Transaction costs as a barrier in the renovation decision-making process
A study of homeowners in the Netherlands

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ABSTRACT

The renovation of housing stock in the Netherlands has the potential to help achieving the country's climate change targets. However, there are non-monetary Transaction Cost (TC) factors, such as searching for information and finding a reliable professional/contractor, that present barriers to householders when making the decision to renovate or not. This study evaluates the impact of the transaction costs on the renovation decision-making process for two groups of householders, current renovators and potential renovators, and for three types of renovations, exterior renovations, interior renovations, and energy efficiency renovations. The study analyses householder renovation decisions in relation to TC barriers at different stages of the renovation processes. The data was collected from a survey of 3,776 homeowners in the Netherlands. The main identified TC barriers were found to be at the consideration, decision, and execution phases of the renovation decision-making process, and are: finding a reliable professional/contractor to do exterior renovations, determining costs for interior renovations, and finding ways to increase the energy efficiency of the house using energy-saving renovations. The main sources of information for householders are construction stores/Do It Yourself (DIY), installations and maintenance companies for exterior and energy efficiency renovations, while for interior renovations it is construction stores/DIY companies, Internet, and recommendations from family/friends. The findings from this study contribute to more effective management and distribution of both information and financial resources in relation to the renovation of housing stock.

1. Introduction

The Netherlands's built environment is undergoing a major renovation due to the country's climate change energy agreement that came into effect at the end of 2018. Under this agreement, the housing stock and other types of buildings that are currently moderately insulated and almost all heated by natural gas, are required to transform to well-insulated buildings using sustainable heating systems with clean or self-generated electricity [1]. However, a recent report by the Netherlands Environmental Assessment Agency (PBL) reveals that achieving the CO_2 emissions and energy efficiency targets set by the agreement are impossible by the horizon of 2020. Regarding the housing sector, the estimated energy consumption and CO_2 emissions are higher than the numbers predicted by the National Energy Outlook in 2017, and data shows that natural gas consumption by households barely decreased between 2015 and 2017 [2].

The owner-occupied sector had about 70% of the housing stock in 2017 [3]. Therefore, energy renovations in this sector can contribute significantly to reaching the energy targets. Despite the great potential of the owner-occupied sector in reducing energy consumption, much less strict targets are designed for this sector compared to social housing rental sector. For example, energy saving for the owner-occupied and rental sectors were set to be 3 and 7 petajoules respectively in the 2013 energy agreement. However, the estimated energy savings of these sectors is predicted to be 3 and 2 petajoules respectively by 2020 [2], which means that by achieving 100% of the energy saving target the owner-occupied sector will have contributed 1.5 times more to energy saving than the social housing sector that only achieved 28% of its target. Notwithstanding these results, managing renovations in the owner-occupied sector is more difficult compared to other housing sectors because individual homeowners are responsible for renovating their own houses, whereas in the social housing sector there is a central organisation to manage energy efficiency renovations.

Homeowners usually need to follow different phases in a renovation process. The phases are: consideration, planning, decision

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making, implementing, and experiencing [4,5]. Transaction costs (TCs) are non-monetary costs associated with different phases of the renovation process for homeowners. TCs are regarded as one of the main barriers in achieving energy efficiency targets. These costs have different forms such as time, effort, complexities in doing renovations, hassle factors, mess and nuisance, and uncertainties. TCs are inevitable and usually unpredictable. For example, in the consideration phase, renovators need to compare different types of energy efficiency measures to find the most appropriate measure in terms of cost and quality. This might prolong the duration of the renovation process and add significant extra effort [4,6]. Also, imperfect information may impede investment from actors in the market and therefore reduce the benefits of using more appropriate energy efficiency measures [7–9].

Despite the importance of TCs in achieving energy targets, only a few studies have investigated householder TCs [4,10,11]. Neglecting TCs in assessing and preparing energy efficiency policies causes sub-optimal decision and allocation of resources[12]. This paper therefore investigates transaction cost (TC) factors at different stages of the renovation process from the householders' perspective to evaluate the importance of these factors on renovation decisions. A survey was conducted among 3,776 homeowners to collect the data, which were quantitatively analysed to determine the importance of the TC factors. Two groups of householders, renovators and potential renovators, are studied to evaluate the effects of TCs at different stages of the renovation process. Renovators have experienced the renovations and can evaluate the barriers during the implementation phase. Potential renovators are in the consideration phase, they are willing and planning to renovate and can evaluate the barriers associated with this phase; targeting this group of householders can accelerate the renovation rates in the owner-occupied sector. Influencing factors are compared for the different types of renovations (categorised into exterior and interior renovations) and energy efficiency renovations [13–16]. The importance of different sources of information is examined. The results can be used to accelerate the rate of energy renovation by identifying the main TC factors to be targeted by policy interventions.

This paper is organised as follows. In Section 2, the recent literature on TCs regarding the decision making and renovation process are reviewed. In Section 3, the research methodology is described, the database is explained, and statistical and logistic regression analysis are provided. The results of the analyses, discussion on these results, and conclusions are presented in Sections 4–6, respectively.

2. State-of-the-art

2.1. Renovation and energy efficiency renovation

In general, the term renovation represents interventions with no energy-saving objective. Energy efficiency renovations on the other hand lead to energy saving, energy efficiency and/or microgeneration of electricity or heat. In this section, literature considering both renovations and energy efficiency renovations are reviewed [13–16].

Pardalis et al. [13] investigated the influencing factors of homeowner renovations for detached houses in Sweden. The renovations were categorised into energy efficiency renovations and aesthetic renovations. The results show the importance of socio-economic variables on householders' energy efficiency renovations. While emphasising the role of one-stop-shop for facilitating energy efficiency renovations, no significant influence of financial incentives were found for the application of the one-stop-shop. Pomianowski et al. [15] proposed a tailor-made renovation packages for individual family homeowners in Denmark. The main motivations of

householders for renovation were improving comfort, repairing deteriorated elements of the house, or doing aesthetic renovation. Most of the time, energy saving is not the main driver of renovation. Therefore, providing a package of renovations that considers both the interests of householders and energy saving measures is essential. In this approach, the most cost-effective renovation package was selected, while the investment cost is comparable with the available budget. A similar study was carried out among Swedish homeowners, where it was found that the rate of renovation is related to the demographic characteristics and construction period of the building [16].

The influencing factors of energy-related refurbishment for German homeowners was investigated by Baumhof et al. [17]. It was concluded that consultations and information sharing at one-stop-shops can increase the rate of energy efficiency renovations. Similar to the aforementioned studies, enhancing the appearance of the house, improving comfort, reducing structural damage, and increasing the house value, were considered as the main motivations for renovation. Among the barriers, complexities in carrying out the renovation, finding a reliable professional/contractor, and not enough time for planning and conducting renovations, were mentioned. In another study, Baumhof et al. [18] demonstrated the impact of behavioural beliefs on the decision-making process for single family houses and multi-family houses. The public authorities can motivate homeowners by using incentives, such as showing the aesthetic appearance of renovated buildings and providing information.

The interactions between different characteristics such as specific type of houses and one specific group of householders or the interactions between different actors on renovation decisions were studied by Buser and Carlsson [14]. The aim was to explore the roles of the interactions of influencing factors on low percentages of energy efficiency renovations in the total renovation activities for the homeowners. Interviews, workshop, and participatory observation methods complemented with in depth analysis were used for 24 small craftsman firms, 8 houses, and homeowners. The identified hindrances were the discovery of unsuspected house characteristics, the complexity of choices and decisions to be made, and the associated financial costs. All these factors, i.e. the role of houses and the various attributed meanings and representations of the renovation process, need to be considered and recognised to achieve successful renovation for single-family households.

Renovations can be categorised into exterior and interior types of renovations, but few articles have evaluated specific interior or exterior types [13,19–22]. Joudi et al. [21] examined the importance of interior covering on the energy efficiency of buildings compared to previous literature that studied the impact of exterior covering and solar heat gain on energy consumption. Joudi et al. [20] analysed different scenarios with reflective coverings and found that reflective covers for the interior and exterior are more suitable for colder climates and warmer climates, respectively.

2.2. Transaction costs definition and the determinants

New institutional economics use TC theories to describe market behaviour that is mainly due to imperfect and asymmetric information. The process of organising and finalising the activities is investigated, especially the impacts of these activities on the performance of the projects and/or actors involved through transactions with other actors in the market. There is no unique or standard way of defining TCs [19,23]. This study uses the definition by Coase [24], Ostertag [25], Mundaca et al. [7] and Kiss [9] in which TC is defined as any indirect inevitable cost in a transaction that affects the consumer's decision [24]. TC is a sub-category of 'hidden costs' that is not adequately considered and consists of search for information, negotiating, and monitoring costs [7,8,25].
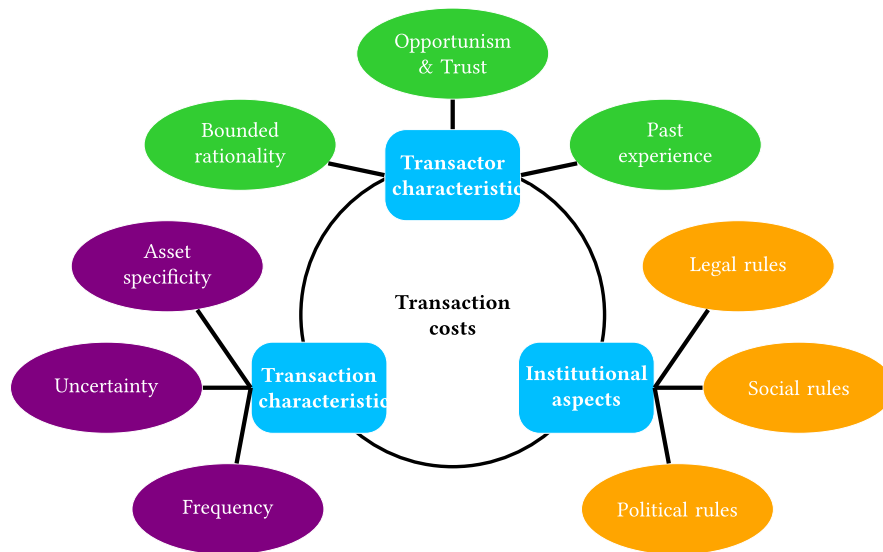
Fig. 1. The determinants of transaction costs.

