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Prospects for the Development of a One-Stop-Shop Business Model for Energy-Efficiency Renovations of Detached Houses in Sweden

Pardalis, Georgios

2021

In Sweden, more than 80% of the two million detached houses are more than 35 years of age. Energy efficiency renovation of those old houses can reduce primary energy use by 65% to 90%. The current low rate of energy renovations needs to be at least doubled to meet the national and EU energy and climate goals. This rate is attributed, among others, to the fragmented market, where various actors offer their service in piecemeal approach without mutual coordination. A renovation also entails a complex decision-making process for homeowners. The introduction of innovative collaborative business models can simplify that process for homeowners and eventually accelerate the rate of energy efficiency renovations. One-stop-shop (OSS) is one such business model to offer comprehensive renovation packages coordinated by a single actor. This model has started to emerge in some EU countries, but the knowledge about it remains limited in the Swedish context. This doctoral thesis examines the prospects for the development of an one-stop-shop business model in Sweden, investigating the demand (homeowners) and supply-side (professionals) of house renovations, as well as, the general market conditions to develop strategies to promote energy renovations. Moreover, insights on key issues to be addressed are provided, so the model to achieve an acceptable market success and provide a sustainable business to the professionals wishing to become active in the renovation market under it.

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Abstract

Pardalis, Georgios (2021). Prospects for the Development of a One-Stop-Shop Business Model for Energy-Efficiency Renovations of Detached Houses in Sweden, Linnaeus University Dissertations No 411/2021, ISBN: 978-91- 89283-57-2 (print), 978-91-89283-58-9 (pdf)

The building sector is the biggest energy user in the European Union (EU) and therefore, has an important role to play in meeting the energy and climate goals of EU. In Sweden, more than 80% of the two million detached houses are more than 35 years of age. Energy efficiency renovation of those old houses can reduce primary energy use by 65% to 90%. However, the current low rate of energy renovations (yearly about 1% of the building stock) in the EU in general must at least be doubled to meet the energy and climate goals.

The low rate of renovations is attributed, among others, to the fragmented market where various actors offer their service in piecemeal approach and homeowners undergo a complex decision-making process. The introduction of innovative collaborative business models can simplify that complex process and eventually accelerate the rate of energy efficiency renovations. One-stop shop (OSS) business model is one such model where a single actor coordinates other actors in the renovation value chain to offer comprehensive renovation packages. This model has started to emerge in some parts of the EU, but the knowledge about it remains limited in the Swedish context.

To examine the prospects for the development of an OSS in the Swedish context, this research investigated the demand (homeowners) and supply-side (professionals) of house renovations, as well as the general market conditions to develop strategies to promote energy renovation. Online questionnaire surveys of homeowners were conducted covering Kronoberg county (year 2017, 971 answers) and whole Sweden (year 2018, 12194 answers). Interviews were conducted with 21 owners/managers of micro-and small-sized construction enterprises, which are dominant in the house renovation market. Furthermore, 16 interviews were conducted with the Project Managers of 4 medium-sized construction enterprises, 4 Loan Officers from four large Swedish banks, and 8 brokers from real-estate agencies. In addition, interviews

have been conducted with the energy advisors of the eight municipalities of Kronoberg County. An analysis based on transaction cost economics and resource-based theory was conducted to identify the conditions under which the OSS concept could emerge in the Swedish market. Market gap analysis, systematic literature review, and consultation with 11 Swedish and international experts in the energy-efficiency renovation market, formed the basis for proposing strategies to support renovations.

The findings demonstrate that the house's age and the age of the homeowner, as well as, annual household income and environmental and energy awareness of the homeowner, are the factors influencing renovation decisions and homeowners' propensity to undertake energy-efficiency renovations. Findings also demonstrate that there are several homeowners capable to constitute a segment of potential early adopters for one-stop-shop. Regarding supply-side actors, the findings demonstrate that, in theory, one-stop shop is viewed positively, but still supply-side actors are hesitant to adopt the concept, mainly due to the lack of resources and management competence, as well as the perceived risks associated with a change of their business model. Nevertheless, this research identified two supply-side actor profiles, who under certain conditions, could be the coordinators of a one-stop-shop. Strategies are also proposed, to make market conditions conducive for energy efficiency renovations in detached houses.

In conclusion, the overall prospects for the development of one-stop shop for energy-efficiency renovations of detached houses in Sweden can be characterized as moderately positive. This thesis provides insights on the key issues to be addressed, for one-stop-shop to achieve an acceptable market success and provide a sustainable business to the professionals wishing to become active in the renovation market under this concept.

Keywords: Detached houses, Energy-efficiency renovations, Homeowners, One-stop shop, Policy instruments, Renovation decisions, Supply-side actors, Transaction costs

Sammanfattning

Den största energianvändaren i Europeiska unionen (EU) är byggnadssektorn, vilken därför har en viktig roll att spela när det gäller att uppfylla energi- och klimatmålen i EU. I Sverige är mer än 80 % av två miljoner småhus äldre än 35 år. Energieffektivitetsrenovering av gamla hus kan minska användningen av primärenergi med 65 % till 90%. Den nuvarande låga energirenoveringen (årsvis ca 1 % av byggnadsbeståndet) i EU i allmänhet måste dock åtminstone fördubblas för att uppfylla energi- och klimatmålen.

Den låga renoveringstakten tillskrivs bland annat en uppdelad marknad där flera olika aktörer erbjuder sina tjänster i en bitvis sätt. För husägare kan detta bli en komplicerad beslutsprocess. Införandet av innovativa samarbetsinriktade affärsmodeller kan förenkla den komplicerade processen och så småningom påskynda graden av energieffektiva renoveringar. One-Stop Shop (OSS) affärsmodell är en sådan modell där en enda aktör samordnar samtliga aktörer i värdekedjan för renoveringar genom att erbjuda ett omfattande renoveringspaket. Denna modell har börjat växa fram i vissa delar av EU, men kunskapen om den är fortfarande begränsad i ett svenskt sammanhang.

Denna forskning undersöker möjligheterna för ett utvecklande av OSS. Forskningen har gått ut på att undersöka efterfrågan hos husägare samt även utbudet hos olika aktörer inom husrenovering, tillsammans med allmänna marknadsvillkor för att utveckla strategier för att främja energirenovering. En omfattande enkätundersökning av husägare har genomförts på nätet. Undersökningen omfattande Kronobergs län år 2017 (971 svar) och hela Sverige år 2018 (12 194 svar). Semi-strukturerade intervjuer genomfördes med 21 mikro- och småstora företag, som är dominerande på renoveringsmarknaden, samt med fyra medelstora byggföretag. Utöver det har representanter från fyra svenska storbanker intervjuats, samt åtta mäklare från olika fastighetsbyråer. Intervjuer har även genomförts med energirådgivare från de åtta kommunerna i Kronobergs län. En analys som bygger på transaktionskostnadsekonomi och resursbaserad teori genomfördes för att identifiera under vilka förhållanden OSS-konceptet skulle kunna växa fram på den svenska marknaden. En analys av marknadsbrister, systematisk

litteraturöversikt och elva expertsamråd har legat till grund att utveckla strategier som stöder energirenoveringar.

Resultaten visar att husets ålder och husägarens ålder, hushållens årliga inkomst och miljö- och energimedvetenhet av husägare är faktorer som påverkar renoveringsbeslut och husägares benägenhet att genomföra energirenoveringar. Resultaten visar också att det finns flera husägare som kan utgöra ett segment av potentiella tidiga användare för one-stop-shop. När det gäller aktörerna på utbudssidan visar resultaten att i teorin en one-stop-shop ses positivt, men fortfarande är aktörerna på utbudssidan tveksamma att anta konceptet, främst på grund av brist på resurser och ledningskompetens, samt de upplevda riskerna förknippade med en förändring av deras affärsmodell. Ändå identifierade denna forskning två aktörsprofiler på utbudssidan, som under vissa förhållanden kunde vara samordnare för en one-stop-shop. Strategier föreslås också för att göra marknadsförhållandena gynnsamma för energieffektivitetsrenoveringar i småhus. Trots detta har forskningen identifierat två aktörsprofiler, som under vissa förutsättningar skulle kunna anta one-stop-shop modellen. Flera olika strategier för småhus har föreslagits för att göra marknadsmässiga villkor som främjar energirenoveringar.

Sammanfattningsvis kan de övergripande utsikterna för utveckling av one-stop-shop för energirenovering av småhus i Sverige karakteriseras som måttligt positiva. Denna avhandling ger insikter om de nyckelfrågor som ska behandlas, för one-stop-shop för att uppnå en acceptabel marknads succés och ge en hållbar verksamhet till de yrkesverksamma som vill bli aktiva på renoveringsmarknaden enligt detta koncept.

Nyckelord: Småhus, Energirenoveringar, Husägare, One-stop-shop, Policyinstrument, Renoveringsbeslut, Aktörer på utbudssidan, Transaktionskostnader

Dedicated to Cookie and Nookie
You inspire me every day to become a better person

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Växjö, 21 February 2021

Georgios Pardalis

"Education is an ornament in prosperity and a refuge in adversity."

— Aristotle

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APPENDED PAPERS

This doctoral dissertation is based on the following papers:

Paper I Bravo, G., Pardalis, G., Mahapatra, K., Mainali, B. (2019). Physical vs. aesthetic renovations: Learning from Swedish house owners. Buildings, 9(1), 12. https://doi.org/10.3390/buildings9010012

Paper II Pardalis, G., Mahapatra, K., Bravo, G., Mainali, B. (2019). Swedish house owners' intentions towards renovations: is there a market for one-stop-shop? Buildings, 9(7), 164. https://doi.org/10.3390/buildings9070164

Paper III Pardalis G., Mahapatra K., Mainali B., Bravo G. (2021) Future Energy-Related House Renovations in Sweden: One-Stop-Shop as a Shortcut to the Decision- Making Journey. In: Howlett R.J., Littlewood J.R., Jain L.C. (eds) Emerging Research in Sustainable Energy and Buildings for a Low-Carbon Future. Advances in Sustainability Science and Technology. Springer, Singapore. https://doi.org/10.1007/978-981-15-8775-7_4

Paper IV Pardalis, G., Mahapatra, K., Mainali, B. (2020). Swedish construction MSEs: simply renovators or renovation service innovators? Building Research and Information, 48(1), 67–83. https://doi.org/10.1080/09613218.2019.1662713

Paper V Pardalis, G., Talmar, M. Keskin, D. To be or not to be: What does it take to launch OSS for Energy Efficient Renovations? Submitted for publication and
under review.

Paper VI Mainali, B., Mahapatra, K., Pardalis, G., (2021). Strategies for deep renovation market of detached houses. Renewable and Sustainable Energy Reviews, 138.
https://doi.org/10.1016/j.rser.2020.110659

AUTHOR'S CONTRIBUTIONS

Paper I The dissertation author was responsible for the overall conception and design of the study, as well as for reviewing the literature, interpreting the results, and drawing conclusions. He was also responsible for analyzing the data, in collaboration with the first author, and for the collection of results, in collaboration with the first and third authors. The co-authors reviewed the manuscript and provided comments.

Paper II The dissertation author was responsible for the overall conception and design of study, as well as for reviewing the literature, interpreting the results, and drawing conclusions. He was also responsible for analyzing the data, in collaboration with the first author, and for the collection of results, in collaboration with the second and third authors. The co-authors reviewed the manuscript and provided comments.

Paper III The dissertation author was responsible for the overall conception and design of study, as well as for reviewing the literature, interpreting the results, and drawing conclusions. He was also responsible for analyzing the data, in collaboration with the fourth author, and for the collection of results, in collaboration with the second and third authors. The co-authors reviewed the manuscript and provided comments.

Paper IV The dissertation author was responsible for planning and conducting the interviews, reviewing the literature to develop the conceptual framework, analyzing the data, and drawing conclusion. The co-authors reviewed the manuscript and provided comments.

Paper V The dissertation author was responsible for the conception and design of study, acquisitions of data, analysis of data and literature review. All three authors were responsible for the interpretation of data and draw conclusions. Additionally, the co-authors reviewed the manuscript and provided comments.

Paper VI The dissertation author was involved, in collaboration with the first author, in face-to-face interviews and online consultation with the experts. He also reviewed the manuscript and provided inputs regarding the content of the paper. The first author reviewed literature in building the conceptual frame, analyzed the data, and interpreted the results for drawing conclusion. Second author has supported in building the structure of the paper and in interpreting the results and deriving the conclusion.

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LIST OF ABBREVIATIONS

DG rho	Dillon-Goldstein's rho
EE	Energy Efficiency
EED	Energy Efficiency Directive
EEMs	Energy Efficiency Measures
EEOs	Energy Efficiency Obligations
EER	Energy Efficiency Renovation(s)
EPBD	Energy Performance of Buildings Directive
ESCO	Energy Service Companies
ETS	Emissions Trading System
EU	European Union
GHG	Greenhouse Gases
MSEs	Micro- and Small-sized Enterprises
OSS	One-Stop Shop
PACE	Property Assessed Clean Energy
PC	Production Costs
PLSPM	Partial Least Squares Path Modelling
PPP	Private Public Partnership
PV	Photovoltaic
SCB	Statistics Sweden
SDG	Sustainable Development Goals
SMEs	Small and Medium-sized Enterprises
TC	Transaction Costs
TCE	Transaction Cost Economics
W.E.T.	Wealthy Educated Town-living

1. INTRODUCTION

This chapter begins with a background to the research, followed by the objectives of the research and the research questions. Moreover, it provides an overview of the appended papers, and presents the delimitations of the study. Last but not the least, the outline of this doctoral thesis is provided.

1.1 Background

The European Union (henceforth referred as EU) is called upon to make major advances in energy efficiency (henceforth referred as EE), as part of the effort to achieve the objectives of the Paris Agreement to limit the increase in temperature to less than 1.5–2°C. EE contributes to energy supply security and makes it easier to fulfil the energy demand by renewable energy sources. The 2030 objectives of the EU call for a 32.5% reduction of energy use in the EU compared to the business-as-usual scenario (Mathiesen et al., 2019).

The building sector has an important role to meet the EE and greenhouse gas (henceforth referred as GHG) emission targets. Buildings in the EU are responsible for 40% of energy consumption and 36% of GHG emissions, which mainly derives from construction, usage, renovation, and demolition (European Commission, 2020). A major focus in achieving the EE goals has been on the construction of new buildings, which must comply with increasingly rigorous EE standards through the years (de Vries and Verhagen, 2016). However, to achieve the energy saving targets on mid-

long (2030) and long-term (2050), the focus must be placed not only on new buildings, but also on the vast existing building stock (Cuffe, 2020). Estimations show that it is possible to reduce energy use of older buildings in Europe by up to 80% (Lechtenböhmer and Schüring, 2011). About 75% of the building stock in EU is residential and most of them (64%) are one- and two-family houses (henceforth referred as "detached houses") (Economidou et al., 2011). The COVID-19 crisis brought those buildings in the spotlight. Throughout the pandemic, homes became the central points of daily activities for many Europeans. They became the offices for those who work remotely, classrooms for pupils and students for remote learning, and hubs for shopping and entertainment. Therefore, redesign and renovation of those buildings is of utmost importance. Moreover, EE in residential buildings has been found to be essential not only for climate change mitigation, but also for the fulfilment of several sustainable development goals (SDG) of Agenda 2030. Energy efficient residential buildings offer benefits like improved lighting, better air quality, improved heat comfort, which have been proven to positively impact health and well-being (Arif et al., 2016) (Goal 3). Furthermore, energy savings from efficient residential buildings create opportunities for lower expenses for energy use. Moreover, EE coupled with renewable sources of energy (e.g., PV systems) leads to improvement of energy security (Strielkowski et al., 2020) (Goal 7). Residential buildings are the foundations of cities and EE in them is key for their long-term sustainability (Goal 11). Hence, cities need to develop and implement policies that promote EE in building practices (Gillingham et al., 2018). There is a need for the building industry to prevent waste through reduction, recycle and reuse and develop 'circular economy' principles where resources are not wasted (Goal 12). Nonetheless, only 11% of the EU existing building stock undergoes some level of renovation every year, but often those renovation works are not connected to the energy performance of buildings.

In Sweden, detached houses constitute about 45% of the housing stock (4.7 million dwellings), which is approximately two million dwellings (Statistics Sweden, 2019). About 80% of those houses are more than 35 years old and need major renovation to improve their energy performance.

About 47% of those houses use energy for space heating and domestic hot water consumption coming from only direct electricity heating systems (30%) or in combination with other heating systems (Swedish Energy Agency,2019). Moreover, the average energy use for those houses is about 40% higher compared to detached houses that have been built between 2010-2019 (Swedish Energy Agency, 2019). Additionally, in those old houses, technical installations are likely to be close to the end of their expected lifetime and need replacement. All these create unique opportunities for the adoption of energy efficiency measures (henceforth refereed as EEMs) that can reduce the energy use and GHG emissions significantly (Mahapatra et al., 2013). Recent research (Ekström, 2017) showed that in electricity heated detached houses from the 1960's and 1970's in Sweden, it is possible to reduce the final energy use by 65% to 90% (compared to their pre-renovation state), by applying EEMs on the building envelope, install a ground source heat pump, and install solar photovoltaic (PV) panels. In this dissertation, building renovation involving such investment intensive measures are referred as energy efficiency renovations (henceforth referred as EER). Literature also refers to such renovations as deep energy renovations [1] and therefore, these two terminologies are used interchangeably.

The European Commission has called for action to stimulate new investments in EE of buildings via the updated Energy Performance of Buildings Directive (EPBD) EU 2018/44 (European Parliament, 2018b), the revised Energy Efficiency Directive (henceforth referred as EED) EU 2018/2002 (European Parliament, 2018a), and the EU "Renovation Wave" strategy (European Commission, 2020). These actions aim, among others, to provide affordable solutions for energy efficient buildings (especially, to medium and lower-income households), and to at least double the current annual rates of renovations, which varies from 0.4% to 1.2% of the building stock in different Member States (an average 3% is considered as optimal) (European Commission, 2018).

[1] Deep energy renovation refers to renovation measures that reduces energy use of building by 75% or more with a focus on the building envelop. The primary energy consumption after renovation, which includes, inter alia, energy used for heating, cooling, ventilation, hot water, and lighting after the deep renovation of an existing building is less than 60 kWh/m2 /yr. (Shnapp et al., 2013).

The inadequate rate of EER is due to a variety of factors, but quite often, it can be attributed to the lack of integrated solutions in the market supported by appropriate business models. The traditional business models that exist in the market are characterized by a fragmented renovation value chain in which different actors deliver separate fractions of the renovation work (piecemeal approach) (Mlecnik et al., 2012; Owen et al., 2014). This requires the homeowners to deal with an extremely complex decision-making process in the absence of proper information (Boza-Kiss and Bertoldi, 2018). The introduction of innovative business models involving collaboration among the different actors in the renovation market can provide homeowners with comprehensive solutions under a simplified decision-making process, which may accelerate the rate of EER (Mlecnik et al., 2019). Such a business model is the One-Stop Shop (henceforth referred as OSS) business model in which a single actor coordinates or collaborates with other actors in the value chain to offer comprehensive EER packages (Mlecnik et al., 2012; Haavik et al., 2012; Mahapatra et al., 2013; Bjørneboe et al., 2017). The current knowledge about this business model is very limited in the Swedish context, although such models are slowly emerging in other parts of EU.

1.2 Objectives

The main aim of this study is to examine the prospects for the development of an OSS for EER renovation of detached houses in Sweden. The dissertation focuses on the analysis of the EER market in Sweden, especially the various conditions that may affect the market for OSS concept. This requires a better understanding of the current situation of the detached houses renovation market from the perspective of demand- and supply-sides as well as general market conditions such as policies, economic situation etc. Therefore, the specific objectives of this study are as follows:

(1) To understand the perceptions of homeowners regarding renovation and examine their interest to get their dwelling renovated by an OSS. Homeowners are pivotal for OSS because they constitute its potential

customer base, and there cannot be an OSS without them being interested.

(2) To understand the perceptions of supply-side actors and examine their interest to initiate an OSS in the detached house market. The views of supply-side actors are important as their perceived capacity, expectations, concerns, and understanding of the current state of the market can influence the initiation of OSS.

(3) To understand the existing market conditions for EER so that strategies can be developed to stimulate EER and the market for OSS.

An overarching analysis of the above aspects contributes to assess the prospects for the development of an OSS business model for EER of detached houses in Sweden.

1.3 Research questions

Considering the aim and objectives described in the previous section, the main research questions that this dissertation attempts to answer are the following:

Research question 1:	Which factors influence homeowners' decisions for EER, and is there an interest from their side to adopt a comprehensive renovation package offered by a single actor?
Research question 2:	What is the perception and level of preparedness of supply-side actors to initiate an OSS? Under which conditions this could be feasible?
Research question 3:	What are the existing market conditions, and which strategies (if needed) should be formulated to support EER for detached houses in Sweden?

1.4 Overview of the papers

Each of the three objectives mentioned above has been the subject of a separate study between February 2017 and December 2020. Six scientific papers were prepared, which are appended to this dissertation.

In papers **I** and **II**, a structural equation model technique using a partial least square approach has been used to analyze the responses of 971 homeowners in Kronoberg province in Sweden. 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 renovation's choice, and whether these have been performed in the past or they are planned. Additionally, homeowners' interest on undertaking an EER of their dwelling, in the case a single actor offered a comprehensive package for the work, has been examined, aiming to identify potential customer segments for OSS.

In paper **III** the responses from a survey of 12194 homeowners from all over Sweden were examined to identify their future renovation plans and their interest for a comprehensive renovation package offered by an OSS. The aim was to validate the results of the survey in Kronoberg province at a national level.

In paper **IV** it is shown how construction micro- and small-sized enterprises (henceforth referred as MSEs) perceive OSS concept and to which extent are prepared to adopt this innovative concept in their business. The data from interviews with 21 MSEs is analyzed in the light of a conceptual model for innovation adoption. The analysis explains how the decision to adopt an innovation is the outcome of various parameters related to the nature of innovation itself, the organizational capability, and external factors, which affect the organization's capability to innovate.

In paper **V** different supply-side actor groups (construction-related micro, small and medium enterprises, real-estate agents, banks, and municipalities) are examined in the light of transaction cost economics and resource-based theory. Data from 45 interviews showed why none of those

actors were interested to take up the OSS role right away and provided information on potential OSS providers.

In paper **VI**, the market for EER of detached houses is studied by exploring the existing market conditions and proposing strategies to strengthen this market. The analysis explains the political, economic, social, and technical factors influencing the EER market, and the strategies are proposed based on the strengths, weaknesses, opportunities, and threats existing in this market.

1.5 Delimitations

The delimitations of this study are as follows:

(1) The research focuses only on the prospects for development of an OSS business model for EER of detached houses in Sweden. This does not cover the technological, economical and energy saving aspects of renovation.

(2) The study is based on data collected from questionnaire surveys and interviews. Although a non-response bias analysis was performed regarding the responses to the questionnaire surveys, still there might exist self-selection bias with respect to aspects that have not been taken under consideration.

(3) The research related to supply side actors has been mostly conducted in a specific geographical location (Kronoberg province). Although efforts were made to include representatives, e.g., bank officials and real-estate agents, of firms with nationwide presence, still a coverage of more geographical regions and examination of a larger sample of actors could have contributed to capture a wider range of perspectives and to draw more robust conclusions.

1.6 Outline of the dissertation

This thesis is organized as follows. Chapter 2 contains an overview of the OSS business model consisting of the background to its development,

summary of different types of OSS, and the different ways the model is delivered in the market. Additionally, a systematic literature review is presented concerning following aspects of EER: barriers and motivators for homeowners', and financing instruments and policies. Chapter 3 is about two theoretical frameworks regarding conditions for OSS emergence in the market and adoption of innovations, respectively. In Chapter 4 the methodology used in this study is discussed. A summary of results from the appended papers to this dissertation is presented in Chapter 5. The conclusions are presented in Chapter 6 and proposals for future research are listed in Chapter 7.

2. STATE OF RESEARCH ON ENERGY EFFICIENCY RENOVATIONS & ONE-STOP SHOP

In this chapter, an overview of the research on EER market and OSS is presented. A presentation of the factors influencing homeowners' decisions for EER is provided, along with a thorough presentation of OSS concept, and the policy instruments, on EU level and in Sweden, for the promotion of EER.

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2.1 Barriers and motivators of energy efficiency renovations for homeowners

Homeowners are the most important actors in the effort to improve EE of existing detached houses (Mortensen et al., 2014). Consequently, the decision-making process for EER has gained increased research interest over the last decade. The decision to adopt or not to adopt investment intensive EEMs, such as improved insulation of the building envelop, energy efficient windows, and renewable based heating systems, depends on a variety of factors, which can act either as motivators or barriers of the decision (e.g., Friege and Chappin, 2014; Achtnicht and Madlener, 2014; Kastner and Stern, 2015; Ebrahimigharehbaghi et al., 2019; Azizi et al., 2020). Literature on barriers is more developed than study of motivators or ways to overcome the barriers. Barriers are generally described as a mechanism that puts constraints in a decision or behavior that appears to be both energy and economically efficient (Sorell et al., 2006). This phenomenon is also described as EE gap (WBCSD/WRI, 2007) and explains the low level of investments in EEMs (Sorell et al., 2007; Reddy, 2013).

The barriers and motivators for the homeowners to adopt EEMs can be divided in three broad categories: (i) financial, (ii) social/behavioral, and (iii) information.

Financial aspects

Financial aspects are the most identified drivers of EER decisions. EER was found to be economically attractive through energy savings (Tommerup and Svendsen, 2006; Zundel and Stieß, 2011; Schleich and Mills, 2012) and increased value property post-renovation (Wilson et al., 2015; Fabbri et al., 2016). On the other hand, the inability of households to afford EEMs of higher upfront cost, due to limited financial capacity or insufficient budget, is the most identified financial barrier to EER (e.g., Banfi et al., 2008; Grösche et al., 2013; Stieß and Dunkelberg, 2013; Risholt and Berker, 2013; Achtnicht and Madlener, 2014; Galvin and Sunikka-Blank, 2014;Mortensen et al., 2014; Baumhof et al., 2018; Bjørneboe et al., 2018; Schleich, 2019). Moreover, the decision is based on the trade-off between the monetary and non-monetary costs (Ebrahimigharehbaghi et al., 2020) and benefits of EEMs (reduction of operating costs of a property, reduction of CO2 emissions, improved comfort etc.) (Jafari and Valentin, 2017). Those non-monetary costs have been found to constitute in some cases as much as 20% of the total cost for a renovation (Ürge- Vorsatz et al., 2012).

Social and behavioral aspects

Social and behavioral aspects are important, but they often remain unnoticed in the literature (Kastner and Stern, 2015). Homeowners decide to implement EEMs not only for the sake of EE, but also to satisfy other needs (Zundel and Stieß, 2011; Bjørneboe et al., 2017) such as aesthetic considerations as part of a more comprehensive renovation (Galvin and Sunikka-Blank, 2014; Pardalis et al., 2019). A recent stream of literature discusses the non-energy benefits or co-benefits deriving from the adoption of EEMs (Michelsen and Madlener, 2013; La Fleur et al., 2017; Nehler et al., 2018; Nehler, Parra and Thollander, 2018; Brounen et al., 2020; Trianni et al., 2020), e.g., improved indoor climate or expected thermal comfort

(Michelsen and Madlener, 2013; Huebner et al., 2013; La Fleur et al., 2017). However, this stream of literature focuses more on the positive and negative effects occurring during the implementation or post implementation phases, but not so much on how non-energy and co-energy benefits affect the decision-making process.

Homeowners' decisions to adopt EEMs are influenced by a series of personal, contextual, and external factors. Personal factors include, cognitive awareness, attitudes and beliefs, experience, and skills (Ebrahimigharehbaghi et al., 2019). Homeowners with greater environmental awareness are likely to have greater interest to adopt EEMs (Achtnicht, 2011; Bravo et al., 2019) as they understand the environmental impacts of energy use (Santin, 2011; Wilson et al., 2013; Knudsen and Jensen, 2014), and they feel to contribute to a greater goal (e.g., mitigate climate change), which strengthens feelings of personal fulfilment (Murphy, 2014). Furthermore, lifestyle choices, like e.g., a do-it yourself culture, play their role in the decision to renovate or not (Zundel and Stieß, 2011; Gram-Hansen, 2014).

Contextual factors contain homeowners' features and property characteristics. Previous research has highlighted age of the homeowner influencing energy behavior and adoptions of EEMs (Sutterlin et al., 2011; Trotta, 2018). Older homeowners usually have the financial capacity to make investments in EEMs, preferring however to invest in low-cost solutions (e.g., energy efficient appliances), while younger homeowners show great interest to adopt EEMs, but lack capacity to invest (Das et al., 2018). Middle-aged homeowners on the other hand, and especially those having families, show willingness to invest in EEMs, but they tend to adopt measures that are necessary within the limits of their budget (Das et al., 2018). House age is an important aspect influencing the decisions of homeowners to renovate. It affects the level of energy consumption (Aksoezen et al., 2015) as well as the renovation needs. Homeowners must deal with the challenge of evaluating their property and deciding on which parts need to be replaced as part of the renovation project (Fyhn and Baron, 2017).

There are also external factors that can influence homeowners' behaviors. Inertia is such an acknowledged factor hindering decisions of homeowners to adopt EEMs (Tommerup and Svedsen, 2006; Zundel and Stieß, 2011; Knudsen and Jensen, 2014). Homeowners hesitate to invest enough time and effort to collect relevant information on EEMs and avoid renovations that they perceive to be complex and a source of disturbance on their daily life activities (Gram-Hansen, 2014; Knudsen and Jensen, 2014; Ebrahimigharehbaghi et al., 2020). That inertia is in some cases connected with a previous unpleasant renovation experience, which inevitably leads homeowners to show low level of trust on the existing market actors and the solutions they propose (Ebrahimigharehbaghi, 2019). Moreover, influences from the close or broader social environment like, e.g., neighbors or relatives that have adopted such measures (Gram-Hansen, 2014), social competition between neighboring homeowners (Bjørneboe et al., 2018), and changing needs of the household may affect the decision to adopt EEMs (Zavadskas et al., 2008).

The implementation of EER often requires wide-ranging information on the services, measures, and processes. Older studies (e.g., Yates and Aronson, 1983) stress the need for information to be communicated in ways that are comprehensible for homeowners and fit their actual needs. Many homeowners are unaware about their energy consumption, the costs of using energy and the opportunities for energy-saving in their dwelling (Jakob, 2007; Nair et al., 2010; Amecke, 2012; Tuominen et al., 2012; Palmer et al., 2013; Risholt and Berker, 2013; Vondung and Kaselowsky, 2017). Moreover, the lack of credible information is a hindering factor for EER (Tuominen et al., 2012; Knudsen and Jensen, 2014; Murphy, 2014; Vondung and Kaselowsky, 2017; Meijer et al., 2018). Homeowners may not carry out EER if they do not find required information or if they question the credibility of the information, e.g., from energy advisors and contractors (Ebrahimigharehbaghi et al., 2019). Hence, continuous training of energy advisors and contractors is important to prepare them to provide more informed advice and create a relationship of trust with the homeowners (Kangas et al., 2018; de Wilde and Spaargaren, 2019).

Models of decision-making

The variety of potential barriers affecting energy renovation decisions indicate that decision-making regarding EEMs is highly individual and characterized by a combination of factors. To identify and structure the effects of benefits and barriers as influencing factors, models have been developed that map decision-making on EEMs as a sequence of distinct process steps (Arning et al., 2020).

While many studies have focused on influencing factors in general that act as motivators of barriers for the decision to invest in EEMs (Organ et al., 2013; Abreu et al., 2017; Baumhof et al., 2018; Broers et al., 2019), others have made an effort to conceptualize homeowners decision-making behavior in models that take a process perspective and/or capture more complex relationships between the influencing factors (Nair et al., 2010; Stieß and Dunkelberg, 2013; Friege and Chappin, 2014; Wilson et al., 2018; Ebrahimigharehbaghi et al., 2019).

Nair et al. (2010) following from Mahapatra and Gustavsson (2008) conceptualized the renovation decisions of homeowners as a process and assume that to reach (or not) a decision, homeowners must follow a series of steps: first, homeowners must feel the need for renovation due to technical reasons (maintenance requirements or technical malfunctions) or attitudinal factors, for example, sustainable lifestyle orientations. Then homeowners put themselves in the process to collect information from various sources. Most homeowners rely on information coming from their network of interpersonal relationships. That network as well as other agents can play an important role in influencing the final decision of homeowners. The decision to implement (or not) EEMs is finally done by the homeowner based on the perceived characteristics of possible alternatives.

In the decision model of Stieß and Dunkelberg (2013), energy renovation decisions of homeowners are regarded as strategic consumer decision. The decision process follows specific steps, spanning from "information procurement" to "planning", "decision-making and implementation" and "use". The model composes sociodemographic data, the life situation of homeowners and attitudes towards their own homes as well as lifestyle orientations. The authors assume that the respective life situation has a

major influence on the decision to engage in energy efficient renovations. Furthermore, the attitudes of the homeowners play an important role, both regarding the refurbishment process and the outcome. These attitudes include, for example, the aim and the reason for the renovation as well as resources (knowledge or access to knowledge), financial capabilities of homeowners, or their ability to carry out the renovation work on their own. The model also contains other parameters leading to decisions for energy efficient renovations, such as current state of the dwelling and current legislation.

The decision-making model of Wilson et al. (2018) is based on Rogers' model of innovation diffusion (Rogers, 2005) (Figure 1). Their model begins with step 0, where homeowners still do not think about renovation. In step 1, homeowners start "thinking about renovation" and consider the possibility of an energy renovation due to "domestic events". In this step, homeowners are open to receive information. In steps 3 and 4, homeowners "planning renovations" and "finalizing renovations" taking intentional decisions on which EEMs are going to adopt and to which extent. In step 5, homeowners "experience renovation" and adapt themselves to the EEMs they have adopted. From step 1 to step 3, the decision-making orientation of homeowners becomes more focused, and it can be associated with an intention for adoption of EEMs.

The existing models of decision-making assume homeowner as a single unit of decision-making, which is not always the case. Homeowners interact with other relevant actors like artisans, installers, energy auditors and municipality energy advisers. These actors, either as individuals or in groups, can provide homeowners with the knowledge required or act as mediators in the renovation process (Bush et al., 2017). Furthermore, the decision towards adoption of EEMs in a renovation project does not occur on a single moment but is a process that evolves during the different steps of the decision-making. At each of those steps, there is always the risk that the decision to renovate and/or adopt EEMs may change and take a negative turn due to a series of potential barriers. Those barriers have been broadly described earlier in this section and an overview of them is presented in the table below (Table 1).

