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Physical vs. Aesthetic Renovations: Learning from Swedish House Owners

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Abstract: In this paper, we identify the socio-economic attributes and attitudes that have influenced house owners in renovating their homes in the past. Our study is based on responses to an online questionnaire survey of 971 house owners living in Kronoberg County in Sweden. Results showed that the interest and willingness of the house owners to perform a renovation varied depending on their demographic background and the age of the house. The latter positively affected past renovations, only when combined with the residence time. Furthermore, the age of house owners strongly and positively affected the probability of performing aesthetic type of renovations, because of a long time of residence in the house. Younger, town living, and highly educated house owners seem to be more concerned regarding saving energy, which motivated them to perform physical renovations on their house. Our results also suggest that income, level of education, and place of residence have an effect on renovation decisions only through their effect on the energy concern of house owners, and a varied effect on renovation decisions, when combined with the time of residence in the house.

Keywords: house owners; renovations; physical renovations; aesthetic renovations; decision-making

1. Introduction

The building sector accounts for more than 40% of the energy use and 32% of carbon dioxide emission in the European Union (EU) [1]. About 75% of the building stock is residential and the majority of them (64%) are detached houses [2]. Directive 2012/27/EU strongly advises member states to establish long-term strategies for investments in building renovations. The goal set by EU is to renovate existing total building stock by 2050.

Sweden has two million detached houses (one and two family houses according to Statistics Sweden) which constitute about 50% of the total building stock [3], and are responsible for 12% of the total final energy use [4]. About 80% of these houses are more than 35 years old and need major renovation to bring them to the energy standard of a new building [5]. This creates unique opportunities for the adoption of energy efficiency measures that can reduce the energy use and greenhouse gas emissions significantly [6], and thereby contribute to meeting the climate and energy usage goals in the sector [7].

In Sweden, detached houses show a low rate of energy renovations [8]. In general, there are two types of renovation; aesthetic renovations that improve the feeling of visual pleasure of house owners, and physical renovations of the building envelope that improve the energy performance of those buildings. Swedish house owners are more engaged in renovation of kitchens and bathrooms (aesthetic renovations), than improving insulation of external walls and attic, or upgrade windows (physical renovations) (see Figure 1).

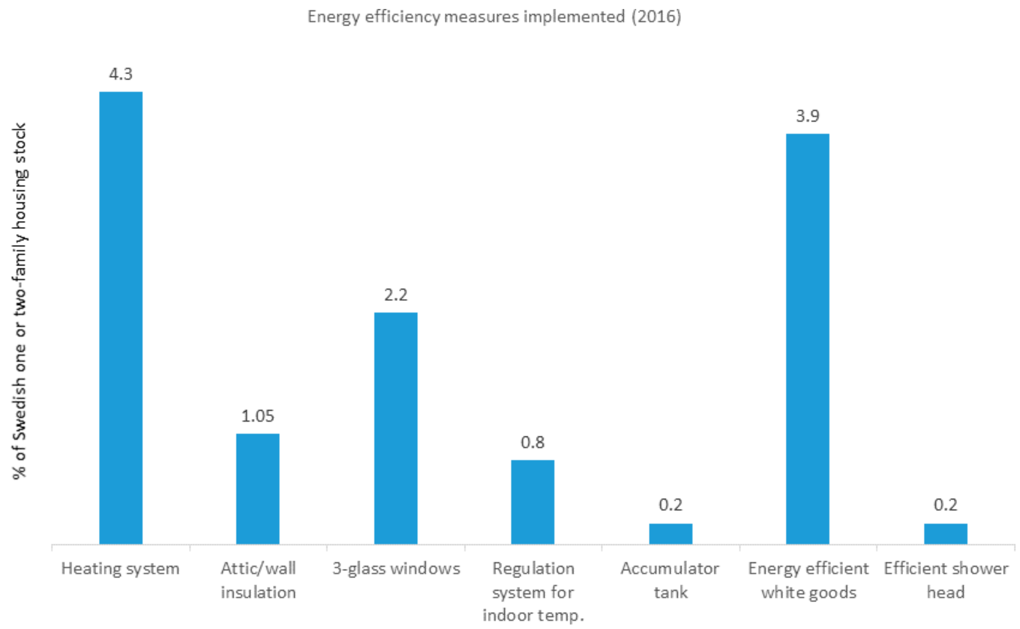

Figure 1. Average annual percentage of homeowners implementing different energy efficiency measures in Sweden (source: Swedish Energy Agency [8]).