The key factors that influence the from and impact of TCs are classified as: 1) Transaction characteristics - degree of asset specificity, uncertainties surrounding transactions and frequencies; 2) Transactor characteristics - bounded rationality and past experiences, opportunism, trust and confidence of the shared information between parties; 3) Type of institutional environment - the formal and informal legal, social and political rules; and 4) Type of institutional arrangement - the ways of production, distribution, and consumption of goods and services [12,26]. Three main elements of transaction characteristics are as follows: (1) Asset specificity - TC can be created whenever an asset is allocated for a specific purpose. In case of the renovation decision-making processes, the asset specificity is due to the investment in a specific type of technology/measure or specific skills/knowledge; (2) Uncertainty - any opportunistic behaviour or asymmetric information affect the confidence, trust, or certainty in making decision. In a renovation decision-making process, the two main types of uncertainties are expected benefits and opportunistic behaviour; and (3) Frequency - this element is related to uncertainty, since a householder with more experiences has less uncertainty over the outcomes of renovation [27]. See Fig. 1.

Some of the TC studies focused only on one of the phases of decision-making process e.g., searching for information and exploration [28], TCs in implementation, controlling, and enforcing [29], while others considered all of the phases (overall activities) [30,31]. The overall activity approach is followed in this study. The scale of TC is usually indicated as a proportion of total investment cost (%),[1] but sometimes in monetary terms or in work load, e.g. time [9]. We consider the time and effort for different activities in the renovation decision-making process as the main currency of TCs.

2.2.1. Supplier transaction costs

The cause and scale of TCs in supplier transactions were studied by Mundaca [32], who discovered that the parties involved found searching for information, advising consumers, and consulting with agents and contractors difficult to handle; the author quantified TCs for lighting and insulation, which were 10% and 30% of the total investment costs respectively. In another study, Mundaca et al. [7] focused on TCs for investors/project developers.

They performed a literature review (meta analysis) and developed a taxonomy consisting of five different TCs: (1) search for information costs, (2) negotiation costs, (3) approval and certification costs, (4) monitoring and verification costs, and (5) trading costs. A list of factors in the implementation and operation of low-carbon technologies and scale of TCs was presented. Endogenous factors, such as size and complexity of the project, large number of intermediaries, and less experience increase the TCs. The investigation showed that the sources and estimates of TCs are specific to cases and circumstances.

Kiss [9] evaluated TCs from the building owner and developer perspective in the planning and implementation phases of a passive house-oriented renovation in Sweden. The TCs associated with passive houses are higher compared to conventional renovations due to the lack of experience that building owners and developers have of concepts and technologies. The most important TCs were associated with the project formulation, target setting, and the search for passive house technologies. Therefore, the major TCs are associated with the planning and implementation phases of renovations and illustrate the differences of TCs at different phases of a renovation. The study also indicated that TCs can be reduced by increasing knowledge over the renovations of passive houses.

Valentova et al. [12] examined the role of actors on the scale and structure of the TCs of two major energy efficiency subsidy programmes in the Czech Republic. The impacts of experience and knowledge were found to be lower compared to the study by Kiss [9]. The results show that the share of TCs are lower for the bigger projects. For instance, TC share with 10,000 and 1,000,000 euros subsidies are 30% and 4%, respectively. However, the dependency between the actors and the TC scale could not be confirmed.

A TC framework from the real estate developer and architect's perspective was developed by Queena K Qian and Chan [33] using a case study in Hong Kong. The aim was to study the reluctance of the market to invest in energy efficiency measures. The method of analysis was in depth interviews, the results of which highlighted the negative impact of TCs on building energy efficiency. Factors, such as split incentive, information asymmetry, opportunistic behaviour, and ill-informed users affect TCs and the stakeholders willingness to participate. In a study by Qian et al. [34], it was assumed that individual stakeholders steadfastly guard their interests in any given investment decision. The researchers investigated the extra TCs affecting the willingness of stakeholders to take part in

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[1] Total investment costs = cost for information+cost for assessment and decision+cost for implementation

green investments. The findings suggest that the decision of developers and end-users over investing in green buildings is complex process, where TCs play a major role. Minimising the TCs incurred in the complex decision-making process will not only benefit the stakeholders but also bring net regenerative outcomes to society.

2.2.2. Public authority transaction costs

Since TCs account for 8–38% of the total costs for public authorities, neglecting TCs in the evaluation (and preparation) of energy efficiency policies causes a sub-optimal allocation of resources [12,35]. However, the TCs of a new energy efficiency policy can be influenced by the existing institutional environment and the TCs would be reduced if the new policy and the existing environment are consistent with each other. The reason being that there would be less information collection, less legislative and administrative activities for controlling the current norms, less information distribution, and less monitoring and enforcement [35]. For instance, if the new policy affects private parties' rights, the public authorities endure high TCs for implementing the new policy [36]. Decentralisation of the governance structure and a trusting relationship between public authorities and private parties can reduce TCs due to less administrative activities [37].

The TCs of parties are interrelated. If public authorities invest in collecting information, analysing and distributing this information for free to other parties, the initial and ongoing TC for gathering information by private parties might reduce at the expense of public authorities. No statistically significant difference was found between total TCs of public entities and private companies who are involved in projects [12]. The optimum level of TCs can be achieved by centralising internal processes (especially in the preparatory phase and in public tenders) and by having transparent local and national laws.

2.2.3. Householder transaction costs

Studies on householder TCs can be categorised as: (1) analysing the householder TCs for any activity in the dwelling (e.g., studying the impact of TCs on more people staying in a particular house) [11]), (2) studying TCs related to renovation (e.g.,[4]).

Bjorkqvist and Wene [10] estimated the TCs involved in changing a heating system as equal to 18 hours, which represented 13–28% of the predicted investment cost. They defined TCs as time spent at each decision stage. However, quantifying TCs has been criticised due to unclear time allocation for a specific activity. A study in California found that high implicit costs were incurred to collect information on the benefits of energy saving of different appliances, i.e. lighting and washing machine, for householders. Inadequacy of utilising and processing information are other hindrances to investing in energy efficiency technologies [38].

Imperfect information and TCs may lead to the selection of less energy efficient appliances by a householder compared to a well-informed social planner. Consumers must decide by evaluating the prices and expected future performance of appliances. Whether or not householders endure high costs and considerable effort to fulfil accurate and proper expectations, the scale of energy efficiency in the competitive market might be lower than socially efficient outcomes [39].

The uptake of energy saving measures is tenfold when monetary incentives are merged with information provisions [40]. In Norway, the owner-occupied sector has a major share of the housing stock. The successful Norwegian homeowners in doing energy efficiency renovations are the informed or the experienced ones. Lack of knowledge, lack of trust in advice from specialists, or preferences for doing the renovations by themselves, hinder energy efficiency renovations [5]. These studies indicate the importance of providing information to stimulate energy efficiency renovations.

In the following section, the main influencing factors in the renovation decision-making process are explained. Although the focus is on TC barriers, other important factors in householders' decision-making processes are included, such as socio-demographic variables and motivation for conducting renovations.

2.3. Different phases and the determinants in the decision-making process

A renovation consists of five different phases: consideration (understanding the needs, information search and pre-evaluating), planning, finalising the decision, executing, and experiencing (post-evaluating) [41]. In the following subsections, the determinants of TCs are discussed for each phase of the renovation process.

2.3.1. Consideration

In the consideration phase, the critical influencing factors are socioeconomic factors, such as age, education, and income. Table 1 summarizes the main socioeconomic variables and motivations in conducting renovations as identified by Ebrahimigharehbaghi et al. [42].

In this phase, householders need to find information on the type of renovations and appropriateness for their houses. Expectations on the cost and benefit of a renovation is essential to evaluate the feasibility. The potential TC barriers are: complexity in finding information and a reliable professional, complexity in determining the cost and benefit, and time and effort to find available and appropriate measures. The cognitive burden of making complex and irreversible decisions is also part of TC barriers at this phase [4,6].

2.3.2. Planning

In the planning phase, householders need to investigate different aspects of the renovation procedure, including the essential permits they require before conducting the renovation [43–45]. The time and effort involved in searching for a reliable expert to help them with finding the essential information are the main TC in this phase. Imperfect or asymmetric information may increase that particular TC [8].

2.3.3. Decision

Householders usually do not have sufficient technological knowledge and are not construction experts. Therefore, they need to rely on experts [4,43,46,47]. Before implementation, renovators need to find a reliable contractor to carry out the work that they are not willing to do or cannot do themselves. The subsidies and loans by public authorities might influence the decision, especially when they lack the necessary resources. At this phase, the complexity in finding a reliable contractor and obtaining subsidies and loans can be sources of TCs. Awareness of the advantages of renovation is a motivator when making decision in relation to the aforementioned TCs.

2.3.4. Executing

Householders explore the renovation activities in which they have to be involved and how much hassle and mess the renovation may cause. At this stage, TCs are disruption in the ordinary life, the hassle factor during the renovation, and the complexity of implementing the renovation [4]. Additionally, lack of trust in the relationship between the contractor and householder might increase the TCs at this phase.