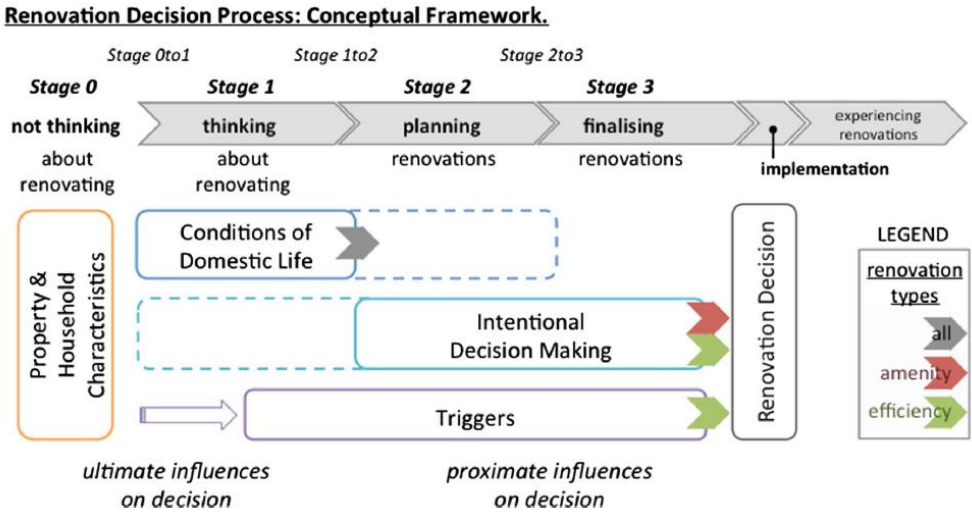

Figure 1: Conceptual framework for renovation decisions made in the context of everyday domestic life (adapted from Wilson et al., 2018)

Table 1: Barriers related to the decision-making of homeowners to proceed in EER, as found in the literature.

BARRIERS & MOTIVATORS	REFERENCES
FINANCIAL	
Transaction costs	Ebrahimigharehbaghi et al., 2020; Chua, 2021; Kiss, 2016; Ürge Vorsatz et al., 2012: Valentova et al., 2018
Limited access to capital / Insufficient budget	Achtnicht and Madlener, 2014; Azizi et al., 2019; Banfi et al., 2008; Baumhof et al., 2018; Bjørneboe et al., 2018; Bottero et al., 2018; Dadzie et al., 2018; D'Oca et al. 2018; Economidou et al., 2011; Galvin and Sunikka-Blank, 2014; Grösche et al., 2013; Mortensen et al., 2014; Pelenur and Cruickshank, 2012; Risholt and Berker, 2013; Schleich,

		2019; Schleich et al., 2016; Stieß and Dunkelberg, 2013
Expectations for return on investment		Alberini et al., 2014; Caird et al., 2008; Jalilzadehazhari et al., 2020; Pelenur and Cruickshank, 2012
Profitability through energy savings		Jafari and Valentin, 2017; Schleich and Mills, 2012; Tommerup and Svendsen, 2006; Zundel and Stieß, 2011
Perception on property value		Fabbri et al., 2016; Wilson et al., 2015
SOCIAL & BEHAVIORAL		
Personal factors	Cognitive awareness	Achtnicht, 2011; Bravo et al., 2019; Haines and Mitchell, 2014; Knudsen and Jensen, 2014; Santin, 2011; Wilson et al., 2013
	Attitudes and beliefs	Alberini et al., 2014; Gram-Hansen, 2014; Knudsen and Jensen, 2014; Lindkvist et al., 2014; Wilson et al., 2015; Zundel and Stieß, 2011
	Experience and skills	Gram-Hansen, 2014; Zundel and Stieß, 2011
Contextual factors	Homeowner's characteristics	Abreu, 2020; Achtnicht and Madlener, 2014; Bjørneboe et al., 2018; Das et al., 2018; Ebrahimigharehbaghi, 2019; Mortensen et al., 2013; Nair et al., 2010; Schwarzer et al., 2015; Sutterlin et al., 2011; Tjørring, 2016; Trotta, 2018
	Property characteristics	Aksoezen et al., 2015; Fyhn and Baron, 2017: Nair et al., 2010; Wilson et al., 2018
External factors	Inertia	Tommerup and Svedsen, 2006; Wilson and Dowlatabadi, 2007; Zundel and Stieß, 2011; Knudsen and Jensen, 2014; Ebrahimigharehbaghi et al., 2019; Ebrahimigharehbaghi et al., 2020; Vlasova and Gram-Hansen, 2014; Wilson and Dowlatabadi, 2007

	Low level of trust on market actors	Kangas et al., 2018; Klöckner and Nayum, 2016; Ringel, 2018
	Influences from social environment	Bjørneboe et al., 2018; Gram-Hansen, 2014; Zavadskas et al., 2008
INFORMATION		
Asymmetric information / Lack of knowledge		Achtnicht and Madlener, 2014; Amecke, 2012; Azizi et al., 2019; Azizi et al., 2020; Bartiaux et al., 2014; Bjørneboe et al., 2017; Charalambides et al., 2019; Jakob, 2007; Lorenzoni et al., 2007; Meijer et al., 2018; Murphy, 2014; Nair et al., 2010; ; Nair et al., 2012; Palmer et al., 2013; Persson and Grönkvist, 2015; Risholt and Berker, 2013; Stieß and Dunkelberg, 2013; Tuominen et al., 2012; Vondung and Kaselowsky, 2017; Wilson et al., 2015
Lack of knowledge on credible information sources		Banfi et al., 2008; Knudsen and Jensen, 2014; Mahapatra et al., 2011; Meijer et al., 2018; Murphy, 2014; Tuominen et al., 2012; Vondung and Kaselowsky, 2017; Zundel and Stieß, 2011

2.2 Overview of one-stop shop business model

The market for EER in detached houses has complexities due to the large number of actors engaged in the different activities at all stages of such renovations. All those different actors and their actions are interlocked during the whole renovations process. In the supply side of EER there exist limitations related to the traditional models through which the renovations are delivered (Mlecnik et al, 2019). Some of the most important limitations are the fragmented value chains (D'Oca and Veld, 2018; Konstantinou et al., 2015), in which different actors deliver separate fractions of the

renovation work (piecemeal approach) (Mlecnik et al., 2012; Owen et al., 2014), and skills gaps among construction professionals (Brown et al., 2018; Desmaris et al., 2019; Killip et al., 2014; Mlecnik et al., 2019; Pardalis et al., 2020; Zuhaib et al., 2017). There is a need for a business model configuration to address the challenge of value chains fragmentation and existing skill gaps, while also providing homeowners with renovation solutions under a simplified decision-making process. The OSS concept offers such a configuration.

OSS is a business concept, which entails that one supply-side actor coordinates all other actors involved in the renovation process and thus serve as the single contact point for homeowners. OSS has been advocated by the European Commission as an important element of the "Smart financing for smart buildings" initiative[2], according to which, member states are encouraged to develop local or regional OSS to provide information and assistance to homeowners through the whole renovation process. The initiative also encourages project developers to address whole customer journey from information, technical assistance up to monitoring of savings, and set up structures to provide homeowners with financial support. Similarly, OSS is advocated by Directive 2018/844/EU (European Parliament, 2018), which amends the Directive 2010/31/EU on the energy performance of buildings (EPBD) and Directive 2012/27/EU on energy efficiency (EED), which calls upon EU Member States to establish a long-term renovation strategy (Art. 2.a.). More specifically, according to the Article 20(2) of the revised EPBD "Member States shall provide the information through accessible and transparent advisory tools such as renovation advice and OSS".

The general objective of the OSS business model was the optimization of the fragmented renovation process, which requires an 'integrated, holistic approach' (Wilson et al., 2015). In that way an upscaling in holistic energy renovation of houses could be achieved by eliminating existing barriers such as lack of coordination/cooperation among the supply-side

[2] Accelerating clean energy in buildings. Annex to the Communications on Clean Energy for All Europeans. Brussels, 30.11.2016. COM (2016) 860 final.

actors, which may improve cost and time efficiency of integrated renovation projects.

OSS business model is a homeowner-centred service model, where the homeowner deals with a single point of contact which takes responsibility to inform him/her about the measures to adopt and takes over the project management of the whole renovation (Mlecnik et al., 2012). This bridges the gap between the fragmented supply side of renovations and demand sides and reduces the non-monetary costs that homeowners must deal with during the renovation process (Kiss, 2016). Moreover, homeowners do not need to manage various building professionals involved in the renovation (Boza-Kiss and Bertoldi, 2018). They may also obtain tailored advice on renovation solutions and their benefits from a single source, which may overcome the informational barriers (Mahapatra et al., 2013; Mlecnik et al., 2012), but the trustworthiness and reliability of such advice should be verified by an independent party. Thus, OSS business model is considered beneficial for supporting the renovation decision-making process and thereby, enable the implementation of more extensive renovations (Ebrahimigharehbaghi et al., 2020; Mahapatra et al., 2013).

OSS model should consider individual household characteristics and socioeconomic considerations and provide homeowners with renovation solutions that incorporate their individual needs and priorities (Boza-Kiss and Bertoldi, 2018; Bjørneboe et al., 2017). In other words, there is a need to provide tailored solutions ensuring optimal renovation packages including EE solutions (Bjørneboe et al., 2017; Boza-Kiss and Bertoldi, 2018; Ebrahimigharehbaghi et al., 2020; Balson et al., 2016). Additionally, supporting and involving homeowners through the whole renovation process makes them more engaged. Quality assurance offered by OSS may increase the attractiveness of the service by minimizing the perceived risks and uncertainties and creating a feeling of trust among the homeowners (Bjørneboe et al., 2017; Mlecnik et al., 2012).

OSS model has various benefits in the context of providing solutions for the financial limitations existing in the renovation market. OSS model often increases access to capital, grants, or loans (Bertoldi et al., 2020; Mahapatra et al., 2013; Mlecnik et al., 2012). Additionally, the existence of a single

contract and a single contact point minimizes the potential for unreliable repayment (Bertoldi et al., 2020). Since the OSS manages the whole renovation process, the high transaction costs related to renovation are minimized. It can guide the homeowners to identify the most financially viable renovation package and provide own or third-party financial solutions depending on the household need (Cicmanova et al., 2020).

OSS model is likely to benefit the supply side actors of renovations as collaboration creates opportunities for them to offer integrated services and expand their operations or value chains. The economies of scale may provide a more sustainable business structure for the companies (Mlecnik et al., 2012). Moreover, collaboration allows for transfer of knowledge, skills, and innovation, bringing balance of skills in the renovation process and thereby, facilitating renovation uptake (Mlecnik et al., 2012).

While the OSS model has some obvious advantages, some disadvantages also exist. Homeowners may have limited scope to interfere in the renovation and choose their preferred suppliers. There might be a limited portfolio of renovation solutions to choose depending on what the OSS provider offers according to its capacity and network of collaborators (Balson et al., 2016). Furthermore, conflicts of interest may arise between the different disciplines involved in the OSS, while having a single point of contact might introduce project biases (Balson et al., 2016). Moreover, conflicts between homeowners and the OSS have an impact on the entire project, as opposed to only on each individual service in the traditional renovation model (Balson et al. 2016). Disadvantages can be also observed on the supply side of renovation, as organizational changes might be required to deliver an OSS service (Pardalis et al., 2020), while supply side actors are called to deal with significant transaction costs that can affect the overall function of the OSS.

2.3 Types of one-stop shop business model

An earlier study has identified four types of OSS business models (Cicmanova et al., 2020). The main difference between these models is the

level of support provided or responsibility taken by the OSS provider in the overall customer journey and the results of the renovation work.

Facilitation model

In this model the main task of the OSS is to raise awareness of the homeowners regarding the benefits of energy renovation and provide them with general information on the optimal measures to be adopted for the renovation of their dwelling. The OSS may also provide homeowners with a list of supply side actors to perform the works required in an EER (Mainali and Mahapatra, 2020). In this model, the OSS does not lead the renovation work but rather provide limited guidance to the homeowners at the planning stage of renovation. Numerous issues to be addressed, when it comes to the planning and execution phase of renovation, are not covered in this kind of models. Facilitation model is suitable for self-motivated homeowners seeking for a trustworthy single contact point to provide them with information/advice (Pardalis et al., 2021).

Coordination model

This model deals with the coordination of the different actors who supply the required renovation services. The OSS provides structural, motivating and enabling guidance to the customer in the planning and implementation stages of renovation (Pardalis et al., 2021). It suggests appropriate renovation measures for the house and takes responsibility of supervising and coordinating the renovation work but is not responsible for the outcome of renovation. The outcome of the work remains a responsibility of the suppliers of technical services.

All-inclusive model

In this model the OSS bears responsibility for the whole renovation project, from planning to final delivery, and fully guide the homeowners throughout the renovation process. The OSS is the main contact point during the whole process, dealing with potential failures or inefficiencies. The key difference of all-inclusive model compared to coordination model is that it provides a single point of contact and offers renovation packages as per homeowners' demands with full quality assurance of the delivered work (Pardalis et al.,

2021). The quality of the work is assured within this model, but the amount of the energy savings is not necessarily guaranteed.

ESCO-type model

In this model, the OSS bears responsibility for the whole renovation project, from planning to final delivery, and provide guarantees for specified energy savings during the contract period. This is a hybrid model including Energy Performance Contracting (henceforth referred as EPC) offered by Energy Service Companies (ESCO) with the EEMs offered by the OSS. The limitation of this model is that guarantees on energy savings increases the risk of the OSS as they are closely connected to the behavior of individual households (Bertoldi et al., 2020; Winther and Gurigard, 2017). ESCO model is being tested in multi-family residential buildings, but not in the detached house segment (Boza-Kiss et al., 2017). Therefore, it will not be further discussed in this doctoral dissertation. The different OSS models discussed in this section are summarized in Figure 2.

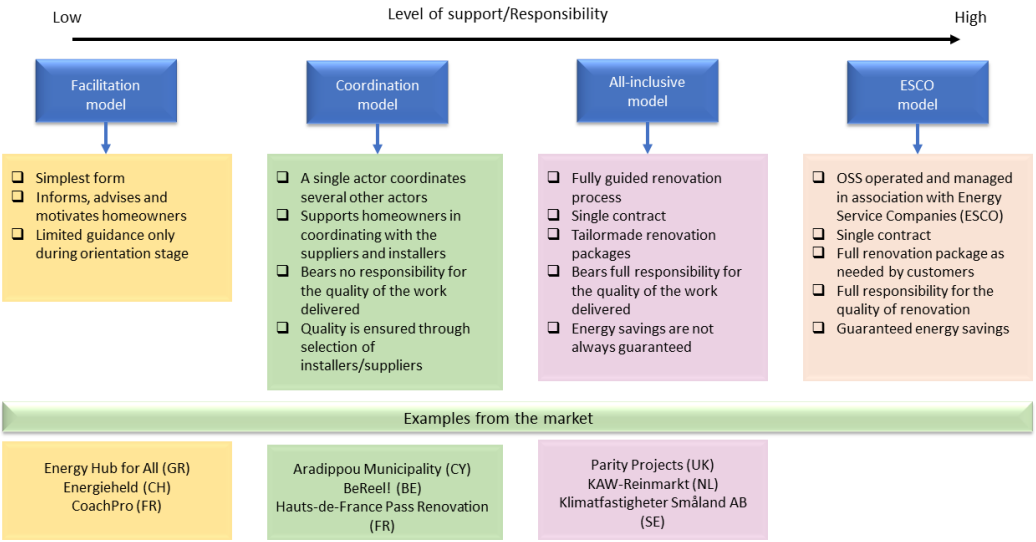

Figure 2: Types of OSS business model for EER (adapted from Pardalis et al., 2021)

2.4 One-stop shop delivery mechanisms

Existing business models that are in operation are often a combination of the different types that have been described in the previous section. Those types should not be considered in isolation; instead, combining different types can provide a more potent business model that can better meet the challenges of the renovation market and the needs of homeowners. The identified ways in which OSS is offered in the market are the following.

OSS provided by a multi-disciplinary team

In this model renovations are carried out by a multi-disciplinary team in a cooperative manner. The teams consist of partners with complementary competences, such as architects, constructors, energy auditors, technology suppliers, financing experts etcetera. The team works together from the initial design phase together with the building owner, to select the renovation solutions and plan the renovation process according to homeowner's needs, desires, and preference. Moreover, they provide homeowner with advice on how to acquire the up-front capital required for the renovation. (Figure 3). The fact that actors with different competence collaborate from early stages allows the development of a holistic approach to the renovation (Kemmer and Koskela, 2020) with control over the total costs and efficiency performances.

OSS provided by an entrepreneur

This business model is like that of OSS by a multi-disciplinary team, but in this case the renovation is coordinated by one entrepreneur. That entrepreneur is responsible to deploy a team of experts, including constructors, energy auditors, technology suppliers, etc. to deliver the commissioned renovation (Mahapatra et al., 2013) (Figure 4). The entrepreneur is responsible for the development of the working plan for the renovation, as well as the coordination of all participating actors from the design phase up to the final delivery. The entrepreneur is also responsible for the control of the total costs of the renovation project and liable for guaranteed efficiency performances.

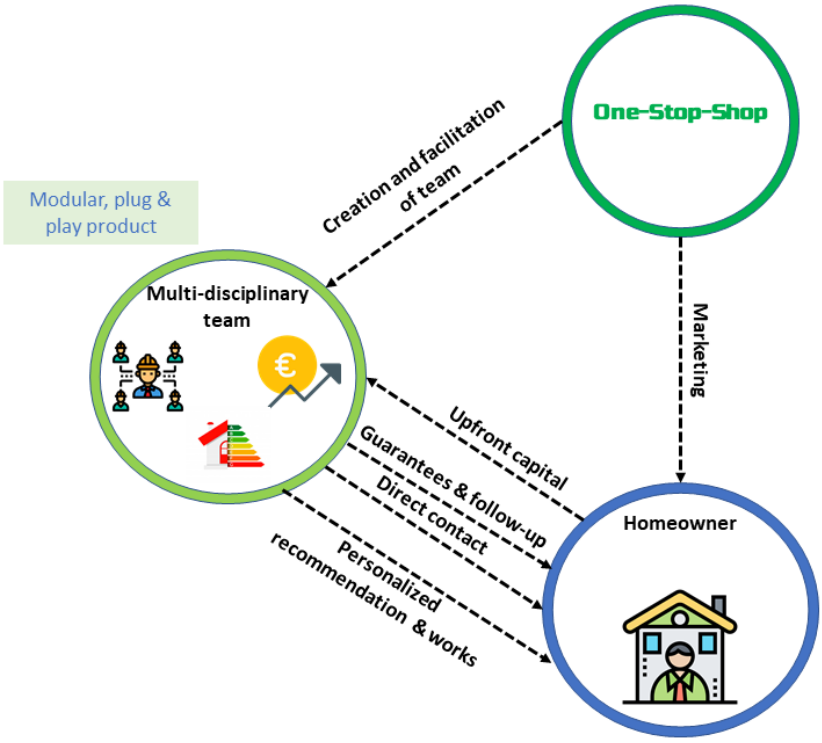

Figure 3: Schematic diagram of OSS provided by a multi-disciplinary team

OSS supported by a step-by-step approach

The approach followed in this model is widely diffused and proposes a renovation approach where different building components (windows, plasterwork, insulation, roof, heating system etc.) are replaced according to their life duration (Nägeli et al., 2019). The benefit of this approach is that homeowners get the most out of each building component, thus their initial investment is taken advantage to the fullest. The need for replacements of various components arises at different points in time, which means in the case of a complete building renovation, components that have not reached the limit of their life duration should not be replaced before their due time.

In the step-by-step approach, a building renovation plan should be made for all measures, including those, which lie in the distant future, before

starting the work. In this way, it can be ensured that an optimal renovation is achieved in terms of cost effectiveness, EE, and quality (Oberegger et al., 2020). A schematic diagram of OSS supported by a step-by-step approach can be seen in Figure 5.

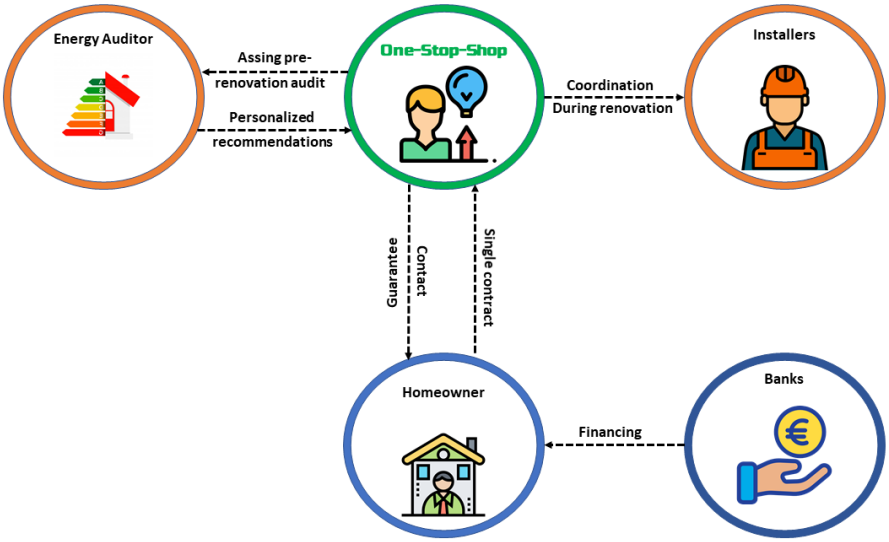

Figure 4: Schematic diagram of OSS provided by an entrepreneur

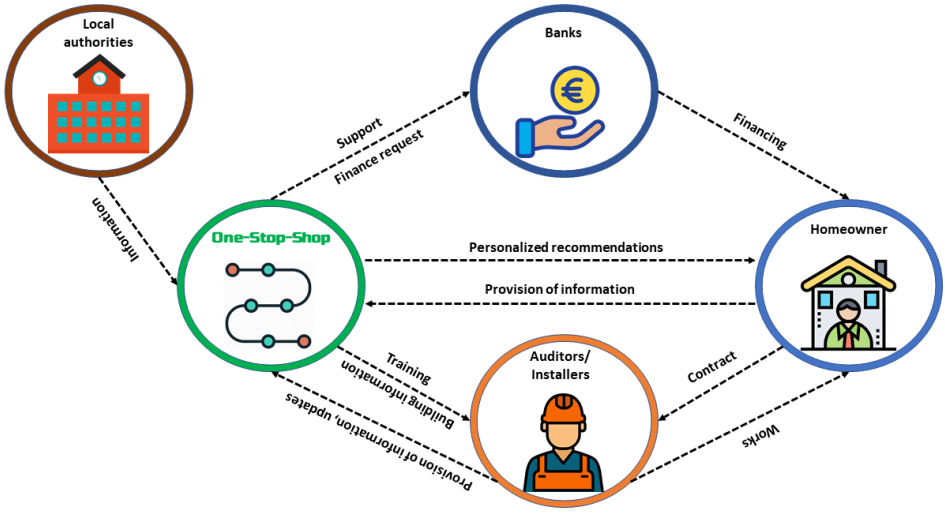

Figure 5: Schematic diagram of OSS supported by a step-by-step approach

OSS supported by digital tools

In this business model the function of OSS is supported by digital tools. The role of those tools is to guide both homeowners and contractors in the planning of the renovation work. Digital tools collect all the information related to the initial state of the building to be renovated as well as information regarding the preferences and financial capacity of the homeowner (Joblot et al., 2019; Park et al., 2014). The information is processed, and the tools suggest an optimized approach to the renovation project. The main advantage of this approach is the ability to create a personalized renovation solution for the homeowner, proposing adoption of measures that fit homeowner's needs and financial capacity. It also provides the possibility for the renovation process to be managed in a comprehensive way (Figure 6).

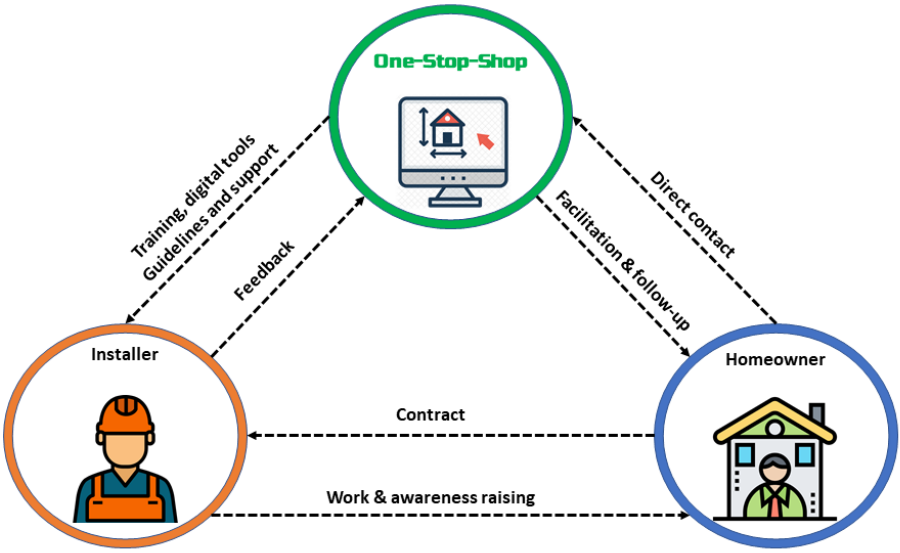

Figure 6: Schematic diagram of OSS supported by digital tools

The use of digital tools reduces the manpower costs of manual assessment. It can provide reliable information regarding the building stock and offer reliable initial proposals for the renovation. The contractors can make reliable assessments about the saving potentials in terms of energy and

costs, provided that the information in the digital tools is accurate. Here the quality of the initial information is highly important. In addition, a solid understanding of the users' behavior and willingness to commit to energy savings is essential.

OSS provided by Public-Private Partnerships and semi-public entities

Public Private Partnerships (PPP) is an already established delivery model in the construction sector. It involves a contract between a public sector authority, the building owner, and a private contractor in charge of the management and the development of the building renovation project. In this model, the private party provides the service to the public authority, assuming substantial financial, technical, and operational risks in the renovation project. Practically, in this model local authorities join forces with private companies, creating a kind of semi-public entities to provide sustainable renovation platforms to the public, supporting that way the residential renovation market (Bertoldi, 2020) (Figure 7).

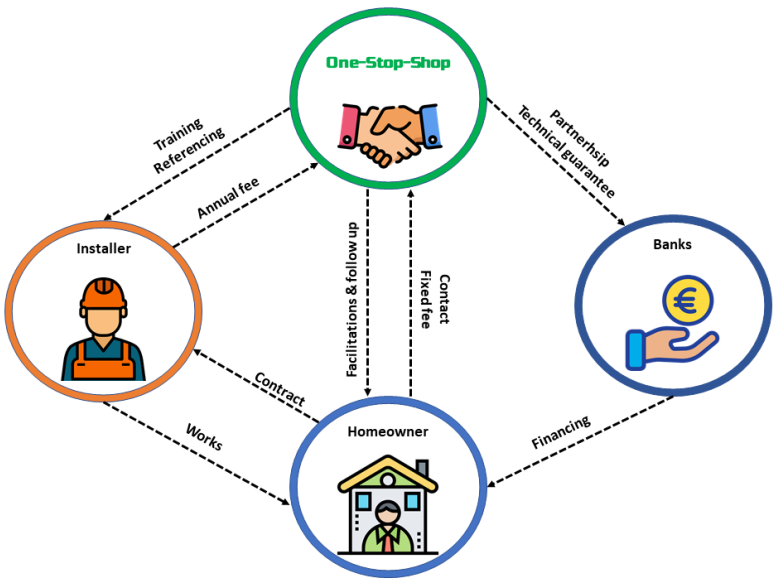

Figure 7: Schematic diagram of OSS provided by PPP

OSS with home-based financing

In this way of delivering OSS, homeowners finance EEMs for their renovation via an additional tax on their property over a certain period (Bertoldi, 2020; Pan, 2020). Local governments issue bonds to pay for the renovation, thus resulting in 100% upfront financing. In the case that the property is sold, the remaining debt is transferred to the new owner as part of the property. In this model, participation of a public authority is necessary. Public authority bears the responsibility to train and coordinate the contractors and capital providers, which purchase the bonds issued by the authority, thus financing the project. A schematic diagram of OSS with home-based financing can be seen in Figure 8.

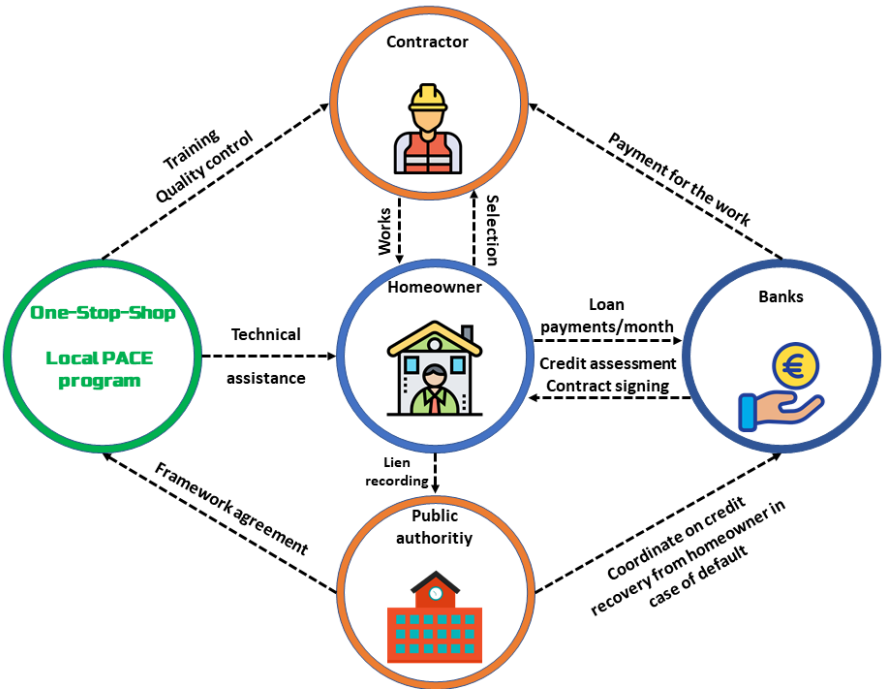

Figure 8: Schematic diagram of OSS with home-based financing

OSS provided as a complementary business

In this model, certain key actors (e.g., real estate agencies, insurance companies, utilities) may take advantage of their existing market to start OSS as complementary business by creating partnership with actors of complementary skills e.g., installers, carpenters, construction company, energy auditor/building inspector, and product suppliers (Mahapatra et al., 2013). The challenge is to create a consortium with a mixture of credible partners, who are established in the market, ensuring capacity and capability to supply a complete renovation package of good quality.

OSS provided by a joint venture of retailers with industry and contractors

This form of OSS is delivered by a joint venture of retailers, product manufacturers/suppliers and contractors. Customers visiting the retail stores are provided with easy access to refurbishment building products and services, all from one trusted vendor as single-point contact. The retailer is also responsible for the management of the renovation project, including help obtaining approvals from local authorities, apply for subsidies, planning of renovation, installation of selected products by a network of installers, quality assurance, energy certificate, etc. (Mahapatra et al., 2013). This type of OSS delivery may offer flexible funding (e.g., monthly payments) and benefits for frequent customers based on different purchasing ways: all/partly installed (the OSS provider installs all or some of the adopted EEMs); just products (the OSS provider sells all products needed in renovation); flexible project schedules (installation of measures is planned according to homeowners' preferences).

OSS provided by a contractors' cluster cooperation

In this model, it may happen that the service provider of the OSS business model is a team of contractors that may all be small- and medium-sized enterprises (henceforth referred as SMEs), or SMEs with a major contractor and its affiliated partners. Small- and medium-sized enterprises collaborate with each other and act as a single, big company with a very informal structure. Each actor specializes on a specific aspect of the

renovation process, and through collaborations covers potential competence gap (Mlecnik et al., 2013; Mlecnik et al., 2019). Contractors' cluster cooperation ensures control over costs and guaranteed performance, and lowers the vulnerability compared to isolated actors. It also makes feasible the possibility to undertake projects of larger scale. In this framework, SMEs operating in the construction industry and in the same region may look for a holistic coverage of the construction industry market, applying business models, which can be profitable by fulfilling a wide spectrum of clients' requirements (Buser and Carlsson, 2020).

2.5 Policy instruments to promote energy efficiency renovations

EU Level

EER of the existing building stock is a political priority for the EU. The updated EPBD (EU) 2018/844 (European Parliament, 2018b) and revised EED (EU) 2018/2002 (European Parliament, 2018a) call for a series of actions towards stimulating new investments in EE. Economidou et al. (2020) has conducted an extensive literature review of the EU policies of the last 50 years to explain how those policies have been effective in transforming the building stock and reducing the energy consumption of the building stock. There is also a considerable amount of literature assessing country specific policy strategies to achieve energy savings from the renovation of existing buildings (Blumberga et al., 2018; Charlier et al., 2018; Ebrahimigharehbaghi et al., 2020; McCormick and Neij, 2009; Sebi et al., 2018; Weiss et al., 2012).

A variety of studies has explored policy aspects and their effect on EER market in Europe. Kiss et al. (2013) discusses the role of policy instruments in the development and dissemination of technological innovations in the EER, using examples of cases from Sweden, Germany, and United Kingdom. Bjørneboe et al. (2017), in their analysis for barriers and motivators in the EER market for detached houses in Denmark, propose subsidies connected to EE as a policy instrument that could help

overcoming market barriers. In contrast, Dubois and Allacker (2015), propose to avoid subsidies for renovations with minor energy savings. Instead, they propose the restructuring of policy instruments for the benefit of deep energy renovations or demolition and reconstruction projects. Aboltins and Blumberga (2019) identify the key factors for the successful implementation of policy instrument for EE in buildings in the case of Latvia. Meijer et al. (2018) propose the development of policy instrument on a local authority level aiming to increase homeowners' awareness about EE.

However, it is also necessary to examine the financial instruments, not only to strengthen the existing instruments but also to develop new ones, to support those who want to invest in the EE of buildings. Based on an extensive literature review, Bertoldi et al. (2020) classified financial mechanisms into three broader categories; (a) traditional and well-established, (b) tested and growing and, (c) new and innovative. Traditional and well-established are those financing mechanisms that already exist in the markets and are implemented in many EU member states (grants and subsidies, loans, tax incentives). Tested and growing financing mechanisms are those that have shown tangible results from their application in several EU member states, and which have potential for more widespread application, like, e.g., Energy Efficiency Obligations (henceforth referred as EEOs) and EPC. New and innovative financing mechanisms are those that are currently developed or applied at limited scale in the EU and have as a goal to address lack of funding, which is considered a key barrier to EER. Such mechanisms, among others, are energy-efficient mortgages, Property Assessed Clean Energy (henceforth referred as PACE) financing and crowdfunding. Moreover, Bertoldi et al. (2020) provides a detailed analysis of those financing instruments and offers examples of applications of those on the EU level[3].

Sweden

The existing building regulations (BBR29) in Sweden mandate an energy

[3] A list of examples of financing measures supporting EER on the EU level can be found in Appendix I

consumption that does not exceed 85 kWh/m^2/year for both newly built and deep renovations (e.g., EER) (Boverket, 2020; BPIE, 2018). But there is no obligation for old buildings to undertake deep renovations. Furthermore, there is an obligation for an EPC in cases of ownership or tenancy changes in a house. The EPC includes recommended potential energy efficient measures appropriate for the specific house. This is assumed to trigger energy renovations through improved information regarding the energy performance of the dwelling. EPC is a measure broadly used in the EU, however in Sweden it has not produced the expected results (Hårsman et al., 2016). For EPC to become more effective the performance criteria and/or indicators should be independent of the occupant behaviour and related to the building operation (Allard et al., 2017). In addition, in Sweden, no energy EEO scheme exists for the residential sector. The Swedish Ministry of the Environment and Energy set up a committee to investigate the possibility on some policy measures like white certificate for enhancing EE based on a broader framework agreement among major political parties (Government Offices of Sweden, 2018). The conclusions from the work of this committee were presented in "Sweden's Integrated National Energy and Climate Plan" published in January 2020 (Government Offices of Sweden, 2020). According to this plan, municipal energy, and climate advisors are called to provide impartial advice to end-users, to improve their knowledge regarding EE and the EEMs that they need to adopt. Moreover, the Swedish Energy Agency has investigated whether white certificates are an appropriate policy for Sweden, and it has concluded that this kind of scheme should not be introduced in Sweden in principle (Government Offices of Sweden, 2020). According to the Swedish Energy Agency the market failures that white certificates aim to correct, are already addressed by other policies, and the introduction of the scheme might affect and be affected by the operation of existing policies, such as the EU Emissions Trading System (ETS) and electricity certificates. The possibility though of using white certificates is not categorically ruled out, but only if another objective in addition to EE is added to the scheme (Government Offices of Sweden, 2020).