Several studies have investigated house owners' decisions regarding adoption and diffusion of energy efficiency measures in their dwellings, e.g., heating systems, windows, building envelope measures, etc. [9–28]. Previous studies examined the influence of sellers/installers on the decision of house owners to adopt a single measure (like e.g., energy efficient windows) [29–32], or the relationship between potential buyers and sellers of houses, and the incentives both sides require adopting energy efficiency measures prior or post purchase of the house [33,34].

For the purposes of our paper, we summarize those studies that focused on investment-intensive renovation measures only. Broadly, the factors affecting the decision to adopt energy efficiency measures can be divided to motivations and barriers. Baumhof et al. [35] applied a motivation-opportunity-ability framework [36] to highlight that indoor comfort is a key motivational trigger for decisions to renovate. The lack of finance and time were highlighted as barriers, while the affordability of house owners, the profitability of the renovation measures, and favorable opportunity/conditions for renovations were found to be some key factors influencing the house owners' decision for energy renovation in Germany [37]. A case study in Portugal highlighted that a combination of house owners' personal and contextual reasoning—viz. needs, wishes, and social practices, and how they are negotiated in the family—influence the renovation decisions [38]. The results from a case study in Norway [39] showed that the main motivators for renovation were house owner's need to minimize operational costs, their attraction towards market promotions, and influences from their social environment. On the other hand, barriers were mostly related to lack of financing, lack of time, and lack of relevant and trustworthy information. Additionally, the investigated house owners pointed out that economic incentives, better comfort, reduced involvement of them in the process, tailored practical information, individual feedback, and legislative actions would motivate them to invest in energy efficiency measures in their houses [40]. A Danish study arranged the motivations and barriers in a framework with three categories, namely information (lack of awareness and education on energy renovation), finance (size of the investment and the lack of capital availability), and process of energy-efficient renovation [41]. A study in Canada identified the demographic attributes as main determinants for the adoption of energy efficiency measures [42]. A study in Finland [43] revealed that concerns for climate change among a segment of house owners influenced them to show greater willingness to receive advice and services towards improving the energy efficiency of their house. A study on decision-making parameters for house owners in four European regions (Denmark, Latvia, Coimbra in Portugal, and Wallonia in Belgium) [44] concluded that it is essential to have trustworthy knowledge networks through which house owners can receive advice and help, both before and during the renovations. This is because house owners do not see energy renovations as a strictly technical issue, but as a matter of trust in the networks.

The above-mentioned studies use different methodological approaches, which have their own limitations. Some of them are based on small number of interviews [38,39], which has limited statistical validity; while some others conducted statistical analysis of responses from questionnaire surveys [35–37,41,44–46]. The used statistical methods multiple regression [41,47], multinomial logistic regression [35,40,45,46], logit models [37], treat the explanatory (independent) variables as independent to each other, which is rarely a reality in decision-making process. Structural equation modeling overcomes this limitation, but only few studies [36] have used this approach and none of them belongs to Sweden. Factors included in different models can be country specific due to political, economic, social, and cultural context, and therefore, country-specific analyses are needed to design appropriate intervention measures.

Hence, we have analyzed responses from an online survey of Swedish house owners by using partial least squares path modeling (PLSPM) [48,49]. This is a structural equation model technique using a partial least square approach, and it allows for more complex causal relationships among the variables. Many of the previous studies on determinants of renovation are based on "intention" to renovate [35,37,38]. However, intentions may not lead to actual behavior, i.e., there is so-called intention-behavior "gap" [50]. Analyzing data obtained from people who have already indulged in renovation will give a more valid result regarding the underlying motivations and barriers to renovation. This knowledge can act as an indicator of understanding the behavior in the future, as past practices usually influence future decisions [51].

The respondents of our study come from Kronoberg County in Sweden. This area is an interesting setting for this study as sustainability is central to its development strategy [52]. The main city Växjö, where the majority of the respondents reside, is internationally known for many years for climate change mitigation related activities and has been awarded with the European Grean Leaf award in 2018. Hence, Växjö city that sets the example for other Swedish cities and Baltic cities [53]. Moreover, the living standard, culture, climate, and condition of the buildings are rather similar in other parts of Sweden and Nordic countries. For example, ca 40–50% of dwellings in different Nordic countries are single-family houses, and a large share of them have electricity heating systems (except for in Denmark where there are oil/gas boilers) and in the need of renovation [6]. Hence, the results from Kronoberg are likely to be applicable in other parts of Sweden and other Nordic countries. Besides, PLSPM technique applied in this study provides a good basis for the complex cause-effect relations analysis linking both manifest variables and latent variables that are not directly observable, but can be inferred from the data in other country cases with different socio-economic settings.

2. Theoretical Framework for the Analysis

In the introduction section, we have referred to house owners' decision for renovations, as the result of various influences. Those influences derive from the combination of two perspectives, namely motivations and barriers [41], which are the functions of various financial, attitudinal, and social attributes. In this section, we will further analyze those attributes in a broader theoretical framework.