2.3.5. Experiencing

After decision-making and implementation, the householder's experiences are disseminated through social networks [6]. The householder should also find the next step of the renovation, such

Table 1
Socioeconomic factors and motivations in conducting renovations.

Categories	Factors
Socioeconomic examples	Age, Education, Income, Mover/ Stayer, Number of Occupants
Drivers	Cost saving, Increasing the house value, Increasing comfort, Repairing/ Replacing equipment
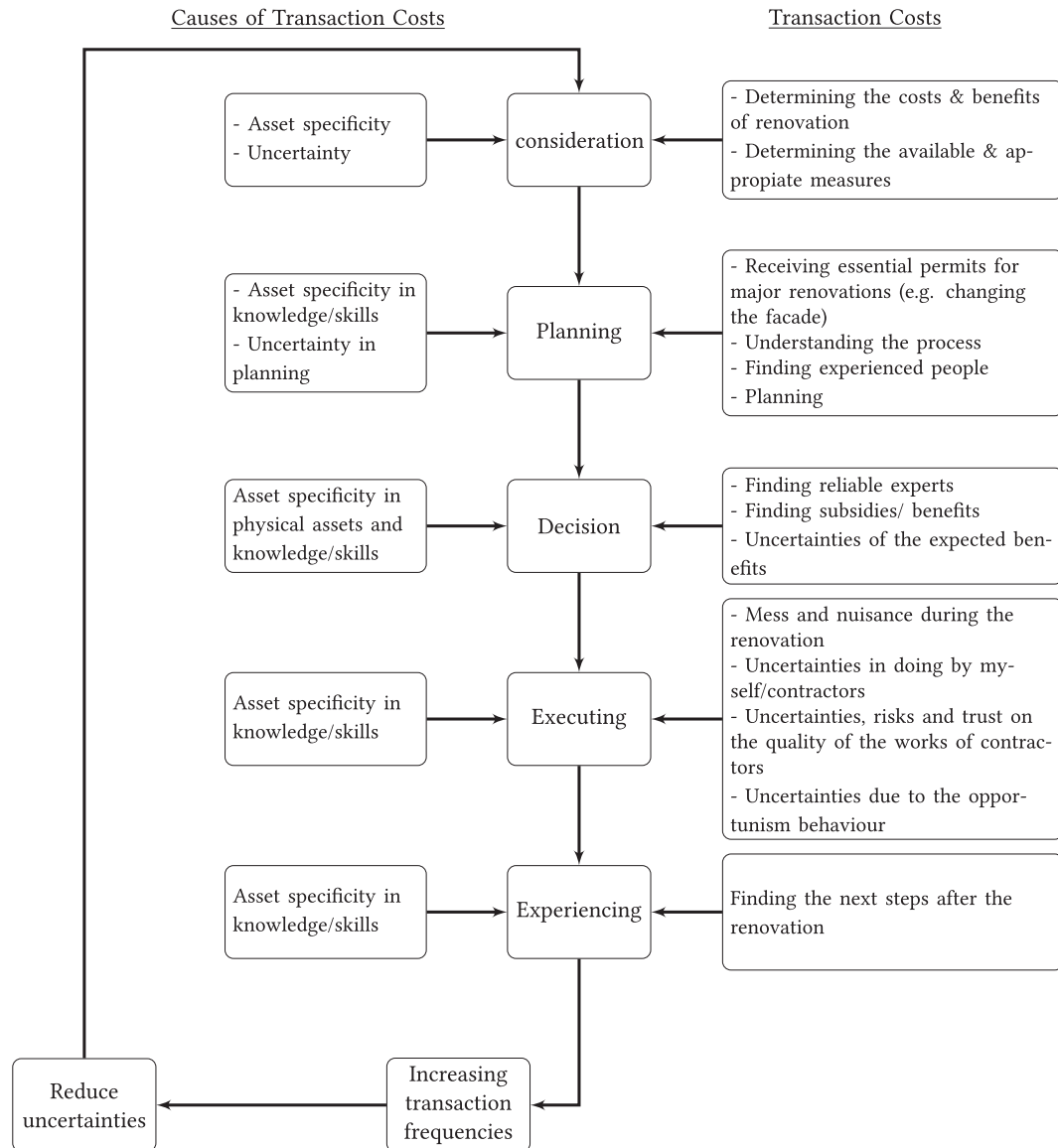
Fig. 2. Transaction costs at different stages of a renovation based on the literature review.

as whether a complementary renovation is necessary. Finding such information is a TC barrier in this stage. Fig. 2 summarises the TCs at different phases of the decision-making process.

3. Methodology

3.1. Database

A questionnaire survey was conducted among 3,776 homeowners in the Netherlands. The questionnaire comprised three sections: household and building characteristics, renovation (two categories: exterior and interior), and energy efficiency renovation. Homeowners were asked whether or not they had implemented a

renovation in the last two years, and whether or not they planned a renovation in the next two years.

To evaluate the representativeness of our sample set in the homeowner sector of the Netherlands, we compared a few variables of our sample with the Woon energy module dataset 2012; Fig. 3 shows the results of this comparison. In both datasets, the highest share belongs to dwellings constructed between 1971 and 1990 where the percentages are 29% and 35%, respectively. For the periods 1945 to 1970 and after 1991 the percentages from the two data sets are very close.

In both samples, the majority of houses in the sample are intermediate houses. However, the percentage of intermediate houses in our sample is greater than the one in Woon energy module

Fig. 3. Comparison of construction periods of survey data vs. Woon energy module 2012.

Fig. 4. Comparison of dwelling types of survey data vs. Woon energy module 2012.

Fig. 5. Comparison of age of respondents of survey data vs. Woon energy module 2012.

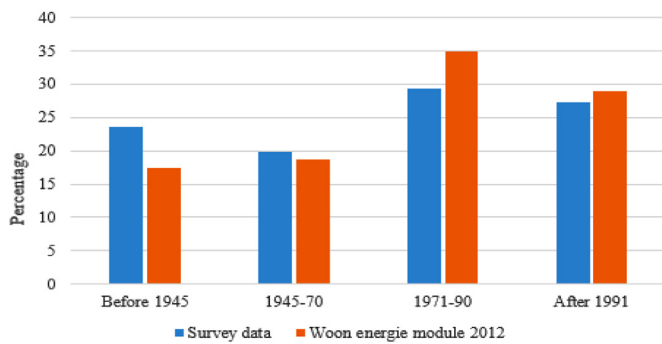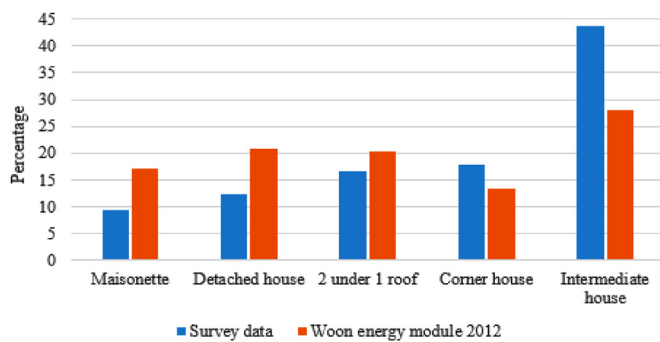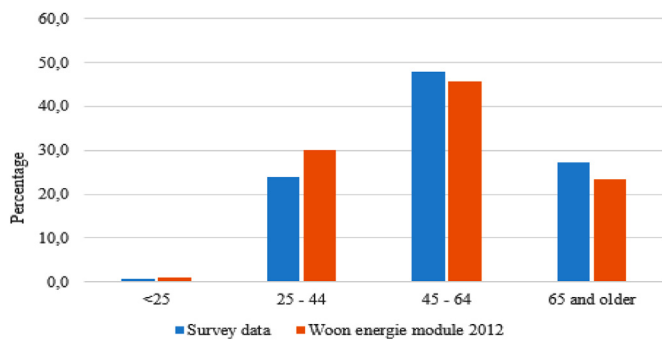2012. The percentage of corner houses is more in our sample. See Fig. 4.

Considering the age distribution, 47% of respondents belong to the age group between 45 and 64 years old. The percentages are approximately similar for all age groups in both datasets. Similar patterns are followed in both datasets for education, with the highest percentage belonging to the professional education group and householders with university degrees. See Figs. 5 and 6.

Table 2 shows the number of people, type of family, and householder incomes of the Woon energy module dataset 2012. Tables 4 and 5 provide the same information from of our survey dataset. Since the categories and scales of income are different for these two datasets, no comparison can be made for the income categories.

3.2. Different types of renovation

Different types of renovations are categorised in Table 3. The questionnaire questions apply to all types of renovation, regard-

Table 2
Data from Woon energy model dataset 2012.

Variable	Categories	Frequency	Percent
Number of people in the household	1	604	21.7
	2	1195	42.9
	3	343	12.3
	4	448	16.1
	5 and more	194	5.7
one / multiple family	Single	2316	83.2
	Multi	468	16.8
Household income (Euro per year)	<=13,000	68	2.4
	13,000 - 26,000	244	8.8
	26,000 - 38,000	527	18.9
	38,000 - 51,000	508	18.2
	51,000 - 63,000	434	15.6
	63,000 - 76,000	387	13.9
	76,000 - 89,000	224	8.0
	89,000 - 100,000	151	5.4
	>=100,000	240	8.6

less of whether they are exterior/interior renovations or energy efficiency renovations.

3.3. Household profile and building characteristics

Table 4 shows the respondent characteristics. The majority have a professional qualification, with 32.3% of householders earning between 1,800-3,150 euro per month and 24.2% receiving more than 3,150 euro per month.