Currently there exists no investment subsidy for the renovation of detached houses. However, there is an investment support for the installation of PV and battery storage systems for detached houses. This support covers 20% (it can go in some cases, up to 60%) of the cost of buying and installing these systems, and it could not exceed 50000 SEK[4] per house owner. To avail this subsidy the system must be connected to the grid. The support has been in place from 1st January 2016 and covers systems that are going to be completed no later than 30th June 2021 (Swedish Parliament, 2016). This investment support has been replaced by a tax deduction program offering a 15% tax reduction for solar systems and 50% for storage of self-generated electricity and charging points for electric vehicles. This tax deduction program has been included in Sweden's Budget Bill for 2021. Furthermore, there is a provision of tax rebate (ROT) on the purchase of household services, repairs, and maintenance up to 50000 SEK per applicant per year (Swedish Tax Agency, 2015). Moreover, related to taxation, the existing housing tax policy in Sweden is more favourable to new constructions, as there is a need to meet the increasing demand for housing, rather than focusing on improvements on the existing housing stock. The real estate fee for single-family houses is 7112 SEK/year but not exceeding 0.75% of the tax assessment value. However, such a fee is waived for newly built dwellings for first ten years encouraging new construction (Swedish Tax Agency, 2015).

Regarding access to credit for adoption of EEMs, most major banks in Sweden offer some form of "energy loans", to which, both individuals and companies have access, and which are advantageous for energy saving purposes. To take this type of loan no collateral is required, but in most cases the size of the loan is rather low (30000-50000 SEK). Those money must not be spent on anything else but EEMs (EFFECT4buildings Project Annex 7, n.d.). In the case of individuals who want credit to adopt EEMs, the most usual practice is to extend their mortgage instead of taking a new loan. Examples from the application of those "energy loans" in the Swedish market show that these mostly focus on the market of new buildings and/or

[4] 1 SEK = 0,098 EUR (current currency)

multi-family residential buildings (EFFECT4buildings Project Annex 7, n.d.).

In addition, there are attempts to encourage EE of residential buildings, but still a transformation in the market is not observed. Such an attempt is the "construction innovation programme" supported by Swedish Innovation Agency VINNOVA with matching fund from the companies. This program promotes the commercialization of research results by supporting the adoption of innovative information and communication technologies and green growth solutions (European Commission, 2020).

3. FRAMEWORKS FOR EMERGENCE & ADOPTION OF ONE-STOP SHOP

This chapter describes the theoretical frameworks to assess the conditions for the emergence of OSS as well as to assess the perceptions and level of preparedness of supply-side actors to adopt the OSS concept.

3.1 Conditions for one-stop shop to emerge

In Sweden, OSS is best illustrated by the concept of "turnkey contract" (totalentreprenad in Swedish). Such a concept is commonly offered by large or medium-size companies, which have the capacity to offer construction management services and take the responsibility of planning, design, and execution of a project. Micro- and small-sized enterprises (henceforth referred as MSEs), which are dominant actors in detached house renovation, usually work as subcontractors to turnkey contractors or spread their resources in individual small-scale projects. There are known applications of turnkey contracts in Sweden in the cases of construction or renovation of multifamily residential buildings or in the construction of blocks of new detached houses. The concept is not tested for detached house renovations, and therefore, the conditions for the emergence of OSS in this market is discussed in this dissertation.

The terms "transaction costs" (henceforth referred as TC) and "non-monetary costs" often appears to describe some of the burdens homeowners must deal within their decisions to perform an EER (Kiss, 2016; Wilson et al., 2015; Ebrahimigharehbaghi et al., 2020). Those costs may account for as high as 20% of total project costs (Ürge-Vorsatz et al., 2012) and may affect the emergence of OSS.

At least three arguments stand out for high TC in the context of the market of EER for detached houses (Coase, 1937; Williamson, 1989). First, EER projects integrate a variety of products and services offered by

different suppliers, which entails multiple transactions (Williamson, 1999). An EER project might have some standard elements, but still the renovation of each detached house is a separate project with its own particularities and planning process (Risholt and Berker, 2013; Owen and Mitchell, 2015; Hrovatin and Zoric, 2018). Consequently, an EER, as well as organizing and coordinating its different aspects, involves elements such as investigating, contracting, monitoring and enforcement costs (Dyer, 1997), which are project-specific TC.

Second, there is knowledge asymmetry between the supply and demand side of those renovations, which is further enforced by the inertia of homeowners (as described in section 2.3), and which leads them not to take a decision for renovation. Other factors enforcing that asymmetry are homeowners' lack of knowledge on EE and its benefits, and personal lifestyle and culture. Moreover, the difficulty to identify and entrust reliable professionals that can deliver an EER further complicate the situation. On the other hand, supply-side actors contribute to knowledge asymmetry by conducting business on a piecemeal approach (Mahapatra et al., 2013). Additionally, previous unpleasant experiences increase the feeling of distrust between homeowners and craftsmen (Klöckner and Nayum, 2016), which becomes even greater when services offered are perceived as overpriced (Buser and Carlsson, 2017).

Third, as noted by D'Oca et al. (2018), due to the peculiarities of each project, there are often inconsistencies between what has been promised and what has been finally delivered. Supply-side actors have difficulties to provide guarantees on quantity of energy savings, and therefore add an extra margin to the service to cover potential post-renovation claims and rework. This appears to be a production cost, but it is a TC.

The main argument for OSS, as expressed by researchers and policy makers, is that it offers a homeowner-centric business model, which bridges the gaps between supply and demand sides, and reduces the TC that homeowners must deal in an EER. Therefore, it is important to examine the conditions under which OSS could emerge in the market through the lens of transaction cost economics (henceforth referred as TCE). TCE can explain what the most efficient governance form would be, given a

transaction is embedded in a specific economic context (Amit and Zott, 2001). Assuming OSS is present in the market, TCE allows to understand to what extent an OSS organization would manage to offer the necessary services included in the concept within its own boundaries and to what extent it will need to sub-contract them to other actors in the market (Williamson, 1989). Based on the examples of existing OSS in the market, the provider can either perform all relevant activities connected to EER, from planning to execution and post renovation monitoring, by themselves (without the involvement of other supply side actors) or do nothing else but organize the activities including in the single contract signed with the homeowner, and procure all services related to EER from external parties. To choose which of those two approaches OSS providers will follow, it is important to consider the internal production and control costs of each activity required by the renovation cycle, and whether such costs are higher or lower from the combination of the price of that service/product on the market and the transaction costs associated with sub-contracting it (Williamson, 1989). Activities where the aggregate cost is lower internally, the OSS can deliver them itself; for the rest OSS must investigate how to get them from the market. Of course, none of these makes it possible to evaluate how an OSS provider would systemize the concept in their organization, and it cannot predict if and under what conditions an existing market actor would decide to undertake the role of OSS coordinator.

For someone to start an OSS, two conditions appear to be necessary to be satisfied. First, assuming that OSS is a cost-reduction mechanism, it is necessary that the sum of the costs incurred by a business from offering the service (production costs or as hereinafter referred to as PC) and TC in the OSS model to be lower than the costs the respective sum of these costs in a market without OSS (Figure 9).

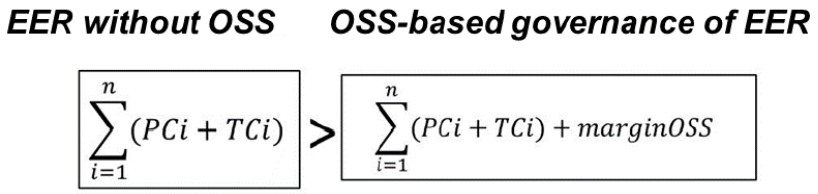

Figure 9: Conditions for OSS to be assumed as a cost reduction mechanism

That condition is satisfied if (a) OSS manages to reduce TC among the suppliers, and (b) if OSS manages to reduce PC among the suppliers, by more than the extra margin the customer must pay to the OSS. For (a), TC are reduced in the case the transacting parties have had previous successful transactions (Ring and Van De Ven, 1992), perceive each other as having a track record in relevant production areas (Ring and Van De Ven, 1989), or grant each other acts of goodwill (Dore, 1983). These lead to the development of relationships of trust and commitment between transaction partners (Williamson, 1983), which ensures the existence of a trusted network of collaborators to which the potential OSS provider can turn to obtain the services required to be externally procured. For (b), PC are not only reduced in the case the OSS is delivered by an actor who have the capacity to offer most of the services required for an EER, but also if the potential provider enables the development of economies of scale for that specific market. Of course, it is difficult for an organization that can provide all services to procure them in other organizations in the market. Furthermore, (b) implies that the more projects are delivered under OSS, the more the processes become standardized, and PC are reduced.

Second, looking back at the two strategies for an organization to become an OSS (offer all the services themselves, or coordinate and procure the services to third parties), only in the first case the OSS is not required to govern any other actors. In any other case, coordinating third parties means also that the OSS provider must take responsibility towards the homeowner over the works that the procured parties will deliver (Madhok, 2002). Moreover, that means that the extra margin charged from OSS to cover that responsibility should be lower than what is charged from another prospective OSS. Obviously, that implies the existence of competition in the market, where other supply-side actors might be more fitting to undertake the role of OSS provider. That can be assessed using resource-based theory.

According to resource-based theory, organizations seek to perform activities within the boundaries of their available resources and capabilities, or else they risk being outperformed by other organizations that have an advantage in the respective activity area (Teece et al., 1997). Capabilities are

developed through learning by doing of delivery of activities related to the organization's area of operations (Nonaka and Takeuchi, 1995). This suggest that the actors who have a stronger record of delivery of one or more activities related to EER and can use their existing resources and capabilities more efficiently are better placed to offer an OSS than other potential suitors for this role. In this regard, even the ability to govern others can be thought as a capability itself (Winter, 1988). Additionally, if an organization considers OSS to be attractive, then it needs to develop missing governance assets and acquire resources, even if those might not be of use in their core area of operation (Williamson and Ouchi, 1981). However, this may still put these organizations to a competitive disadvantage compared to existing established actors, because it requires time and resources to acquire the capabilities and learn to use them efficiently.

3.2 The innovation adoption approach

The OSS business model is characterized as an innovation (Boza-Kiss and Bertoldi, 2018; Mahapatra et al., 2013), since it introduces a new type of service in the renovation market (Dodgson and Gann, 2018; Kahn, 2018). The building sector is generally regarded as slow to change, and innovation is key for the success of firms regardless of their size (Kyrgidou and Spyropoulou, 2013; Turk, 2016; Zubizarreta et al., 2017). Especially for MSEs, innovation is essential to stay competitive, and this requires use of external and internal resources (Chesbrough 2003; Gambatese and Hallowell 2011).

By adopting innovations, those MSEs can gain new perspectives and knowledge on existing problems they face (Pérez-Luño et al., 2011). However, innovation patterns for the large construction industry are not necessarily appropriate for MSEs and vice versa (Barrett and Sexton, 2006). A study showed that many of those MSEs are unfamiliar with existing renovations within their sector, and that they face difficulties when required to work together with other similar companies on whole building solutions (Mlecnik et al., 2019). There exists extensive literature on the various factors

affecting the adoption of innovations in general (Anderson et al., 2014; Arpaci et al., 2012; Damanpour and Schneider, 2006; Frambach and Schillewaert, 2002; Gumusluoglu and Ilsev, 2009), and in construction (Bygballe and Ingemansson, 2014; Martin and Perry, 2019).

According to Rogers (2005), the decision of an organization to adopt an innovation passes through different stages. More specifically, the adoption process (Figure 10) is defined as "the process through which an individual or other decision-making unit passes from first knowledge of an innovation, to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision." (Rogers, 2005, p.21). The way an organization perceives an innovation influences the evaluation of it and the propensity of an organization to adopt it (Pichlak, 2016). Furthermore, the perceived benefits of adopting an innovation (relative advantage and cost-effectivity) are also evaluated, since the returns from the adoption of an innovation should exceed those of current practice (Heidenreich and Kraemer, 2016). Other innovation characteristics influencing the adoption decision include perceived compatibility, complexity, observability and trialability (Rogers, 2005).

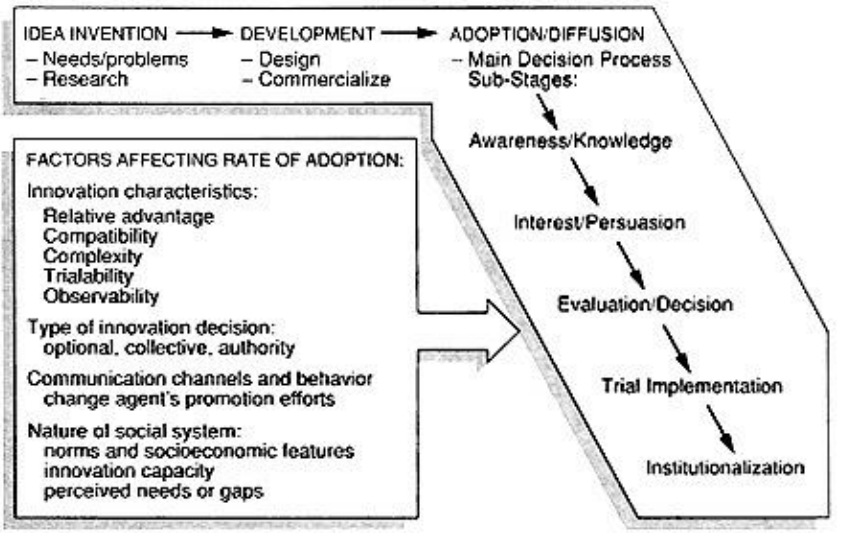

Figure 10: Rogers's basic model of the process stages in innovation invention, development, diffusion, and adoption (adopted from Rogers, 2005)

The decision of an organization to adopt an innovation is influenced by its internal characteristics such as its size, structure, business vision, and culture. Constructions MSEs are mostly family-owned and therefore, their business vision and culture coincide with those of the owner/manager (Teirlinck and Spithoven, 2013). Due to their small size, they can conduct their business in a flexible way (McGuirk et al., 2015), but they often lack extra resources to pursue innovation. Integration with other similar companies within the limits of their business networks allows them to fill resource gaps and mitigate the costs deriving from innovation adoption (Gronum et al., 2012). Therefore, the existence of business networks is very important.

The overall business environment can also have significant influence on the propensity of an organization to adopt an innovation. It is more probable for an organization to adopt an innovation, if other organizations in its business environment have adopted it (Wu and Chiu, 2015), which makes it easy to understand the risks that the adoption entails (Lee et al., 2013). Moreover, the need for smaller organizations to remain competitive in their markets sets pressures for them to innovate (Aydalot and Keeble, 2018; Bossle et al, 2016; Kirzner, 2015). In addition to market influences, existing policies are a great source of influence for innovation adoption decisions. Regulations that promote innovation adoption have a positive influence (Aarons et al., 2011), while targeted governmental incentives for development of innovative products and services for the needs of a specific market, increase the probability for an organization to adopt an innovation (Bossle et al., 2016).

4. METHODOLOGY

This chapter begins with an overview on how the appended papers connect to the research questions. Then, the methods applied in developing the dissertation are described. This includes methodological steps for (i) realising the study on the factors influencing homeowners' decisions for EER using partial least squares path modelling (PLSPM); (ii) the study on perceptions, level of preparedness and suitability of supply-side actors towards initiating one-stop-stop; (iii) the examination of existing market condition, and PEST and SWOT analysis to develop strategies to support EER of detached houses in Sweden.

4.1 Connecting the research questions to the appended papers

The research presented in this dissertation started with a broad study of the state of the art on energy-efficiency renovation market and OSS in the EU (presented in section 2). This study provided the insight to narrow down the research to the Swedish context, examining the market situation for EER and the prospects for the development of an OSS. Three research questions were formulated to address this aim (Figure 11). The first research question is addressed in papers I, II and III, which examine the factors influencing homeowners' decisions for EER, and their interest in OSS. Although papers I and II focus on a specific geographical region of Sweden (Kronoberg province), paper III acts as validation tool transferring the research from the local to the national level. The second research question is addressed in papers IV and V, which examine the perceptions of various supply-side actors regarding the OSS concept, and their potential fit to initiate an OSS. Paper VI addresses the third research question on strategies to promote EER of detached houses in Sweden by conducting SWOT (Strength, Weakness, Opportunity, and Threat) and PEST (Political Economic, Social and Technical (PEST) analysis of the EER market.

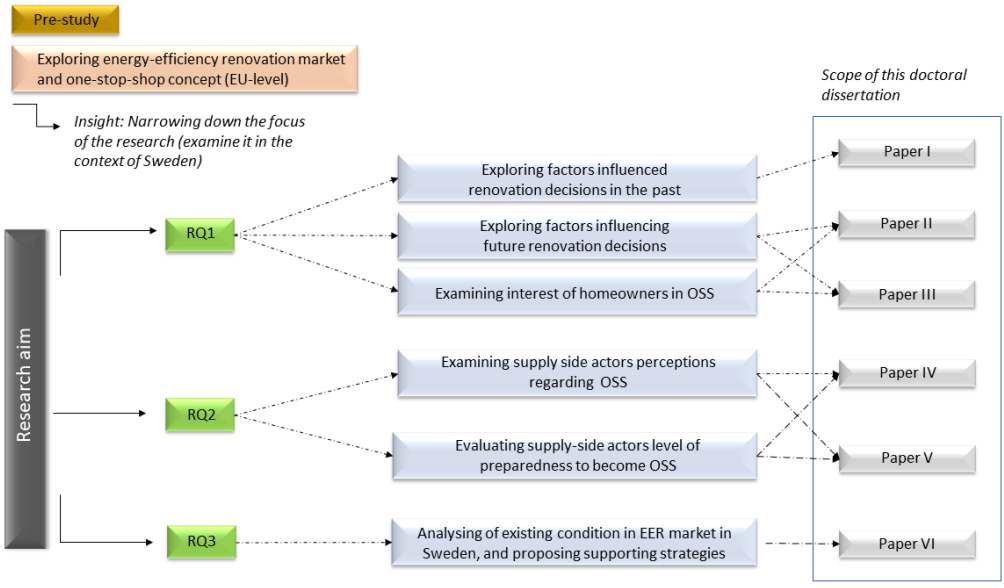

Figure 11: Overview of the papers, research aim and research questions

4.2 How methods are used in the thesis

Research is the systematic and organized effort to investigate a specific problem and provide a solution to it (Sekaran and Bougie, 2016). Understanding the theory and techniques of investigation are important parameters of any scientific research. The research related to multi-disciplinary and complex societal challenges needs to be answered using multiple methods (Mainali, 2014; Jacobs, 2005). This thesis also uses multiple methods blending qualitative and quantitative research results together in answering key research questions within the study. This provides the potential of gaining knowledge on multidisciplinary aspects of an issue under study and provides its comprehensive enlightenments (Mingers, 2001; Gil-Garcia and Pardo, 2006).

In this dissertation, multiple approaches were followed in analysing the three research questions. For papers **I**, **II** and **III** an inferential approach was followed, while for papers **IV** and **V** an exploratory approach was followed. Finally, for paper **VI**, a descriptive approach was followed.

The inferential approach is a type of quantitative research (Brannen, 2017) where a sample of population is studied (questioned or observed) to determine its characteristics. For that purpose, surveys conducted to gather large volumes of data that can be analysed for frequencies, averages, and patterns (Rea and Parker, 2014). For papers **I**, **II** and **III**, two web-based questionnaire surveys were conducted, covering homeowners at local (Kronoberg province) and national (all Sweden) level. Web-based surveys have the advantage of cost efficiency and anonymity of the respondents. The administration of long and complex questionnaires is feasible, and the interviewer-induced bias is avoided. However, there is the danger of a low response rate, since many respondents may not have access to a computer, they may lack computer skills, or they may not like to use web-based technology (Rea and Parker, 2014).

The exploratory approach (papers **IV** and **V**) is useful to gain a better understanding of the nature of the problem and its underlying causes, but it is not intended to provide conclusive evidence. In this kind of approach, the research direction may change because of revelation of new data and new insights (Saunders et al., 2012). Open-ended or semi-structured interviews are common data collection methods as they allow focused, conversational, and two-way communication (Harrell and Bradley, 2009). The interviewee has the flexibility to go into details when needed, providing useful qualitative data, and sharing actual opinion on a topic (Harrell and Bradley, 2009). Therefore, in this thesis work, in-person, semi-structured interviews were conducted with various supply-side actors. In-person interviews have the advantage of the presence of the interviewer, which enables the respondent to clarify answers or ask for clarification on the questions asked. They also have the advantage of getting more detailed information about a particular response, while non-response is almost absent (Lavrakas, 2008). On the other hand, some answers might not be thought out thoroughly as compared to a web-based survey. The expectation to answer on the spot, might not be very convenient for the interviewee and affect accuracy of answers. Furthermore, according to Lavrakas (2008), respondents must build trust in the interviewer to disclose sensitive information. In addition, semi-structured in-person interviews

mainly consist of open-ended questions based on the topics the researcher is aiming to cover in the interview. Although the focus is on key topics, there is the opportunity for further discussion on specific areas of interest (Lavrakas, 2008).

The descriptive approach followed in paper **VI** is based on systematic literature review and expert consultation. Literature review increases the knowledge on how and what other researchers have studied on a specific topic of interest (Booth et al., 2016). A systematic literature review allows the identification, selection, and critical appraisal of research to answer clearly formulated questions (Dewey and Drahota, 2016). The literature review on paper **VI** was systematic since it had, according to the criteria set by Jesson et al. (2011, p.12), "a clear stated purpose, a question, a defined search approach, and stated inclusion and exclusion criteria, producing a qualitative appraisal of the articles". Stakeholder consultation provides with a valuable source of information, as the incorporated knowledge from expert stakeholders allows the bridging of potential knowledge gaps (Kvam, 2017).

An overview of the research approaches in this dissertation is presented in Table 2. The selected methods for each of the approaches, and the applied data collection and analysis techniques are described further below.

Table 2: Overview of the research approaches and methods used

PUBLICATION	PAPERS I, II AND III	PAPERS IV AND V	PAPER VI
Research approach	Inferential	Exploratory	Descriptive
Aim	Identify the factors influencing homeowners' decisions for EER. Identify their interest for a full-service renovation package offered by a single actor	Identify perceptions of supply side actors on OSS and assess their preparedness to adopt it	Provide an overview of existing market conditions for detached house renovations and examine the need for potential development of

			tools to stimulate EER for detached houses
Method used	Survey research	– Interviews – Systematic literature review	– Systematic literature review – Stakeholder consultation
Research tool used	Online distributed questionnaires	Semi-structured interviews	– Systematic research for peer-reviewed articles – Semi-structured interviews and expert consultation
Data analysis	– Quantitative data analysis – Partial least squares path Modelling (PLSPM)	– Qualitative data analysis – Iterative coding	– Qualitative analysis – SWOT and PEST analysis

4.3 Online Survey

Two online questionnaire surveys were conducted to identify the factors influencing homeowners' decisions for EER and their interest in OSS. The first online questionnaire survey was conducted in the late spring 2017, and covered homeowners who were customers of 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). The latter send the questionnaire to 7193 email addresses of its customers owning detached houses. A total of 971 house owners answered after one reminder. That corresponds to a response rate of 13.5%, which agrees with the standards for online surveys (Baruch and Holtom, 2008). The second online questionnaire survey was conducted in spring 2018, covering homeowners from whole Sweden, who were members of

the Swedish house owners' association "Villaägarna" (a non-profit and non-partisan consumer and interest organization for residents and owners of single-family houses). The questionnaire was sent via email to 144660 members of Villaägarna. In total, 12194 answers were received after one reminder, corresponding to a response rate of 8.43%, which is low, but acceptable considering the large number of respondents.

The questionnaire

The questionnaire used in both surveys almost similar, but the one used in the national survey (Appendix II) contained some additional questions. The questionnaire was based on literature review regarding homeowners' decision-making and behaviour towards EER. The questionnaire included several sections related to respondents' demographic characteristics, characteristics of their dwelling, past experiences on renovation, plans for renovation in the close future, and perceptions towards a holistic service for house renovation, among others. The questionnaire was developed in Swedish language in consultation researchers, house owners' association "Villaägarna", and the insurance company Länsförsäkring Kronoberg. In the cover letter of the questionnaire surveys, the participants were informed that their participation was voluntary and that their identity and individual responses would be kept anonymous.

Non-response bias

Since only 13.5% of the surveyed homeowners, living in Kronoberg province and 8.43% of the surveyed homeowners from all Sweden responded, it was important to check whether they are a representative sample of homeowners. Therefore, the distribution of the survey results was compared to data from the Statistics Sweden (SCB) (Tables 3 and 4). The distribution of the survey sample regarding age of homeowners and the construction year of dwellings was broadly consistent with national distribution data from SCB.

Table 3: Distribution (%) of age of house owners and house construction year in own survey compared to SCB data (Kronoberg sample)

Age group (years)	<29	30-39	40-49	50-59	60-69	>70
Own survey	2.69	18.29	16.05	20.76	23.23	18.97
SCB data	2.45	11.61	19.14	20.83	21.05	24.93
Construction year	<1960	1961-1970	1971-1980	1981-1990	1990-2000	>2001
Own survey	32.72	17.24	29.21	10.18	3.84	6.13
SCB data	46.91	15.76	22.28	6.73	2.41	5.90

Table 4: Distribution (%) of age of house owners and house construction year in own survey compared to SCB data (national sample)

Age group (years)	<29	30-39	40-49	50-59	60-69	>70
Own survey	0.89	13.43	21.20	21.22	18.86	24.40
SCB data	2.18	12.34	20.57	22.28	20.32	22.31
Construction year	<1960	1961-1970	1971-1980	1981-1990	1990-2000	>2001
Own survey	34.12	15.85	26.15	10.40	4.30	9.20
SCB data	41.70	14.10	20.80	10.40	4.80	7.70

Analysis of quantitative data

All statistical analyses of the survey data were performed using the R 3.4 platform. To better understand the complex causal relationships among the factors affecting the owners' decisions (as presented in the appended papers **I** and **II**), a structural equation model was estimated using a partial least square approach, a method also known as partial least squares path modelling (PLSPM) (Esposito-Vinzi and Russolillo 2013; Lohmöller 2013). This method can deal with models that contain variables that can be directly observed (manifest variables) and variables which cannot be observed directly, but instead inferred through a measurement model from other observed variables (latent constructs) (Hair et al., 2016), allowing the

estimation of the complex cause-effect relationships of those variable (Dijkstra and Henseler, 2015).

Any PLSPM is built in two steps. In the first step, latent constructs are built from the manifest observations through principal component analysis. Those latent constructs usually represent theoretical concepts of behavioural research such as personality traits, individual behaviour, and individual attitude, underlying the observed variables. In the second step, the constructs are used in separate regression analyses applying null hypothesis significance testing by comparing the ratio of a regression coefficient and its bootstrapped standard error against Student's t distribution (Std.) (Rönkkö et al., 2016).

A network of relations (paths) among the constructs is hypothesised, 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. Path coefficients vary from -1 (strong inverse relationship) to +1 (strong direct relationship). More detailed descriptions on the way those PLSPMs were built and estimated can be found in the appended papers **I** and **II** (Bravo et al., 2019; Pardalis et al., 2019).

4.4 Semi-structured interviews

To identify the perceptions of supply side actors towards OSS (papers **IV** and **V**) and to examine their level of preparedness (paper **IV**) and suitability to become OSS providers (paper **V**), 45 semi-structured interviews were conducted with actors from five distinct classes of market participants: construction-related micro- and small- sized enterprises (MSEs) (21 interviews), medium-sized construction enterprises (4 interviews), mortgage loan officers of banks (4 interviews), energy advisors from various

municipalities (8 interviews), and real estate agents (8 interviews). The interviews were conducted during the period between late spring 2017 to late Autumn 2019.

Construction-related MSEs were sampled randomly from online yellow pages based on their activity descriptions including 'construction works' (byggarbeten in Swedish) and 'renovation works' (renoveringsarbeten in Swedish). Medium-sized construction enterprises were selected to represent construction organizations with both local and nationwide activities. Real-estate agents were sampled to include both bigger firms with local branches in the entire country, and smaller family-owned firms. Mortgage loan officers were sampled in such a way to represent some of the largest banks in Sweden. Finally, energy advisors from all the eight municipalities of Kronoberg province were interviewed. Those actor classes have been selected due to the fact they appear in literature as supply-side actors with direct or indirect involvement in EER processes.

Instead of potentially priming interviewees to some theoretically driven perspective, data collection was performed in an open-ended but semi-structured fashion. Interviewees were asked to explain how they conduct business, their intra-organizational functions, their relationships with other actors in the market, and their views on the current state of EER market. Additionally, interviewees were asked how their organization relates to the OSS concept, their possible roles within an OSS network, views on other potential actors of OSS and their roles, and views on strategic considerations around initiating the OSS model. The interviews were performed in-person at the workplaces of the interviewees and the interviewer followed up on the answers given to the protocol-based questions. Where possible, the interviews were recorded for later transcription. Where recording was not allowed, extensive notes were taken during the interviews.

Analysis of qualitative data

Given the open approach taken to data collection, the first step in both the papers **IV** and **V**, was to prioritize potentially useful theoretical perspectives that appear to provide best explanatory power regarding the context at

hand. For paper **IV**, the theoretical perspective explaining best the context of the paper was that of organizational innovation adoption (described in section 3.2). Similarly, for paper **V**, two theoretical perspectives were relevant: transaction cost economics and resource-based theory (described in section 3.1). These theoretical frameworks formed the basis for coding of the interviewed data. Next, an iterative approach was used to identify specific thematic dimensions within each category of the initial coding scheme. Thereinafter, and for the purposes of data display, the condensed data, and categories were organized in data matrices. Tables and figures were created to structure the data, which, with a few exceptions (partial table display of data in paper **V**) were used as background material. The matrices, tables and figures were evaluated and interpreted to infer conclusions regarding the second research question.

4.5 Systematic literature review and expert consultation

Data collection

The study presented in paper VI aims to provide an overview of the existing market conditions for EER market and propose strategies that could be developed to support the EER market for detached houses in Sweden. This study was based on a systematic literature review and expert consultation. The data for the systematic literature review was collected between spring 2018 and September 2019. Literature review increases knowledge on how and what other researchers have studied on a specific topic (Booth et al., 2016). The review can be characterized systematic since it followed the following criteria (Xiao and Watson, 2019): the review had a clearly stated purpose, with a defined question and inclusion and exclusion criteria; it involved rigorous and systematic search of the literature and the appraisal of included studies was critical. The review was performed following a four steps approach for content analysis: (1) collection of material, (2) descriptive analysis, (3) categorization of sources, (4) evaluation of the material (Seuring and Gold, 2012). The databases Scopus and JSTOR were

used to collect literature on policy, economic, social, and technical dimensions of deep renovation of single-family houses. The research was delimited by only including articles and reviews in English language.

Following the literature review, a broad expert consultation took place. It included elements of the 33 interviews with supply-side actors (from the pool of interviews described in section 4.4) and 11 online question-answering sessions with expert in the renovation market (both Swedish and international). During the online sessions the objective of the study was communicated with the participants to establish common understanding. Participants were asked to provide and describe three key strengths, weaknesses, opportunities, and threats, according to their own experience, related to the EER market of detached houses in their country.

PEST and SWOT analysis

In paper **VI**, the condition for EER market have been examined within Political, Economic, Social and Technical (PEST) dimensions. The political dimension includes, among others, housing regulations, tax regulations and procedural bureaucracy. The economic dimension includes, among others, financial incentives, availability of credit finance and customers' economic gain. The social dimension includes, among others, perceptions, cultural and social conventions. Finally, the technological dimension includes, among others, technological advancements, synergies, and trade-offs among the technologies/service providers. The related literature was identified, and the topics addressed in each literature source were assigned to each dimension.

PEST analysis is useful for four main reasons (Sammut-Bonnici and Galea, 2015): (i) it helps to spot existing opportunities within a market, and it gives warning of significant threats; (ii) it reveals the direction of change within a business environment, helping to shape strategies that will bring changes rather than preventing those changes; (iii) it helps to avoid starting points for the shaped strategies, which will lead to potential failure of those; and (iv) it allows to develop an objective view on the existing market environment.

The PEST analysis was followed by an analysis aiming to identify the key internal characteristics (strengths and weaknesses) and external influences (opportunities and threats) of the EER market for detached house in Sweden. The main benefit from the use of SWOT analysis lies in the fact that it provides the opportunity to integrate and synthesize diverse information (Bell and Rochford, 2016). SWOT analysis organizes information that is already known, as well as information that has just been acquired or discovered. SWOT analysis deals with a wide diversity of information sources (Bell and Rochford, 2016). The SWOT analysis included the findings of the PEST analysis, and the responses from the expert consultations were the basis for the development of the proposed strategies in paper **VI**.

4.6 Research quality

Quality of quantitative research

The quantitative research conducted in papers **I**, **II** and **III** is important to be measured for its consistency and accuracy. These are assessed by considering research's reliability and validity (Harkness et al., 2004). Reliability refers to replicability of the process and the results, and the robustness of the study. Replicability refers to the ability of research to be repeated and its findings to be tested and confirmed or corroborated by others (Harkness et al., 2004). The fact that the questionnaire survey was conducted first locally (Kronoberg province) and then replicated nationally (covering all Sweden) confirms replicability of the method. Robustness refers to the strength of a statistical model according to the specific conditions of the statistical analysis a study hopes to achieve (Neumayer and Plümper, 2017). The robustness of the models in papers **I** and **II** was confirmed by conducting bootstrap validation.

The quantitative findings of this thesis are relevant in the broader context of Nordic countries, as those countries share similar cultural and socioeconomic characteristics. Additionally, the quantitative findings are in line with findings of similar studies in other countries, where other data

collection and analysis methods were used. Moreover, the questionnaire survey used in papers **I**, **II** and **III** can be used in other country contexts, given some adjustments based on the characteristics of those countries.

Quality of qualitative research

The quality of qualitative research performed in papers **IV**, **V** and **VI** has been maintained by following the criteria for this type of research developed by Guba, Lincoln, and colleagues (Guba, 1981; Lincoln, 1995; Lincoln and Guba, 1985; Lincoln et al., 2011). Those criteria are credibility, transferability, dependability, and confirmability.