2.1. Financial Motivations and Barriers

There have been studies showing that the aspiration to reduce operating costs has been a driving factor for house owners towards performing a renovation in their houses [54]. That can be considered as an investment-driven motivation. Beliefs about potential energy savings, which may pay off the initial investment, are also a motivating factor for house owners towards deciding to renovate their house [42,43]. In addition, budgetary instruments like allowances, loans with low-interest rates, and tax benefits can act as motives for house owners to renovate and adopt energy efficient measures [6]. Household income is another factor that can also motivate energy-related renovations. Families with higher income are more likely to adopt energy efficient measures compared to those with lower annual income, who miss, in that way, the opportunity to get the benefits that the aforementioned financial motives can provide them [36].

When we discuss financial barriers for energy-related renovations, (a) increased cost of investment for such a type of renovation and, (b) lack of financial means hold a dominant position [2]. Previous survey-based studies [36,55] on house owners have shown that the household's income and perceptions on energy costs were important predictors of the decision to invest in measures that would improve energy efficiency. The high investment costs of energy renovations are identified as a major barrier, especially for young families who have relatively lower income and savings, even though they are most likely to be interested to perform such renovation [41,56,57]. Furthermore, there are house owners who believe that the household will not have significant gains from the reduction of energy cost compared to the initial investment, which stops them from moving forward an energy-related renovation [44].

2.2. Attitudinal Motivations and Barriers

There is a number of barriers and motivators of attitudinal/psychological nature that influence subjects that either will enable the process of decision-making or they will act as preventing factors for a decision. Risholt and Barker [55] state that the house owners base their decision to renovate their house purely on a qualitative basis and not strictly on quantitative. House owners' aspirations are varied, like simply giving an old house a new look, changing their lifestyle, or changing their status [41]. House owners may not engage in renovation if they are satisfied with the present condition of their house. Past research has shown that in their majority, house owners have been satisfied with the physical condition, aesthetics, and energy performance of their house, and therefore, they were not willing to renovate [6]. Another set of aspects increasingly researched is related to the internal decision-making mechanisms of house owners. They refer to expectations of positive or negative impacts of the decision to proceed in an energy renovation [58,59]. The expectation that energy renovations can lead to a better indoor environment of living conditions in general, thereby improving the health of the occupants, might have a positive impact on house owners to make such a decision [59–62].

Energy consumption of houses has been found to be largely dependent on the preferences and behaviors of occupants [47]. Those preferences and behaviors are affected by a variety of parameters, namely the size of the household, the age of the house, the presence of occupants at home, and other individual preferences and characteristics that are related to the overall perceptions of occupants on moral environmental behavior [63]. Behavior is an important factor towards adopting energy-efficient measures and is a parameter that changes over time, especially when a discontinuity occurs in the household context [61]. The profile of occupants is a key element to be considered when discussing adoption of energy efficient measures. Energy-conscious households actively seek ways to adopt such measures, while less energy-conscious households try to find solutions and systems that will not require high investments [64,65].

2.3. Socially-Driven Motivations and Barriers

Socially driven motivations for renovations include influence from the close or broader social environment like, e.g., a neighbor or relative that has performed a renovation [66], and comparison between house owners [41]. In addition, the changing needs of families in their living environment is an important motivating factor for house owners to renovate [34]. Another social aspect for decision-making about renovations has also to do with heritage values [67]. House owners aspirations for the heritage value of their houses are of crucial importance to a broad and balanced understanding of the sustainability concept (energy saving parameter). Those aspirations have to be protected when deciding to perform renovations on a house, especially when energy-related measures are to be applied [68].

Although there is a perception that knowledge regarding energy efficiency measures is highly diffused, and thus can work as a motive for house owners to renovate, in reality, there is restricted knowledge concerning the subject, which can potentially lead to opposite results [66]. Knowledge related barriers include a lack of awareness regarding technical aspects or a lack of competent artisans/contractors to perform renovations [47,69].

House age is an important aspect when house owners decide to perform a renovation project. The age of the building signifies the level of energy consumption [70]. Having that in mind, house owners need to address an additional challenge and decide which parts of their property need to be renewed as the subject of a renovation project [71]. Other aspects related to owners' understanding of the need for renovation are their age, level of income, and educational level. Especially house owners' age, when solutions related to energy efficiency are discussed, house owners' age plays a significant role in the decision-making [6,34]. Older house owners are less willing to invest in sustainable, energy efficient solutions, as they are uncertain if their investment will provide them with a significant return. They also likely to have lower knowledge regarding energy efficiency. House owners of an older age have lower knowledge regarding energy efficiency compared to house owners of younger age, who are more familiar with the concepts of sustainability, and are more willing to invest in the adoption of energy efficient solutions [40].