61.6% of houses have one or two inhabitants, which is a very close to the 70.5% reported in [3] for the entire country.

3.4. Method of analysis

In the survey, respondents are asked whether they have done renovations in the past or are planning to do any renovation in the up-coming years. The answers to these questions are: a) Yes (1), b) No (0). The number of respondents for different types of renovations are listed in Table 6:

3.4.1. Renovators
TC barriers: renovation vs. energy efficiency renovation. Fig. 7 shows the importance of complexities from the renovator perspectives of the renovation (exterior and interior) and energy efficiency renovations. For renovation (exterior and interior types), the main identified complexities are carrying out the renovation, determining the costs, and finding a reliable professional/contractor. The least important factors are finding financial support, determining the state of maintenance, and making the house more energy efficient.

For energy efficiency renovations, the influencing TC barriers are similar to the renovations. However, 19% of respondents mentioned a high degree of complexity involved in finding the best way to make their house more energy efficient.

Information: renovation vs. energy efficiency renovation. Fig. 8 demonstrates the importance of sources of information for renovations (exterior and interior) and energy efficiency renovations. For renovations, the main identified sources are the maintenance/installation companies, family/friends, and Internet.

3.4.2. Potential renovators
TC barriers: Renovation vs. energy efficiency renovation. Fig. 9 shows the importance of TC barriers for potential renovators. For the exterior, the main identified factors are in determining the costs, looking for a reliable professional and carrying out the renovation. The least important TCs are in determining the maintenance state, planning the work, and performing the work themselves.
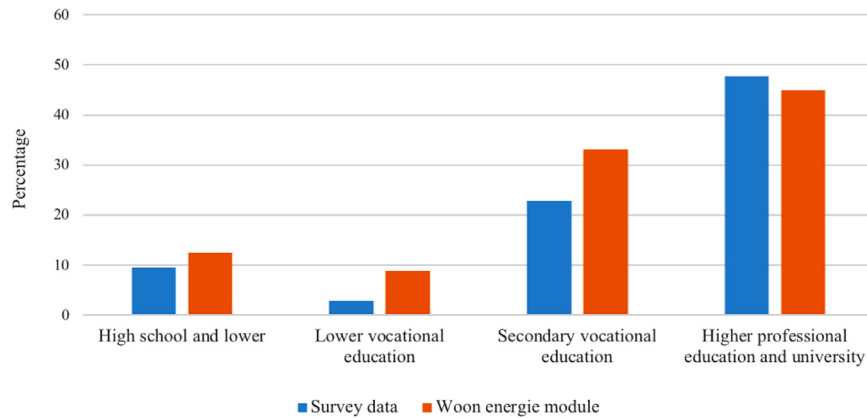
Fig. 6. Comparison of education of respondents of survey data vs. Woon energy module 2012.

Table 3
Categorisation of different types of renovations.

Type of renovation		Subtype of renovation
Renovation	Exterior	Roof construction/covering, Gutters/ drainpipes, Masonry/ jointing of the façade, Wood/ painting outside, new installation/ extension, Foundation repair
	Interior	Inner walls, Kitchen, Toilet and bathroom, Paint / wallpapering / tiling, electricity
Energy efficiency renovation		CV boiler, ventilation, roof insulation, glass insulation, floor insulation, facade/ cavity insulation, insulation of the pipes, solar panels, solar water heater, heat pump

Table 4
Homeowners' profile.

Homeowners' profile	Categories/Average	Frequency	Percentage
Age	<25	27	0.7
	25–44	782	20.7
	45–64	1566	41.5
	65–105	890	23.6
Education	High school and lower	363	9.6
	Lower vocational education	104	2.8
	Secondary vocational education	862	22.8
	Higher professional education	1216	32.2
	University	589	15.6
Average net monthly income of respondents (Euro per month)	Lower than 1000	37	1.0
	1000–1350	101	2.7
	1350–1800	416	11.0
	1800–3150	1218	32.2
	More than 3150	915	24.2
Planning to move within 2 years	Yes	228	6.0
	No	2644	70.0
	Probably	666	17.6

Table 5
Building characteristics.

| Building characteristics	Categories/ Average	Frequency	Percentage
Number of people in the house	1	781	20.7
	2	1,544	40.9
	3	393	10.4
	4	390	10.3
	5 and more	133	3.5
One/ multifamily	Multi	1,186	31.4
	Single	2,336	61.9
Construction period	Before 1945	622	16.5
	1945–1970	670	17.7
	1971–1990	1,252	33.2
	After 1990	1,041	27.6
Type of house	Apartment	942	24.9
	Detached house	317	8.4
	2 under 1 roof	428	11.3
	Maisonette	244	6.5
	Corner house	464	12.3
	Middle house	1,127	29.8
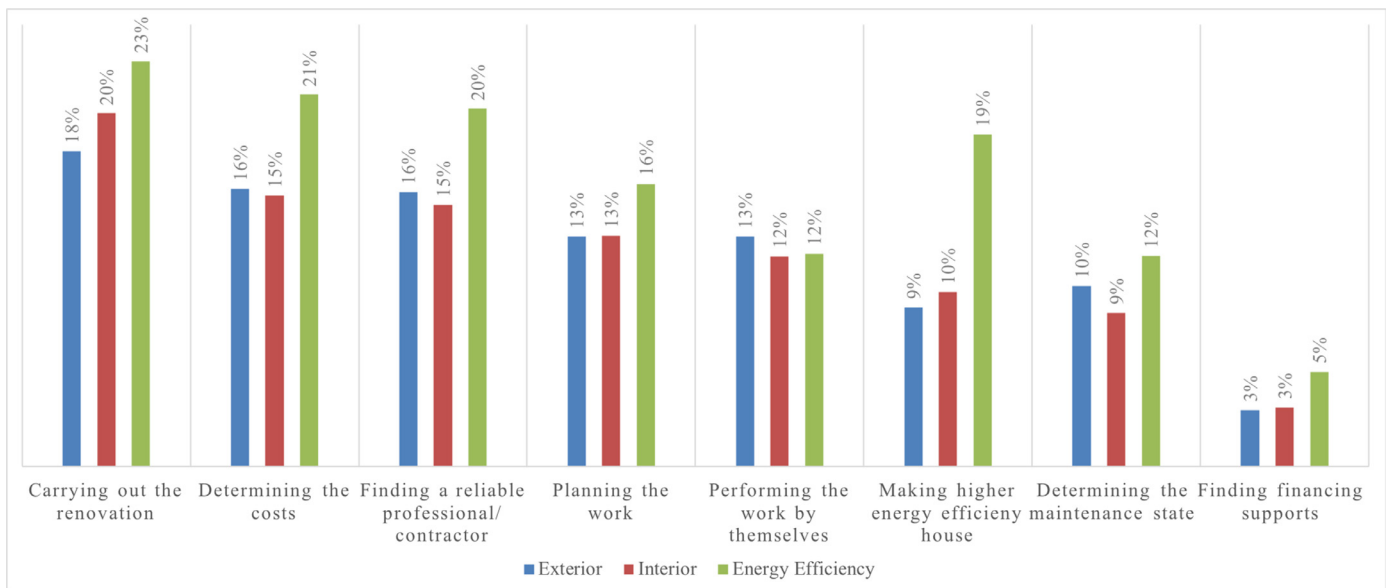
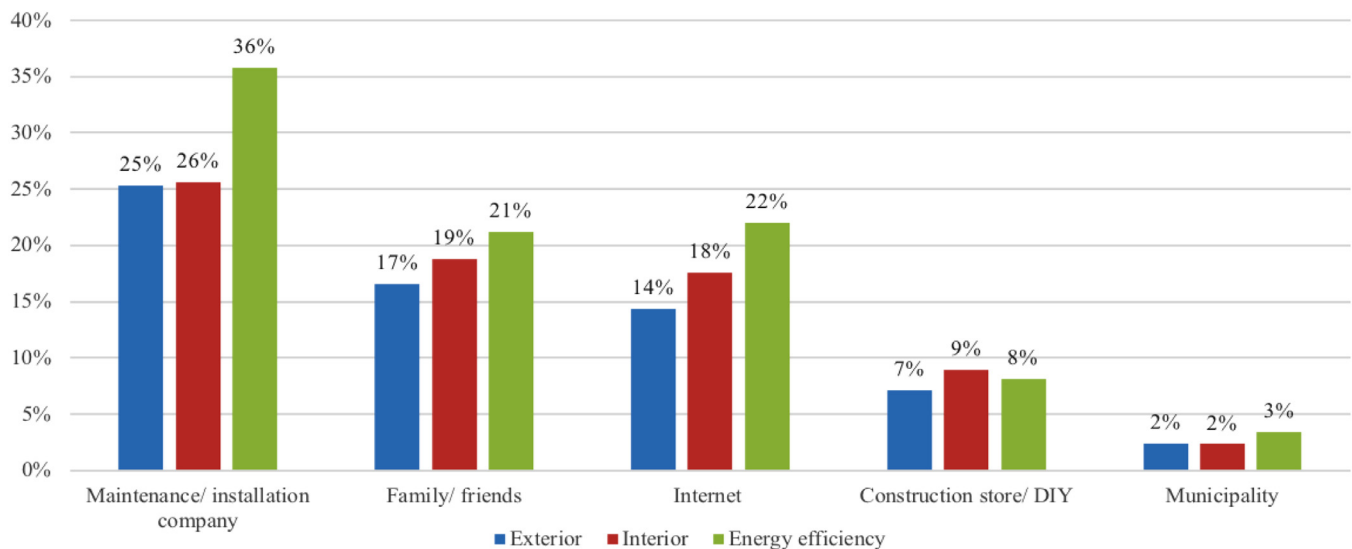**Fig. 7.** Ranking the TCs barriers by renovators.