Credibility concerns the confidence that is placed in the truth of the research findings (Lincoln and Guba, 1985). Regarding the interviews, the fact that they have been conducted in a face-to-face fashion and in the premises of interviewees provided certain benefits. Face-to-face interviews allow to capture verbal and non-verbal ques, indicating discomfort or enthusiasm for the topics being discussed. Moreover, there was the possibility to cross-check answers with screening questions, contributing that way on the richness of the data gathered. The interviewer had control over the process and kept the interviewee focused and on track to completion. Where limitations occurred, they were clearly stated on each paper. This provides the reader with an accurate representation of the situation. In addition, to gauge the accuracy of findings, theory and investigator triangulation has been applied, further strengthening the credibility of findings. Regarding the online question answering sessions in the study of paper **VI**, both the objective of the study and the purpose of the questions asked were thoroughly communicated to the participants prior to the sessions, aiming to achieve common understanding. Related to the systematic literature review, all the selected sources were assessed based on predefined criteria to avoid potential bias in the selection and analysis. A variety of sources has been selected to obtain data from covering a broad set of topics. To reduce researcher bias in all studies, planning, data collection and analysis and conclusions were discussed among the participating researchers.

Transferability concerns the degree to which the results of qualitative research can be transferred to other contexts or settings with other respondents (Lincoln and Guba, 1985). This research, presented in papers **IV** and **V**, has a specific focus on the actors involved in the detached house renovation market in Sweden, but some of the insights might be of interest in other contexts as well. The findings are relevant in the broader context of Nordic countries, as those countries share similar cultural and socioeconomic characteristics. The thematic areas covered in the interviews, as well as the questions asked can be used in similar studies in other country contexts. Additionally, an effort has been made to present relevant data regarding the interviewed actors and the context of research, enabling the reader to interpret potential relevance of the findings in other contexts.

Dependability refers to the trustworthiness of research findings, that must be proven consistent and repeatable (Lincoln and Guba, 1985). That means that the findings of the study are consistent with the raw data collected. To increase credibility of the study, applied methods need to be clearly explained (Lincoln, 1995). In papers **IV**, **V** and **VI**, the motivations for and application of specific scientific methods is clearly described. This allows the assessment of the consistency of the research and helps to understand how and why conclusions were drawn.

Qualitative research tends to assume that each researcher brings a unique perspective to the study. Confirmability refers to the degree to which the results could be confirmed or corroborated by others (Lincoln and Guba, 1985). Here, proven scientific methods, such as triangulation with the use of multiple investigators (paper IV) and Cohen's Kappa calculation (paper V) were applied to cross check the consistency of the collected data. The findings were also verified by the respondents (Lincoln and Guba, 1985). The qualitative data provided information regarding respondents' personal perspectives and interpretations of the OSS concept. During the interviews, the concepts was defined and discussed using specific examples. This was made to assure that the interviewer and the respondents were discussing over a commonly understood topic.

5. RESEARCH FINDINGS

This chapter provides a presentation of the main findings, connecting the appended papers to the research questions. The aim of each of the appended papers and a summary of the findings related to the research questions is presented.

5.1 Factors influencing past renovation decisions

Paper I presents the results of a study on 971 homeowners residing in Kronoberg province in Sweden. The aim of the study was to identify the factors that influenced the decisions of homeowners to renovate in the past. In this study renovations have been divided into two broader categories, namely aesthetic (aiming to improve the visual feeling and aesthetics of the dwelling) and physical (aiming to improve the energy performance of the building) renovations. Previous relevant studies have examined the intentions of homeowners to renovate, trying to identify the factors making them more, or less, inclined to proceed in the renovation of their dwelling. However, intentions may not lead to actual renovations since in many cases exists what is called intention-behaviour gap (Sheeran and Webb, 2016). Analysis of data from homeowners, whose dwellings have already undergone some sort of renovation, offers more valid results on underlying motivations and barriers to renovation. This knowledge can be an indicator of understanding the behaviour of these owners in the future, as past practices influence future decisions (Rogers, 2005).

The first step of analysis aimed to identify the factors driving decisions for renovation regardless of type of renovations. About 88% of the surveyed homeowners were found to have performed any renovation in the past. Figure 12 shows the percentage of homeowners from different categories more (greater than 0 in the x-axis) or less (lesser than 0) likely to have renovated compared to the average of all respondents. Those who were more likely to have renovated were either over 55 years of age or

below 36 years of age, and those who recently moved into the dwelling (residing not exceeding two years) or lived in it for more than ten years. Additionally, the age of houses that have been renovated was usually more than 20 years with most of them being 30 years of age or older.

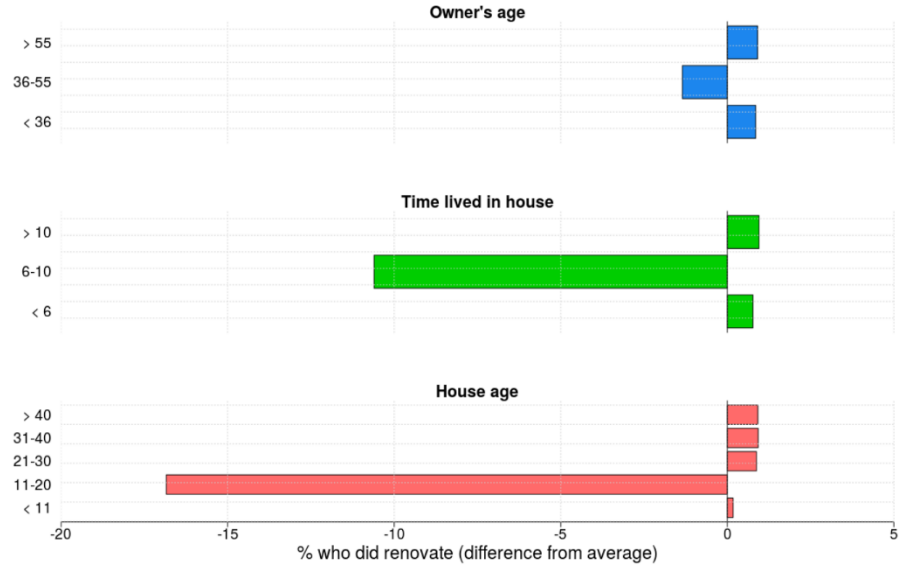

Figure 12: Age group, time of residency and house age for respondents who have performed renovations

Based on the review of factors influencing homeowners' decision to renovate (section 2.1), a PLSPM model was created (Figure 13) and tested using the data from the Kronoberg province questionnaire survey (a more detailed description of how the model is structured is provided in Bravo et al., 2019).

Age of the respondent, age of the house, and time of residency in the house, were manifested (or observed) variables. The socioeconomic characteristics were grouped in a latent construct reflecting respondents' annual household gross income (>600,000 SEK/year), their educational level (at least a university degree) and their place of residency (towns with more than 25.000 inhabitants). This led to the estimation of a wealthy-educated-town-living construct (henceforth W.E.T.). The internal consistency of this construct was measured through Dillon-Goldstein's rho

(DG rho), and it has been found to be 0.70 which indicates the unidimensionality of this construct. The energy concern construct was estimated based on questions about the importance for homeowners to save energy and their willingness to adopt technical measures and change their behaviour to do so (DG rho = 0.79).

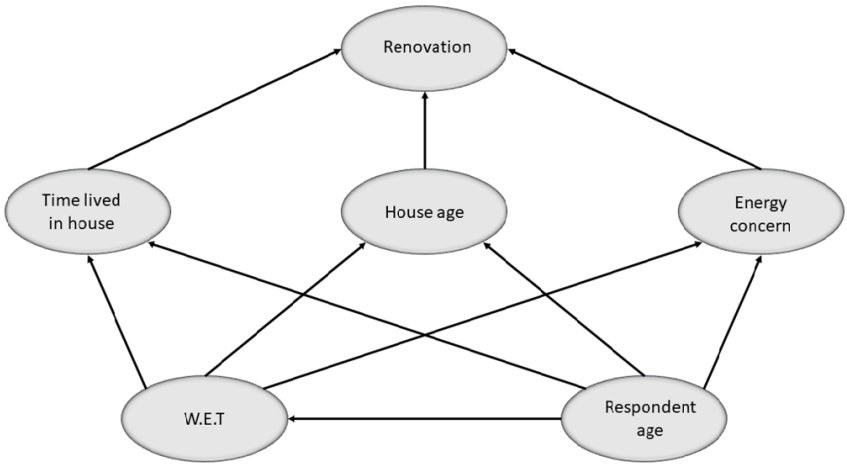

Figure 13: Age group, time of residency and house age for respondents who have performed renovations

Age of the respondents was considered as the starting point of the PLSPM model. Figure 14 shows the resulting model (significant paths only). The average R2 of the model was 0.28. The blue lines show positive relationship between the variables, while red lines show a negative relationship. The numbers adjacent to each line indicates the strength of the relationship, where - 1 means a strong inverse relationship and +1 a strong direct one. The results show that respondents' age affect the W.E.T. (socioeconomic characteristics). W.E.T. affects the energy concern of homeowners, leading them to the decision to renovate, while their age is not a factor affecting their energy concern. The age of homeowners, in combination with the time that they live in the house, significantly affect the renovation decision. Another factor affecting the decision for renovation is the age of the house. If another variable than age of the respondents was used as a starting point,

then that would have been a different model, but the direct relations among the constructs would remain approximately the same.

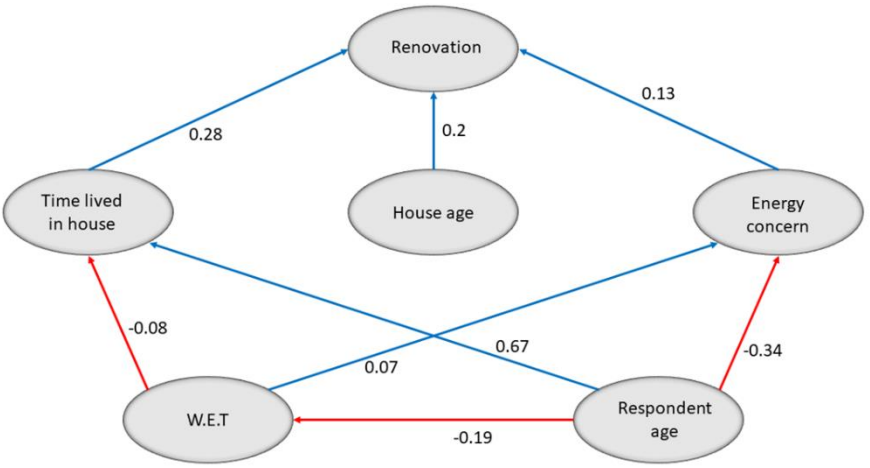

Figure 14: Path coefficients for the renovation PLSPM model (adapted from Bravo et al., 2019)

The second step was to identify the factors influencing the type of performed renovation (aesthetic or physical). As Figure 15 shows, renovations linked to the improvement of the aesthetic aspects of the house (e.g., kitchens and bathrooms) were more preferred, while those related to improved energy performance being less frequent (heating systems) or even rare (insulation).

A second PLSPM model was estimated having the same structure as that of Figure 13, but the node referring to house renovation in general was replaced by two new nodes, referring to aesthetic and physical renovations respectively. The aesthetic renovation construct reflected works to renovate the kitchen, bathroom, indoor walls, and heating system (DG rho=0.75); the physical renovation constructs instead reflected works linked to the attic, cellar or wall insulation, drainage, windows, roof, facade, and sewage (DG rho = 0.85).

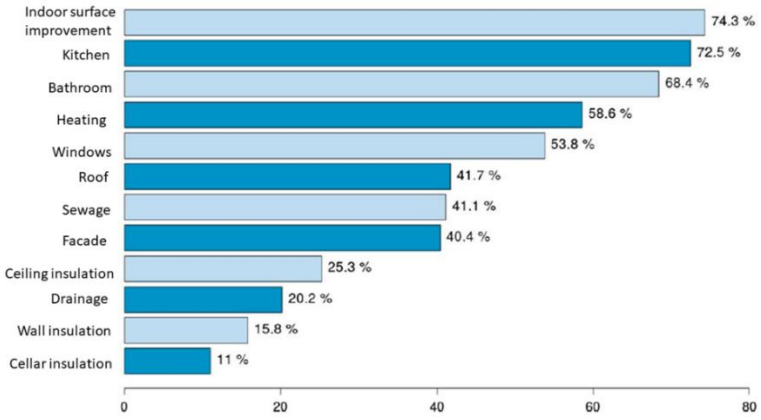

Figure 15: Frequency of renovation work by type (adapted from Bravo et al., 2019)

The resulting model (only the significant paths) is presented in Figure 16. Results show that homeowner's age has a strong and positive influence on the decision to perform a renovation linked to the aesthetic aspects of the dwelling, because the homeowner has resided in it for a longer period. The influence though on the probability to perform a physical renovation (which improves EE) is lower, because increased age of the homeowner was found to lower energy concern (negative correlation in Figure 16). On the other hand, younger, wealthy, educated, and town living-homeowners (W.E.T. construct) show a greater energy-saving concern, which influences positively their decision to perform physical renovations.

5.2 Factors influencing future renovation decisions

Paper **II** includes the same sample of homeowners as in paper **I**, examining the factors influencing their decisions regarding future renovations in general, and the preferred type of renovation (referred as aesthetic or physical in the paper) in particular. The aim was to understand the pathway that leads to the intention/plan for future renovation and to examine if such decisions are influenced by the renovation performed in the past. Furthermore, the potential interest of those homeowners for an integrated

renovation service offered by a single actor is examined. Analysing that interest allows the identification of the existence of non-existence of the market for OSS and allows for a first estimate of its size. In addition, it is possible to identify those characteristics of homeowners who are interested in "buying" an EER offered by an OSS, providing a first segmentation of the market.

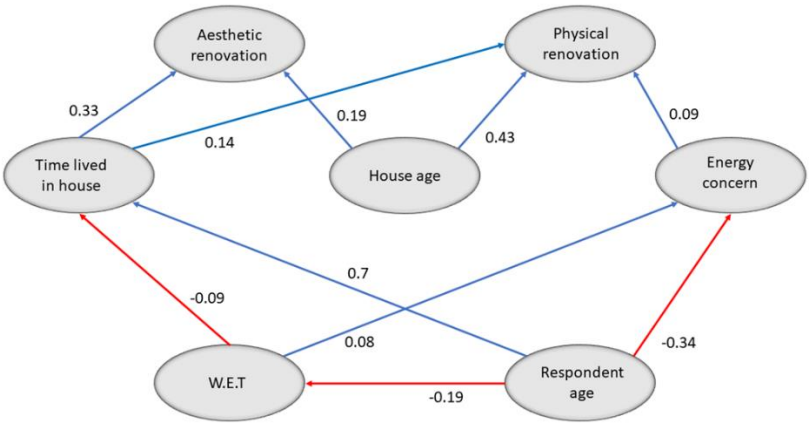

Figure 16: Path coefficients for the past physical or aesthetic renovation model (adapted from Bravo et al.,2019)

Related to plans for renovation, about 76% of the surveyed homeowners in Kronoberg stated that they have the intention to renovate their dwelling in the proximate future. Only 5.5% stated that they intend to have holistic renovation of their dwelling (the whole house at once or in steps), while about 71% stated that their intention is to renovate only specific components (Figure 17a). Also, majority preferred aesthetic renovations. Among the EEMs, changing windows was the most preferred option followed by renovation of the dwellings' façade (Figure 17b).

Following a similar approach as in paper I, a PLSPM model was estimated for future renovations (a detailed description of how the model is structured can be found in Pardalis et al., 2019). The variables time lived in the house, house age, and past renovation were directly drawn from the survey data. The latent socioeconomic construct used in paper I was

modified to find a better fit to the dependent variables, which are the intention to perform physical or aesthetic type of renovation, and interest for OSS. The construct was based on data regarding homeowners' age, household annual gross income, and level of education showing a sufficient degree of reliability to be considered as a single variable (DG rho=0.70). The energy concern construct was estimated in the same way as for past renovation decisions. The house satisfaction is a latent construct deriving from a series of questions on different aspects related to the satisfaction of homeowners with their dwellings, such as size, energy costs etc. (DG rho=0.87). The aesthetic renovation construct reflects works to renovate the kitchen, bathroom, and indoor walls (DG rho = 0.80). The physical renovation construct instead reflects works linked to the ceiling, cellar or wall insulation, sewage, windows, roof, facade, drainage, and the heating system (DG rho = 0.84).

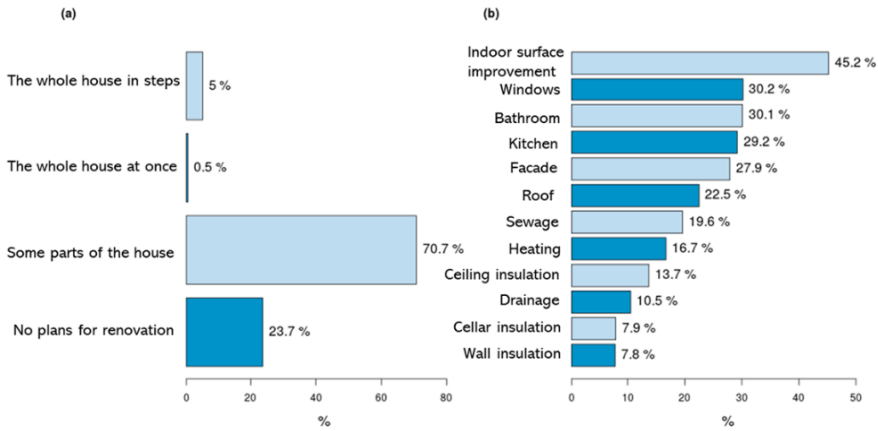

Figure 17: Frequency distribution for the renovation prospects as a whole (a) and the components that respondents are planning to change (b) (adapted from Pardalis et al., 2019)

In the resulting model (presented in Figure 18), the decision for physical renovations (which improves energy performance of the dwelling) is positively influenced by the socioeconomic characteristics and the energy concern of the homeowner. Having already performed a renovation in the past and satisfaction with the current state of the dwelling have a negative influence on such a decision.

The robustness of the results from the Kronoberg province study was compared with the results of a similar survey of homeowners from whole Sweden (some of its results are presented on paper III). The results were found to be almost similar. The national survey showed that 75% of respondents planned to perform renovation, regardless of type, in the proximate future. From them about 7% planned to perform a holistic renovation (at once or in steps) and almost 70% were interested to renovate specific components of their dwelling. Aesthetic renovation was preferred the most, while renovation of roof and additional ceiling insulation were the most preferred components related to improvements of energy performance of the house.

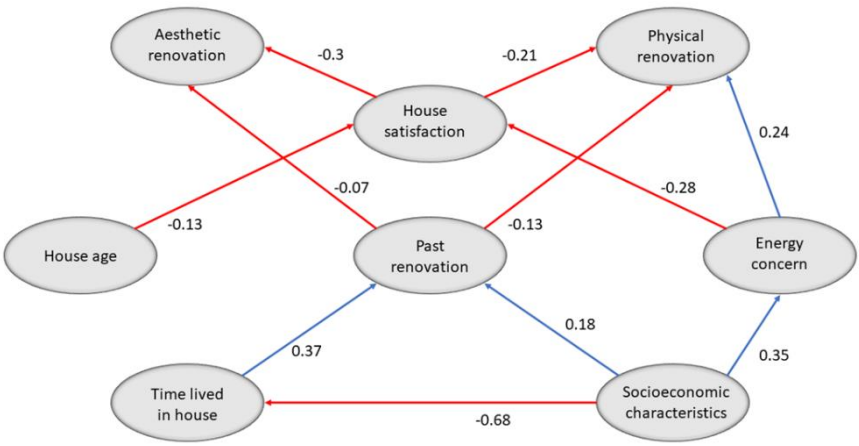

Figure 18: Path coefficients for future physical and aesthetic renovation plans (significant paths only) (adapted from Pardalis et al.,2019)

Homeowners on the national level were asked questions related to the financing of those renovations. Most of them (67.8%) intend to finance the renovation from their own savings, while only a small group of them (3.6%) would choose a personal loan. Moreover, homeowners were asked to express their opinion on how four different financial incentives (energy loans introduced by the government, tax subsidies connected to energy reduction, return on turnover connected to energy reduction, and mortgage loans from banks considering energy reduction from renovation) would influence (positively, negatively, or neutral) their decision to perform an

EER. According to their expressed opinions, the financing incentives that would have the most positive influence on their decision to perform an EER are, connection of tax subsidies with energy reduction and the introduction of state funding (in the form of loans) for energy renovations.

5.3 Homeowners' interest in one-stop shop

The questionnaire survey (described in section 4.2.1) also included a question regarding the interest of homeowners to perform an EER in the case a single actor would offer a comprehensive renovation package for the work (e.g., an OSS). The responses were coded on a Likert scale ranging from 1 (not interested) to 5 (very interested). Regarding the sample of homeowners living in Kronoberg province, about 21% of the surveyed homeowners showed interest for such an offer. Homeowners were also asked on the different aspects that would increase their interest for an OSS. As it can be seen in Figure 19, aspects like guarantee on the work quality, clear estimation of costs and expected energy savings, inspection of the building and recommendation of improvement measures were very important, while the possibility of financing as part of the package was not interesting. On the other hand, homeowners not interested in OSS, cited the perceived high cost of a comprehensive renovation package and their inability to choose the different craftsmen, who will deliver the renovation works, as the main reasons for their disinterest.

To understand better the factors influencing the interest for an OSS, a new PLSPM model was estimated (a more detailed description of how the model was structured can be seen in Pardalis et al., 2019). In this model, which can be seen in Figure 20, the interest for an OSS is mainly influenced by the socioeconomic characteristics of the homeowner, e.g., being young, highly educated and with a high income. Homeowners who are satisfied with the current situation of their dwelling tend to be less interested in OSS.

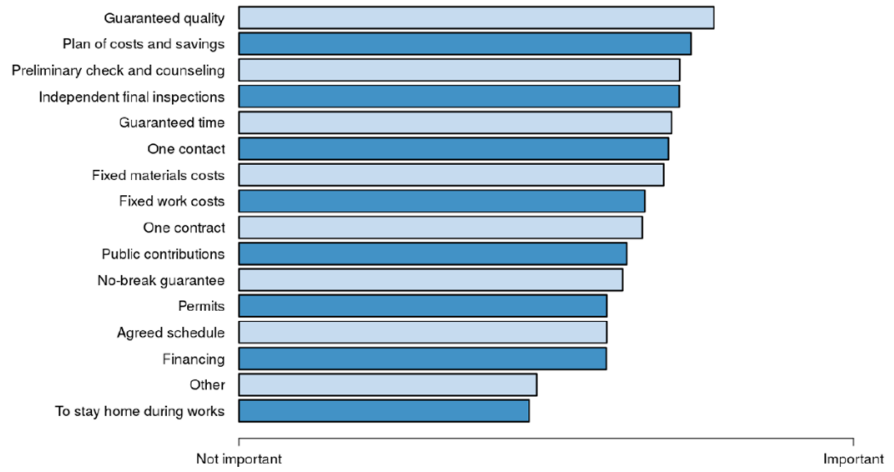

Figure 19: Opinions of respondents interested in OSS about factors important for the success of the concept

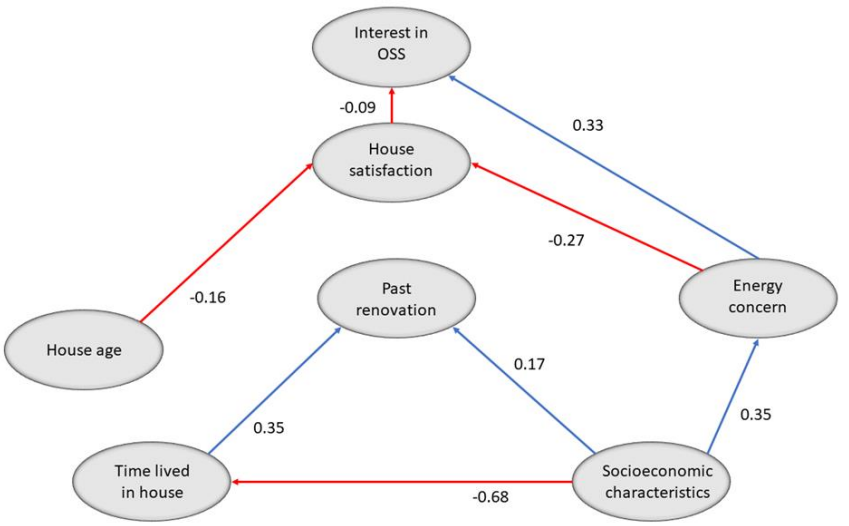

Figure 20: Path coefficients for interest towards the OSS concept (significant paths only) (adapted from Pardalis et al.,2019)

In the national survey, approximately 25% of the respondents were interested or very interested in OSS. A geographical distribution of these

homeowners is presented in Figure 21. It can be observed that there are geographical variations among homeowners who show greater interest in OSS. Except for one province (Jämtland), homeowners from the Northern provinces of Sweden show relatively lower interest in OSS compared to those living in provinces of Central and Southern Sweden. Even in Southern Sweden, some provinces (e.g., Blekinge and Kalmar) has low interest in OSS. Regarding the aspects considered important for the success of OSS, those do not differ from the findings of the Kronoberg sample. Similar result can be also observed in the opinions of those not interested in OSS, with assumed high costs of OSS being the main factor making OSS not appealing to this group of homeowners.

An analysis was made to identify the characteristics of the respondents that influence their interest in OSS. An ordered logit model was used (Greene and Hensher, 2010), where the ordinal-scale OSS interest was the dependent variable and predictor variables were the age and income of the homeowner, their environmental concern and willingness to take action to protect the environment, and age and geographical location of the house. The square of both the age of the respondent and age of the house were included to allow for non-linear relations. Results showed that homeowners' age and income, as well as energy concern and willingness to take action to protect the environment are the main drivers of the interest in OSS (Figure 22).

The coefficients presented in the figure estimates the change in the mean response per unit increase in X-axis when all other predictors are held constant. In the figure, 0 represents the average (neither interested nor disinterested in OSS), the positive values of coefficient estimate reflect positive influence in the interest in OSS and negative values, a negative influence. In addition, points represent the estimated value for each coefficient and the bars its standard error. Regarding homeowners' age, those between the ages of 35 to 45 years show the greatest interest for OSS (Figure 23). In the figure, the numbers on y-axis are the average of a Likert scale 1-5 (where 1 represents not at all interested in OSS and 5 represents very interested in OSS). Regarding house age, homeowners living in houses that are between 45 and 60 years old were interested in OSS.

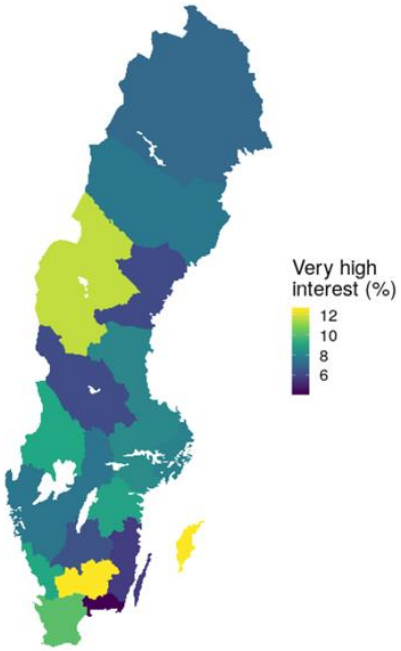

Figure 21: Geographical distribution of homeowners interested in OSS

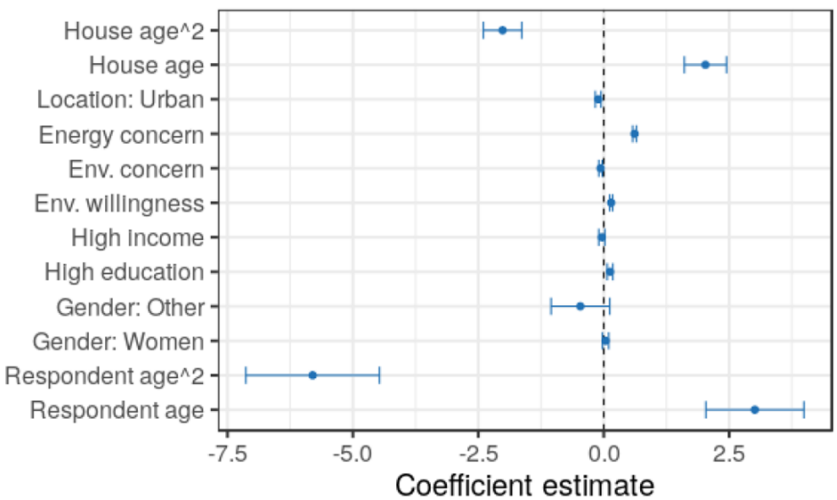

Figure 22: Variables affecting interest in OSS (national sample) (adapted from Pardalis et al., 2021)

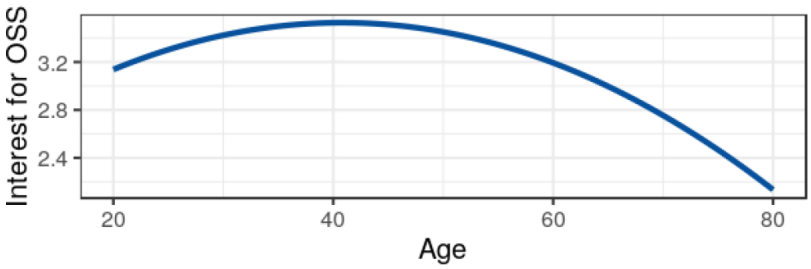

Figure 23: Correlation of interest in OSS and homeowner's age (adapted from Pardalis et al., 2021)

5.4 Supply-side actors' perceptions regarding one-stop shop & preparedness to initiate one

The examination of supply-side actors' perceptions regarding OSS and the examination of their level of preparedness to become an OSS begun with a study on construction MSEs (paper **IV**), as they are those mostly active in detached house renovations. For that purpose, 21 construction MSEs active in three geographical regions in Sweden (namely Kronoberg, Västra Götaland and Kalmar) were examined. The findings from the interviews were analysed in the light of the framework presented in the section 3.2.

The study showed that when the OSS concept was initially presented to them (on a theoretical basis), they seem to understand the benefits the OSS concept could bring to the renovation market. They mentioned about the opportunity for knowledge exchange and collaborations with other actors, which according to them could potentially lead to improved performance and better placement in the market. The examined MSEs referred to concepts resembling OSS that already exist in the market, e.g., the turnkey or totalentreprenad (in Swedish) concept, which is applied to large-scale renovations. The interviewed companies recognised the existence of competitive pressures in the local renovation markets, but they also pointed out that the competing actors have, in general, good relationships and respect for each other. They mentioned that word of mouth is the main strategy to promote business in their market segment, and therefore, they

actively build networks with other companies and develop relationships of trust with them. Related to renovation of detached houses, the examined MSEs clarified that this market is not a priority for them, as new construction is booming, and they do not have the resources that will allow them greater operational efficiency. Moreover, government incentives for support and development of small businesses remain largely unknown to most construction MSEs, which, according to their testimonies deprives them from taking advantage of those incentives to expand their business. The owners/managers of the examined construction MSEs presented their companies as "entrepreneurial" and "innovative", but they keep on treating business, at least most of them, in a traditional and conservative way. Risk avoidance remain their priority, while the control that those owners/managers have over their companies does not leave space for changes. Those characteristics became more evident, when those companies were asked to place themselves, in a hypothetical scenario, as the provider of OSS.

OSS was perceived as a risky business move with unknown impact to their current operations. Those risks are also related to their stated lack of managerial competence that was perceived as a barrier to the efficient coordination of other actors participating in OSS. Furthermore, they mentioned that the risk factor includes inefficient knowledge transfer between different professionals and a lack of understanding of each other's operations, thus the inability to evaluate other's work and provide guarantees. Other reasons, which further reinforce their doubt to offer an OSS, can be summarized as following:

(a) it needs supply-side parties to significantly change their attitude and ways of working,
(b) the concept is seen as too costly for most homeowners, so the market is limited, and it is risky to offer an expensive service in an uncertain market,
(c) there are presently more attractive opportunities for craftsmen in the new construction market,

(d) to become successful, the concept needs to start at scale, which requires significantly up-front investment, and
(e) although they are confident that any missing production capabilities can be procured from well-established local networks, the need to coordinate and take responsibility over the work of other suppliers is not seen as feasible.

The influence of all those different parameters, which eventually lead to low level of preparedness to adopt the OSS concept and become its coordinator is displayed graphically in Figure 24.

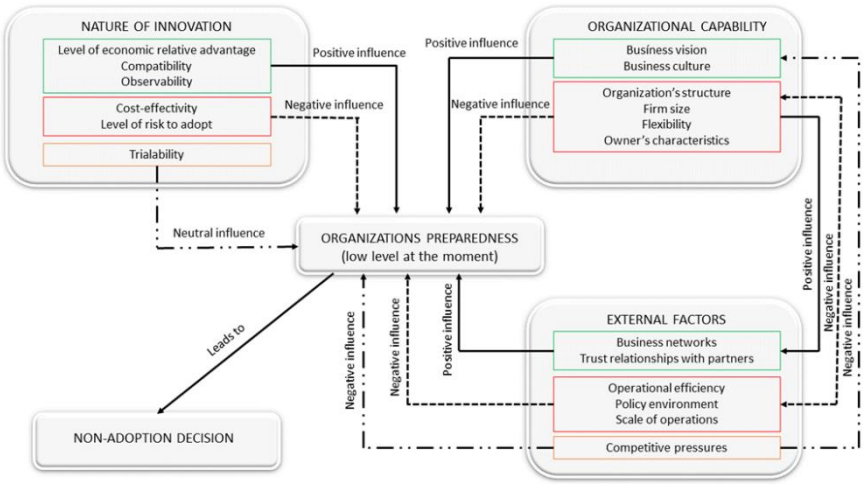

Figure 24: Influence of different variables on the decision of the MSEs to adopt OSS (adapted from Pardalis et al., 2020)

The study on construction MSEs was followed by second study, in which four additional supply-side actor groups were examined on their perceptions and ability to start up an OSS (presented in paper **V**). Those actor groups were banks, medium-sized construction companies, real-estate agents and municipalities. Moreover, in this study the conditions required for OSS to materialize in practice were examined. The data gathered from the interviews with those supply-side actors was analysed in the light of the framework described in section 3.1 and examined in five categories. They

include access to trusted partners, ability to create local economies of scale, transaction capabilities, production capabilities, and perceived attractiveness of OSS opportunity. A detailed description of those parameters is provided on **Appendix III**.

Banks

Banks appeared to have a very clear view regarding their role in OSS. They perceive the OSS concept attractive, but not related to their operations. Therefore, the role of OSS provider is not a strategic choice for them. However, their interventions (development of green loans and EE funds) can create local economies of scale and pave the way for OSS to emerge. They also see construction MSEs, and other similar companies as not fitting for the role of OSS coordinator and call for local and regional governments, as well as regional energy agencies, to take a more active role in the realisation of OSS in the market.

Medium-sized construction companies

Even though these companies can address most of the challenges that construction MSEs face, they perceive several aspects of OSS as potentially problematic for them. Cooperation with actors outside their network or with whom they have never worked before creates certain concerns on how the relationship will work. Collaboration with actors outside their existing network is seen as potentially harmful since it can disrupt their relationship with existing partners. Moreover, quality assurance and budgeting risks makes them unsure on how they will be able to deliver a coherent project. They are unwilling to bear risks not related to their work. In case they would take such risks, they would put a premium for that risk which will increase the cost of renovation. This is problematic, since EER are already considered expensive. According to them, an OSS consisting of a collaboration of individuals with knowledge of construction processes (entrepreneurs, consultants etc.), municipalities, and homeowners' associations, could provide a functional governance structure for the delivery of the concept in the market.