3. Materials and Methods

The data analyzed in this paper has been derived from an online survey of house owners in the Kronoberg County, Sweden, conducted in the spring 2017. The survey was designed to analyze the perception of house owners regarding energy consumption in their houses and towards renovation. The questionnaire was developed in Swedish language by the authors in consultation with different stakeholders, which include researchers, the Swedish house owners association, and the insurance company Länsförsäkring Kronoberg (the daughter company of Länsförsäkring AB, which is a Swedish federation of 23 mutual insurance companies owned by the customers). Länsförsäkring Kronoberg sent the questionnaire to the 7193 email addresses of its customers owning detached houses. 971 house owners answered after one reminder, which corresponds to a response rate of 13.5%, which is in line with the standards for online surveys [72]. In the introductory note of the survey, the participants were informed that their participation was voluntary and that their identity and individual responses would be kept anonymous.

The questions on which we focused were associated with the past renovation performed. This would offer a better picture of factors influencing the house owners' choices to compare with their plans. This information would predict behavior of house owners in the future; as past practices are usually known to influence future decisions [51]. The renovations may have been performed in order to reduce the overall household energy use, improve the indoor comfort, improve the physical condition, and/or the aesthetic appearance of the houses. All measures towards renovation are possible to have been applied together, or in steps, with house owners prioritizing them based on immediate needs. The preference for a specific measure might be the result of valuing different parameters, like the ease of work, the investment required for a renovation project, the potential cost savings, etc. The decision to proceed in any type of renovation comes up from a complex interplay of socio-cultural, economic, and contextual factors [52–54].

The respondents' answers were first analyzed as a whole to understand the factors leading to house renovation. In a second step, we only selected the group of house owners who actually performed some type of renovation in their houses. The goal of this analysis was to identify the effect of architectural (e.g., house age and size), socio-demographic (e.g., gender, age, income, education) and attitudinal (e.g., environmental concern, willingness to adopt energy efficient measures) attributes on the renovations choice. The questionnaire included a series of standard questions derived from international studies [73] to understand the respondents' attitude on energy and the environment. A principal component analysis (PCA) based on a partial-least square approach was performed to classify the questions/statements into different components [49] (see Section 4.1). The three resulting components were included in a logit model, including all respondents, along with socioeconomic and house characteristics; with the aim to better understand the factors leading to the choice of renovating the house (see Section 4.1).

We have analyzed the survey data utilizing partial least squares path modeling (PLSPM). This technique allows the estimation of models including complex cause-effect relations linking both manifest variables and latent constructs, i.e., variables that are not directly observable, but can be inferred from the data. More specifically, PLSPM includes two linked parts. First, latent constructs are built from the manifest observations through principal component analysis. Each construct is thought to represent a single 'dimension' underlying the observed variables. Then, a network of relations among these constructs is hypothesized, where links are assumed to represent cause-effects processes. The network is formed by one or more starting nodes ('independent' variables only affecting other nodes), one or more intermediate nodes (construct both affecting and being affected by other nodes) and one or more terminal nodes (constructs affected but not affecting other nodes). Finally, the resulting 'paths' are quantitatively estimated by considering the overall network as a system of multiple interconnected linear regressions. PLSPM models were estimated to better understand the reasons why past renovation was performed (Section 4.1) and the ones leading to the renovation of specific parts of the house (Section 4.2).

4. Results and Discussion

4.1. Drivers of House Renovation

As a first step, we explored whether respondents renovated at least some parts of their current house in the past, starting from the day, they lived in the house. Overall, 88% of the respondents did at least some renovation work. According to the survey, most past renovations were performed by house-owners who were either over 55 years old or below 36 years old. In most cases works, they were done either by people who just moved into the house (i.e., they have lived in the house for two years or less) or who have lived in the same place for 10 years or more. A large majority of the houses that have been renovated are over 20 years old.

To summarize the attitude of the respondents on energy and the environment, we performed a PCA based on a partial-least square approach—which is especially indicated for questionnaire data based on interval-scale variables and presenting missing observations [73]—on the questions in the survey focusing on these aspects. This resulted in three components explaining almost 50% of the total variance (Table 1): the first, mainly loading on the willingness to bear costs (e.g., pay higher prices or having higher taxes) to help the environment (PCA1); the second, specifically loading on energy issues and including the willingness to both change behaviors and invest in house renovation to decrease energy consumption (PCA2); the third, mainly negating the seriousness of environmental issues and expressing trust in the technology as a way to solve environmental problems (PCA3).