Fig. 8. Ranking the sources of information by renovators.

Table 6
Number of respondents for different types of renovations.

Group	Renovators	Potential renovators
Exterior	1,958	1,353
Interior	1,826	1,035
Energy efficiency renovation	1,008	342

For the interior renovations, the main identified TCs are in determining the costs, carrying out the renovation, and finding a reliable professional. Determining whether the house maintenance is adequate is the least important TC. For the energy efficiency renovations, the main identified TCs are determining the costs, making the house more energy efficient, and finding funding/ financing options. The least important ones are in determining the adequate maintenance of the house, planning the work, and performing the work themselves. The main difference is that finding a reliable professional and maximising energy efficiency is ranked higher for energy efficiency renovations.

Information: Renovation (exterior and interior) vs. energy efficiency renovation. Fig. 10 shows the selected sources of information by potential renovators. For all types of renovations, the main identified sources are the Internet, maintenance/ installation companies, and family/friends. The least important sources are banks/mortgage lenders and municipalities.

3.4.3. Transaction costs in the decision-making process of renovation

The questionnaire survey asked general questions about the main TC factors and sources of information for the renovation. These questions were answered for each type of renovation (exterior, interior, and energy efficiency renovation).

The importance of TC barriers at different stages of the decision-making process of renovation and the sources of information are investigated using logistic regression. In the analysis, the binary dependent variable is the renovation decision, and some assumptions are made. In total, we have estimated six regressions for renovators and potential renovators. For each group, three regressions are estimated for the renovations (exterior and inte-

Fig. 9. Ranking the stages of TCs barriers by potential renovators.
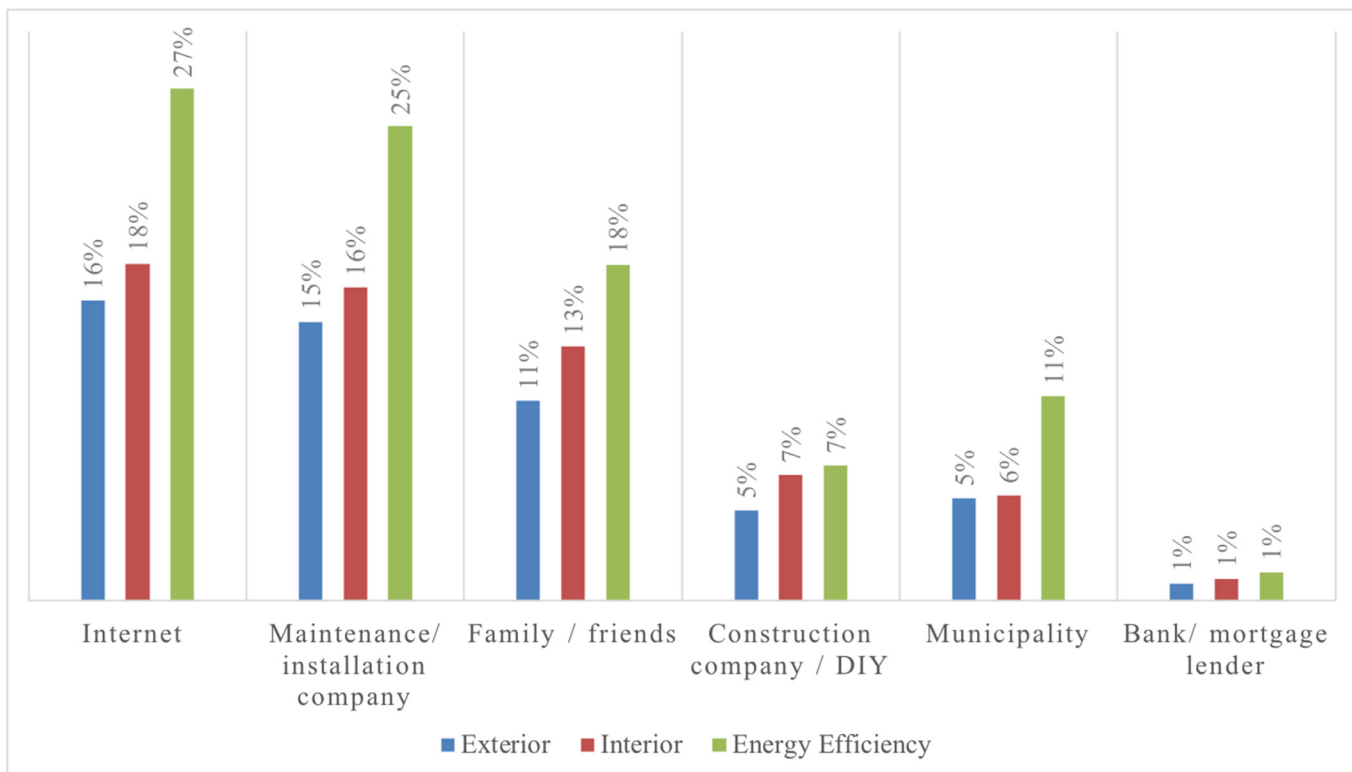
Fig. 10. Ranking the sources of information by potential renovators.

Table 7
SPSS outputs for logistic regression.

Independent variables	B	S.E.	Wald	df	Sig.	Exp(B)
Constant						

rior), and energy efficiency renovations. The question was whether the homeowner implemented/planned to do the renovation in the last/next 2 years. The independent variables are the household and building characteristics, the sources of information, TC barriers, motivation, and the state of maintenance of a specific renovation.

Table 7 shows a logistic regression output in Statistical Package for the Social Sciences (SPSS). Coefficient B indicates the changes in log of the dependent variable for every one-unit change in an independent variable. Odds ratios (column exp(B)) explain the degree of association between dependent and independent variables and are used to compare the relative probabilities of the occurrence (chance criterion) of the renovation, given the presence of variable such as TC barriers. For the variables with categories, generally the chance criterion is compared with the reference category. Binary variables can be seen as category variables with only two categories. The percentages of selecting the category j by respondents can be calculated using the chance criterion

Table 8
Multicollinearity tests in six regressions.

Regression	max VIF
Renovators	
Renovations - exterior	1.484
Renovations - interior	1.254
Energy efficiency renovations	1.202
Potential renovators	
Renovation - exterior	1.460
Renovation - interior	1.538
Energy efficiency renovations	1.731

$(exp(B_j)/(\sum_{i=1}^{n} exp(B_i)) \times 100$. A Wald test demonstrates the significance of each coefficient in the regression.

There are some assumptions in conducting logistic regressions, including the binary dependent variable, not having multicollinearity between independent variables, and a large sample size. Validity of the multicollinearity assumption is verified by calculating the Variance Inflation Factors (VIF). The VIF = 2.5 is the initial point of concern and VIF>10 shows multicollinearity [48]. The VIF for the six regressions are presented in Table 8. There is no serious multicollinearity between the independent variables in the sample.

Binary logistic regression model, used to describe the relation between the dependent variable and independent variables, is presented in Eq. (1):

$$Log\left(\frac{P_{\text{renovation}}}{(1 - P_{\text{renovation}})}\right)$$
$$= \beta_0 + \beta_1 X_{\text{households and buildings' characteristics}}$$
$$+ \beta_2 X_{\text{motivations for renovations}}$$
$$\times \beta_3 X_{\text{sources of information}} + \beta_4 X_{\text{TCs barriers}}$$
$$+ \beta_5 X_{\text{state of maintenance for each type}} \qquad (1)$$

\WWhere P is the probability of the events, and X represents independent variables. After estimation, the Omnibus tests of model coefficients and the Hosmer and Lemeshow test are applied to validate the models, as shown in Table 9. The Omnibus test checks whether the model estimates the outcome with the explanatory variables better than without [49]. The Omnibus tests are statistically significant, and the models are better with explanatory variables than without. The Hosmer and Lemeshow test illustrates the goodness of fit, which is a significant factor for a good model.

4. Results

The importance of TC barriers was investigated using regression analysis. We estimated six regressions for exterior, interior, and energy efficiency renovations for renovators and potential renovators.

4.1. Renovators

4.1.1. Regression analysis
Exterior type of renovation. Table 10 shows the result of logistic regression for exterior type of renovations. Among socioeconomic factors, income and education have a significant impact on renovation decisions. Higher income and education result in higher probability of exterior type of renovations. For instance, renovators with an income of more than 3,150 euro are 2.3 times more likely to perform an exterior renovation compared to the income group

with less than 1,350. Regarding the building characteristics, the regression shows a relationship between building types and exterior type of renovations. Corner and detached houses are more likely to renovate the exterior of buildings compared to apartments.

The significant TC barriers are in determining the state of maintenance of the house by experts and in doing the work themselves, as identified by 68% and 62% of respondents indicated that these TC barriers were difficult to handle respectively. These are all TC barriers that hinder the process of doing exterior type of renovations (execution phase). It can be concluded from the complexities of exterior type of renovations that householders need the help of an expert. The main identified source of information verifies this result. 62% of respondents indicate construction stores and Do-It-Yourself (DIY) companies as the main source of information for exterior type of renovation. The second significant source of information is via internet with 40% of respondents indicating the importance of this information source. The conditions of different types of exterior renovations are included in the analysis to investigate on which types of exterior renovation the householders invest. Based on the regression, householders are more likely to perform renovations when the states of maintenance of outside wood and painting and foundation are not good; these influencing factors were mentioned by 80% and 76% of respondents respectively. The state of glass insulation is also significant and triggers householders to renovate their windows.