Real-estate agents

Real-estate agents evaluated OSS from a broader perspective, stressing the benefits that this concept will bring to the building sector. However, they emphasized the strong influence of local conditions (e.g., climate and property value) for the attractiveness of the concept to building owners, creating large differences between regions of the country. The real-estate agents suggested that the state should take a leading role in developing a national strategy for EE.

On a local scale, real-estate agents do not see themselves in the role of OSS coordinator. Their main weakness is identified as their inability to understand technical details of an EER and their limited knowledge of construction processes. Nonetheless, they are interested to participate in an OSS if someone else take the lead. They identify potential OSS providers as independent consultants with knowledge of the construction industry, large and well-established construction companies, and regional energy agencies.

Municipalities

Municipalities were frequently brought up by the other actors as potential OS providers. However, they themselves show low inclination to perform commercial integration on the supply side. Municipalities currently perceive demand for energy related renovations in the detached house market to be limited (multi-family residential interest are in focus). They also report lack of resources to dedicate to the development of such a concept. Moreover, they foresee legal limitations for them, as well as ethical limitations since they cannot interfere in local markets.

Even if they satisfy all the conditions from transaction cost (TC) perspective to successfully initiate the OSS concept, they prefer to take a supporting role, if that is to be initiated by an independent consultant with relevant competency, and with the close participation of homeowners' associations.

Figure 25 represents the framework on the conditions of OSS emergence as informed by both TCE and resource-based theory (developed on section 3.1) and the empirical findings from supply-side actors. The framework

serves as a template to estimate the suitability of any actor group to deliver OSS in the market. The application of the framework, to each of the examined supply-side actor groups, explains why, although the reasons differ between those actor groups, each of them seems unlikely to deliver the OSS.

Construction MSEs predominantly possess specialized production capabilities, but very low capabilities and resources to perform formal exchange governance. That is why they want to participate in OSS, but not initiate it. On the other hand, medium-sized construction enterprises, have both the resources and the exchange governance capabilities to provide the OSS. However, the possibility of working with unfamiliar partners weakens their perceived governance capability and creates a sense of fear and anxiety regarding the potential implications of such collaborations. Municipalities could drive economies of scale on the local level by connecting a broad network of supply-side collaborators with systemic actors on the demand side (e.g., owners' associations). However, the existence of legal restrictions (according to what they claim) to participate in market transactions, the lack of immediate resources to dedicate to the concept, and the reluctance to carry the actual transactional risk on behalf of commercial actors makes them not willing to initiate OSS. For real-estate agents, the lack of strategic interest makes OSS not a business choice, although they possess governance capabilities and, to a certain extent, the resources required. Finally, banks opt out from delivering OSS because of a perceived lack of supply-side network and renovation competency.

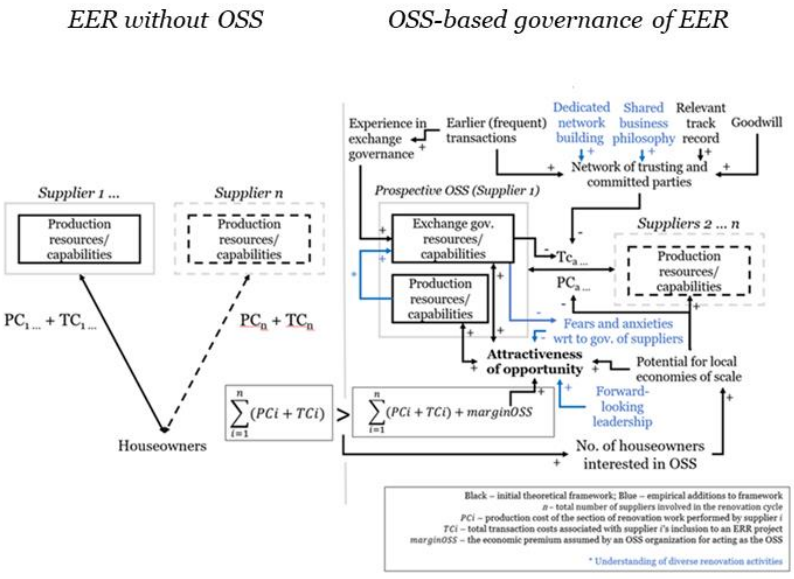

Figure 25: Theoretical framework for estimating the attractiveness for an actor to become the OSS for EER in detached houses

5.5 Market conditions & strategies for energy efficiency renovations in Sweden

Existing market conditions for EER in Sweden was the subject of the study presented in paper **VI**. The aim of this study was to formulate proposals for strategies that can be developed to strengthen the market of EER by analysing the market conditions in a holistic approach. Existing EER market conditions were examined in the light of an analysis which considered the identified strengths, weaknesses, opportunities, and risks of this market (paper **VI**). The identification of those elements makes it possible to propose targeted solutions towards accelerating EER of detached houses.

A major strength of the EER market in Sweden is the availability of high-quality materials and construction practices in the market. Moreover, the municipality advisory service on EE in general, and EEMs specifically,

enhance the knowledge of homeowners and provide them with a trusted source of information. Furthermore, the new tax deduction program for PV systems installations is considered additional strength in the market. This measure also creates an opportunity for further development of the EER market. Development of systematic plans for the renovation of the existing building stock in a stepwise approach could be an initiative supported by municipalities, which will bring a positive vibe in the market of EER, also satisfying some of the concerns of homeowners (see section 5.1). In addition, the existing tax rebate (ROT) on the purchase of household repair and maintenance services can further strengthen the market, if specified for EE.

On the side of weaknesses, the existing building regulations in Sweden, requiring energy performance of the deep renovated building equal to newly built, sets certain barriers, as in most of cases such a demand means very high cost of EER. Not all homeowners have the financial capacity to afford such high costs, which prevents adoption of EER. Moreover, renovation projects are usually paid from homeowners' own savings or through extension of existing mortgages. The existing "energy loans" do not provide enough capital for deep renovations, and they usually are targeted towards new buildings or large-scale renovations such as multi-family houses (see section 2.4). Moreover, homeowners do not foresee the economic benefit of EER to make it a priority. The fact that the real estate fee (see section 2.4) is waived only for newly built dwellings can be perceived as a weakness, but it also creates an opportunity for a new property taxation scheme to be developed linked to the energy performance of a renovated dwelling.

EER of detached houses are most often delivered by construction MSEs, which have limited competence on deep renovation. They follow a craftsman-based approach to renovation, often offering single products and services not connected to EE. That makes them less inclined to promote integrated renovation solutions for their customers. The main threat for the EER remains the prioritization of new construction, which takes away competent craftsmen from EER market. Moreover, homeowners give priority to aesthetic renovations produce more visible results and thus have a greater impact on property value and social status.

Based on the above, Table 3 presents potential strategy recommendations that are assumed to have a positive impact for the development of the EER market. Those strategies are categorized as: strengths used to reduce vulnerability to threats (S-T); strengths to take advantage of opportunities (S-O); overcome weaknesses by taking advantage of opportunities (W-O); minimize weaknesses to reduce exposure to threats (W-T) (Mainali et al., 2021).

Table 5: Recommended strategies for EER market

TYPE OF STRATEGY	EXISTING ELEMENT IN THE MARKET	THREAT OR OPPORTUNITY ADDRESSED	RECOMMENDED STRATEGY
S-O	Availability of high-quality building materials and competent construction practices.	Public positive attitude towards climate change mitigation and sustainability	Development of stepwise renovation packages fitting homeowners needs and financial capacity
S-O	Large stocks of old inefficient detached houses needing renovation	Targeted loans/incentives and taxation schemes for deep renovation.	Expansion of energy loans to all types of buildings and orientation of existing subsidies and taxation schemes towards EE could encourage large stocks of the old inefficient detached houses to go through deep renovation.
S-O	Energy performance certificate required during renting or selling a house	Targeted loans/incentives and taxation schemes for deep renovation.	Revision of current tax system to give benefits to homeowners having high energy efficient buildings
S-T	Availability of high-quality building materials and competent construction practices	Scarcity of competent service providers for EER	Develop training schemes for new and existing human resources to increase knowledge capacity

S-T	Availability of high-quality building materials and competent construction practices	Perceived risk of poor-quality work due to inefficient coordination among various artisans	Enforcement of quality standards for actors participating in EER to ensure quality of work and increase trust
W-T	Companies' interest in new construction than renovation due to higher business volume	Construction companies have greater interest in new construction than renovation	Development of programs and initiatives for neighbourhood/ district approach to create a volume of operation, which construction companies would perceive attractive
W-O	Existing tax rebate (ROT) specified for EE	EER is not priority due to low return on investment	Link stepwise approach to renovation with financial motives to create a more attractive environment for OSS
W-O	Existing policy measures and advisory services from municipalities	EER is not priority due to strict regulations for renovated buildings	Development of plans for the renovation of existing building stock initiated by municipalities. Stepwise approach and revision of building regulations for old buildings
W-O	Existing actors have limited competence in EER, companies show interest in new construction than renovation due to higher business volume	Innovation in the construction technology and practices	Develop training schemes for new and existing human resources, develop programs related to circularity and resource efficiency, and contribute to the innovation in the market

6. CONCLUSIONS

This chapter summarizes the main conclusions of the research and addresses the research questions. Furthermore, the main contributions of the research are presented.

This dissertation has examined the prospects for the development of an OSS business model for the EER of detached houses in Sweden. To achieve that, the research focused on the examination of both demand and supply-side perspectives of renovations, as well as existing market conditions in the Swedish context. More specifically, the research performed examinations of (i) the factors influencing the homeowners' decisions on renovation and their interest for performing an EER offered by an OSS; (ii) supply-side actors to understand their perceptions of OSS and their level of preparedness to adopt the concept: and (iii) the existing EER market conditions to propose strategies to further support the EER market.

On the demand side of renovations, the homeowners' age, household income and environmental and energy concern have been found to significantly affect their decision to undertake EER. Environmental and energy concern appear to be closely connected to the age and level of education of homeowners. EER attracts mostly younger homeowners, while for those of older age, a renovation that satisfies their aesthetic needs is the preferred option, mostly since long time of residence in the dwelling creates a need for change. The age of house is another factor influencing renovation decisions. This factor is associated to both aesthetic renovation and EER, influencing the decisions for the later more, since older buildings have greater need for improvements of their energy performance. On the other hand, past renovations may make the homeowners satisfied with the state of their dwelling, which can inhibit future renovation decisions. Related to renovation plans, a holistic approach to renovation (renovating the whole house at once or in steps) does not seem to be the most preferred option for most homeowners. The choice of renovating specific

components of the dwelling attracts greater interest, while renovations related to aesthetic improvements are preferred over EER.

Regarding the attractiveness of a comprehensive renovation package offered by an OSS, a considerable number of homeowners planning to renovate their whole house, at once or in steps, consider it as an attractive option. About one in four in this homeowners' group showed interest for OSS, which indicates the existence of a segment of early adopters for the concept, revealing the existence of a perspective for the further development of the market. Those early adopters are middle-aged (between 35 and 45 years old) homeowners, who belong to high-income groups and have high level of education. They also live in houses that are between 45 and 60 years old. For those homeowners, factors like guarantee on the work quality, clear estimation of costs and expected energy savings, inspection of the building and recommendation of improvement measures, were important for their decisions to choose OSS. Most of the respondents plan to finance the renovation from their own savings, with a few of them choosing a personal loan. It should also be noted that their decisions to perform an EER would have been more positively influenced, if financing incentives, like tax subsidies connected to energy reduction and state initiatives, were introduced in the market.

On the supply side, the perception of the actors on deep renovation, the usefulness of the OSS model and the possible value additions that it could bring to the renovation market were examined. These actors were positive towards OSS model but were reluctant to take responsibility for initiating an OSS due to various reasons. Construction MSEs, who are dominant in the detached house renovation market, lack resources (competency, financial, managerial) and flexibility and perceive to have high risk of venturing into a new business proposition such as OSS. The reluctance of other supply-side actors to initiate OSS was found to be connected to limited production and governance capabilities, and structural changes in their organization. All of them though appear not to reject OSS itself but have reservations regarding them being the OSS coordinator. In conclusion, increased transaction costs associated with the OSS model and the lack of strategic resources/capabilities of these actors are the main

factors for OSS being not a strategic business choice for the companies. These transaction costs can be hidden for supply-side actors as part of at least two components: a) margins added by actors in the value chain to mitigate the quality/coordination risk of other actors' work; and b) previous network ties causing imperfect competition in the cost-efficiency of subsections of work.

The examination of supply-side actors' perception contributed to the development of OSS model further, which makes possible to hypothesize about potential other candidates that could initiate OSS. Based on the framework depicted in Figure 25, a potential OSS provider would be an actor that has a widespread portfolio of internal production capabilities therefore needing little external governance. These are the large construction companies, which so far have shown little interest in small-scale residential renovations as the associated production and transaction costs are higher compared to those of renovation of a multi-family residential building or construction of a new building. The other potential actor is the one which possesses a combination of following characteristics: (a) extensive experience of coordinating other parties in executing various types of renovation work, (b) a trusted network of partners with production capabilities across the categories of renovation work, (c) an ability to drive local economies of scale, and (d) strategic interest to commit to OSS as a path of growth. The start-up company Klimatfastigheter Småland AB is an example of such an actor, which was established with significant research contribution from this thesis work. The company has the combination of the characteristics (b), (d) and to some extent (a). Other potential actors include energy auditors and/or engineering consultants, who may start OSS as a spinoff from their current business. However, in an ideal situation, an OSS should have all the four characteristics, and this needs to be investigated further.

There exist policy and financial instruments to promote energy efficient buildings. However, they appear to be oriented mostly towards new buildings and renovation of publicly owned buildings, both in terms of policies and technical resources available. There is a need of policy instruments to change focus and address detached houses, as those

dwellings also have great potential to improve their energy performance. There is a need for economic incentives, e.g., subsidies and attractive loans to encourage homeowners to undertake EER. The role of local and national authorities is also important as these can become the driving force of initiatives that will bring a positive vibe in the market. Moreover, there exist opportunities for addressing the competence gaps of supply-side actors through capacity building activities, and opportunities for local authorities to shift their focus towards raising homeowners' awareness on the benefits of EE. The latter could be also accompanied by the development of local initiatives to enable and increase access to EEMs and energy saving technologies. In addition, business opportunities which allow improved resource efficiency in the market of detached houses renovations could be fostered, contributing further to innovation and development of local economies. All these are likely to pave the way for a higher rate of EER of detached houses in Sweden.

Overall, the prospects for the development of a one-stop-shop for EE of detached houses in Sweden can be characterized as ***moderately positive***. Moreover, effort and support are needed for the OSS to have an acceptable market success and a sustainable business opportunity for the perspective entrepreneurs.

This dissertation has addressed some of the key issues that are crucial in the discussion concerning EER of detached houses in Sweden and OSS. The role of supply-side actors is important in the effort to increase the rate of introduced in this study provides information on the inter- and intra-organizational structures that would have to emerge in providing OSS. It also makes possible to examine the fit of potential other candidates that would be interested in initiating OSS in the market. Moreover, the study on market conditions for EER in Sweden, it became obvious that policy adjustments are required, to further support EER and increase the uptake of such renovations. In addition, the strategies proposed in the study provide insights, which can be the starting point of the dialogue between involved parties (homeowners, supply-side actors, policy/makers, financial institutions etc.) fostering actions for the overall benefit the market of EER.

Finally, this dissertation provides important insights for the enhancement of the EER market, which is crucial in achieving the goals associated with EE (SDG 7), climate change (SDG 13), and which is also contributing to achieving the targets related to employment in construction (SDG 8), cultivation of innovation in the construction industry (SDG 9) and promotion of EE in building practices (SDG 11).

7. FUTURE RESEARCH

This chapter presents proposals for extension of the research presented in this dissertation, as well as proposals for the expansion of this research in new dimensions.

7.1 Extension of current research

In this dissertation, the examination of supply-side actors revealed the potential of other actors to initiate an OSS. Those actors, whose profiles were found fitting to the role of OSS coordinator, are large construction companies, and energy auditors and engineering consultants. Their perspectives on the development and governance of OSS should be examined to have an overview on the conditions set by them so that they have a more active role in the OSS concept. Additionally, the role of other actors viz. municipalities and governmental agencies, needs to be examined to explore how those actors can contribute to the increase of the rate of EER.

Further, OSS has been, so far, examined from its economic dimensions' point of view. However, economics is not the only dimension in a business model. Environmental and social dimensions must be also included, from a sustainability perspective. A first attempt to examine these dimensions was made in Pardalis et al. (2020), but a deeper analysis of those dimensions is required to provide a holistic perspective on the sustainability benefits of OSS. It is important to capture the value created for OSS business model considering the integration of economic, social, and environmental goals.

Moreover, in the effort to further increase the rate of house renovations, integrated solutions supported by business models like OSS might not be sufficient. There is need to address the varying renovation needs and choices of homeowners. The development of appropriate renovation design solutions is important, not only to achieve improved EE of existing houses, but also to improve their function and comfort. Developing and

applying renovations approaches, as well as, adding building facilities and architectural elements, will allow the identification of those building components that need to be repaired, replaced, removed, modified, and renovated. Moreover, it allows homeowners and other stakeholders involved in renovations to participate in a co-creation process, where they must decide what renovation alternatives can be potentially implemented, and how, while simultaneously adjudicate against different renovation (design) criteria, like e.g., energy consumption, investment cost, etc.

This research showed, among others, that a prominent actor to deliver an OSS is the large construction companies. However, those companies show little interest since for the renovation of a single house the associated production and transaction costs so high that their coverage would make the final cost for homeowners prohibitive. To create the scale needed for those companies to be involved, and to speed up the rate of renovations in detached houses, the potential for district scale renovation approach of detached houses should be further examined. This approach allows the optimization of the implementation and integration of EEMs. Moreover, there is a need to analyse the TCs associated with running an OSS business. While previous research has estimated the TCs for homeowners, this has not happened for the case of supply-side actors.

7.2 Expansion in new dimensions

A large proportion of homeowners have been found to prioritize the renovation of only specific components of their dwelling. With this as a starting point, we are given the opportunity to see renovations from a different point of view. First, it is easier to discuss the performance of a specific component than the performance of a whole house. Second, houses have much more variables, so the chance a different house with all the same variables, to occur is limited. However, when only a component is considered there are opportunities for repetitions in the solutions proposed. Additionally, renovating only a component instead of a complete dwelling needs lower level of investment from homeowners. That paves the way for a higher uptake of EEMs, aiming in the gradual improvement of

the energy performance of the dwelling, through the renovation of those specific components, according to their needs and capabilities. This approach also leaves space for the existing instruments to be exploited in their full capacity and expanding to a broader base of homeowners. Moreover, industrialization on the component level, allows opportunities for circularity to come on surface. This opens doors for small and medium enterprises (SMEs), to develop their own solutions on component level. Additionally, the probability of single components to be combined (different components renovated at different times can be interchanged), enables existing tools, such as BIM, to be used in the renovation market of detached houses. Lastly, the development of different component solutions, allows homeowners to choose from a range of options, selecting those solutions that better fit their needs and financial capacity.

BIBLIOGRAPHY

A

Aarons, G. A., Hurlburt, M., & Horwitz, S. M. (2011). Advancing a conceptual model of evidence-based practice implementation in public service sectors. Administration and Policy in Mental Health and Mental Health Services Research, 38(1), 4–23. https://doi.org/10.1007/s10488-010-0327-7

Abreu, M. I., de Oliveira, R., & Lopes, J. (2017). Attitudes and practices of homeowners in the decision-making process for building energy renovation. Procedia Engineering, 172, 52-59. https://doi.org/10.1016/j.proeng.2017.02.016

Abreu, M. I., de Oliveira, R. A., & Lopes, J. (2020). Younger vs. older homeowners in building energy-related renovations: Learning from the Portuguese case. Energy Reports, 6, 159-164. https://doi.org/10.1016/j.egyr.2019.08.036

Aboltins, R., & Blumberga, D. (2019). Key Factors for Successful Implementation of Energy Efficiency Policy Instruments: A Theoretical Study and the Case of Latvia. Environmental and Climate Technologies, 23(2), 187-206. https://doi.org/10.2478/rtuect-2019-0063

Achtnicht, M. (2011). Do environmental benefits matter? Evidence from a choice experiment among house owners in Germany. Ecological Economics, 70(11), 2191-2200. https://doi.org/10.1016/j.ecolecon.2011.06.026

Achtnicht, M., & Madlener, R. (2014). Factors influencing German house owners' preferences on energy retrofits. Energy Policy, 68, 254-263. https://doi.org/10.1016/j.enpol.2014.01.006

Aksoezen, M., Daniel, M., Hassler, U., & Kohler, N. (2015). Building age as an indicator for energy consumption. Energy and Buildings, 87, 74-86. https://doi.org/10.1016/j.enbuild.2014.10.074

Alberini, A., Bigano, A., & Boeri, M. (2014). Looking for free riding: energy efficiency incentives and Italian homeowners. Energy Efficiency, 7(4), 571-590. https://doi.org/10.1007/s12053-013-9241-7

Allard, I., Olofsson, T., & Nair, G. (2017). Energy performance indicators in the Swedish building procurement process. Sustainability, 9(10), 1877. https://doi.org/10.3390/su9101877

Amecke, H. (2012). The impact of energy performance certificates: A survey of German homeowners. Energy Policy, 46, 4-14. https://doi.org/10.1016/j.enpol.2012.01.064

Amit, R., & Zott, C. (2001). Value creation in e-business. Strategic management journal, 22(6-7), 493-520. https://doi.org/10.1002/smj.187

Anderson, N., Potocnik, K., & Zhou, J. (2014). Innovation and creativity in organizations: A state-of-the-science review, prospective commentary, and guiding framework. Journal of Management, 40(5), 1297–1333. https://doi.org/10.1177/0149206314527128

Arif, M., Katafygiotou, M., Mazroei, A., Kaushik, A., & Elsarrag, E. (2016). Impact of indoor environmental quality on occupant well-being and comfort: A review of the literature. International Journal of Sustainable Built Environment, 5(1), 1-11. https://doi.org/10.1016/j.ijsbe.2016.03.006

Arning, K., Dütschke, E., Globisch, J., & Zaunbrecher, B. (2020). The challenge of improving energy efficiency in the building sector: Taking an in-depth look at decision-making on investments in EE refurbishments. In Energy and Behaviour (pp. 129-151). Academic Press. https://doi.org/10.1016/B978-0-12-818567-4.00002-8

Arpaci, I., Yardimci, Y. C., Ozkan, S., & Turetken, O. (2012). Organizational adoption of information technologies: A literature review. International Journal of eBusiness and eGovernment Studies, 4(2), 37–50.

Aydalot, P., & Keeble, D. (2018). High-technology industry and innovative environments in Europe: An overview. In High technology industry and innovative environments (pp. 1– 21). Oxon: Routledge.

Azizi, S., Nair, G., & Olofsson, T. (2020). Adoption of Energy Efficiency Measures in Renovation of Single-Family Houses: A Comparative Approach. Energies, 13(22), 6042. https://doi.org/10.3390/en13226042

Azizi, S., Nair, G., & Olofsson, T. (2019). Analysing the house-owners perceptions on benefits and barriers of energy renovation in Swedish single-family houses. Energy and Buildings, 198, 187-196. https://doi.org/10.1016/j.enbuild.2019.05.034

B

Balson, K., Moreira, M., & Simkovicova, L. (2016). Description of OSS models for step-by-step refurbishments. EuroPHit.

Banfi, S., Farsi, M., Filippini, M., & Jakob, M. (2008). Willingness to pay for energy-saving measures in residential buildings. Energy economics, 30(2), 503-516. https://doi.org/10.1016/j.eneco.2006.06.001

Barrett, P., & Sexton, M. (2006). Innovation in small, project-based construction firms. British Journal of Management, 17 (4), 331–346. https://doi.org/10.1111/j.1467-8551.2005.00461.x

Bartiaux, F., Gram-Hanssen, K., Fonseca, P., Ozoliņa, L., & Christensen, T. H. (2014). A practice–theory approach to homeowners' energy retrofits in four European areas. Building Research & Information, 42(4), 525-538. https://doi.org/10.1080/09613218.2014.900253

Baruch, Y., & Holtom, B. C. (2008). Survey response rate levels and trends in organizational research. Human relations, 61(8), 1139-1160. https://doi.org/10.1177/0018726708094863

Baumhof, R., Decker, T., Röder, H., & Menrad, K. (2018). Which factors determine the extent of house owners' energy-related refurbishment projects? A Motivation- Opportunity-Ability Approach. Sustainable cities and society, 36, 33-41. https://doi.org/10.1016/j.scs.2017.09.025

Bell, G. G., & Rochford, L. (2016). Rediscovering SWOT's integrative nature: A new understanding of an old framework. The International Journal of Management Education, 14(3), 310-326. https://doi.org/10.1016/j.ijme.2016.06.003

Bertoldi, P., Economidou, M., Palermo, V., Boza-Kiss, B., & Todeschi, V. (2020). How to finance energy renovation of residential buildings: Review of current and emerging financing instruments in the EU. Wiley Interdisciplinary Reviews: Energy and Environment, 10(1), e384. https://doi.org/10.1002/wene.384

Bjørneboe, M. G., Svendsen, S., & Heller, A. (2018). Initiatives for the energy renovation of single-family houses in Denmark evaluated on the basis of barriers and motivators. Energy and Buildings, 167, 347-358. https://doi.org/10.1016/j.enbuild.2017.11.065

Bjørneboe, M. G., Svendsen, S., & Heller, A. (2017). Using a OSS concept to guide decisions when single-family houses are renovated. Journal of Architectural Engineering, 23(2), 05017001. https://doi.org/10.1061/(ASCE)AE.1943-5568.0000238

Blumberga, A., Cilinskis, E., Gravelsins, A., Svarckopfa, A., & Blumberga, D. (2018). Analysis of regulatory instruments promoting building energy efficiency. Energy Procedia, 147, 258-267. https://doi.org/10.1016/j.egypro.2018.07.090

Booth, A., Sutton, A., & Papaioannou, D. (2016). Systematic approaches to a successful literature review. SAGE Publications

BPIE (2018). Sweden Current use of EPCs and potential links to iBRoad (individual Building Roadmap). Factsheet. Buildings Performance Institute Europe.

Bossle, M. B., de Barcellos, M. D., Vieira, L. M., & Sauvée, L. (2016). The drivers for adoption of eco-innovation. Journal of Cleaner Production, 113, 861–872. https://doi.org/10.1016/j.jclepro.2015.11.033

Bottero, M., D'Alpaos, C., & Dell'Anna, F. (2018, May). Boosting investments in buildings energy retrofit: The role of incentives. In International Symposium on New Metropolitan Perspectives (pp. 593-600). Springer, Cham. https://doi.org/10.1007/978-3-319-92102-0_63

Boverket (2020). Boverket's building regulations – mandatory provisions and general recommendations, BBR. In: Swedish National Board of Housing BaPB, editor. BFS 2011:6 with amendments up to BFS BFS 2020:4- BBR 29. Stockholm: Swedish National Board of Housing, Building and Planning (Boverket).

Boza-Kiss, B., & Bertoldi, P. (2018). OSS for energy renovations of buildings. JRC Science for Policy Report.

Boza-Kiss, B., Bertoldi, P., & Economidou, M. (2017). Energy Service Companies in the EU - Status review and recommendations for further market development with a focus on Energy Performance Contracting, EUR 28716 EN [JRC106624]. Luxembourg: Publications Office of the European Union. https://doi.org/10.2760/12258

Brannen, J. (Ed.). (2017). Mixing methods: Qualitative and quantitative research. Routledge.

Bravo, G., Pardalis, G., Mahapatra, K., & Mainali, B. (2019). Physical vs. aesthetic renovations: Learning from Swedish house owners. Buildings, 9(1), 12. https://doi.org/10.3390/buildings9010012

Broers, W. M. H., Vasseur, V., Kemp, R., Abujidi, N., & Vroon, Z. A. E. P. (2019). Decided or divided? An empirical analysis of the decision-making process of Dutch homeowners for energy renovation measures. Energy Research & Social Science, 58, 101284. https://doi.org/10.1016/j.erss.2019.101284

Brounen, D., Groh, A. M., & Haran, M. (2020). The value effects of green retrofits. Journal of European Real Estate Research. https://doi.org/10.1108/JERER-12-2019-0049

Brown, D., Kivimaa, P., & Sorrell, S. R. (2018). How can intermediaries promote business model innovation: the case of 'Energiesprong' whole-house retrofits in the United Kingdom (UK) and The Netherlands. http://dx.doi.org/10.2139/ssrn.3270880

Buser, M., & Carlsson, V. (2020). Developing New Sustainable Strategy: The Struggle of Small and Medium Swedish Contractors Companies to Experiment with Business Models. Journal of Business models, 8(2), 101-114

Buser, M., & Carlsson, V. (2017). What you see is not what you get: single-family house renovation and energy retrofit seen through the lens of sociomateriality. Construction Management and Economics, 35(5), 276-287. https://doi.org/10.1080/01446193.2016.1250929

Bush, R. E., Bale, C. S., Powell, M., Gouldson, A., Taylor, P. G., & Gale, W. F. (2017). The role of intermediaries in low carbon transitions–empowering innovations to unlock district heating in the UK. Journal of cleaner production, 148, 137-147. https://doi.org/10.1016/j.jclepro.2017.01.129

Bygballe, L. E., Ingemansson, M. (2011). Public policy and industry views on innovation in construction. The IMP Journal, 5 (3): 157–171.

C

Caird, S., Roy, R., & Herring, H. (2008). Improving the energy performance of UK households: Results from surveys of consumer adoption and use of low- and zero-carbon technologies. Energy Efficiency, 1(2), 149. https://doi.org/10.1007/s12053-008-9013-y

Charalambides, A. G., Maxoulis, C. N., Kyriacou, O., Blakeley, E., & Frances, L. S. (2019). The impact of Energy Performance Certificates on building deep energy renovation targets. International Journal of Sustainable Energy, 38(1), 1–12. https://doi.org/10.1080/14786451.2018.1448399

Charlier, D., Risch, A., & Salmon, C. (2018). Energy burden alleviation and greenhouse gas emissions reduction: Can we reach two objectives with one policy? Ecological Economics, 143, 294–313. https://doi.org/10.1016/j.ecolecon.2017.07.002

Chesbrough, H. 2003. Open innovation: The new imperative for creating and profiting from technology. Boston, MA: Harvard Business School Publishing Corporation

Chua, M. H. (2021). Home renovation waste upon change of ownership: A Coasian way of addressing an urban externality. Waste Management, 119, 145–151. https://doi.org/10.1016/j.wasman.2020.09.046

Cicmanova, J, Eisermann, M., Maraquin, T. (2020). How to set up an OSS for integrated home energy renovation: a step-by-step guide for local authorities and other actors. July 2020

Coase, R.H. (1937). The Nature of the Firm. Economica, 4(16), 386–405.

Cuffe, C. (2020). Report on maximising the energy efficiency potential of the EU building stock (2020/2070(INI). Committee on Industry, Research and Energy. Retrieved, December 19, 2021, from https://www.europarl.europa.eu/doceo/document/ITRE-PR 648631_EN.pdf

D

Dadzie, J., Runeson, G., Ding, G., & Bondinuba, F. K. (2018). Barriers to adoption of sustainable technologies for EE building upgrade—semi-Structured interviews. Buildings, 8(4), 57. https://doi.org/10.3390/buildings8040057

Damanpour, F., & Schneider, M. (2006). Phases of the adoption of innovation in organizations: Effects of environment, organization, and top managers 1. British Journal of Management, 17(3), 215–236. https://doi.org/10.1111/j.1467-8551.2006.00498.x

Das, R., Richman, R., & Brown, C. (2018). Demographic determinants of Canada's households' adoption of energy efficiency measures: observations from the Households and Environment Survey, 2013. Energy Efficiency, 11(2), 465-482. https://doi.org/10.1007/s12053-017-9578-4

Desmaris, R., Jauregui, O., McGinley, O., and J. Volt (2019). "D 2.1 Market and PESTLE Analysis." TURNKEY RETROFIT Consortium

de Vries, H. J., & Verhagen, W. P. (2016). Impact of changes in regulatory performance standards on innovation: A case of energy performance standards for newly built houses. Technovation, 48, 56-68. https://doi.org/10.1016/j.technovation.2016.01.008

de Wilde, M., & Spaargaren, G. (2019). Designing trust: how strategic intermediaries choreograph homeowners' low carbon retrofit experience. Building Research & Information, 47(4), 362-374. https://doi.org/10.1080/09613218.2018.1443256

Dewey, A. & Drahota, A. (2016) Introduction to systematic reviews: online learning module Cochrane Training. Retrieved, January 25, 2021, from https://training.cochrane.org/interactivelearning/module-1-introduction-conductingsystematic-reviews

Dijkstra, T., & Henseler, J. (2015). Consistent Partial Least Squares Path Modelling. MIS Quarterly, 39(2), 297–316. doi:10 2307/26628355

D'Oca, S., Ferrante, A., Ferrer, C., Pernetti, R., Gralka, A., Sebastian, R., & Op't Veld, P. (2018). Technical, financial, and social barriers and challenges in deep building renovation: Integration of lessons learned from the H2020 cluster projects. Buildings, 8(12), 174. https://doi.org/10.3390/buildings8120174

D'Oca, S., & Op't Veld, P. (2018). People-centred deep renovation practices: from challenges to strategies. Tema: Technology, Engineering, Materials and Architecture, 4(3), 81-91. https://doi.org/10.17410/tema.v4i3.206

Dodgson, M., & Gann, D. (2018). Innovation: A very short introduction. Oxford, UK: Oxford University Press

Dore, R. (1983). Goodwill and the Spirit of Market Capitalism. The British Journal of Sociology, 34(4), 459-482. doi:10.2307/590932

Dubois, M., & Allacker, K. (2015). Energy savings from housing: Ineffective renovation subsidies vs efficient demolition and reconstruction incentives. Energy Policy, 86, 697- 704. https://doi.org/10.1016/j.enpol.2015.07.029

Dyer, J. I. (1997). Effective interfirm collaboration: How firms minimize transaction costs and maximize transaction value. Strategic Management Journal, 18 (7): 535-556. https://doi.org/10.1002/(SICI)1097-0266(199708)18:7<535::AID-SMJ885>3.0.CO;2-Z

E

Ebrahimigharehbaghi, S., Qian, Q. K., Meijer, F. M., & Visscher, H. J. (2020). Transaction costs as a barrier in the renovation decision-making process: A study of homeowners in the Netherlands. Energy and Buildings, 215, 109849. https://doi.org/10.1016/j.enbuild.2020.109849

Ebrahimigharehbaghi, S., Qian, Q. K., Meijer, F. M., & Visscher, H. J. (2019). Unravelling Dutch homeowners' behaviour towards energy efficiency renovations: What drives and hinders their decision-making? Energy Policy, 129, 546-561. https://doi.org/10.1016/j.enpol.2019.02.046

Economidou, M., Atanasiu, B., Despret, C., Maio, J., Nolte, I., Rapf, O., Lausten, J., Ruyssevelt, P., Staniaszek, D., Strong, D., Zinetti, S. (2011). Europe's buildings under the microscope. A country-by-country review of the energy performance of buildings. Buildings Performance Institute Europe (BPIE), 35-36.