The three PCA components were subsequently included in a logit model, along with socioeconomic and house characteristics, predicting whether the house was renovated or not. The model estimates showed that the respondents' age (with a negative effect), their interest and stated willingness to adopt technical and behavioral measures to reduce energy consumption (positive), the time span of their residency in their houses, and the age of the houses themselves (both positive) were the only significant predictors of renovation (Table 2).

Table 1. Variables included in the PLS principal component analysis and corresponding loading. All variables (statements on environmental concern) were measured on a 1to 5 scale, where 1 represented "completely disagree" (i.e., lower environmental concern) and 5 represented "completely agree" (i.e., higher environmental concern). In some cases, the scale was reversed so that a lower number indicated a higher environmental concern.

Variable	PCA1	PCA2	PCA3
Too difficult to do much about the environment	0.36	0.16	0.27
Do enough to protect the environment	0.10	0.16	−0.27
Not meaningful to do much for the environment unless the other do the same	0.33	0.18	0.30
Claims about environmental threats are exaggerated	0.38	0.10	0.23
Hard to know whether the way I live is helpful or harmful to the environment	0.20	0.25	0.41
Environmental problems have a direct effect on my everyday life	−0.19	0.35	−0.02
There are many opportunities to reduce energy use by renovating the house	−0.13	0.59	−0.05
There are many opportunities to reduce energy use through changes in the behavior	−0.21	0.57	−0.01
The state does enough to make Sweden a sustainable society	0.09	0.01	−0.13
New technologies can help solve today's environmental problems	−0.09	0.20	−0.45
Willing to pay higher prices for products and services to protect the environment	0.40	0.07	−0.33
Willing to pay higher taxes to protect the environment	0.39	0.07	−0.34
Willing to accept cuts in the standard of living to protect the environment	0.38	0.01	−0.30

As common in case of imbalanced outcomes (recall that only 12% of the respondents did not renovate their houses at all), the logit model strongly underestimated the occurrence of the smallest outcome group and was hence able to correctly predict only a subset of the no-renovation cases. To improve our capacity to correctly predict the data and to allow for more complex causal relationships among the variables, we estimated PLSPM model including the same outcome variable. The model used the respondents' age as a starting point, which affected, among others, their socioeconomic characteristics (labeled WET in Figure 2). Age and socioeconomic characteristics, in turn, were assumed to affect the energy concern of the respondents, the age of the house where they lived and the time span of their living in the house. Finally, the energy concern, the age of the house, and the time span they lived in the house were assumed to affect house renovation. Figure 3 shows the resulting model structure. If we used another variable as a starting point that would have been a different model, but the direct relations among the constructs would remain approximately the same.

In the PLSPM model, the respondents' age, the house age, the time span they lived in the house and whether the house was renovated or not were manifest variable, i.e., variables that directly derive from the survey items. The socioeconomic characteristics of the respondents were instead grouped in a single latent construct reflecting the respondents' gross income (>600,000 SEK per year), their educational level (at least a university degree), and the fact that they lived in towns with more than 25,000 inhabitants. This led to the estimation of a wealthy-educated-town-living construct (henceforth WET) showing a sufficient degree of reliability to be considered as a single variable (Dillon-Goldstein's $\rho = 0.70$). The energy concern construct was instead estimated on the basis of questions about the importance for the house owner to save energy and his/her willingness to adopt technical and behavioral measures to do so (DG $\rho = 0.79$).

Table 2. Logit model on past renovations. Reference categories are female unmarried, income lower than 300,000 SEK, elementary education and row houses for the house type.

Variable	Estimate	Std. Error	z Value	*p*
(Intercept)	1.627	1.250	1.302	0.193
Respondent age	−0.032	0.010	−3.071	0.002
Male	−0.215	0.340	−0.633	0.527
Married	−0.253	0.456	−0.555	0.579
Education (high school)	−0.418	0.604	−0.693	0.489
Education (university)	−0.187	0.612	−0.306	0.760
Education (other)	−0.523	1.043	−0.502	0.616
Environmental group member	−0.004	0.453	−0.008	0.994
Household income (300,001–450,000 SEK)	0.067	0.595	0.113	0.910
Household income (450,001–600,000 SEK)	0.245	0.610	0.402	0.688
Household income (600,001–750,000 SEK)	0.137	0.615	0.223	0.824
Household income (>750,000 SEK)	0.534	0.633	0.844	0.399
PCA1: willingness	0.017	0.079	0.213	0.832
PCA2: energy	0.212	0.108	1.969	0.049
PCA3: no concern	−0.030	0.110	−0.269	0.788
House type (terraced house)	0.205	1.056	0.194	0.846
House type (semi-detached house)	0.728	1.601	0.455	0.649
House type (independent villa)	−0.269	0.820	−0.328	0.743
House (m^2)	−0.000	0.000	0.906	0.365
Time lived in house (year)	0.107	0.016	6.579	0.000
House age (year)	0.031	0.006	5.324	0.000
AIC	472.270			
N.	771			