Interior type of renovation. Table 11 shows the result of logistic regression for interior type of renovations. Younger householders are more willing to renovate. Householders in the age group of less than 44 are 2.40 times more likely to renovate their houses compared to householders in the 64–105 age group. Respondents who indicated that they are planning to move within 2 years are 1.5 times more likely to renovate the interior part of the houses compared to the ones that plan to stay. Householders with the highest income (more than 3,150 euros) are 2.23 times more likely to renovate the interior of the house compared to the group with the least income (less than 1,350 euros). The coefficients of different levels of education are not significant and no relationships can be found with renovating the interior of houses and education. There is a significant relationship between the building type and interior renovation. Detached and 2 under 1 roof homeowners are 3 and 2.6 times respectively more likely to renovate compared to apartment owners.

Householders did not indicate any complexities for conducting the actual work for interior types of renovations. The only significant TC barriers regarding the complexities is on determining the costs of doing these renovations. Approximately 40% of respondents mentioned this TC barrier as important. On the other hand, the information sources are very important and have a considerable impact on the interior renovation decision-making process. The main identified sources of information are construction stores and DIY companies. In the Netherlands, DIY companies supply the components that the consumers need for undertaking house renovations by themselves. These companies have all the necessary building materials and components. They also support their customers by providing information.

These results show that the majority of interior renovations are done by householders themselves. This is consistent with the fact that they did not mention complexities in finding a reliable professional/contractor but did mention that all sources of information, especially from DIY companies, are very important. 61% and 67% of respondents mentioned construction stores/DIY and the Internet as the main sources of information. The municipality seems not to be a chosen source of information for interior types of renovations. The coefficient of this variable is not significant in the regression analysis. There is no statistically significant relationships between the state of maintenance of interiors and renovations. One close

Table 9
Assessing the regressions regarding the goodness of fit.

	Omnibus Tests of Model Coefficient			Hosmer and Lemeshow Test			R²
	Chi-square	df	Sig.	Chi-square	df	Sig.	
	Renovators						
Exterior	132.871	33	0.000	13.021	8	0.111	0.223
Interior	143.216	27	0.000	8.465	8	0.389	0.231
Energy efficiency	127.343	31	0.000	2.664	8	0.954	0.192
	Potential renovators						
Exterior	41.174	23	0.011	9.366	8	0.312	0.143
Interior	99.938	35	0.000	11.532	8	0.173	0.357
Energy efficiency	109.455	33	0.000	8.887	8	0.352	0.336

Table 10
Logistic regression for the exterior type of renovation in the last 2 years

Variables	B	S.E.	Wald	df	Sig.	Exp(B)
Income- Ref: less than 1350			11.857	3	0.008	
(a) 1350–1800 euro	-0.224	0.487	0.211	1	0.646	0.799
(b) 1800–3150 euro	0.375	0.448	0.701	1	0.402	1.455
(c) more than 3150 euro	0.813	0.465	3.054	1	0.081	2.254
Education- Ref: high school and less			9.406	4	0.052	
(a) Lower vocational education	-1.348	0.631	4.558	1	0.033	0.260
(b) Secondary vocational education	-0.481	0.352	1.870	1	0.172	0.618
(c) Higher professional education	-0.223	0.340	0.430	1	0.512	0.800
(d) University	0.193.	0.389	0.246	1	0.620	1.213
Type of house- Ref: Apartment			30.812	5	0.000	
(a) Detached	-0.646	0.409	2.498	1	0.114	0.524
(b) 2 under 1 roof	-1.586	0.338	22.064	1	0.000	0.205
(c) Maisonette	-0.353	0.445	0.631	1	0.427	0.702
(d) Corner house	-1.335	0.324	17.029	1	0.000	0.263
(e) Middle house	-1.184	0.280	17.835	1	0.000	0.306
TC:(a) In determining the maintenance state of house	0.756	0.261	8.387	1	0.004	2.130
(b) In performing the work (yourself)	0.515	0.243	4.496	1	0.034	1.673
(c) In finding a reliable contractor	0.313	0.207	2.294	1	0.130	1.368
Information: (a) Internet	-0.391	0.204	3.688	1	0.055	0.676
(b) Family/ friends	0.378	0.204	3.422	1	0.064	1.459
(c) Construction store / do it yourself company	0.474	0.195	5.935	1	0.015	1.606
State of maintenance: (a) Wood and paint outside	1.483	0.329	20.335	1	0.000	4.405
(b) Foundation	1.168	0.535	4.775	1	0.029	3.217
(c) Glass insulation	-0.937	0.420	4.961	1	0.026	0.392
Constant	0.231	1.455	0.025	1	0.874	1.260

Table 11
Logistic regression for the interior type of renovation in the last 2 years.

Variables	B	S.E.	Wald	df	Sig.	Exp(B)
Age group- Ref: less than 44			14.262	2	0.001	
(a) 44–64	−0.185	0.231	0.641	1	0.423	0.831
(b) 64–105	−0.875	0.260	11.366	1	0.001	0.417
mover-stayer(1)	0.416	0.206	4.070	1	0.044	1.516
Income- Ref: less than 1350			4.326	3	0.228	
(a) 1350–1800 euro	0.738	0.476	2.398	1	0.122	2.091
(b) 1800–3150 euro	0.516	0.434	1.418	1	0.234	1.676
(c) more than 3150 euro	0.800	0.453	3.125	1	0.077	2.226
Type of house- Ref: Apartment			19.144	5	0.002	
(a) Detached	1.132	0.373	9.237	1	0.002	3.103
(b) 2 under 1 roof	0.946	0.321	8.674	1	0.003	2.575
(c) Maisonette	0.135	0.327	0.170	1	0.680	1.144
(d) Corner house	0.846	0.307	7.599	1	0.006	2.329
(e) Middle house	0.710	0.237	8.954	1	0.003	2.034
TC: In determining the costs	−0.486	0.199	5.963	1	0.015	0.615
Information: (a) Internet	0.725	0.216	1.249	1	0.001	2.064
(b) Family/ friends	0.461	0.202	5.215	1	0.022	1.585
(c) Construction store/ Do it yourself company	1.150	0.349	10.876	1	0.001	3.159
(d) Maintenance/ installation company	0.465	0.193	5.782	1	0.016	1.592
State of maintenance: paint, wallpaper and tile work	0.842	0.552	2.325	1	0.127	2.322
Constant	−0.929	1.143	0.660	1	0.416	0.395

Table 12

Logistic regression for energy efficiency renovation decision in the last 2 years.

Variables	B	S.E.	Wald	df	Sig.	Exp(B)
Income- Ref: less than 1350			6.849	3	0.077	
(a) 1350–1800 euro	−0.117	0.446	0.068	1	0.794	0.890
(b) 1800–3150 euro	−0.197	0.408	0.234	1	0.629	0.821
(c) more than 3150 euro	−0.632	0.420	2.260	1	0.133	0.532
Education- Ref: high school and less			6.972	4	0.137	
(a) Lower vocational education	0.933	0.602	2.407	1	0.121	2.543
(b) Secondary vocational education	0.495	0.298	2.765	1	0.096	1.641
(c) Higher professional education	0.661	0.283	5.455	1	0.020	1.937
(d) University	0.367	0.308	1.418	1	0.234	1.444
Type of house- Ref: Apartment			9.852	5	0.080	
(a) Detached	0.576	0.315	3.344	1	0.067	1.778
(b) 2 under 1 roof	0.394	0.280	1.970	1	0.160	1.482
(c) Maisonette	−0.391	0.321	1.483	1	0.223	0.677
(d) Corner house	−0.060	0.264	0.052	1	0.819	0.941
(e) Middle house	0.264	0.219	1.443	1	0.230	1.3021302
TC:(a) In determining the ways to increase energy efficiency	1.609	0.208	59.868	1	0.000	4.997
Information: (a) Internet	0.265	0.175	2.285	1	0.131	1.303
(b) Construction store/ Do it yourself company	−0.509	0.222	5.249	1	0.022	0.601
(c) Maintenance/ installation company	0.387	0.167	5.336	1	0.021	1.472
State of maintenance: (a) Humidity	0.708	0.422	2.822	1	0.093	2.031
(b) Flow of fresh air	−0.998	0.498	4.014	1	0.045	0.369
Constant	−1.860	1.621	1.316	1	0.251	0.156

to a significant coefficient (90% confidence interval) is for painting, wallpaper and tile work.

Energy efficiency renovations. Table 12 shows the logistic regression for energy efficiency renovations that are conducted in the last two years by the renovators. The income variable is significant, however the coefficients of different categories of income are not significant. Therefore, it cannot be stated that the higher income householders have done more energy efficiency renovations. Higher education levels show significant coefficients for two categories of secondary vocational and higher professional educations. Householders with higher professional educations are twice as likely to renovate the houses to make them more energy efficient. The coefficient of university degree is not significant and no conclusion can be made for this group of householders.

The coefficient of building type variable is significant. However, for the sub-categories of this variable, only the coefficient for the detached houses is statistically significant. Homeowners with detached houses have more probability to renovate their house energy efficiently compared to other building types. The householders with detached houses are 1.8 times more likely to renovate their houses more energy efficiently compared to the householders with apartments.

Among the TC barriers, only one has a highly significant coefficient. Householders indicated the complexities in determining the ways to increase the energy efficiency of their houses as the main TC barrier. 83% of householders that renovated their houses more energy efficiently mentioned this barrier as being very significant.

The sources of information show statistically significant coefficients. Among sources of information, maintenance and installation companies have higher significant impact compared to other sources. The coefficients for maintenance and installation companies and construction stores/DIY companies are also significant. 59% and 37% of householders that renovate their houses more energy efficiently indicated the maintenance/installation and construction store/DIY companies as the main sources of information, respectively. The coefficient for the Internet as a source of information is also close to being statistically significant. The least significant sources of information regarding energy efficiency renovations are family/friends and municipalities.