Economidou, M., Todeschi, V., Bertoldi, P., Agostino, D. D., Zangheri, P., & Castellazzi, L. (2020). Review of 50 years of EU energy efficiency policies for buildings. Energy and Buildings, 110 322. https://doi.org/10.1016/j.enbuild.2020.110322

EFFECT4buildings Project (n.d.). Green Loans in Poland, Sweden, Norway, and Finland.

EFFECT4buildings Toolbox: Funding; Annex 7. Retrieved, February 10, 2021, from https://www.effect4buildings.se/wp-content/uploads/7-Green-Loans-in-Poland-Sweden-Denmark-Norway-and-Finland.pdf

Ekström, T. (2017). Passive house renovation of Swedish single-family houses from the 1960s and 1970s: Evaluation of cost-effective renovation packages. Licentiate thesis

Esposito Vinzi, V., & Russolillo, G. (2013). Partial least squares algorithms and methods. Wiley Interdisciplinary Reviews: Computational Statistics, 5(1), 1-19. https://doi.org/10.1002/wics.1239

European Commission (2020). COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A Renovation Wave for Europe - greening our buildings, creating jobs, improving lives. COM/2020/662 final. Retrieved, February 9, 2021, from https://eur-lex.europa.eu/legalcontent/EN/TXT/?uri=CELEX%3A52020DC0662

European Commission (2018). CORDIS Results Pack on Deep Renovation. Publications Office of the European Union. Luxembourg, November 2018. European Commission (2020). Energy efficiency in buildings. European Commission – Department: Energy – In focus. Retrieved, January 5, 2021, from https://ec.europa.eu/info/sites/info/files/energy_climate_change_environment/events/documents/in_focus_energy_efficiency_in_buildings_en.pdf

European Parliament (2018a). Directive (EU) 2018/2002 of the European Parliament and of the Council of December 11, 2018, amending Directive 2012/27/EU on energy efficiency. Official Journal of the European Communities. Retrieved, February 24, 2021, from

https://eurlex.europa.eu/legalcontent/EN/TXT/PDF/?uri=CELEX:32018L2002&from=EN

European Parliament (2018b). Directive 2018/844/EU of the European Parliament and of the council of 19 June 2018 on the energy performance of buildings (recast). Official Journal of the European Communities, 61(156), 75–91.

F

Fabbri, M., De Groote, M., Rapf, O. (2016). Building renovation passports: customised roadmaps towards deep renovation and better homes, 2nd edition, Building Performance Institute Europe.

Frambach, R. T., & Schillewaert, N. (2002). Organizational innovation adoption: A multi-level framework of determinants and opportunities for future research. Journal of Business Research, 55(2), 163–176. https://doi.org/10.1016/S0148-2963(00)00152-1

Friege, J., & Chappin, E. (2014). Modelling decisions on energy-efficient renovations: A review. Renewable and Sustainable Energy Reviews, 39, 196-208. https://doi.org/10.1016/j.rser.2014.07.091

Fyhn, H., & Baron, N. (2017). The nature of decision making in the practice of dwelling: A practice theoretical approach to understanding maintenance and retrofitting of homes in the context of climate change. Society & Natural Resources, 30(5), 555–568. https://doi.org/10.1080/08941920.2016.1239149

G

Galvin, R., & Sunikka-Blank, M. (2014). The UK homeowner-retrofitter as an innovator in a socio-technical system. Energy Policy, 74, 655-662. https://doi.org/10.1016/j.enpol.2014.08.013

Gambatese, J. A., Hallowell, M. (2011). Factors that influence the development and diffusion of technical innovations in the construction industry. Construction Management and Economics, 29(5), 507-517. https://doi.org/10.1080/01446193.2011.570355

Gil-Garcia, J. R., & Pardo, T. A. (2006). Multimethod Approaches to Understanding the Complexity of e-Government. International Journal of Computer, Systems and Signal, 7(2), 3-17.

Gillingham, K., Keyes, A., & Palmer, K. (2018). Advances in evaluating energy efficiency policies and programs. Annual Review of Resource Economics, 10, 511-532. https://doi.org/10.1146/annurev-resource-100517-023028

Gram-Hanssen, K. (2014). Existing buildings–Users, renovations, and energy policy. Renewable Energy, 61, 136-140. https://doi.org/10.1016/j.renene.2013.05.004

Government Offices of Sweden (2018). Framework agreement between the Swedish social democratic party, the moderate party, the Swedish green party, the centre party and the Christian democrats. Swedish Government Homepage. Retrieved January 20, 2021, from https://www.government.se/49d8c1/contentassets/8239ed8e9517442580aac9bcb00197cc/ek-ok-eng.pdf

Government Offices of Sweden (2020). Sweden's Integrated National Energy and Climate Plan. Reporting under Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council. European Commission Homepage. Retrieved February 12, 2021, from https://ec.europa.eu/energy/sites/ener/files/documents/se_final_necp_main_en.pdf

Greene WH, Hensher DA (2010). Modeling Ordered Choices: A Primer. Cambridge University Press.

Gronum, S., Verreynne, M. L., & Kastelle, T. (2012). The role of networks in small and medium-sized enterprise innovation and firm performance. Journal of Small Business Management, 50(2), 257–282. https://doi.org/10.1111/j.1540-627X.2012.00353.x

Grösche, P., Schmidt, C. M., & Vance, C. (2013). Identifying free-riding in home-renovation programs using revealed preference data. Jahrbücher für Nationalökonomie und Statistik. Leibniz Information Centre for Economics. pages 600-618.

Guba, E. G. (1981). Criteria for assessing the trustworthiness of naturalistic inquiries. Ectj, 29(2), 75-91. https://doi.org/10.1007/BF02766777

Gumusluoglu, L., & Ilsev, A. (2009). Transformational leadership, creativity, and organizational innovation. Journal of Business Research, 62(4), 461–473. https://doi.org/10.1016/j.jbusres.2007.07.032

H

Haavik, T., Aabrekk, S. E., Mlecnik, E., Cre, J., Kondratenko, I., Paiho, S., Grøn, M., Hansen S, Vrijders, J., Mostad, K., van der Have, J. A. (2012). Guidelines: How to develop a business model for One Stop Shop house renovation: ERA-NET Eracobuild project report

Haines, V., & Mitchell, V. (2014). A persona-based approach to domestic energy retrofit. Building Research & Information, 42(4), 462-476. https://doi.org/10.1080/09613218.2014.893161

Hair Jr, J. F., Hult, G. T. M., Ringle, C., & Sarstedt, M. (2016). A primer on partial least squares structural equation modelling (PLS-SEM). Sage publications.

Harkness, J., Pennell, B. E., & Schoua-Glusberg, A. (2004). Survey questionnaire translation and assessment. Methods for testing and evaluating survey questionnaires, 453-473. https://doi.org/10.1002/0471654728.ch22

Harrell, M. C., & Bradley, M. A. (2009). Data collection methods. Semi-structured interviews and focus groups. Rand National Defence Research Inst Santa Monica CA.

Heidenreich, S., & Kraemer, T. (2016). Innovations—doomed to fail? Investigating strategies to overcome passive innovation resistance. Journal of Product Innovation Management, 33(3), 277-297. https://doi.org/10.1111/jpim.12273

Hrovatin, N., & Zoric, J. (2018). Determinants of energy-efficient home retrofits in Slovenia: The role of information sources. Energy and Buildings, 180, 42-50. https://doi.org/10.1016/j.enbuild.2018.09.029

Huebner, G. M., Cooper, J., & Jones, K. (2013). Domestic energy consumption—What role do comfort, habit, and knowledge about the heating system play? Energy and Buildings, 66, 626-636. https://doi.org/10.1016/j.enbuild.2013.07.043

Hårsman, B., Daghbashyan, Z., & Chaudhary, P. (2016). On the quality and impact of residential energy performance certificates. Energy and buildings, 133, 711–723. https://doi.org/10.1016/j.enbuild.2016.10.033

J

Jacobs, J. A. (2005). Multiple methods in ASR. Editor. American Sociological Review

Jafari, A., & Valentin, V. (2017). An optimization framework for building energy retrofits decision-making. Building and environment, 115, 118-129. https://doi.org/10.1016/j.buildenv.2017.01.020

Jakob, M. (2007). The drivers of and barriers to energy efficiency in renovation decisions of single-family homeowners. Zurich, Switzerland: Centre for Energy Policy & Economics (CEPE).

Jalilzadehazhari, E., Pardalis, G., & Vadiee, A. (2020). Profitability of Various Energy Supply Systems in Light of Their Different Energy Prices and Climate Conditions. Buildings, 10(6), 100. https://doi.org/10.3390/buildings10060100

Jesson, J., Matheson, L. & Lacey, F.M. (2011). Doing Your Literature Review: Traditional and Systematic Techniques. SAGE Publications

Joblot, L., Paviot, T., Deneux, D., & Lamouri, S. (2019). Building Information Maturity Model specific to the renovation sector. Automation in Construction, 101, 140–159. https://doi.org/10.1016/j.autcon.2019.01.019

K

Kahn, K. B. (2018). Understanding innovation. Business Horizons, 61(3), 453–460. https://doi.org/10.1016/j.bushor.2018.01.011

Kangas, H. L., Lazarevic, D., & Kivimaa, P. (2018). Technical skills, disinterest, and non-functional regulation: Barriers to building energy efficiency in Finland viewed by energy service companies. Energy Policy, 114, 63-76. https://doi.org/10.1016/j.enpol.2017.11.060

Kastner, I., & Stern, P. C. (2015). Examining the decision-making processes behind household energy investments: A review. Energy Research & Social Science, 10, 72-89. https://doi.org/10.1016/j.erss.2015.07.008

Kemmer, S., & Koskela, L. (2020). Lean as an appropriate approach for managing production in refurbishment projects. Lean Construction: Core Concepts and New Frontiers, 230. DOI: 10.1201/9780429203732-12

Killip, G., Fawcett, T., & Janda, K. B. (2014). Innovation in low-energy residential renovation: UK and France. Proceedings of the Institution of Civil Engineers-Energy, 167(3), 117-124. https://doi.org/10.1680/ener.14.00011

Kirzner, I. M. (2015). Competition and entrepreneurship. Chicago, IL: University of Chicago press.

Kiss, B. (2016). Exploring transaction costs in passive house-oriented retrofitting. Journal of Cleaner Production, 123, 65-76. https://doi.org/10.1016/j.jclepro.2015.09.035

Kiss, B., González Manchón, C., & Neij, L. (2013). The role of policy instruments in supporting the development of mineral wool insulation in Germany, Sweden, and the United Kingdom. Journal of Cleaner Production, 48, 187-199. https://doi.org/10.1016/j.jclepro.2012.12.016

Klöckner, C. A., & Nayum, A. (2016). Specific barriers and drivers in different stages of decision-making about energy efficiency upgrades in private homes. Frontiers in psychology, 7, 1362. https://doi.org/10.3389/fpsyg.2016.0136

Knudsen, H.N., Jensen, O.M. (2014). Indoor climate perceived as improved after energy retrofitting of single-family houses. In 13th International Conference on Indoor Air Quality and Climate, Indoor Air 2014International Conference on Indoor Air Quality and Climate. ISIAQ.

Konstantinou, T., Klein, T., Guerra Santin, O., Boess, S. U., & Silvester, S. (2015). An integrated design process for a zero-energy refurbishment prototype for post-war residential buildings in the Netherlands. In SASBE 2015: Proceedings of the 5th CIB International Conference on Smart and Sustainable Built Environments, Pretoria, South Africa, 9-11 December 2015. CIB (International Council for Research and Innovation in Building and Construction).

Kvam, R. (2017). Meaningful stakeholder consultation. Washington, DC: Inter-American Development Bank.

Kyrgidou, L. P., & Spyropoulou, S. (2013). Drivers and performance outcomes of innovativeness: An empirical study. British Journal of Management, 24(3), 281–298. https://doi.org/10.1111/j.1467-8551.2011.00803.x

L

La Fleur, L., Moshfegh, B., & Rohdin, P. (2017). Measured and predicted energy use and indoor climate before and after a major renovation of an apartment building in Sweden. Energy and Buildings, 146, 98–110. https://doi.org/10.1016/j.enbuild.2017.04.042

Lechtenböhmer, S., & Schüring, A. (2011). The potential for large-scale savings from insulating residential buildings in the EU. Energy efficiency, 4(2), 257–270. https://doi.org/10.1007/s12053-010-9090-6

Lee, V. H., Leong, L. Y., Hew, T. S., & Ooi, K. B. (2013). Knowledge management: A key determinant in advancing technological innovation? Journal of Knowledge Management, 17(6), 848–872. https://doi.org/10.1108/JKM-08-2013-0315

Lindkvist, C., Karlsson, A., Sørnes, K., & Wyckmans, A. (2014). Barriers and challenges in nZEB Projects in Sweden and Norway. Energy procedia, 58, 199–206. https://doi.org/10.1016/j.egypro.2014.10.429

Lincoln, Y. S. (1995). Emerging criteria for quality in qualitative and interpretive research. Qualitative inquiry, 1(3), 275-289. https://doi.org/10.1177/107780049500100301

Lincoln, Y., & Guba, E. (1985). Validity trustworthiness and rigor: Quality and the idea of qualitative research. Methodological Issues in Nursing Research, 304-310.

Lincoln, Y. S., Lynham, S. A., & Guba, E. G. (2011). Paradigmatic controversies, contradictions, and emerging confluences, revisited. The Sage handbook of qualitative research, 4(2), 97-128.

Lohmöller, J. B. (2013). Latent variable path modeling with partial least squares. Springer Science & Business Media.

Lorenzoni, I., Nicholson-Cole, S., & Whitmarsh, L. (2007). Barriers perceived to engaging with climate change among the UK public and their policy implications. Global Environmental change, 17(3–4), 445–459. https://doi.org/10.1016/j.gloenvcha.2007.01.004

M

Madhok, A. (2002). Reassessing the fundamentals and beyond: Ronald Coase, the transaction cost and resource-based theories of the firm and the institutional structure of production. Strategic management journal, 23(6), 535-550. https://doi.org/10.1002/smj.247

Mainali, B. (2014). Sustainability of rural energy access in developing countries (Doctoral dissertation, KTH Royal Institute of Technology).

Mainali, B and K Mahapatra (2020). One-Stop-Shop for Deep Renovation: Examples of Local Interventions in residential sector in achieving SDG 7.3, in Bhattacharyya, SC, 2021, Proceedings of the Virtual International Conference on Aligning Local Interventions with the UN Sustainable Development Goals, Conference held on 2nd July 2020, Institute of Energy and Sustainable Development, Leicester.

Mainali, B., Mahapatra, K., & Pardalis, G. (2021). Strategies for deep renovation market of detached houses. Renewable and Sustainable Energy Reviews, 138, 110659. https://doi.org/10.1016/j.rser.2020.110659

Mahapatra, K., & Gustavsson, L. (2008). An adopter-centric approach to analyze the diffusion patterns of innovative residential heating systems in Sweden. Energy Policy, 36(2), 577-590. https://doi.org/10.1016/j.enpol.2007.10.006

Mahapatra, K., Gustavsson, L., Haavik, T., Aabrekk, S., Svendsen, S., Vanhoutteghem, L., Paiho, S. & Ala-Juusela, M. (2013). Business models for full-service energy renovation of single-family houses in Nordic countries. Applied energy, 112, 1558–1565. https://doi.org/10.1016/j.apenergy.2013.01.010

Mahapatra, K., Nair, G., & Gustavsson, L. (2011). Energy advice service as perceived by Swedish homeowners. International journal of consumer studies, 35(1), 104-111. https://doi.org/10.1111/j.1470-6431.2010.00924.x

Martin, L., & Perry, F. (2019). Sustainable construction technology adoption. In Sustainable construction technologies (pp. 299–316). Oxford, UK: Butterworth-Heinemann.

Mathiesen, B. V., Bertelsen, N., Schneider, N. C. A., García, L. S., Paardekooper, S., Thellufsen, J. Z., & Djørup, S. R. (2019). Towards a decarbonised heating and cooling sector in Europe: Unlocking the potential of energy efficiency and district energy. Aalborg Universitet.

McGuirk, H., Lenihan, H., & Hart, M. (2015). Measuring the impact of innovative human capital on small firms' propensity to innovate. Research policy, 44(4), 965-976. https://doi.org/10.1016/j.respol.2014.11.008

McCormick, K. and Neij, L., (2009). Experience of Policy Instruments for Energy Efficiency in Buildings in the Nordic Countries, International Institute for Industrial Environmental Economics (IIIEE), Lund University

Meijer, F., Straub, A., & Mlecnik, E. (2018). Consultancy centres and pop-ups as local authority policy instruments to stimulate adoption of energy efficiency by homeowners. Sustainability, 10(8), 2734. https://doi.org/10.3390/su10082734

Michelsen, C. C., & Madlener, R. (2013). Motivational factors influencing the homeowners' decisions between residential heating systems: An empirical analysis for Germany. Energy Policy, 57, 221-233. https://doi.org/10.1016/j.enpol.2013.01.045

Mingers, J. (2001). Combining IS research methods: towards a pluralist methodology. Information systems research, 12(3), 240–259. https://doi.org/10.1287/isre.12.3.240.9709

Mlecnik, E., Kondratenko, I., Cré, J., Vrijders, J., Degraeve, P., van der Have, J. A., Haavik, T., Aabrekk, S., Grøn, M., Hansen, S., Svendsen, S., Stenlund, O., Paiho, S. (2012). Collaboration opportunities in advanced housing renovation. Energy Procedia, 30, 1380- 1389. https://doi.org/10.1016/j.egypro.2012.11.152

Mlecnik, E., Kondratenko, I., & Haavik, T. (2013). Opportunities and barriers related to supply chain collaboration for delivering integrated single-family home renovations. OTB Working papers 2013-02.

Mlecnik, E., Straub, A., & Haavik, T. (2019). Collaborative business model development for home energy renovations. Energy Efficiency, 12(1), 123-138. https://doi.org/10.1007/s12053-018-9663-3

Mortensen, A., Heiselberg, P., & Knudstrup, M. (2014). Economy controls energy retrofits of Danish single-family houses. Comfort, indoor environment, and architecture increase the budget. Energy and buildings, 72, 465-475. http://dx.doi.org/10.1016/j.enbuild.2013.12.054

Murphy, L. (2014). The influence of energy audits on the energy efficiency investments of private owner-occupied households in the Netherlands. Energy Policy, 65, 398–407. https://doi.org/10.1016/j.enpol.2013.10.016

N

Nair, G., Gustavsson, L., & Mahapatra, K. (2010). Factors influencing energy efficiency investments in existing Swedish residential buildings. Energy Policy, 38(6), 2956-2963. https://doi.org/10.1016/j.enpol.2010.01.033

Nehler, T., Parra, R., & Thollander, P. (2018). Implementation of energy efficiency measures in compressed air systems: Barriers, drivers, and non-energy benefits. Energy Efficiency, 11(5), 1281-1302. https://doi.org/10.1007/s12053-018-9647-3

Nehler, T., Thollander, P., Fredriksson, L., Friberg, S., & Nordberg, T. (2018). Non-energy benefits of Swedish energy efficiency policy instruments: A three-levelled perspective. In ECEEE Industrial Summer Study (pp. 139-149).

Neumayer, E., & Plümper, T. (2017). Robustness tests for quantitative research. Cambridge University Press.

Nonaka, I. and Takeuchi, H. (1995) The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation, Oxford University Press, New York.

Nägeli, C., Farahani, A., Österbring, M., Dalenbäck, J. O., & Wallbaum, H. (2019). A service-life cycle approach to maintenance and energy retrofit planning for building portfolios. Building and Environment, 160, 106 212. https://doi.org/10.1016/j.buildenv.2019.106212

O

Oberegger, U. F., Pernetti, R., & Lollini, R. (2020). Bottom-up building stock retrofit based on levelized cost of saved energy. Energy and Buildings, 210, 109757. https://doi.org/10.1016/j.enbuild.2020.109757

Organ, S., Proverbs, D., & Squires, G. (2013). Motivations for energy efficiency refurbishment in owner-occupied housing. Structural Survey, 31 (2), 101-120. https://doi.org/10.1108/02630801311317527

Owen, A., Mitchell, G., & Gouldson, A. (2014). Unseen influence— the role of low carbon retrofit advisers and installers in the adoption and use of domestic energy technology. Energy Policy, 73, 169–179. https://doi.org/10.1016/j.enpol.2014.06.013

P

Palmer, K., Walls, M., Gordon, H., & Gerarden, T. (2013). Assessing the energy-efficiency information gap: results from a survey of home energy auditors. Energy Efficiency, 6(2), 271-292. https://doi.org/10.1007/s12053-012-9178-2

Pan Q. (2020) Economic Impact Analysis for an Energy Efficient Home Improvement Program. In: Ye X., Lin H. (eds) Spatial Synthesis. Human Dynamics in Smart Cities. Springer, Cham. https://doi.org/10.1007/978-3-030-52734-1_12

Pardalis, G., Mahapatra, K., & Mainali, B. (2020, November). A triple-layered one-stop-shop business model canvas for sustainable house renovations. In IOP Conference Series: Earth and Environmental Science (Vol. 588, No. 2, p. 022060). IOP Publishing. doi:10.1088/1755-1315/588/2/022060

Pardalis, G., Mahapatra, K., Bravo, G., & Mainali, B. (2019). Swedish house owners' intentions towards renovations: is there a market for one-stop-shop? Buildings, 9(7), 164. https://doi.org/10.3390/buildings9070164

Pardalis, G., Mahapatra, K., Mainali, B. (2021). Analysis or existing One-Stop-Shop Business Models in the EU Promoting Building Retrofits in the Private Residential Sector. Deliverable 2.1 (project deliverable ProRetro)

Pardalis, G., Mahapatra, K., & Mainali, B. (2020). Swedish construction MSEs: simply renovators or renovation service innovators? Building Research & Information, 48(1), 67- 83. https://doi.org/10.1080/09613218.2019.1662713

Pardalis, G., Mahapatra, K., Mainali, B., & Bravo, G. (2021). Future Energy-Related House Renovations in Sweden: One-Stop-Shop as a Shortcut to the Decision-Making Journey. In Emerging Research in Sustainable Energy and Buildings for a Low-Carbon Future (pp. 37-52). Springer, Singapore. https://doi.org/10.1007/978-981-15-8775-7_4

Pardalis, G., Talmar, M. and Keskin, D. (2020). To be or not to be: What does it take to launch OSS for Energy Efficient Renovations? (Working paper)

Park, K. S., & Kim, K. P. (2014). Essential BIM input data study for housing refurbishment: homeowners' preferences in the UK. Buildings, 4(3), 467-487. https://doi.org/10.3390/buildings4030467

Pelenur, M. J., & Cruickshank, H. J. (2012). Closing the energy efficiency gap: a study linking demographics with barriers to adopting energy efficiency measures in the home. Energy, 47(1), 348–357. https://doi.org/10.1016/j.energy.2012.09.058

Pérez-Luño, A., Wiklund, J., & Cabrera, R. V. (2011). The dual nature of innovative activity: How entrepreneurial orientation influences innovation generation and adoption. Journal of Business Venturing, 26(5), 555–571. https://doi.org/10.1016/j.jbusvent.2010.03.001

Persson, J., & Grönkvist, S. (2015). Drivers for and barriers to low-energy buildings in Sweden. Journal of cleaner production, 109, 296-304. https://doi.org/10.1016/j.jclepro.2014.09.094

Pichlak, M. (2016). The innovation adoption process: A multidimensional approach. Journal of Management and Organization, 22(4), 476. https://doi.org/10.1017/jmo.2015.52

R

Rea, L. M., & Parker, R. A. (2014). Designing and conducting survey research: A comprehensive guide. John Wiley & Sons.

Reddy, B. S. (2013). Barriers and drivers to energy efficiency–A new taxonomical approach. Energy Conversion and Management, 74, 403-416. https://doi.org/10.1016/j.enconman.2013.06.040

Ring, P. S., and A. H. Van de Ven (1989). 'Legal and managerial dimensions of transactions'. In A. H. Van de Ven, H. Angle and M. S. Poole (eds.), Research on the Management of Innovation: The Minnesota Studies, Ballinger/Harper Row, New York, pp. 171-192

Ring, P., & Van De Ven, A. (1992). Structuring Cooperative Relationships between Organizations. Strategic Management Journal, 13(7), 483-498. Retrieved January 3, 2021, from http://www.jstor.org/stable/2486599

Ringel, M. (2018). Energy advice in Germany: A market actors' perspective. International Journal of Energy Sector Management, 12 (4), 656-674. https://doi.org/10.1108/IJESM-04-2018-0002

Risholt, B., & Berker, T. (2013). Success for energy efficient renovation of dwellings— Learning from private homeowners. Energy Policy, 61, 1022-1030. https://doi.org/10.1016/j.enpol.2013.06.011

Rogers, E. M. (2005). Diffusion of innovations (5th ed.). New York, NY: Free Press.

Rönkkö, M., McIntosh, C. N., Antonakis, J., & Edwards, J. R. (2016). Partial least squares path modelling: Time for some serious second thoughts. Journal of Operations Management, 47, 9-27. https://doi.org/10.1016/j.jom.2016.05.002

S

Sammut-Bonnici, T., & Galea, D. (2015). PEST analysis. Wiley Encyclopedia of Management, 1-1. https://doi.org/10.1002/9781118785317.weom120113

Santin, O. G. (2011). Behavioural patterns and user profiles related to energy consumption for heating. Energy and Buildings, 43(10), 2662-2672. https://doi.org/10.1016/j.enbuild.2011.06.024

Saunders, M., Lewis, P. & Thornhill, A. (2012) "Research Methods for Business Students" 6th edition, Pearson Education Limited

Schleich, J. (2019). Energy efficient technology adoption in low-income households in the European Union–What is the evidence? Energy Policy, 125, 196-206. https://doi.org/10.1016/j.enpol.2018.10.061

Schleich, J., Mills, B. (2012). Determinants and distributional implications in the purchase of energy-efficient household appliances. In: Defila, R., Di Giulo, A., Kaufmann-Hayoz, R. (Eds.), The Nature of Sustainable Consumption and How to Achieve it: Results from the Focal Topic "From Knowledge to Action - New Paths towards Sustainable Consumption. Ökom, Munich, pp. 181–194.

Schwarzer, K. B., Hansmann, R., Popp, M., Von Streit, A., & Binder, C. R. (2015). Energy efficiency standards of single-family houses: factors in homeowners' decision-making in two Austrian regions. Energy and Environment Research, 5(2), 49-66. http://dx.doi.org/10.5539/eer.v5n2p49

Sebi, C., Nadel, S., Schlomann, B., & Steinbach, J. (2019). Policy strategies for achieving large long-term savings from retrofitting existing buildings. Energy Efficiency, 12(1), 89-105. https://doi.org/10.1007/s12053-018-9661-5

Sekaran, U., & Bougie, R. (2016). Research methods for business: A skill building approach. John Wiley & Sons.

Seuring, S., & Gold, S. (2012). Conducting content-analysis based literature reviews in supply chain management. Supply Chain Management: An International Journal. Vol. 17 (5), pp. 544-555. https://doi.org/10.1108/13598541211258609

Sheeran, P., & Webb, T. L. (2016). The intention–behaviour gap. Social and personality psychology compass, 10(9), 503-518. https://doi.org/10.1111/spc3.12265

Shnapp, S., Sitjà, R., & Laustsen, J. (2013). What is a deep renovation definition? Global Building Performance Network, Technical Report, February.

Sorrell, S., O'Malley, E., Schleich, J., Scott, S. (2006). The Economics of Energy Efficiency:Barriers to Cost-Effective Investment. Energy Stud. Rev., 14, 186.

Statistics Sweden (SCB) (2019). Bostads- Och Byggnadsstatistisk Årsbok. Statistics Sweden, Publikationstjänsten: Örebro, Sweden.

Stieß, I., & Dunkelberg, E. (2013). Objectives, barriers, and occasions for energy efficient refurbishment by private homeowners. Journal of Cleaner Production, 48, 250–259. https://doi.org/10.1016/j.jclepro.2012.09.041

Strielkowski, W., Veinbender, T., Tvaronaviciene, M., & Lace, N. (2020). Economic efficiency and energy security of smart cities. Economic Research-Ekonomska Istraživanja, 33(1), 788–803. https://doi.org/10.1080/1331677X.2020.1734854

Sutterlin, B., Brunner, T., & Siegrist, M. (2011). Who puts the most energy into energy conservation? A segmentation of energy consumer based on energy-related behavioural characteristics. Energy Policy, 39, 8137–8152. https://doi.org/10.1016/j.enpol.2011.10.008

Swedish Energy Agency (Energimyndigheten) (2019). Energy statistics for one- and two-dwelling buildings in 2019 (Energistatistik i småhus 2019). Statistics Sweden.In Swedish. Retrieved February 2, 2021, from https://www.energimyndigheten.se/statistik/denofficiella-statistiken/

Swedish Parliament (2016). Förordning (2016:899) om Bidrag Till Lagring av Egenproducerad Elenergi. Ministry of Infrastucture. Swedish Parliament Homepage. Retrieved February 13, 2021, from https://www.riksdagen.se/sv/dokumentlagar/dokument/svensk-forfattningssamling/forordning-2016899-om-bidrag-till-lagringav_sfs-2016-899

Swedish Tax Agency (Skatteverket) (2015). Taxes in Sweden 2015. an English Summary of Tax Statistical Yearbook of Sweden.

T

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. Strategic Management Journal, 18(7), 509-533. https://www.jstor.org/stable/3088148

Teirlinck, P., & Spithoven, A. (2013). Research collaboration and R&D outsourcing: Different R&D personnel requirements in SMEs. Technovation, 33(4-5), 142–153. https://doi.org/10.1016/j.technovation.2012.11.005

Tjørring, L. (2016). We forgot half of the population! The significance of gender in Danish energy renovation projects. Energy research & social science, 22, 115-124. https://doi.org/10.1016/j.erss.2016.08.008

Tommerup, H., & Svendsen, S. (2006). Energy savings in Danish residential building stock. Energy and buildings, 38(6), 618-626. https://doi.org/10.1016/j.enbuild.2005.08.017

Trianni, A., Accordini, D., & Cagno, E. (2020). Identification and Categorization of Factors Affecting the Adoption of Energy Efficiency Measures within Compressed Air Systems. Energies, 13(19), 5116. https://doi.org/10.3390/en13195116

Trotta, G. (2018). Factors affecting energy-saving behaviours and energy efficiency investments in British households. Energy Policy, 114, 529-539. https://doi.org/10.1016/j.enpol.2017.12.042

Tuominen, P., Klobut, K., Tolman, A., Adjei, A., & de Best-Waldhober, M. (2012). Energy savings potential in buildings and overcoming market barriers in member states of the European Union. Energy and Buildings, 51, 48-55. https://doi.org/10.1016/j.enbuild.2012.04.015

Turk, Ž. (2016). Responsible research and innovation in construction. Procedia Engineering, 164, 461–466. https://doi.org/10.1016/j.proeng.2016.11.645

U

Ürge-Vorsatz, D., Eyre, N., Graham, P., Harvey, D., Hertwich, E., Jiang, Y., Kornevall, C., Majumdar, M., McMahon, J. E., Mirasgedis, S., Murakami, S., Novikova, A., Janda, K., Masera, O., McNeil, M., Petrichenko, K. & Herrero, S. T. (2012). Energy end-use: buildings. In Global Energy Assessment: Toward a Sustainable Future (pp. 649-760). Cambridge University Press. https://doi.org/10.1017/CBO9780511793677.016

V

Valentová, M., Lízal, L., & Knápek, J. (2018). Designing energy efficiency subsidy programmes: The factors of transaction costs. Energy Policy, 120, 382–391. https://doi.org/10.1016/j.enpol.2018.04.055

Vlasova, L., & Gram-Hanssen, K. (2014). Incorporating inhabitants' everyday practices into domestic retrofits. Building Research & Information, 42(4), 512-524. doi:10.1080/09613218.2014.907682.

Vondung, F., & Kaselofsky, J. (2017). Bridging the information gap on energy efficiency? Experiences from energy advice experiments in three German cities. In: ECEEE Summer Study 2017 Proceedings

W

WBCSD/WRI (2007). The Greenhouse Gas Protocol. World Business Council for Sustainable Development and World Resources Institute, Geneva pp. 1–116.

Weiss, J., Dunkelberg, E., & Vogelpohl, T. (2012). Improving policy instruments to better tap into homeowner refurbishment potential: Lessons learned from a case study in Germany. Energy Policy, 44, 406-415. https://doi.org/10.1016/j.enpol.2012.02.006

Williamson, O.E. (1983). Credible commitments: using hostages to support exchange. American Economic Review, 73(4), 519–40. http://www.jstor.org/stable/1816557

Williamson, O. E. (1999). Public and private bureaucracies: a transaction cost economics perspective. The Journal of Law, Economics, and Organization, 15(1), 306-342. https://www.jstor.org/stable/3554953

Williamson, O. E. (1989). Transaction cost economics. Handbook of industrial organization, 1, 135-182.

Williamson, O.E. & Ouchi, W.G. (1981). The Markets and Hierarchies and Visible Hand Perspectives. In Van de Ven, A. & Joyce, W. (eds.), Perspectives on Organization Design and Behavior, New York: Wiley.

Wilson, C., Crane, L., & Chryssochoidis, G. (2015). Why do homeowners renovate energy efficiently? Contrasting perspectives and implications for policy. Energy Research & Social Science, 7, 12-22. https://doi.org/10.1016/j.erss.2015.03.002

Wilson, C., Chrysochoidis, G., & Pettifor, H. (2013). Understanding homeowners' renovation decisions: Findings of the VERD project.

Wilson, C., & Dowlatabadi, H. (2007). Models of decision making and residential energy use. Annual Review of Environment and Resources 32, 169–203. https://doi.org/10.1146/annurev.energy.32.053006.141137

Wilson, C., Pettifor, H., & Chryssochoidis, G. (2018). Quantitative modelling of why and how homeowners decide to renovate energy efficiently. Applied energy, 212, 1333-1344. https://doi.org/10.1016/j.apenergy.2017.11.099

Winter, S. G. (1988). On Coase, competence, and the corporation. JL Econ. & Org., 4, 1. https://www.jstor.org/stable/765019

Winther, T., & Gurigard, K. (2017). Energy performance contracting (EPC): a suitable mechanism for achieving energy savings in housing cooperatives? Results from a Norwegian pilot project. Energy Efficiency, 10(3), 577-596. https://doi.org/10.1007/s12053-016-9477-0

Wu, L., & Chiu, M. L. (2015). Organizational applications of IT innovation and firm's competitive performance: A resource-based view and the innovation diffusion approach. Journal of Engineering and Technology Management, 35, 25–44. https://doi.org/10.1016/j.jengtecman.2014.09.002

X

Xiao, Y., & Watson, M. (2019). Guidance on conducting a systematic literature review. Journal of Planning Education and Research, 39(1), 93–112. https://doi.org/10.1177/0739456X17723971

Y

Yates, S. M., & Aronson, E. (1983). A social psychological perspective on energy conservation in residential buildings. American Psychologist, 38(4), 435.

Z

Zavadskas, E., Raslanas, S., & Kaklauskas, A. (2008). The selection of effective retrofit scenarios for panel houses in urban neighbourhoods based on expected energy savings and increase in market value: The Vilnius case. Energy and Buildings, 40(4), 573-587. https://doi.org/10.1016/j.enbuild.2007.04.015

Zubizarreta, M., Cuadrado, J., Iradi, J., García, H., & Orbe, A. (2017). Innovation evaluation model for macro-construction sector companies: A study in Spain.