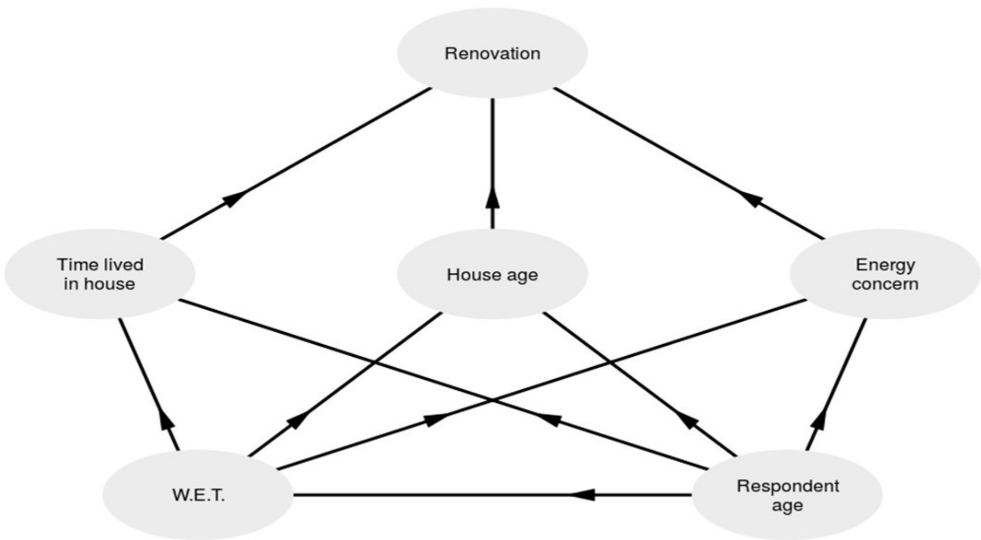

Figure 2. Structure of the renovation model.

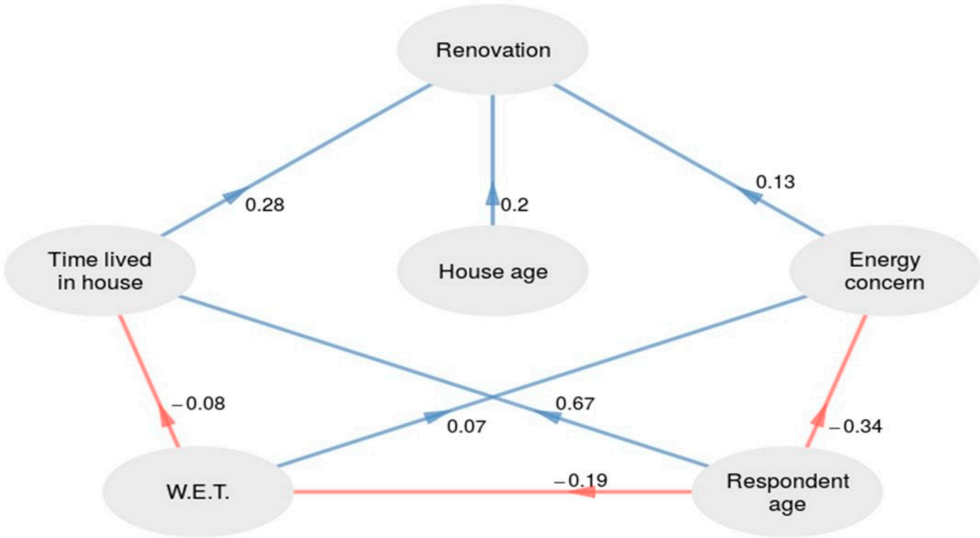

Figure 3. Path coefficients for the renovation PLSPM model.

Once the missing ones were excluded, the total number of observations used to estimate the model was 854. Its overall goodness of fit—which, as usual in PLSPM, was computed as the geometric mean of the average commonality and the average R^2 of the model—was 0.28. Figure 3 shows the resulting model (significant paths only). Path coefficients vary from −1 to +1, where −1 means a strong inverse relationship and +1 a strong direct one. Table 3 reports the direct, indirect and total effects of each variable. Direct effects are equivalent to one-segment path coefficients (e.g., the one from the respondent's age to energy concern); indirect effects are computed for paths including more than one segment (e.g., the one going from the respondent's age to renovation and passing through the energy concern), and total effects are the sum of direct and indirect effects. Following the standard procedure in PLSPM [49], bootstrap validation was performed confirming the robustness of the effect estimates.