The comfort levels of humidity and flow of fresh air has statistically significant impacts on energy efficiency renovation decisions. 27% of respondents mentioned that the level of comfort of fresh air would be reason for a renovation, while for humidity it was 67% with a confidence interval of 90%.

4.2. Potential renovators

4.2.1. Regression analysis

Exterior types of renovations. Table 13 shows the results of logistic regression for potential renovators for the exterior of buildings. The coefficient of age group is significant. The respondents younger than 44 are 2.1 times more likely to plan a renovation compared to respondents in the 44–64 age range. Education also has a significant impact on planning for a renovation. Respondents with university degrees are 2.8 times more likely to plan for a renovation compared to respondents with high school certificate or less. The coefficient of professionally qualified respondents is close to a 90% confidence interval and this group are 1.9 times more likely to plan for a renovation compared to the reference group.

The coefficients of sources of information are not significant. Among the TC barriers, finding a good professional/ contractor is the main identified one. 65% of respondents who plan to renovate, mentioned it as the main barrier for exterior types of renovations. The second most significant TC barrier (close to 90% confidence interval) is in determining the best ways to achieve energy efficiency. 39% of respondents mentioned the significance of this barrier. The third TC barrier (close to significant) is on determining the maintenance state of the house, with 38% of respondents predicting to have difficulty with this barrier. As expected for potential renovators, TC barriers on the implementation phase are not significant, such as in performing the work. This might be due to the fact that people do not have an overall picture of the whole renovation process.

The state of maintenance of exterior parts of buildings has a significant impact on planning for a renovation. The main identified maintenance states are 'masonry and jointing of the facade' and 'wood and paint outside'. Approximately 30% of respondents mentioned these maintenance issues as important for planning a renovation of the exterior of their building.

Interior types of renovations. Table 14 shows the logistic regression for potential renovators planning to renovate the interior of their building. The coefficients of age, income, and education levels are not significant for planning an interior renovation. Re-

Table 13

Logistic regression on the planning of exterior types of renovations in the next 2 year.

Variables	B	S.E.	Wald	df	Sig.	Exp(B)
Age group- Ref: less than 44			8.018	2	0.018	
(a) 44–64	−0.722	0.318	5.148	1	0.023	0.486
(b) 64–105	0.039	0.442	0.008	1	0.930	1.040
Education- Ref: high school and less			11.021	4	0.026	
(a) Lower vocational education	−1.645	0.986	2.788	1	0.095	0.193
(b) Secondary vocational education	0.366	0.456	0.644	1	0.422	1.442
(c) Higher professional education	0.645	0.424	2.319	1	0.128	1.907
(d) University	1.033	0.470	4.825	1	0.028	2.809
Information: Family/ friends	−0.396	0.285	1.935	1	0.164	0.673
TC: (a) in determining the maintenance state	−0.460	0.317	2.108	1	0.147	0.631
(b) in determining the ways to increase energy efficiency	−0.443	0.284	2.434	1	0.119	0.642
(c) finding a reliable professional	0.642	0.295	4.719	1	0.030	1.900
State of maintenance: (a) Masonry and jointing of the façade	−0.906	0.465	3.796	1	0.051	0.404
(b) Wood and paint outside	−0.881	0.431	4.177	1	0.041	0.414
Constant	4.269	1.358	9.887	1	0.002	71.415

Table 14

Logistic regression for the planning interior types of renovation decisions in the next 2 years.

Variables	B	S.E.	Wald	df	Sig.	Exp(B)
mover-stayer(1)	−0.640	0.403	2.514	1	0.113	0.527
Education-Ref: high school and less			5.457	4	0.244	
(a) Lower vocational education	−2.035	1.150	3.134	1	0.077	0.131
(b) Secondary vocational education	0.037	0.645	0.003	1	0.954	1.038
(c) Higher professional education	−0.219	0.583	0.141	1	0.707	0.803
(d) University	−0.636	0.636	1.000	1	0.317	0.530
Type of house- Ref: Apartment			16.033	5	0.007	
(a) Detached	0.513	0.566	0.822	1	0.365	1.670
(b) 2 under 1 roof	1.013	0.580	3.050	1	0.081	2.755
(c) Maisonette	−0.803	0.632	1.614	1	0.204	0.448
(d) Corner house	0.860	0.541	2.528	1	0.112	2.363
(e) Middle house	1.254	0.460	7.434	1	0.006	3.506
Construction year - Ref: <1945			4.269	3	0.234	
(a) 1945-70	0.877	0.514	2.918	1	0.088	2.404
(b) 1971-90	0.022	0.440	0.003	1	0.960	1.022
(c) >1991	−0.067	0.477	0.020	1	0.888	0.935
Information: (a) internet	0.521	0.355	2.161	1	0.142	1.684
(b) family/ friends	0.836	0.351	5.692	1	0.017	2.308
(c) construction store / do it yourself company	1.682	0.566	8.828	1	0.003	5.375
TC:(a) in determining the best way to do the renovation	0.625	0.329	3.603	1	0.058	1.868
(b) in determining the ways to increase energy efficiency	−1.042	0.367	8.045	1	0.005	0.353
(c) in planning the work	0.597	0.415	2.068	1	0.150	1.817
(d) finding a reliable professional	−0.767	0.353	4.713	1	0.030	0.464
Constant	3.231	2.535	1.625	1	0.202	25.317

spondents that are planning to stay are 1.9 times more likely to plan for interior renovations compared to the movers. The confidence interval for this coefficient is close to 90%.

Regarding building characteristics, there could be a relationship between type of buildings and planning for interior types of renovations. Middle houses and 2 under 1 roof houses have statistically significant coefficients and they are respectively 3.5 and 2.8 times more likely to plan for interior renovations compared to apartments. The coefficient of houses constructed between the years 1945 and 1970 is significant. Respondents in this category are 2.4 times more likely to plan for a renovation compared to respondents in houses built before 1945.

Few information sources have statistically significant coefficients. The most significant one is the construction store/DIY companies with 84% of respondents mentioned the importance of this source. The second significant source of information is family/friends with 69% of respondents mentioning the importance of this source. The coefficient of the Internet source has close to a 90% confidence interval significance with 63% of respondents. The least significant sources of information are from municipalities and maintenance/ installation companies.

Significant relationships exist between TC barriers and planning to renovate interior parts of buildings. The main identified TC barrier is in determining the best way to do the interior renovations with 65% of respondents mentioning the importance of this barrier. 'The ways to increase energy efficiency' and 'finding a good professional/contractor' are also significant. The coefficients of maintenance are not significant.

Energy efficiency renovations. Table 15 shows the results of logistic regression for potential renovators and energy efficiency renovations. The socio-economic variables are not significant. Type of building is a significant variable in the regression. Respondents with apartments are 6 times more likely to plan for an energy efficiency renovation compared to respondents with corner houses.

The coefficients of information sources are significant. The main identified source of information is the Internet and maintenance/installation companies. Respectively, 66% and 65% of respondents mentioned the importance of these sources. The least significant coefficients are the construction store/DIY companies, bank/mortgage lenders, family/friends, and municipalities.

TC barriers affect energy efficiency renovations. The coefficients for some barriers are statistically significant. The first important barrier is in determining the best ways to increase energy efficiency. 74% of respondents mentioned the importance of this barrier for energy efficiency renovations. The second most significant

Table 15

Logistic regression for energy efficiency renovation decision in the next 2 years.

Variables	B	S.E.	Wald	df	Sig.	Exp(B)
Type of house- Ref: Apartment			12.863	5	0.025	
(a) Detached	0.255	0.378	0.457	1	0.499	1.291
(b) 2 under 1 roof	0.262	0.438	0.359	1	0.549	1.3
(c) Maisonette	−0.153	0.405	0.143	1	0.705	0.858
(d) Corner house	−1.792	0.601	8.877	1	0.003	0.167
(e) Middle house	−0.627	0.379	2.736	1	0.098	0.534
Information: (a) internet	0.674	0.291	5.365	1	0.021	1.963
(b) maintenance/ installation company	0.636	0.296	4.604	1	0.032	1.889
TC:(a) in determining the best way to do the renovation	−0.876	0.266	10.817	1	0.001	0.416
(b) in determining the ways to increase energy efficiency	1.07	0.29	13.651	1	0	2.915
(c) finding financing supports	0.534	0.315	2.87	1	0.09	1.706
State of maintenance: (a) Roof insulation	−1.443	0.42	11.812	1	0.001	0.236
(b) Glass insulation	−1.106	0.434	6.495	1	0.011	0.331
(c) heating	−3.078	0.869	12.54	1	0	0.046
Constant	9.434	2.213	18.175	1	0	12.509

Table 16

Overview of the influencing factors for renovators.

Exterior			
Socioeconomic variables	building characteristic	TC barriers	Information
Income	Yes	The maintenance states	construction stores/DIY companies
Education	–	Doing the work by themselves	Internet
Interior			
Socioeconomic variables	Building characteristic	TC barriers	Information
Age group	Yes	Determining the costs	Construction store/ Do it Yourself Companies
Income	–	–	–
Mover/ stayer	–	–	–
Energy efficiency			
Socioeconomic variables	Building characteristic	TC barriers	Information
Income	Yes	Complexities in determining the ways to increase the energy efficiency	Maintenance/ installation companies
Education	–	–	Internet

one is in determining the best way to do the renovation. 30% of respondents confirmed the importance of this TC. The last significant coefficient (90% confidence interval) is the TC of finding financial support with 63% of respondents mentioning the importance of this barrier.