Evaluation and Program Planning, 61, 22–37. https://doi.org/10.1016/j.evalprogplan.2016.10.014

Zuhaib, S., Manton, R., Hajdukiewicz, M., Keane, M. M., & Goggins, J. (2017). Attitudes and approaches of Irish retrofit industry professionals towards achieving nearly zero energy buildings. International Journal of Building Pathology and Adaptation. https://doi.org/10.1108/IJBPA-07-2016-0015

Zundel, S., & Stieß, I. (2011). Beyond profitability of energy-saving measures—attitudes towards energy saving. Journal of Consumer Policy, 34(1), 91-105. https://doi.org/10.1007/s10603-011-9156-7

APPENDICES

APPENDIX I – Examples of financial instruments in the residential sector across the EU

FINANCING MECHANISM	ADOPTION RATE	EXAMPLE OF GOOD PRACTICE	SOURCE OF FINANCE	ADVANTAGES	DISADVANTAGES
TRADITIONAL AND WELL-ESTABLISHED					
Grants and subsidies	High	Better energy home scheme (Ireland) https://www.seai.ie/grants/home-energy-grants/free-upgrades-for-eligible-homes/	Taxpayer and subsidy recipient	Support of new emerging technologies; help to kick start market; can be combined with other types of instruments	Public budget restrictions; free riders; mostly shallow measure support
Tax incentives	Low/Medium	Eco-bonus (Italy) https://www.eco-bonus.it/	Taxpayer		Reduced tax revenue to government; success depends on tax collection rate; less beneficial to low-income households
TESTED AND GROWING					
EEO	Medium/High	Energy savings agreement (Denmark) https://ens.dk/en/our-responsibilities/energy-savings	Energy consumers	No public budget burden; wide range skills offered by energy suppliers; third party involvement	Energy bill surcharge; low consumer trust to energy suppliers; mostly shallow measure support
EPC	Medium	Renesco (Latvia) http://www.renesco.lv/en lemon (Italy) http://www.lemon-project.eu/	ESCO/client	No upfront costs for consumers; know-how of ESCOs	Performance risk; high fees charged by ESCOs
Revolving funds	Medium	KredEx (Estonia) https://kredex.ee/et	Goverment/Private investors/Repayments	Repayments cycled back into fund for future projects	Fund may "revolve" quite slowly; limited short-term impact of public funds

Table continues on next page

NEW AND INNOVATIVE					
Preferential loans	Medium	KfW (Germany) https://www.kfw.de/inlandsfoerderung	Government/Private investors	Less burden on public resources than grants; support to deeper renovations	Upfront cost barrier due to down-payment; reluctance to take on additional debt; large transaction costs in small projects
Energy efficient mortgages	Low	Raifaissen; Nordea; Muenchener; Hyp	Lender	Easy access to capital (low cost); increase in ability to pay monthly instalments; long repayment period; support to deeper renovations	Large transaction costs in small projects; strict collateral requirements
PACE	N/A	EuroPACE (Spain) https://www.europace2020.eu/	Municipal bonds	Long repayment period; lower transaction costs by streamlining application processes; support to deeper renovations	Available only to homeowners; not available for small investments; high set up costs for municipalities
Crowdfunding	Low	Bettervest (Germany) https://www.bettervest.com/en/	Individuals	Access to finance for consumers not eligible for conventional financing products	Difficulty to reach funding target; risky investments; weak regulatory framework

APPENDIX II – Survey Questionnaire

Frågeformulär

Energirenovering av villor

Bäste medlem!

Villaägarna undersöker i samarbete med Linnéuniversitetet vilka behov landets villahushåll har av underhåll, energiåtgärder och renovering. Syftet är att få information för framtida forskning, men också för att Villaägarna vill erbjuda ännu bättre tjänster och produkter till dig som är medlem.

Enkäten tar cirka 10-15 minuter att besvara och jag hoppas att du vill hjälpa oss.

Dina svar är helt skyddade och du förbinder dig inte till något.

DEL A

Allmänna uppgifter om din befintliga bostad, dess uppvärmning och energianvändning

1.	Du bor i	☐ Radhus ☐ Kedjehus ☐ Parhus ☐ Fristående villa ☐ Annat (ange vad) _____*...Då är det sista frågan för dig*
2.	Vilket år är ditt/ert hus byggt? År:	ı ı ı
3.	Vilken/vilka typer av värmesystem använder du i ditt hus? ***(Flera alternativ kan väljas)*** ☐ Värmepump – ytjord/berg/sjö ☐ Värmepump – luft-luft ☐ Värmepump – luft-vatten ☐ Fjärrvärme ☐ Pelletspanna ☐ Direktverkande el ☐ Elpanna (vattenburen) ☐ Vedpanna ☐ Oljepanna ☐ Öppen spis ☐ Solfångare ☐ Annat (ange vad) ……	
4.	Om du använder flera värmesystem, vilket system använder du mest? ☐ Värmepump – ytjord/berg/sjö ☐ Värmepump – luft-luft ☐ Värmepump – luft-vatten ☐ Fjärrvärme ☐ Pelletspanna ☐ Direktverkande el ☐ Elpanna (vattenburen) ☐ Vedpanna ☐ Oljepanna ☐ Öppen spis ☐ Solfångare ☐ Annat (ange vad) ……	
5.	Vilken typ av fönster har huset idag? *(Flera alternativ kan väljas)*	☐ 2-glas ☐ 3-glas ☐ 2-glas med isolerruta ☐ 3-glas med isolerruta ☐ Annat (ange vad) …… ☐ Vet ej

6. Vilken tjocklek har isoleringen?	0–200 mm	201–300 mm	Över 300 mm	Vet ej
Vinden	☐	☐	☐	☐
Ytterväggar	☐	☐	☐	☐
Källare	☐	☐	☐	☐

7. Vilket är det huvudsakliga fasadmaterialet på husets ytterväggar?

☐ Tegel
☐ Betong
☐ Trä
☐ Annat (ange vad) _____

8. Vilken typ av ventilationssystem finns i huset?

☐ Vet ej
☐ Självdrag utan köksfläkt
☐ Självdrag med köksfläkt
☐ Frånluft
☐ Från- och tilluft
☐ Annat (ange vad) _____

9. Hur är det huvudsakligen grundlagt?

☐ Betongplatta på mark
☐ Torpargrund/krypgrund/plintgrund
☐ Källare/souterräng
☐ Vet ej

10. Hur många våningsplan ovan mark har huset?

……..

11. Hur många kvadratmeter (m2) golvyta (inkl. biarea) har den del av bostaden som uppvärms till minst 10 grader?

……m^2

12. Hur länge har du/ni bott i huset?

……år

13. Hur anser du att din årliga energikostnad är?

Mycket låg 1				Mycket hög 5
☐	☐	☐	☐	☐

14. Hur viktigt är det för dig att minska din bostads energianvändning?

Inte alls viktigt 1				Mycket viktigt 5
☐	☐	☐	☐	☐

15. Vilka åtgärder vidtar du för att minska din energianvändning?
(Flera alternativ kan väljas)

☐ Känner inte till några möjligheter
☐ Stänger av apparater när de inte används
☐ Släcker lyset
☐ Sänker värmen inne
☐ Genomför byggnadsåtgärder för att minska uppvärmningsbehovet
☐ Annat (ange vad) _____

16. I sin helhet – hur nöjd eller missnöjd är du med din bostad?	Mycket missnöjd 1	2	3	4	Mycket nöjd 5	Vet ej
	☐	☐	☐	☐	☐	☐

17. Hur pass nöjd eller missnöjd är du med bostaden vad gäller …	Mycket missnöjd 1	2	3	4	Mycket nöjd 5	Vet ej
Storlek	☐	☐	☐	☐	☐	☐
Standard	☐	☐	☐	☐	☐	☐
Planlösning	☐	☐	☐	☐	☐	☐
Dagsljus	☐	☐	☐	☐	☐	☐
Utseende, skönhetsvärde	☐	☐	☐	☐	☐	☐
Inomhusmiljön	☐	☐	☐	☐	☐	☐
Marknadsvärde på huset	☐	☐	☐	☐	☐	☐
Underhållskostnad	☐	☐	☐	☐	☐	☐
Energikostnad	☐	☐	☐	☐	☐	☐
Miljöpåverkan	☐	☐	☐	☐	☐	☐

18. Håller du med om eller tar du avstånd från följande påståenden?	Instämmer starkt 1	2	3	4	Tar starkt avstånd 5
a. Det är helt enkelt för svårt för någon som jag att göra särskilt mycket för miljön	☐	☐	☐	☐	☐
b. Jag/familjen gör tillräckligt mycket för att värna om miljön	☐	☐	☐	☐	☐
c. Det är ingen idé att jag gör vad jag kan för miljön om inte andra också gör det	☐	☐	☐	☐	☐
d. Många påståenden om miljöhoten är överdrivna	☐	☐	☐	☐	☐
e. Jag tycker det är svårt att avgöra om mitt sätt att leva är bra eller skadligt för miljön	☐	☐	☐	☐	☐
f. Miljöproblem har en direkt påverkan på mitt vardagsliv	☐	☐	☐	☐	☐
g. Det finns stora möjligheter att jag/familjen kan minska energianvändningen genom att renovera av vårt hus	☐	☐	☐	☐	☐
h. Det finns stora möjligheter att jag/familjen kan minska energianvändningen genom förändrat beteende	☐	☐	☐	☐	☐
i. Staten gör tillräckligt för att Sverige ska bli ett hållbart samhälle	☐	☐	☐	☐	☐
j. Ny teknik kan bidra till att lösa dagens miljöproblem	☐	☐	☐	☐	☐

19. Hur villig skulle du vara att …	Mycket ovillig 1	2	3	4	Mycket villig 5
a. betala mycket högre priser för produkter och tjänster för att värna om miljön?	☐	☐	☐	☐	☐
b. betala mycket högre skatter för att värna om miljön?	☐	☐	☐	☐	☐
c. acceptera en sänkt levnadsstandard för att värna om miljön?	☐	☐	☐	☐	☐

20. Hur tycker du att inomhusmiljön är i stort sett i din bostad när det gäller …	Mycket dålig 1	2	3	4	Mycket bra 5	Vet ej
a. Värmekomfort	☐	☐	☐	☐	☐	☐
b. Luftkvalitet	☐	☐	☐	☐	☐	☐
c. Ljudförhållanden	☐	☐	☐	☐	☐	☐

21. I vilket skick är följande byggnadsdelar i ditt hus?	Mycket dålig 1	2	3	4	Mycket bra 5	Vet ej
Kök	☐	☐	☐	☐	☐	☐
Badrum	☐	☐	☐	☐	☐	☐
Avlopp	☐	☐	☐	☐	☐	☐
Fönster	☐	☐	☐	☐	☐	☐
Tak	☐	☐	☐	☐	☐	☐
Fasad	☐	☐	☐	☐	☐	☐
Isolering – *vinden*	☐	☐	☐	☐	☐	☐
Isolering – *källaren*	☐	☐	☐	☐	☐	☐
Isolering – *ytterväggar*	☐	☐	☐	☐	☐	☐
Värmesystem	☐	☐	☐	☐	☐	☐

22. Finns det eller har det under de senaste fem åren funnits…	Nej	Ja	Vet ej
a. ……synliga fuktfläckar på golv, väggar eller tak	☐	☐	☐
b. ……vattenläckage/vattenskador på väggar, golv eller tak	☐	☐	☐
c. ……synligt mögel på golv, väggar eller tak i något rum	☐	☐	☐
d. ……mögellukt i ett eller flera av boningsrummen	☐	☐	☐
e. ……buckliga plastmattor, gulnade plastmattor eller svartnad parkett	☐	☐	☐

23. I vilken omfattning och när renoverades/byttes följande byggnadsdelar i ditt hus under de senaste 20 åren? Notera: Om du inte har gjort någon renovering alls i ditt hus, gå till *fråga 31*.	Omfattning			När			
	Inte alls	Delvis	Helt		(cirka) vilket år		
Kök	☐	☐	☐				
Badrum	☐	☐	☐				
Avlopp	☐	☐	☐				
Fönster	☐	☐	☐				
Tak	☐	☐	☐				
Fasad	☐	☐	☐				
Tilläggsisolering – *vinden*	☐	☐	☐				
Tilläggsisolering – *källaren*	☐	☐	☐				
Tilläggsisolering –	☐	☐	☐				
Dränering	☐	☐	☐				
Värmesystem	☐	☐	☐				

24. Hur upplevde du att renoveringen var när det gäller …	Mycket svår 1	2	3	4	Mycket lätt 5	Vet ej
a. Hela processen	☐	☐	☐	☐	☐	☐
b. Hitta anlitad firma(or)	☐	☐	☐	☐	☐	☐
c. Få relevant information om renoveringen	☐	☐	☐	☐	☐	☐
d. Välja material/produkter	☐	☐	☐	☐	☐	☐
e. Ordna finansiering	☐	☐	☐	☐	☐	☐

25. Vem har utfört renoveringsarbetet?	☐ Du själv ellermed hjälp av släktingar/vänner/grannar ☐ Dels själv, dels anlitades ett eller flera företag ☐ Anlitade flera företag för hela arbetet och skrev kontrakt med varje ☐ Anlitade en totalentreprenör för hela renoveringen

26. Enligt din erfarenhet, hur pålitligt är det (de) företag du anlitade?	Inte alls pålitligt 1	2	3	4	Mycket pålitligt 5	Vet ej
	☐	☐	☐	☐	☐	☐

27. Hur finansierade du renoveringen? (Flera alternativ kan väljas)	☐ Egna besparingar ☐ Bolån ☐ Privat lån ☐ Annat_____

28. Du har renoverat någonting i ditt hus för att …

	Stämmer inte alls 1	2	3	4	Stämmer helt 5
Det var gammalt	☐	☐	☐	☐	☐
Det var skadat	☐	☐	☐	☐	☐
Inomhusmiljön var dålig	☐	☐	☐	☐	☐
Förbättra estetik/utseende	☐	☐	☐	☐	☐
Ändra planlösningen/storleken	☐	☐	☐	☐	☐
Öka tillgängligheten	☐	☐	☐	☐	☐
Öka säkerheten	☐	☐	☐	☐	☐
Hyra ut delar av bostaden	☐	☐	☐	☐	☐
Minska underhållskostnaden	☐	☐	☐	☐	☐
Minska energikostnaden	☐	☐	☐	☐	☐
Öka marknadsvärdet på huset	☐	☐	☐	☐	☐
Grannar eller bekanta har gjort så	☐	☐	☐	☐	☐
Värna om miljön	☐	☐	☐	☐	☐
Annat (ange vad) ……	☐	☐	☐	☐	☐

29. Hur pass nöjd eller missnöjd är du med renoveringen(ar) vad gäller …	Mycket missnöjd 1	2	3	4	Mycket nöjd 5	Vet ej/ej aktuell
Hela processen	☐	☐	☐	☐	☐	☐
Företaget(en) du anlitade	☐	☐	☐	☐	☐	☐
Kvaliten på arbetet	☐	☐	☐	☐	☐	☐
Kostnaden	☐	☐	☐	☐	☐	☐
Kommunikation med företaget(en)	☐	☐	☐	☐	☐	☐
Hantverkarnas bemötande	☐	☐	☐	☐	☐	☐
Samordningen av flera företag (om det var aktuellt)	☐	☐	☐	☐	☐	☐
Företaget(en) höll tidsschemat enligt plan	☐	☐	☐	☐	☐	☐
Söka bygglov	☐	☐	☐	☐	☐	☐
Söka statliga bidrag	☐	☐	☐	☐	☐	☐
Annat (ange vad) ……	☐	☐	☐	☐	☐	☐

30. Hur valde du det (de) företag som renoverade ditt hus? (Flera alternativ kan väljas)

- ☐ Rekommendation från släktingar/ vänner/grannar
- ☐ Jag känner till företaget(en) sen tidigare
- ☐ Annonsering och reklam i lokaltidningen/TV/direktreklam
- ☐ Rekommendation från ett byggvaruhus
- ☐ Internetsökning
- ☐ Sociala medier
- ☐ Annat (ange vad) _____

31. Du har **inte** renoverat vissa delar i ditt hus under de senaste 20 åren för att du….

	Stämmer inte alls	2	3	4	Stämmer helt 5
bor i ett nybyggt hus	☐	☐	☐	☐	☐
har köpt ett renoverat hus	☐	☐	☐	☐	☐
tänker sälja huset	☐	☐	☐	☐	☐
känner inte till renoveringsbehovet i huset	☐	☐	☐	☐	☐
är nöjd med standarden i huset	☐	☐	☐	☐	☐
är nöjd med inomhusklimatet	☐	☐	☐	☐	☐
är nöjd med underhållskostnaden	☐	☐	☐	☐	☐
är nöjd med energikostnaden	☐	☐	☐	☐	☐
tror att det är krångligt att renovera	☐	☐	☐	☐	☐
har inte tid	☐	☐	☐	☐	☐
prioriterar andra saker i livet	☐	☐	☐	☐	☐
har svårt att komma överens inom familjen om renoveringsbehovet/renoveringsåtgärder	☐	☐	☐	☐	☐
inte vill störas av renoveringen när det gäller smuts, buller osv	☐	☐	☐	☐	☐
har svårt att hitta bra företag	☐	☐	☐	☐	☐

fick ingen eller "kan inte renovera nu" respons från företaget(en) du kontaktade	☐	☐	☐	☐	☐
litar inte på entreprenadfirmor	☐	☐	☐	☐	☐
har inte råd att finansiera renoveringen	☐	☐	☐	☐	☐
tror inte att det är ekonomiskt lönsamt	☐	☐	☐	☐	☐
tror inte att husets värdeökning motsvarar investeringskostnaden	☐	☐	☐	☐	☐
Annat (ange vad)	☐	☐	☐	☐	☐

32. Vad har du för plan angående renoveringar av ditt hus fram till år 2020?

- ☐ Ingen renovering alls → Gå till fråga 36
- ☐ Hela huset ska renoveras på en gång
- ☐ Hela huset ska renoveras stegvis
- ☐ Några delar ska renoveras

33. I vilken omfattning (helt eller delvis) ska följande byggnadsdelar renoveras/bytas?

	Helt	Delvis
a. Kök	☐	☐
b. Badrum	☐	☐
c. Avlopp	☐	☐
d. Fönster	☐	☐
e. Tak	☐	☐
f. Fasad	☐	☐
g. Tilläggsisolering – *vinden*	☐	☐
h. Tilläggsisolering – *källaren*	☐	☐
i. Tilläggsisolering – *ytterväggar*	☐	☐
j. Dränering	☐	☐
k. Värmesystem	☐	☐

34. Om du vill renovera, hur väl stämmer det att du skulle vilja renovera/byta olika byggnadsdelar i ditt hus för att …

	Stämmer inte alls 1	2	3	4	Stämmer helt 5
a. Den/de är för gammal	☐	☐	☐	☐	☐
b. Den/de är skadad	☐	☐	☐	☐	☐
c. Inomhusmiljön är dålig	☐	☐	☐	☐	☐
d. Förbättra estetik/utseende	☐	☐	☐	☐	☐
e. Ändra planlösningen/storleken	☐	☐	☐	☐	☐
f. Öka tillgängligheten	☐	☐	☐	☐	☐
g. Öka säkerheten	☐	☐	☐	☐	☐
h. Hyra ut delar av bostaden	☐	☐	☐	☐	☐
i. Minska underhållskostnaden	☐	☐	☐	☐	☐
j. Öka marknadsvärdet på huset	☐	☐	☐	☐	☐
k. Minska energikostnaden	☐	☐	☐	☐	☐
l. Grannar eller bekanta har gjort så	☐	☐	☐	☐	☐

m. Värna om miljön	☐	☐	☐	☐	☐	
n. Annat (ange vad)	☐	☐	☐	☐	☐	

35. Var söker du information, när du överväger att renovera ditt hus? (Flera alternativ kan väljas)

- ☐ Släktingar/vänner/grannar
- ☐ Sociala medier
- ☐ Bygg-/renoveringsfirma
- ☐ Elleverantörer/värmeleverantörer
- ☐ Kommunal energi- och klimatrådgivare
- ☐ Konsult
- ☐ Besiktningsfirma
- ☐ Installatörer/hantverkare
- ☐ Byggvaruhus
- ☐ Internetsökning
- ☐ Fackpress till exempel Vi i Villa, Villaägaren
- ☐ Annat (ange vad) _____

36. Hur trovärdiga är följande informationskällor för ditt beslut när du överväger att renovera ditt hus?	Inte alls trovärdiga 1	2	3	4	Mycket trovärdiga 5
a. Släktingar/vänner/grannar	☐	☐	☐	☐	☐
b. Sociala medier	☐	☐	☐	☐	☐
c. Bygg-/renoveringsfirma	☐	☐	☐	☐	☐
d. Elleverantörer/värmeleverantörer	☐	☐	☐	☐	☐
e. Kommunal energi- och klimatrådgivare	☐	☐	☐	☐	☐
f. Konsult	☐	☐	☐	☐	☐
g. Besiktningsfirma	☐	☐	☐	☐	☐
h. Installatörer/hantverkare	☐	☐	☐	☐	☐
i. Byggvaruhus	☐	☐	☐	☐	☐
j. Internetsökning	☐	☐	☐	☐	☐
k. Fackpress till exempel Vi i Villa, Villaägaren	☐	☐	☐	☐	☐
l. Annat (ange vad) _____	☐	☐	☐	☐	☐

37. Hur kommer du att välja det/de företag som ska renovera ditt hus? (Flera alternativ kan väljas)

- ☐ Rekommendation från vänner/släktingar/grannar
- ☐ Jag känner till företaget(en) sen tidigare
- ☐ Reklam i tidningar/TV/hemskickat reklamblad
- ☐ Rekommendation från ett byggvaruhus
- ☐ Internetsökning
- ☐ Sociala medier
- ☐ Annat (ange vad) _____

38. Vem ska utföra renoveringsarbetet?
(Flera alternativ kan väljas)

- ☐ Du själv eller med hjälp av släktingar/vänner/grannar
- ☐ Dels själv, dels anlitas ett eller flera företag
- ☐ Anlitar flera företag för hela arbetet och skriver kontrakt med varje
- ☐ Anlitar en totalentreprenör för hela renoveringen

39. Hur svår eller lätt tror du att renoveringen kan bli när det gäller...

	Mycket svår 1	2	3	4	Mycket lätt 5	Vet ej
a. Hela processen	☐	☐	☐	☐	☐	☐
b. Hitta den firma(or) du ska anlita	☐	☐	☐	☐	☐	☐
c. Få relevant information om renoveringen	☐	☐	☐	☐	☐	☐
d. Välja material/produkter	☐	☐	☐	☐	☐	☐
e. Ordna finansiering	☐	☐	☐	☐	☐	☐

40. Enligt din uppskattning, hur stor blir kostnaden i svenska kronor för renoveringen (inklusive byte av värmesystem)?

- ☐ Vet ej
- ☐_____

41. Hur ska du finansiera renoveringen?

- ☐ Egen besparing
- ☐ Bolån
- ☐ Privat lån
- ☐ Annat (ange vad) _____

42. Hur väl stämmer följande om finansering för energirenovering?
(Med energirenovering menar vi åtgärder som kan minska energibehovet till motsvarande ett nytt hus eller mindre)

	Stämmer inte alls 1	2	3	4	Stämmer helt 5
a. Jag skulle vara intresserad av att energirenovera mitt hus om staten skulle införa lågräntelån för energirenovering av villor	☐	☐	☐	☐	☐
b. Det borde finnas ett särskilt bidrag för energirenovering av villor, där bidraget ökar med en ökad energibesparing	☐	☐	☐	☐	☐
c. ROT-avdraget måste kopplas till energiprestandan av renoveringen	☐	☐	☐	☐	☐
d. Banker har inget intresse av att ge lån för energirenovering	☐	☐	☐	☐	☐
e. Banker tar inte hänsyn till energiprestandan hos hus när de beviljar bolån	☐	☐	☐	☐	☐

43. Känner du till att det faktiskt finns entreprenör som erbjuder paketlösningar för energirenovering av villor, så att du skriver ett kontrakt med en entreprenör och därmed undviker att anlita/skriva kontrakt med flera företag?

- ☐ Ja
- ☐ Nej

Om ja, ange gärna nedan namnet på företag du känner till

_____

44. Vilken aktör erbjuder/kan erbjuda en sådan tjänst? (Flera alternativ kan väljas)	☐ Ett stort bygg-/renoveringsföretag ☐ Ett litet/mellanstort bygg-/renoveringsföretag ☐ Installatörer/hantverkare/snickare ☐ Elleverantörer/värmeleverantörer ☐ Småhustillverkare ☐ Annat (ange vad) _____

	Inte intresserad alls 1	2	3	4	Mycket intresserad 5
45. Hur intresserad är du av att energirenovera ditt hus om en entreprenör erbjuder en paketlösning för hela arbetet?	☐	☐	☐	☐	☐

46. Hur viktigt är det att följande ingår i en paketlösning för energirenoveringen?	Inte alls viktigt 1	2	3	4	Mycket viktigt 5
Kontrakt med en entreprenör	☐	☐	☐	☐	☐
En kontaktperson hos entreprenören	☐	☐	☐	☐	☐
Besiktning innan renovering och förslag på åtgärder	☐	☐	☐	☐	☐
Kostnads- och energibesparingskalkyl	☐	☐	☐	☐	☐
Fastpris på arbetskostnaden, exklusive material/produkter	☐	☐	☐	☐	☐
Fastpris på renoveringen där material/produkter ingår	☐	☐	☐	☐	☐
Garantier om kvalitet	☐	☐	☐	☐	☐
Garantier om att hålla tiden	☐	☐	☐	☐	☐
Garantier om att inget avbrott i el-/värme-/vattenförsörjning sker	☐	☐	☐	☐	☐
Oberoende besiktning efter renovering	☐	☐	☐	☐	☐
Finansiering	☐	☐	☐	☐	☐
Alternativt boende under renoveringstiden	☐	☐	☐	☐	☐
Söka bygglov	☐	☐	☐	☐	☐
Söka statliga bidrag	☐	☐	☐	☐	☐
Stegvis renovering enligt en bestämd tidsplan	☐	☐	☐	☐	☐
Annat (ange vad) _____	☐	☐	☐	☐	☐

47. Hur väl stämmer det med följande om varför du/ni ej är intresserad av en entreprenör som erbjuder paketlösningar för energirenovering?	Stämmer inte alls 1	2	3	4	Stämmer helt 5
a. Det bli mycket dyrt	☐	☐	☐	☐	☐
b. Man kan inte lita på eller ha kontroll över ett företag som erbjuder sådana tjänster	☐	☐	☐	☐	☐
c. Man kan inte lita på kvaliteten	☐	☐	☐	☐	☐
d. Du föredrar att välja olika entreprenörer för olika delar av renoveringen	☐	☐	☐	☐	☐
e. Annat (ange vad) _____	☐	☐	☐	☐	☐

48. Lämna gärna dina kontaktuppgifter om du vill veta mer om paketlösningar för energirenovering av villor, och/eller medverka i ett pilotprojekt om energirenovering av villor

.....

49. Var bor du?	☐ På landsbygden eller i en ort (utanför storstadsområdena) med mindre än 5000 invånare ☐ I en ort (utanför storstadsområdena) med 5 000–24 999 invånare ☐ I en ort (utanför storstadsområdena) med 25 000–175 000 invånare ☐ I ett storstadsområde (Storstockholm, Storgöteborg eller Stormalmö)
50. I vilket län är du bosatt	• Stockholms län • Uppsala län • Södermanlands län • Östergötlands län • Jönköpings län • Kronobergs län • Kalmar län • Gotlands län • Blekinge län • Skåne län • Hallands län • Västra Götalands län • Värmlands län • Örebro län • Västmanlands län • Dalarnas län • Gävleborgs län • Västernorrlands län • Jämtlands län • Västerbottens län • Norrbottens län

51. Vilket år är du född?	_____
52. Du är …	☐ Man ☐ Kvinna ☐ Annan
53. Är du gift/sambo?	☐ Ja ☐ Nej
54. Vilken är din högsta utbildning?	☐ Grundskola, folkskola, realskola eller liknande ☐ Gymnasieutbildning ☐ Universitets- eller högskoleutbildning ☐ Annat (ange vad)
55. Är du eller annan person i hushållen medlem i någon miljöorganisation?	☐ Ja ☐ Nej
56. Hur stor är hushållets ungefärliga sammanlagda årsinkomst före skatt?	☐ Upp till 300 000 SEK ☐ 300 001–450 000 SEK ☐ 450 001–600 000 SEK ☐ 600 001–750 000 SEK ☐ Mer än 750 000 SEK
57. Hur många personer bor i bostaden? *Räkna med alla vuxna och barn som bor i bostaden minst hälften av tiden.*	
a. Vuxna (18 år och äldre)	_____
b. Barn 13-17 år	_____
c. Barn 0-12 år	_____

Du är välkommen att göra egna tillägg eller kommentarer till enkäten

Tack för att du besvarat dessa frågor!

APPENDIX III – Parameters of analysis of data gathered from interviews with supply-side actors

CATEGORY	DIMENSION	EMPIRICAL INDICATORS
Access to trusted partners	Previous collaborations in accomplishing projects	Working together in past projects (municipal or private) Working together with local actors
	Appreciation of the craftsmanship of others	Rumours of good work/skill of others Showing mutual respect
	Acts of goodwill	Client referrals to one another Reciprocal provision of favours to one another
	Dedicated network-building activities	Presenting at/organizing industry events Networking as firm strategy Researching the background of other supply actors
	Sharing similar philosophy/vision	Speaking the same 'language Sharing similar philosophy and/or vision
Creating economies of scale	Local market limitations	(High) opportunity costs to EER activities in the region (Lack of) willingness to pay by customers in the region Losing face with customers for proposing expensive services (Lack of) suitable local partners (Delays in) customer acceptance
	Local market opportunities	Involving owners' associations to increase scale Local support schemes to boost demand Numbers of similar dwellings in the region

		Increased role of municipalities in supporting OSS emergence
	Multi-locality	Ambition/opportunity to scale beyond local context
Exchange governance capabilities	Own capabilities with respect to governing others	Availability of resources/capabilities to govern others Availability of structures and legal entities to govern others Fit with overall profile of the organization
	Experience in governing others	References to previous instances of governance performed by the organization and to the profile of those governed over
	Experience in end customer interaction	References to previous instances of customer contract governance and the complexity of those projects
	Opportunities for standardizing the offering	References to innovative approaches (technology) that enables standardizing renovation offerings
	Fears concerning transactions costs and governing of others	Willingness to guarantee the quality of others' work Conflicts arising from supply-side actors not aligning with each other Delays caused by coordination challenges Costs associated with ensuring profitability for all
	Financial attractiveness of performing governance	References to margin (expectations) and/or profitability of serving the OSS role
Production capabilities	Production profile of the organization	References to the extent of own production capabilities, and the corresponding scale of internalization (integration) of EER services
Perceived attractiveness	Belief in market emergence	Perceived alignment of OSS with

of OSS opportunity		broad societal/market trends Perceived influence on industry Growth Perceived match of OSS model with local context
	Strategic interest in being OSS	Overall conclusion and rationale on how the organization sees themselves regarding OSS – as coordinator, supplier, or else
	Perception of others' fit for becoming OSS	References and rationale for proposing other actors to become OSS

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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).

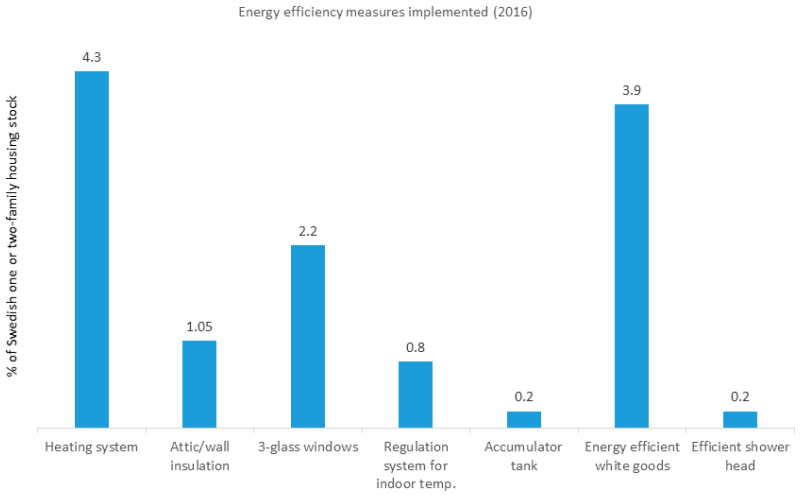

Figure 1. Average annual percentage of homeowners implementing different energy efficiency measures in Sweden (source: Swedish Energy Agency [8]).

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			

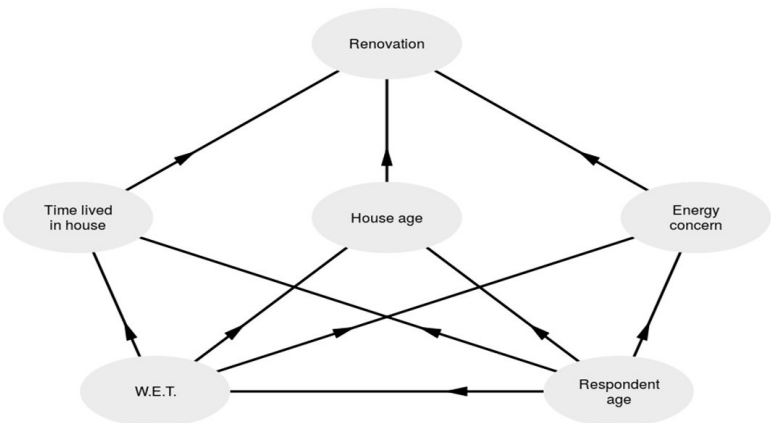

Figure 2. Structure of the renovation model.

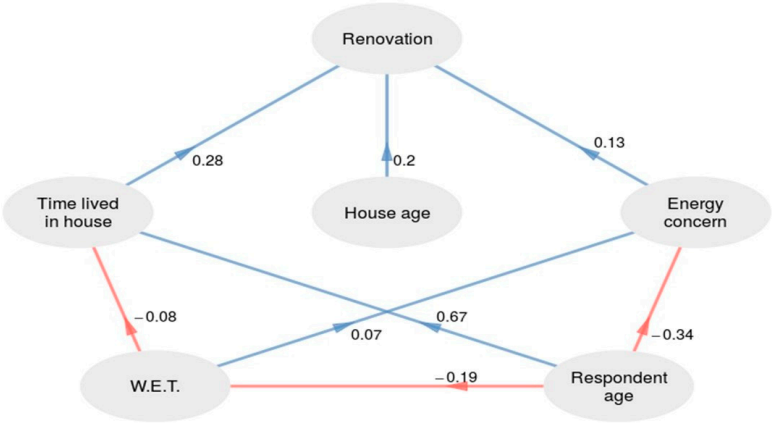

Figure 3. Path coefficients for the renovation PLSPM model.

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).