Table 3. Direct, indirect, and total effects for the renovation model.

Paths	Direct Effect	Indirect Effect	Total Effect
Respondent age→WET	−0.19	0.00	−0.19
Respondent age→Energy concern	−0.34	−0.01	−0.36
Respondent age→House Age	−0.01	0.01	0.00
Respondent age→Period lived in house	0.67	0.01	0.69
Respondent age→Renovation	0.00	0.15	0.15
WET→Energy concern	0.07	0.00	0.07
WET→House age	−0.06	0.00	−0.06
WET→Time lived in house	−0.08	0.00	−0.08
WET→Renovation	0.00	−0.02	−0.02
Energy concern→Renovation	0.13	0.00	0.13
House age→Renovation	0.20	0.00	0.20
Time lived in house→Renovation	0.28	0.00	0.28

4.2. *Physical vs. Aesthetic Renovation*

In most cases, renovation works were linked to the aesthetic aspects of the house, like indoor walls, kitchen or bathroom, while less frequently they concerned the heating system and even more rarely the house insulation (Figure 4).

Focusing on the large subset of respondents (694, after missing observations in the relevant variables were excluded) who did renovate their house; we estimated a second PLSPM model having the same structure as presented in Figure 2. The node referring to generic renovation has been replaced by two new nodes, aesthetic and physical renovations respectively. More specifically, the aesthetic renovation construct reflected works to renovate the kitchen, bathroom, indoor walls, and heating system (DG ρ = 0.75); the physical renovation construct instead reflected works linked to the attic, cellar or wall insulation, draining (especially important in a humid climate like the one in Southern Sweden), windows, roof, facade, and drains (DG ρ = 0.85).

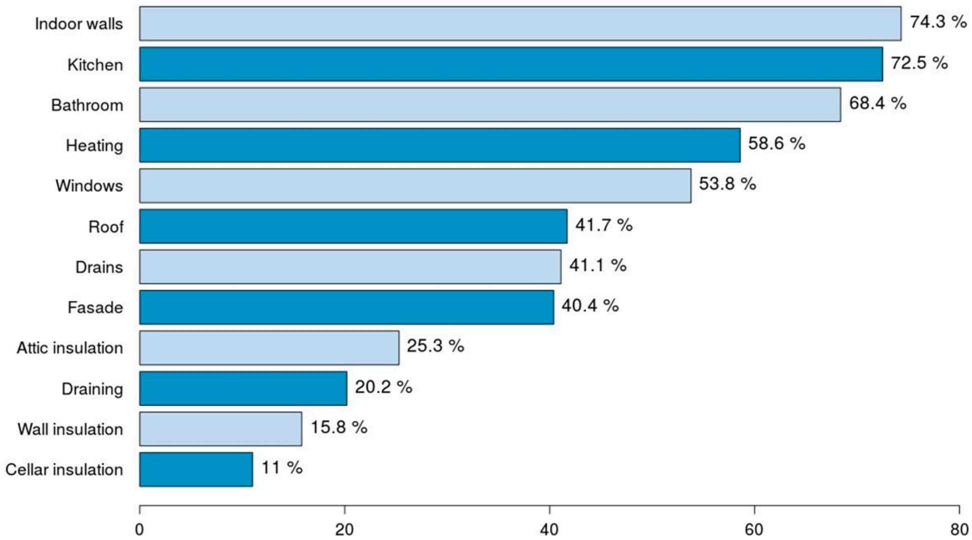

Figure 4. Frequency of renovation work by type.

Model estimates led to an overall goodness of fit of 0.27. Figure 5 shows the resulting significant paths while Table 4 reports the direct and indirect effects of each variable. Bootstrap validation was performed as above, confirming the robustness of the effect estimates. Overall, house owner's age has a strong and positive effect on the probability to perform aesthetic renovations, due to the fact that house owners had resided in the house for a longer period of time, but less effect on the probability to perform physical renovation (due to lower energy concern). Younger, wealthy, well-educated, and town-living house owners hold a higher concern to save energy, which increases the probability to perform physical renovations. The socioeconomic characteristics have a weak negative effect on the probability of performing aesthetic renovations, mainly because of the shorter time of residence in the house.

