INTERMEDIARIES ON THE RETROFIT DECISION

Looking in more detail at the impact of intermediaries on EE-retrofit decisions, the study confirms that intermediaries are a highly influential factor, which needs to be further analysed. Craftsmen have less influence on the basic decision to engage in EE-retrofit activities but strongly affect the design of EE-measures. This is in line with findings by, e.g. Nair et al., (2011).

For the first time, the impact of contextual factors in relation to other, mainly monetary factors was empirically tested and the weight of the intermediaries' advice was quantified in relation to other impact factors. Although other studies already found evidence for the effect of intermediaries, this evidence was mainly gained from qualitative studies and/or theoretical considerations (e.g., Stieß and Dunkelberg, 2013; Wilson et al., 2015). Even though we expected that house owners consider the intermediaries' advice, the decision-relevance of this factor was higher than expected. Therefore, we strongly recommend the inclusion of intermediaries as impact factor in models on decision-making behaviour in the context of EE-refurbishment.

As introduced by Maneschi (2013), the term "intermediary" is an under defined term. Our findings indicate that from the perspectives of house owners, craftsmen are the most relevant group of intermediaries: Overall, the craftsman was not only the type of intermediary who was involved in almost all refurbishment projects and the intermediary most renovators collaborated most intensely with. For the majority of the renovators, it was the intermediary who had the greatest influence on decisions in the refurbishment process, but only as long as no planning or advising intermediary was involved. When architects or energy advisors were involved in the EE-retrofit, the influence of the craftsmen in the EE-retrofit project was lower. Thus, intermediaries are powerful actors in knowledge dissemination, shaping the scope and quality of EE-retrofits and finally affecting consumption patterns in the residential sector. Accordingly, when craftsmen are also acting as planners, they should be able to convey the complex topic of EE-retrofitting to laypeople, to develop qualitatively optimal retrofit solutions for the individual property, and, above all, they must also be convinced of the (added) value of EE-retrofit ("being adopters themselves" (Owen and Mitchell, 2015)) and be familiar with current technical EE-solutions. In order to increase the renovation rate and quality, efforts should be directed on the practical support for the *target group of craftsmen*. On the one hand, further practical training is necessary to introduce craftsmen to new EE-measures, technologies, and methods. This way, craftsmen can be convinced of the value of EE-refurbishments and accordingly adapt their portfolio by integrating state-of-the-art technologies and measures. Especially for innovative technologies, the readiness and willingness of craftsmen to offer these to customers might be reduced due to restricted experience and due to liability issues. Furthermore, planning security and reliability on legislation and funding opportunities is urgently needed so that intermediaries and homeowners can better assess the consequences and added value of EE-retrofits.

Compared to craftsmen, energy advisors had a significantly lower influence on EE-retrofit decisions in our conjoint study, although this intermediary-subgroup is currently receiving intensive support, at least in Germany. Although energy consultants were consulted for advice by our respondents, they had actually little influence on the decision and design of the retrofit project. What is striking here is the negative image of energy advisors: especially non-certified energy consultants are extremely rejected. This is especially relevant because of the heterogeneity with regard to the technical training background of energy advisors in Germany, which leads to a lack of transparency of quality standards for the advisory process for energy advisors (Feser et al., 2015). This, in turn, also leads to a low willingness to pay for this kind of advice, because it is not clear what it entails (Feser et al., 2015). Energy advisors are often only consulted because their involvement is mandatory to receive certain state subsidies (Feser et al., 2015), which might explain why the non-certified energy advisor was even more rejected by renovators than non-EE-certified craftsmen. In 2018 a new policy measure was introduced in Germany to promote energy advisory services, which allows craftsmen to offer energy advice services *and* to implement them (BMWi, 2018b). Even though the effects of this measure have to be evaluated, we assume that the stronger connection of energy advisory services to the portfolio of craftsmen lowers the barrier for house owners to engage in "holistic" EE strategies for their house. Further, by acquiring this qualification, craftsmen might become more aware and knowledgeable in the field of EE-retrofitting and might act as more efficient multiplicators in the diffusion of EE-measures and technologies.

In addition to the influence of intermediaries, other – monetary – influencing factors also had an impact on retrofit decisions. Overall, personal savings or subsidies are preferred, while bank loans are rejected *for financing EE-refurbishments*. Subsidies are more likely to be accepted by homeowners with renovation experience than by non-renovators. We assume that non-renovators have not yet seriously dealt with the financing of renovation measures and therefore their willingness to apply for subsidies is lower.

METHODOLOGICAL CONSIDERATIONS AND FUTURE STEPS

Although the conjoint-design proved to be suitable for investigating complex decision scenarios in relation to retrofit-decisions, some methodological improvements should be considered. The attribute „total cost" of the retrofit-measure should be operationalized in a different form to achieve a higher measurement sensitivity with more gradations between the investigated "cost"-levels. The effect of intermediaries on EE-retrofit should be also analysed with regard to the total investment made as well as the type of EE-measure installed. Furthermore, the study should be conducted with a larger sample of house owners to confirm the result pattern and to differentiate between renovator-types (Stiess et al., 2010) and their decision patterns when interacting with intermediaries. A larger sample would also allow analysing subgroups in more detail and uncovering, e.g., the relationship between the most influential intermediary and the investment sum in order to gain better insights into the specific effects of intermediaries' advice on the dimension or depth of EE-retrofit.

It has been shown – at least from the perspective of house owners as respondents of our survey, that craftsmen are a highly relevant intermediary subgroup with a decisive influence on the course and outcome of the EE-retrofit. It should be noted, however, that the relevance of intermediaries could also be determined based on the type of measure chosen or the amount of investment in the EE-retrofit. Previous findings suggest, that house owners preferably choose intermediaries from the personal network, based on personal acquaintance or recommendation (Zaunbrecher et al., 2018). Future studies should therefore investigate selection criteria and the selection process of house owners when selecting intermediaries.

Due to methodological characteristics of the conjoint measurement approach, only a limited set of decision-relevant attributes was empirically investigated. Future studies should therefore include further factors which might act as drivers or barriers in EE-retrofit decisions, such as the intrusiveness of the construction work during the EE-retrofit or differing degrees of innovativeness or market share of EE-measures.

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