The maintenance states of the energy related parts of the buildings has significant impact on energy efficiency renovations. The roof and glass insulation have the highest significant coefficients, with respectively 20% and 24% of respondents mentioning the importance of these maintenance issues. The least important maintenance issue belongs to ground floor insulation. Although the heating system shows a significant coefficient, at about 4% the percentage is low.

4.3. Overview of the influencing factors for the renovators and potential renovators

Tables 16 and 17 present the key socio-economic variables, TC barriers, and sources of information to make it easier to follow the regression analysis results.

5. Discussion

5.1. Comparison of renovators and potential renovators

One of the aims of this study was to compare the TC barriers and the main sources of information for renovators and potential renovators. The key differences between the influencing factors of renovators and potential renovators are discussed in the following.

5.1.1. Exterior types of renovations

The maintenance states of wood and painting and foundations are important influencing factors for exterior types of renovations. This indicates that the majority of exterior renovations in the sample are done due to deterioration. For potential renovators, age has significant influence on planning but not for renovators. This shows that the younger generation is willing to renovate, although they cannot achieve their plans possibly because of the TC barriers.

For renovators, the influence of building characteristics is significant, although the same cannot be said of potential renovators. The reason for this difference might be that there is less data for potential renovators compared to the renovators.

For renovators, the most significant TC barriers are in determining the maintenance state of the house and in carrying out the renovations by themselves.

For potential renovators, the main TC is finding a reliable professional/contractor. Considering these barriers, removing TC barrier for potential renovators might remove the barriers for renovators as well. A reliable professional/contractor can contribute in checking the maintenance state of the house, as well as reduce the complexities in doing the renovations. construction stores/DIY companies are perceived as the main information source for renovators. This source demonstrates the need of an expert in conducting exterior types of renovations. For potential renovators, no sig-

Table 17
Overview of the main influencing factors for potential renovators.

Exterior			
Socioeconomic variables	building characteristic	TC barriers	Information
Age group	No	Finding a good professional/ contractor	Family/ friends
Education	–	Maintenance states of the house	–
–	–	In determining the best way to carry out the renovations	–
Interior			
Socioeconomic variables	Building characteristic	TC barriers	Information
Mover/ stayer	Yes	In determining the best way to carry out the renovations	Construction store/ Do it Yourself Company
–	–	–	Family/ friends
–	–	–	Internet
Energy efficiency			
Socioeconomic variables	Building characteristic	TC barriers	Information
–	Yes	Complexities in determining the ways to increase the energy efficiency	Internet
–	–	In determining the best way to carry out the renovations	maintenance/ installation companies
–	–	In finding financial supports	

nificant source of information is identified with a 95% confidence interval. This could also be due to missing data for potential renovators.

5.1.2. Interior types of renovations

Age and income levels are important factors for conducting interior types of renovations by renovators. Higher renovation probability was found for younger homeowners with higher income. For potential renovators, no statistically significant socio-economic variables are identified. For both renovators and potential renovators, movers are more likely to renovate the interior of their house, which could be for selling it at a higher price.

The main TC barriers for renovators are determining the costs of the interior renovations. However, for potential renovators, the most important factor is determining the most efficient way to carry out the interior renovations. Since the TC barriers for renovators and potential renovators are related to each other, costs can be more easily estimated by providing information regarding efficient ways of renovating.

Sources of information are important influencing factors for both renovators and potential renovators, especially DIY companies. For the potential renovators, family/friends is also an important one but for renovators, the Internet is strongly significant. This shows that the interior renovations might be conducted by the homeowners themselves. For both renovators and potential renovators, there is no relationship with the maintenance states of the interior of the building.

5.1.3. Energy efficiency renovations

For renovators and among socio-economic variables, only education level has an impact on energy efficiency renovation decisions. Higher educated respondents have a higher probability to renovate compared to less educated people. For potential renovators, no significant relationships are found between the socio-economic variables and planning for energy efficiency renovations. For renovators, detached houses have a higher probability of being renovated for energy efficiency purposes. However, for potential renovators apartments have a higher probability.

For both renovators and potential renovators, the main TC barrier is determining the best ways to increase the energy efficiency of the houses. This barrier also has the highest impact among all the variables in the regressions. For the sources of information, maintenance/installation companies have a significant impact on energy efficiency renovations for both renovators and poten-

tial renovators. For renovators, the comfort levels of fresh air and humidity are important influencing factors. However, for potential renovators, the maintenance states of roof and glass insulation has a major impact. Therefore, renovators are concerned more with the level of comfort than with the maintenance of energy saving measures.

5.2. Comparison of TC barriers of different types of renovations

The second aim of this study was to compare the differences between TC barriers and sources of information for different types of renovations. The key differences between the TC barriers and sources of information for renovations and energy efficiency renovations are discussed below:

For the exterior of buildings, the main TC barriers are carrying out the renovations and finding a reliable professional/contractor. Therefore, the main TCs are on decision-making and executing the exterior renovations. For interior renovation types, the main complexities are to do with determining the costs and finding an efficient way of renovating. Therefore, the main TC barrier is at the consideration stage. Compared to other types of renovations, householders have difficulties in determining the best ways to increase the energy efficiency of their house. Therefore, the main TC barrier of energy efficiency renovations is at the consideration stage.

For all types of renovations, the sources of information have relations with TC barriers. Householders require an expert to conduct the exterior renovation and they mention the importance of construction stores/DIY companies in providing information. For accessing information on interior renovations, householders use DIY companies, the Internet, and family/friends. Finally, for energy efficiency renovations, an expert is essential to provide support and advice on the best ways to increase the energy efficiency of the house. Therefore, maintenance/installation companies are a key factor.

5.3. Insight for policy makers

Based on the energy agreement and energy agenda, over € 100 million has been assigned for energy efficiency renovations in the owner-occupied sector [50]. The monetary policies could be more effective in combination with information provision and work complexity reduction. Reliability of a professional/contractor was mentioned as an important barrier for different types of ren-

ovations and especially for energy efficiency renovations. In the Netherlands, specialist organisations are assigned to work in close collaboration with local initiatives, residents, municipalities, housing associations and suppliers. These organisations promote the sustainability of housing in the Netherlands. They provide free consultation, free energy scans, and cheaper packages of energy saving measures for householders. Four of these organisations currently operate in the Netherlands (Reimarkt.nl) but there is a need for involvement of more parties in order to achieve energy efficiency targets.

One of the main TC barriers for energy efficiency renovation types was 'determining the ways to increase the energy efficiency of the houses'. Municipalities contribute considerably to supporting and increasing awareness of the householders in the Netherlands. The examples are explained extensively in the latest articles published by [42,51]. The energy desks (energieloket.nl) of 200 municipalities provide tailor-made solutions and advice regarding energy efficiency and improving comfort levels. One stop shop/pop up stores provide energy saving solutions at the neighbourhood level and individual building level and are contributing to reducing TC barriers.

In the climate agreement [1], development of a digital platform has been proposed to bring together the demand and supply side of energy efficiency renovations with a neighbourhood-oriented approach. The digital platform can play a role in bundling the demand and provide attractive offers for householders. Before joining the platform, the suppliers are assessed qualitatively to guarantee the services provided through the platform. From householders' perspective, the advantages of using this type of digital platforms are basically information provision and search cost (money and time) reduction. Moreover, householders can have access to a larger network of suppliers, and have higher trust in suppliers due to quality assessments, cheaper prices, etc. [52,53].

For the public authorities, a key question is what type of information needs to be distributed to different agents, such as municipalities, suppliers, and more importantly to householders. They have to find ways to make the overall process far more efficient. To answer this question, a comprehensive study is essential to consider the interests of all the agents involved and their interaction with others.

6. Conclusions

This study evaluated the TC barriers and sources of information for different types of renovations (exterior, interior, and energy efficiency renovations) and for two groups of householders (renovators and potential renovators). TCs negatively influence the renovation decision-making process and reduces the effectiveness of policy instruments, such as subsidies and tax reductions on energy efficiency measures. Following the institutional economist, a conceptual framework of TCs on different stages of decision-making process of renovations was developed. Using the theoretical framework, statistical and regression analysis were conducted on data gathered from a questionnaire survey of 3,775 homeowners in the Netherlands to evaluate the significance of TC factors and identify the main ones. From the results of the study the following can be concluded:

(a) The main identified TCs are in the consideration, decision, and executing phases of the different types of renovations. Executing exterior renovations and finding a reliable professional/ contractor to do exterior renovations, determining costs for interior renovations and finding ways to increase the energy efficiency of renovations are the main identified TC factors.

(b) For exterior renovations and energy efficiency renovations, the main source of information is construction stores/DIY companies and maintenance/installation companies, respectively. For interior renovations, householders use DIY companies, the Internet, and family/friends and are strongly influenced by these sources of information.

(c) TC factors are related to the type of renovations. For instance, renovators have difficulties in finding out the most efficient ways to renovate for energy efficiency. However, the influence of this factor is not significant in non-energy efficiency renovations.

(d) Renovators mentioned TC barriers at later stages of the decision-making processes, such as carrying out the exterior renovations. However, potential renovators identified TC barriers at the early stages, such as finding the most efficient ways to carry out interior renovations. Therefore, the perspectives of these two groups are complementary for explaining TC barriers in the whole renovation process chain.

Declaration of Competing Interest

None.

CRediT authorship contribution statement

Shima Ebrahimigharehbaghi: Formal analysis, Writing - original draft. **Queena K. Qian:** Supervision. **Frits M. Meijer:** Data curation. **Henk J. Visscher:** Supervision.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at 10.1016/j.enbuild.2020.109849

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