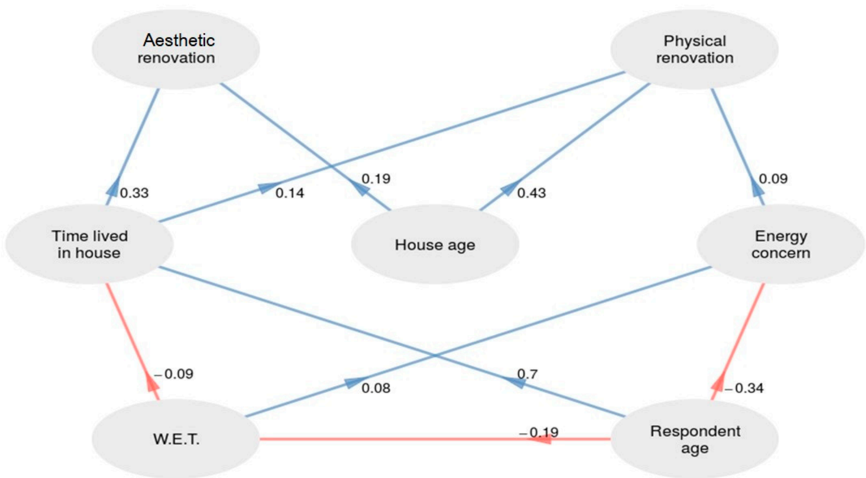

Figure 5. Path coefficients for the physical vs. aesthetic renovation model (significant paths only).

Table 4. Direct, indirect, and total effects for the physical vs. aesthetic renovation model.

Paths	Direct Effect	Indirect Effect	Total Effect
Respondent age→WET	−0.19	0.00	−0.19
Respondent age→Energy concern	−0.34	−0.02	−0.35
Respondent age→House age	−0.02	0.01	−0.01
Respondent age→Time lived in house	0.70	0.02	0.72
Respondent age→Physical renovation	0.00	0.07	0.07
Respondent age→Aesthetic renovation	0.00	0.24	0.24
WET→Energy concern	0.08	0.00	0.08
WET→House age	−0.03	0.00	−0.03
WET→Time lived in house	−0.09	0.00	−0.09
WET→Physical renovation	0.00	−0.02	−0.02
WET→Aesthetic renovation	0.00	−0.04	−0.04
Energy concern→Physical renovation	0.09	0.00	0.09
Energy concern→Aesthetic renovation	0.00	0.00	0.00
House age→Physical renovation	0.43	0.00	0.43
House age→Aesthetic renovation	0.19	0.00	0.19
Time lived in house→Physical renovation	0.14	0.00	0.14
Time lived in house→Aesthetic renovation	0.33	0.00	0.33

5. Conclusions

Our study identified the specific characteristics of those house owners who have performed physical or aesthetic renovations. The vast majority of the respondents (88%) did at least some renovation. A logit model showed that the age of the respondents, their interest and stated willingness to adopt technical and behavioral measures to reduce energy consumption, the time span of living in the house, and the age of the houses were the main drivers of renovation. More advanced analyses based on structural equation modeling showed that house owners' age and other socioeconomic characteristics, such as education, income, and living in larger towns affected the likelihood and type of renovation, mainly through their effect on the energy concern.

Our work highlighted that the house owners cannot be treated as a homogeneous group. The same heterogeneity reflects on their motivations to do the renovation work. The age of house owners positively affects the probability of renovations. With increased age, house owners are more likely to have renovated because they had more opportunities to do that in the long time they lived in their houses. However, with increased age, homeowners have less concern for saving energy, which negatively affected their interest in physical renovations. Younger homeowners, especially wealthier, educated, and town-living house owners, have greater concern for the environment and to save energy, which motivates them to perform at least certain types of physical renovations despite the shorter time they lived in their houses. These young homeowners, especially those lacking financial means, could be further encouraged to renovate their houses for energy savings through incentives and innovative business models such as a one-stop-shop renovation service [6,41]. Older house owners that conduct mostly aesthetic renovations but avoid performing physical renovations may also be motivated by a different set of policies and innovative business models considering that they have different needs and socioeconomic characteristics.

The questionnaire was only distributed to residents in the Kronoberg region, and therefore it might not reflect perceptions and motives of the residents in other parts of Sweden. Nevertheless, we were able to obtain statistically robust results, providing interesting insights into attitudes and motivational factors behind house renovation. The process leading to the decision to renovate is complex, with several variables interacting with each other to reach the final outcome. The complexity of the causal relations suggests that multiple factors should be taken into account to identify the target groups for energy renovation, when designing policy and market interventions to improve the energy performance of existing houses. Future research could extend the analysis to other geographical areas in Sweden, as the four different climate zones in the country may mean different needs and perceptions regarding energy performance of buildings. Furthermore, the intention to renovate the houses in the future needs to be examined in order to further validate the determinants of aesthetic vs. physical renovation. In such a way, promotional activities towards energy efficiency of buildings can be more efficiently designed.

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