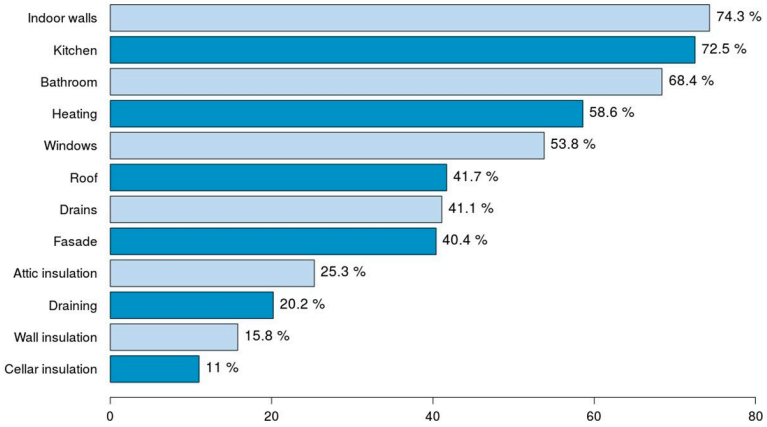

Figure 4. Frequency of renovation work by type.

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.

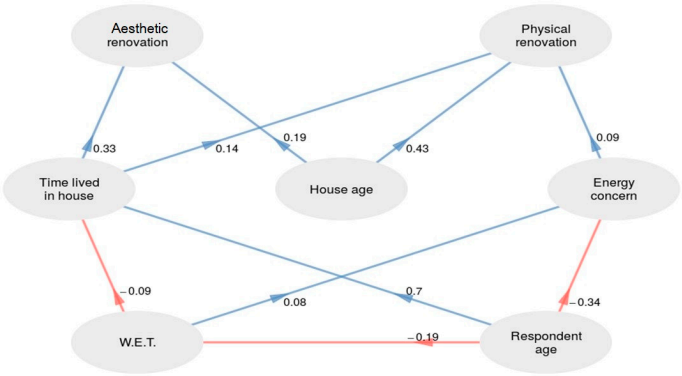

Figure 5. Path coefficients for the physical vs. aesthetic renovation model (significant paths only).

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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References

1. Brambilla, A.; Salvalai, G.; Imperadori, M.; Sesan, M.M. Nearly zero energy building renovation: From energy efficiency to environmental efficiency, a pilot case study. *Energy Build.* **2018**, *166*, 271–283. [CrossRef]
2. Economidou, M.; Atanasiu, B.; Despret, C.; Maio, J.; Nolte, I.; Rapf, O. *Europe's Buildings under the Microscope. A Country-by-Country Review of the Energy Performance of Buildings*; Buildings Performance Institute Europe (BPIE): Brussels, Belgium, 2011; pp. 35–36.
3. Eurostat. Distribution of Population by Dwelling Type, 2015 (% of Population) (2015). Available online: http://ec.europa.eu/eurostat/statistics-explained/images/e/e4/Distribution/_of/_population/ (accessed on 20 June 2018).
4. Swedish Energy Agency. Energy in Sweden: Facts and Figures. 2017. Available online: http://www.energimyndigheten.se/en/facts-and-figures/publications/ (accessed on 20 June 2018).
5. Boverket. *Förslag till Utvecklad Nationell Strategi för Energieffektiviserande Renovering Boverket [Proposal to Develop National Strategy for Energy Efficient Renovation]*; Boverket Publikationsservice: Stockholm, Sweden, 2015.
6. Mahapatra, K.; Gustavsson, L.; Haavik, T.; Aabrekk, S.; Svendsen, S.; Vanhoutteghem, L.; Paiho, S.; Ala-Juusela, M. Business models for full service energy renovation of single-family houses in Nordic countries. *Appl. Energy.* **2013**, *112*, 1558–1565. [CrossRef]
7. Boverket. *Energi i Bebyggelsen, Tekniska Egenskaper och Beräkningar: Resultat från Projektet BETSI [Energy in Buildings, Technical Characteristics and Calculations: Results from the Project BETSI]*; Boverket Publikationsservice: Stockholm, Sweden, 2010.
8. Swedish Energy Agency. *Energy Statistics for One- and Two-Dwelling Buildings in 2016 ES 2001-2017:06*; Swedish Energy Agency: Stockholm, Sweden, 2017.
9. Curtius, H.C. The adoption of building-integrated photovoltaics: Barriers and facilitators. *Renew. Energy* **2018**, *126*, 783–790. [CrossRef]
10. Jia, J.J.; Xu, J.H.; Fan, Y.; Ji, Q. Willingness to accept energy-saving measures and adoption barriers in the residential sector: An empirical analysis in Beijing, China. *Renew. Sustain. Energy Rev.* **2018**, *95*, 56–73. [CrossRef]
11. März, S. Beyond economics—Understanding the decision-making of German small private landlords in terms of energy efficiency investment. *Energy Effic.* **2018**, *11*, 1721–1743. [CrossRef]
12. Matosovic, M.; Tomšic, Ž. Evaluating homeowners' retrofit choices–Croatian case study. *Energy Build.* **2018**, *171*, 40–49. [CrossRef]
13. Matosovic, M.; Tomšic, Ž. Modeling energy efficiency investment choices—A case study on Croatia's residential sector. *Energy Sources Part B: Econ. Plan. Policy* **2018**, *13*, 311–319. [CrossRef]
14. Meijer, F.; Straub, A.; Mlecnik, E. Consultancy Centres and Pop-Ups as Local Authority Policy Instruments to Stimulate Adoption of Energy Efficiency by Homeowners. *Sustainability* **2018**, *10*, 2734. [CrossRef]
15. Karytsas, S. An empirical analysis on awareness and intention adoption of residential ground source heat pump systems in Greece. *Energy Policy* **2018**, *123*, 167–179. [CrossRef]
16. Petrovich, B.; Hille, S.L.; Wüstenhagen, R.; Petrovich, B.; Hille, S.; Wüstenhagen, R. Beauty and the Budget: Homeowners' Motives for Adopting Solar Panels in a Post-Grid Parity World. *Manuscript Accepted and*

Presented at 6th World Congress of Environmental and Resource Economists (June 2018). Available online: http://fleximeets.com/wcere2018/?p=programme (accessed on 7 November 2018).
17. Hrovatin, N.; Zoric, J. Determinants of energy-efficient home retrofits in Slovenia: The role of information sources. *Energy Build.* **2018**, *180*, 42–50. [CrossRef]
18. Dieu-Hang, T.; Grafton, R.Q.; Martínez-Espiñeira, R.; Garcia-Valiñas, M. Household adoption of energy and water-efficient appliances: An analysis of attitudes, labelling and complementary green behaviours in selected OECD countries. *J. Environ. Manag.* **2017**, *197*, 140–150. [CrossRef] [PubMed]
19. Mahapatra, K. Diffusion of Innovative Domestic Heating Systems and Multi-Storey Wood-Framed Buildings in Sweden. Doctoral Dissertation, Mid Sweden University, Sundsvall, Sweden, 2007.
20. Mahapatra, K.; Gustavsson, L. An adopter-centric approach to analyze the diffusion patterns of innovative residential heating systems in Sweden. *Energy Policy* **2008**, *36*, 577–590. [CrossRef]
21. Mahapatra, K.; Gustavsson, L. Adoption of innovative heating systems—Needs and attitudes of Swedish homeowners. *Energy Effic.* **2010**, *3*, 1–8. [CrossRef]
22. Christie, L.; Donn, M.; Walton, D. The 'apparent disconnect' towards the adoption of energy-efficient technologies. *Build. Res. Inf.* **2011**, *39*, 450–458. [CrossRef]
23. Stolyarova, E.; Le Cadre, H.; Osso, D.; Allibe, B. Stated preferences for space heating investment. Available online: https://hal-ensmp.archives-ouvertes.fr/hal-01160059/document (accessed on 9 November 2018).
24. Claudy, M.C.; Michelsen, C.; O'Driscoll, A. The diffusion of microgeneration technologies–assessing the influence of perceived product characteristics on home owners' willingness to pay. *Energy Policy* **2011**, *39*, 1459–1469. [CrossRef]
25. Sopha, B.M.; Klöckner, C.A. Psychological factors in the diffusion of sustainable technology: A study of Norwegian households' adoption of wood pellet heating. *Renew. Sustain. Energy Rev.* **2011**, *15*, 2756–2765. [CrossRef]
26. Tapaninen, A.; Seppänen, M.; Mäkinen, S. Characteristics of innovation in adopting a renewable residential energy system. *J. Syst. Inf. Technol.* **2009**, *11*, 347–366. [CrossRef]
27. Michelsen, C.C.; Madlener, R. Motivational factors influencing the homeowners' decisions between residential heating systems: An empirical analysis for Germany. *Energy Policy* **2013**, *57*, 221–233. [CrossRef]
28. Aravena, C.; Riquelme, A.; Denny, E. Money, comfort or environment? Priorities and determinants of energy efficiency investments in Irish households. *J. Consum. Policy* **2016**, *39*, 159–186. [CrossRef]
29. Nair, G.; Mahapatra, K.; Gustavsson, L. Implementation of energy-efficient windows in Swedish single-family houses. *Appl. Energy.* **2012**, *89*, 329–338. [CrossRef]
30. Nair, G.; Mahapatra, K.; Gustavsson, L. Influence of external actors in Swedish homeowners' adoption of energy efficient windows. In Proceedings of the World Renewable Energy Congress 2011, Linköping, Sweden, 8–11 May 2011; Linköping University Electronic Press: Linköping, Sweden, 2011.
31. Nair, G.; Hemström, K.; Mahapatra, K.; Gustavsson, L. Role of sellers/installers in the diffusion of energy efficient windows in Swedish detached houses. In Proceedings of the SB10: Sustainable Community, Espoo, Finland, 22–24 September 2010.
32. Nair, G. Implementation of Energy Efficiency Measures in Swedish Single-Family Houses. Doctoral Dissertation, Mid Sweden University, Östersund, Sweden, 2012.
33. Högberg, L. The impact of energy performance on single-family home selling prices in Sweden. *J. Eur. Real Estate Res.* **2013**, *6*, 242–261. [CrossRef]
34. Zavadskas, E.; Raslanas, S.; Kaklauskas, A. The selection of effective retrofit scenarios for panel houses in urban neighborhoods based on expected energy savings and increase in market value: The Vilnius case. *Energy Build.* **2008**, *40*, 573–587. [CrossRef]
35. Baumhof, R.; Decker, T.; Röder, H.; Menrad, K. An expectancy theory approach: What motivates and differentiates German house owners in the context of energy efficient refurbishment measures? *Energy Build.* **2017**, *152*, 483–491. [CrossRef]
36. Baumhof, R.; Decker, T.; Röder, H.; Menrad, K. Which factors determine the extent of house owners' energy-related refurbishment projects? A Motivation-Opportunity-Ability Approach. *Sustain. Cities Soc.* **2018**, *36*, 33–41. [CrossRef]
37. Achtnicht, M.; Madlener, R. Factors influencing German house owners' preferences on energy retrofits. *Energy Policy* **2014**, *68*, 254–263. [CrossRef]

38. Abreu, M.I.; Oliveira, R.; Lopes, J. Attitudes and practices of homeowners in the decision-making process for building energy renovation. *Procedia Eng.* **2017**, *172*, 52–59. [CrossRef]
39. Klöckner, C.A.; Sopha, B.M.; Matthies, E.; Bjørnstad, E. Energy efficiency in Norwegian households–identifying motivators and barriers with a focus group approach. *Int. J. Environ. Sustain. Dev.* **2013**, *12*, 396–415. [CrossRef]
40. Klöckner, C.A.; Nayum, A. Psychological and structural facilitators and barriers to energy upgrades of the privately owned building stock. *Energy* **2017**, *140*, 1005–1017. [CrossRef]
41. Bjørneboe, M.G.; Svendsen, S.; Heller, A. Initiatives for the energy renovation of single-family houses in Denmark evaluated on the basis of barriers and motivators. *Energy Build.* **2018**, *167*, 347–358. [CrossRef]
42. Das, R.; Richman, R.; Brown, C. Demographic determinants of Canada's households' adoption of energy efficiency measures: Observations from the Households and Environment Survey, 2013. *Energy Effic.* **2018**, *11*, 465–482. [CrossRef]
43. Salo, M.; Nissinen, A.; Lilja, R.; Olkanen, E.; O'Neill, M.; Uotinen, M. Tailored advice and services to enhance sustainable household consumption in Finland. *J. Clean. Prod.* **2016**, *121*, 200–207. [CrossRef]
44. Bartiaux, F.; Gram-Hanssen, K.; Fonseca, P.; Ozoliņa, L.; Christensen, T.H. A practice–theory approach to homeowners' energy retrofits in four European areas. *Build. Res. Inf.* **2014**, *42*, 525–538. [CrossRef]
45. Klöckner, C.A.; Nayum, A. Specific Barriers and Drivers in Different Stages of Decision-Making about Energy Efficiency Upgrades in Private Homes. *Front. Psychol.* **2016**, *7*, 1362. [CrossRef] [PubMed]
46. Klöckner, C.A. Psychological determinants of intentions to upgrade the energy standards of privately-owned buildings: Results from a Norwegian survey. *Int. J. Sustain. Build. Technol. Urban Dev.* **2014**, *5*, 222–229. [CrossRef]
47. Zundel, S.; Stieß, I. Beyond profitability of energy-saving measures—attitudes towards energy saving. *J. Consum. Policy* **2011**, *34*, 91–105. [CrossRef]
48. Lohmöller, J.B. *Latent Variable Path Modeling with Partial Least Squares*; Springer Science & Business Media: Berlin, Germany, 2013.
49. Esposito Vinzi, V.; Russolillo, G. Partial least squares algorithms and methods. *Wiley Interdiscip. Rev. Comput. Stat.* **2013**, *5*, 1–9. [CrossRef]
50. Godin, G.; Conner, M.; Sheeran, P. Bridging the intention–behaviour gap: The role of moral norm. *Br. J. Soc. Psychol.* **2005**, *44*, 497–512. [CrossRef] [PubMed]
51. Rogers, E.M. *Diffusion of Innovations*; Simon and Schuster: New York, NY, USA, 2010.
52. Länsstyrelsen i Kronobergs Län. *Energikontor Sydost: Climate and Energy Strategy for Kronoberg County and the Region of Southern Småland*; Länsstyrelsen i Kronobergs Län: Växjö, Sweden, 2010.
53. Löhr, M.; Mante, C.; Mörl, K.; Schulz, A. (Eds.) Improving Energy Efficiency—EnercitEE. Saxon State Ministry of the Environment and Agriculture. Available online: http://www.bing.com/cr?IG=548A62338FC744C5831E45D1BE0B1301&CID=30A6BC807A286B40245BB09A7BD56AD5&rd=1&h=OKBkxlq4GK9DL4Vkpfnz7j5HhdRImMEzBWgnSRxiPI&v=1&r=http://enercitee.eu/files/dokumente/FinalHandbook_single-pages.pdf&p=DevEx.LB.1,5071.1 (accessed on 26 June 2018).
54. Stieß, I.; Zundel, S.; Deffner, J. Making the home consume less–putting energy efficiency on the refurbishment agenda. In Proceedings of the Conference Proceedings: ECEEE Summer Studies, La Colle sur Loup, France, 1 July 2009.
55. Risholt, B.; Berker, T. Success for energy efficient renovation of dwellings—Learning from private homeowners. *Energy Policy* **2013**, *61*, 1022–1030. [CrossRef]
56. Mills, B.; Schleich, J. Residential energy-efficient technology adoption, energy conservation, knowledge, and attitudes: An analysis of European countries. *Energy Policy* **2012**, *49*, 616–628. [CrossRef]
57. Stieß, I.; Dunkelberg, E. Objectives, barriers and occasions for energy efficient refurbishment by private homeowners. *J. Clean. Prod.* **2013**, *48*, 250–259. [CrossRef]
58. Mahapatra, K.; Gustavsson, L. Innovative approaches to domestic heating: Homeowners' perceptions and factors influencing their choice of heating system. *Int. J. Consum. Stud.* **2008**, *32*, 75–87. [CrossRef]
59. Leather, P.; Littlewood, A.; Munro, M.; Lancaster, S. *Make Do and Mend?: Explaining Homeowners' Approaches to Repair and Maintenance*; Policy Press: Bristol, UK, 1998.
60. Organ, S.; Proverbs, D.; Squires, G. Motivations for energy efficiency refurbishment in owner-occupied housing. *Struct. Surv.* **2013**, *31*, 101–120. [CrossRef]

61. Steemers, K.; Yun, G.Y. Household energy consumption: A study of the role of occupants. *Build. Res. Inf.* **2009**, *37*, 625–637. [CrossRef]
62. Huebner, G.M.; Cooper, J.; Jones, K. Domestic energy consumption—What role do comfort, habit, and knowledge about the heating system play? *Energy Build.* **2013**, *66*, 626–636. [CrossRef]
63. Hamrin, J. Energy-saving Homes-Don't Bet on Technology Alone. *Psychol. Today* **1979**, *12*, 18.
64. Santin, O.G. Behavioural patterns and user profiles related to energy consumption for heating. *Energy Build.* **2011**, *43*, 2662–2672. [CrossRef]
65. Wilson, C.; Crane, L.; Chryssochoidis, G. *Why Do People Decide to Renovate Their Homes to Improve Energy Efficiency*; Working Paper; Tyndall Centre for Climate Change Research: Norwich, UK, 2013.
66. Gram-Hanssen, K. Existing buildings–Users, renovations and energy policy. *Renew. Energy.* **2014**, *61*, 136–140. [CrossRef]
67. Sunikka-Blank, M.; Galvin, R. Irrational homeowners? How aesthetics and heritage values influence thermal retrofit decisions in the United Kingdom. *Energy Res. Soc. Sci.* **2016**, *11*, 97–108. [CrossRef]
68. Sohail, M.; Cavill, S.; Cotton, A.P. Sustainable operation and maintenance of urban infrastructure: Myth or reality? *J. Urban Plan. Dev.* **2005**, *131*, 39–49. [CrossRef]
69. Costanzo, M.; Archer, D.; Aronson, E.; Pettigrew, T. Energy conservation behavior: The difficult path from information to action. *Am. Psychol.* **1986**, *41*, 521–528. [CrossRef]
70. Aksoezen, M.; Daniel, M.; Hassler, U.; Kohler, N. Building age as an indicator for energy consumption. *Energy Build.* **2015**, *87*, 74–86. [CrossRef]
71. Fyhn, H.; Baron, N. The nature of decision making in the practice of dwelling: A practice theoretical approach to understanding maintenance and retrofitting of homes in the context of climate change. *Soc. Nat. Resour.* **2017**, *30*, 555–568. [CrossRef]
72. Baruch, Y.; Holtom, B.C. Survey response rate levels and trends in organizational research. *Hum. Relat.* **2008**, *61*, 1139–1160. [CrossRef]
73. ISSP Research Group. *International Social Survey Programme: Environment III-ISSP 2010*; GESIS Data Archive, Cologne, ZA5500 Data File Version; ISSP Research Group: Cologne, Germany, 2012; Volume 2. [CrossRef]

II

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Article

Swedish House Owners' Intentions Towards Renovations: Is there a Market for One-Stop-Shop?

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Abstract: In this paper, we examine factors affecting owners' intention for renovation of their detached houses. Furthermore, we analyze their interest in choosing a one-stop-shop (OSS) service for the renovation, even though such a concept is not yet established in Sweden, but emerging in other parts of Europe. Our study is based on responses to an online questionnaire survey of 971 house owners residing in Kronoberg Region in Sweden. About 76% of the respondents intend to renovate in the near future, with approximately 71% of them preferring to renovate individual components of their dwelling and 5% to renovate their whole house in steps. House owners of younger age, higher income, higher education, and those with an interest for environmental issues, were the ones most interested in physical renovations, which improves energy efficiency of the building. For those house owners, one-stop-shop can facilitate the decision-making process, and help them to choose those measures that will improve their quality of life. Approximately 20% of the respondents had a positive view towards an one-stop-shop, which is an indicator that market for such a service exists. Parameters such as quality of work, cost and energy savings and specification of measures to be adopted are the key for the promotion of one-stop-shop. Additionally, house owners want to have a certain level of involvement in the selection of actors performing the renovation. Moreover, financial incentives, e.g., loans, do not play a significant role for the selection of one-stop-shop, but act as complementary motive for house owners.

Keywords: house owners; detached house; renovation; retrofit; energy efficiency; one-stop-shop

1. Introduction

The European Union has recently set a new goal of 32.5% energy efficiency for 2030 compared to the levels of 2005. Efforts towards the improvement of the energy efficiency of the housing stock is essential to the decrease of negative effects of climate change and energy systems objectives [1]. Scenarios for the energy use in buildings show an increase of up to five times by 2100 compared to 2010 [2]. Furthermore, European Union Directives urge member states to develop long-term strategies for investments in building renovations, with a goal that the existing building stock be renovated by 2050 [3,4].

Sweden has a cross-sectoral target of reducing energy intensity by 20% between 2008 and 2020. Especially for the building sector, Sweden has a national goal to reduce energy consumption by 20% compared to the 1995 level by the year 2020 [5]. The residential sector could be a major contributor to achieve this target, as it is responsible for almost 40% of the total energy use, with 12% of it coming from single-family houses [6]. Out of 4.7 million residential dwellings, 51% (2.4 million) are one- or two-family houses (stand-alone houses or houses divided either vertically or horizontally and designed

for two families occupying separate apartments), and they account for 293 million square meters of floor area, which is larger than that of multi-family houses [7].

According to Statistics Central Bureau (SCB) in Sweden, 86% of the one- and two-family dwellings are about 30 years old. They have poor energy standard and are in need of renovation. About 50% of these houses use direct electricity heating or in combination with air-source heating [8]. Moreover, in these old houses, technical installations are likely to be close to the end of their expected life cycle and need replacement.

Renovations in multi-family dwellings, which are carried out by medium to large contractors, have been in the center of political debate in Sweden [9], and a subject of different studies [10–13]. On the other hand, discussions about the renovations of one or two-family dwellings are falling behind. For those houses, energy efficiency is not the main renovation rationale, but a potential additional benefit in a renovation project [14].

Renovations of kitchen and bathrooms are still the most dominant activities, and usually the return on such an investment is rather low, as it has been found in studies in Germany and some other European countries [15,16]. In Sweden, house owners carry out renovations, which in small numbers are related to interventions towards improving energy efficiency (e.g., additional ceiling/wall insulation, change of windows, and installation of an advanced heating system) [17]. The same situation applies to other European countries [18,19], where energy renovations seem not to have become a common practice among house owners.

There is large potential for energy efficiency improvements in house renovations, but that potential is not realized due to various barriers. The existing literature examines the reasons for the "energy efficiency gap" [20,21] and explains investments on products and services would improve energy efficiency levels [22]. Results show that investments on those, at this stage, are low, compared to other investment opportunities available in the market [23,24].

Haavik et al. [25] argued that renovation should be a learning process for house owners, as they become aware of the measures they can or should perform in their dwelling, to improve its overall energy performance. Mahapatra et al. [26] described a full-service renovation concept named One-Stop-Shop (OSS). This concept consists of five phases, namely initial evaluation, thorough analysis, proposal of a set of solutions, coordinated execution of the renovation and quality assurance and continued commissioning of the house. Such a concept guides house owners through all the phases of renovation, allowing the adoption of those measures that will improve the energy performance of the dwelling, while at the same time it offers them a renovated house that satisfies their needs. One-stop-shop as a concept has been proposed or tested as a guide in national contexts, such as Norway [27] and Denmark [28]. In Sweden, one-stop-shop still is a theoretical concept for house renovations [26].

For that purpose, renovations are divided in two categories. Physical renovations, which are renovations related to the improvement of the energy performance of the dwelling, and which often require interventions in the building envelope, and aesthetic renovations, which are related to the aesthetic improvement of the dwelling (new kitchen or bathroom, painting the walls or install new wallpaper, etc.).

There exist several studies on house owners' decision-making towards renovations [29–34]. Each of these studies apply to specific contexts. Therefore, the need to examine country-specific factors affecting house owners' decisions to renovate is important to design intervention measures, as these factors are influenced by the political, economic, social and cultural context of each country. In a previous study [35], we examined factors that influence Swedish house owners' decisions to renovate in the past. The study showed that majority of the households had performed aesthetic renovation in the past and limited households had performed physical renovation in steps. In most cases, house owners would like to tailor the renovation package to their specific wishes providing less importance to the proper sequence and scope of necessary renovation tasks to gain synergy in the entire renovation project [36]. In this paper, we examine the factors affecting Swedish house owners'

decisions to renovate in the near future in general, and the preferred type of renovation in particular. We are interested in understanding the pathway that leads to the intention/plan for future renovation and to examine if such decisions are influenced by the renovation performed in the past.

The European Commission through the "Smart financing for smart buildings" initiative and through the "new" Energy Performance of Buildings Directive (EPBD) supports one-stop-shop concepts as part of the Directive 2018/844/EU [37]. In this particular directive [4], "Member States are required to facilitate access to appropriate mechanisms for accessible and transparent advisory tools, such as one-stop-shops for consumers and energy advisory services, on relevant energy efficiency renovations and financing instruments." Since one-stop-shop models in the European Union are at an initial stage of market development, it is important to know if a market for that concept exists, and who can be the beneficiaries from this model. Analyzing the potential interest of Swedish house owners on one-stop-shop helps us to acquire knowledge regarding the level of market in the country, and those specific attributes of house owners interested to renovate their dwelling with that model. The results can be used as a guide on a broader European level for the further development of the concept in the future. Moreover, this paper analyzes the potential interest of Swedish house owners on a one-stop-shop concept for renovation.

The study was based on the responses to an online questionnaire survey of 971 house owners in Kronoberg County, focusing on their plans to renovate until 2020. Examining house owners' plans for renovation provided understanding on how these house owners think and the factors that can affect their decisions. Kronoberg County is an interesting setting for this study as it has energy efficiency and sustainability central to its development strategy [38].

2. Literature Review

The inadequate adoption of energy efficient measures by the house owners is a subject widely examined in the literature. Several studies identify the factors motivating or preventing house owners from adopting such measures (e.g., [27,29–35,37–41]). In general, the decision of house owners regarding energy efficiency related renovations is the outcome of different factors, which can act either as motives or as barriers for those decisions. Weiss et al. [42] excluded from the agenda potential barriers and motives that have to do with regulatory instruments, as those instruments can be addressed and renewed as long as we understand the broader set of motives and barriers house owners are facing towards performing energy renovations. The rest can be divided into the following broader categories: (1) economic factors; (2) behavioral factors; (3) physical factors related to the house; and (4) social factors. Before examining those different categories, it is important to understand the overall context of renovation decisions.

2.1. Contexts of Renovation Decisions

According to Guy and Shove [43], "greater attention should be paid to the changing contexts of energy-related decision making". For energy efficient renovation, these "changing contexts" are closely connected to life at home, or, as Maller and Horne [44] specified it, "the conventions and practices of households" (p61). The decision to renovate and the selection of what needs to be renovated, derives from the need of households to adapt to the changing demands of domestic life. Karvonen [45] claimed that "Domestic retrofit is not an activity of changing a house from poor energy performance to exceptional energy performance, but an intervention into the rhythms of domestic habitation". From a decision-making perspective, households do not consider the adoption of energy efficiency measures as a separate type of renovations. Previous research has found that adoption of energy efficiency measures often is combined with expansions or intensifications of other parts of the dwelling [46]. That can lead us to the conclusion that the decision-making process for a renovation is not something static, but the outcome of a "journey" for house owners leading to the decision of what needs to be done.

Wilson et al. [47] developed a decision model depicting the decision-making process of each household towards renovations (Figure 1). In this model, the stages of the renovation decision process are "thinking about" (Stage 1), "planning" (Stage 2), and "finalizing" renovations (Stage 3). A final "experiencing" stage describes how households experience and adapt domestic life to the structural changes made to their home. The transition from each stage to the other is affected by factors which are described in the following subsections.

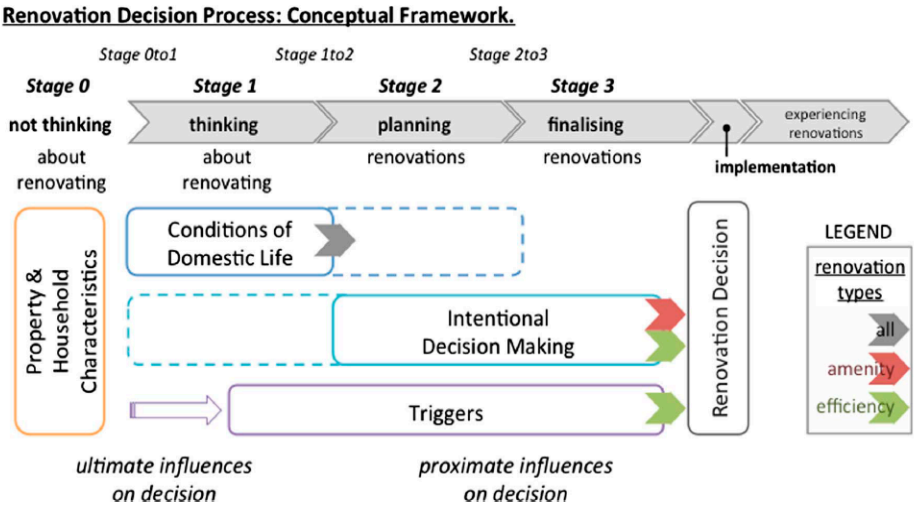

Figure 1. Conceptual framework for renovation decision made in the context of everyday domestic life (retrieved from [47]).

2.2. Economic Factors

High cost of investment for energy efficient renovations and the lack of financial resources from house owners' side is the most common preventing factor appearing in studies [31,35,48–52]. There is a need for a significant upfront funding to overcome that barrier [26]. Furthermore, the banking system, and especially the interest rates of loans, have a great impact on the feasibility of renovations. Those households seeking for financial support for a renovation project banks might get demotivated since there is a lack of funding opportunities for such projects, with the existing opportunities not having acceptable terms that could ensure investments in energy efficiency measures [53]. Additionally, transaction costs have been found to affect negatively the renovation decision. Mundaca et al. [54] interpreted it as part of "hidden costs" that have not been adequately considered in the initial cost analysis of a household. Households with higher income are more positively inclined to adopt energy efficient measures, while families with lower income are reluctant to proceed in such an investment [30]. The low-income households, when deciding to perform a renovation, are more likely to perform a more obvious change in their dwelling, such as changing a bathroom or kitchen [55]. The financial returns from an investment in energy efficiency measures is considered another motivating factor for house owners. Many house owners consider that the financial returns from investments in multiple energy efficiency measures are negative [56], while others find a strong motive in their belief that potential energy savings will pay off their initial investment [57]. Those house owners who find a negative relationship between multiple energy efficiency investments and financial returns are more willing to adopt the energy efficiency measures that will bring them short term investment returns, especially if the investment cost for them is modest [58]. For households consuming a vast amount of energy, lowering the energy needs and thus the cost is a significant motive [59].

2.3. Behavioral Factors

Many studies highlight that the motivations and barriers to individual behaviors have great influence on decision-making [60,61]. House owners' decisions to renovate or not, and the type of preferred renovation (physical or aesthetic), are influenced by factors such as environmental awareness, age, lack of awareness or uncertainty regarding which artisans are capable of performing energy renovations, and personal attitude. House owners, who show sensitivity for environmental subjects and show a high level of environmental awareness, are more inclined to adopt energy efficiency measures [62]. Their awareness is also the determining factor of the specific measures they are going to adopt [31,63]. Moreover, the feeling that they contribute to a broader goal (e.g., protection of environment) enforces the feeling of fulfillment and motivates them to adopt measures and behaviors towards that direction [64].

Older house owners are usually more able to invest in energy efficiency, preferring however to make the least of changes (e.g., using energy efficient light bulbs), while younger house owners being more probable to actually adopt energy efficient measures [34]. Middle-aged house owners, and especially those having families, despite their willingness to invest in energy efficiency, tend to adopt only the absolutely necessary measures [34]. The perception of house owners regarding the acceptable levels of comfort in their dwelling motivates them to proceed in mediocre energy-efficient renovations, compared to very technical packages of changes proposed, which cannot be fully understood by them [65].

An important factor in the adoption decision is the experience of a renovation in the past. House owners who have performed a renovation, become more aware, and gain the ability to make more rational choices in the measures they need to adopt [17]. Risholt and Barker [27] claimed that house owners' decisions to renovate has a qualitative basis. House owners whose goal is modernizing the look of their dwelling, improve their lifestyle and their behavior as dwellers by simply proceeding with a renovation to change social status [35]. Moreover, it is important for house owners not to be pushed to see energy saving as an individual goal. If energy saving becomes a part of a more integrated process, which includes other improvements on their house, then they are more willing to consider energy efficient solutions [14,30]. The availability of trustworthy technical solutions and policies supporting energy efficiency and allowing house owners to benefit from it is a significant motive to renovations of that type [35]. However, the most common barrier for house owners is their lack of awareness regarding availability of competent companies, and trust on them in executing renovations [66]. This barrier is less visible, when house owners deal with professionals that have performed more renovation projects and gained experience [67,68].

2.4. Physical Factors

Physical factors are related to the physical condition of the house, such as age, state of the envelope, and needs for extensions or comfort improvements. The later has been found to be a great motive for the decisions of house owners to adopt energy-efficiency measures [31,42,43,46,69–73]. The willingness of house owners to improve the appearance, architecture and generally update the physical context of the property can act as strong motives [14,74].

2.5. Social Factors

A supportive social environment (support from family, appreciation by neighbors etc.) increases the motivation of house owners to undertake a renovation project [30]. Especially, for energy related renovations, a supporting social environment has a positive influence on house owners, both on the decision-making process but also during the renovation itself [75]. Another motivation is the presentation of the best practice renovated house to "Future Renovators" [76]. This practice can motivate house owners who have decided to undertake a renovation project to implement more optimized measures and adopt a holistic approach to the renovation project. Additionally, it can act

as a strong motivational factor even to those house owners who do not have in mind to perform any renovation at all [76]. The best practice approach can also improve the information channels between house owners towards understanding the benefits they can gain from adopting optimized measures [46]. Through those communication channels, they can get trustworthy answers to potentially similar concerns, which made them reluctant to undertake a renovation.

3. Methods and Data

The data analyzed in this study was gathered from an online survey of house owners in the Kronoberg Region, Sweden, conducted in late spring 2017. The survey included different sections related to respondents' demographic characteristics, characteristics of their dwelling, past experiences on renovation, plans for renovation up to 2020, and perception towards a holistic service for house renovation among others. The house insurance company Länsförsäkring Kronoberg (the daughter company of Länsförsäkring AB, a Swedish federation of 23 mutual insurance companies owned by the customers) emailed the online questionnaire to 7193 house owners. A total of 971 house owners answered after one reminder. The response rate of 13.5% is in line with the standards for online surveys [77]. All statistical analyses were performed using the *R 3.4* platform [78]

To better understand the complex causal relationships among the factors affecting the owners' decisions, we estimated a structural equation model using a partial least square approach, a technique also known as partial least squares path modeling (PLSPM) [79,80]. This technique—which has found large application in marketing and tourism studies [81–84] and in construction research [85]—employs rigorous statistical tools [86] to estimate models including complex cause–effect relationships. Models usually comprise both manifest variables and latent constructs, i.e., variables that are not directly observable but can be inferred from the data. More specifically, any PLSPM is built in two steps. 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 estimated quantitatively by considering the overall network as a system of multiple interconnected linear regressions.

4. Presentation of Findings

4.1. Non-Response Bias

Since only 13.5% of those surveyed responded, it was important to check that they represent the house owners living in Kronoberg County. Therefore, we compared the distribution of our results with data from the Swedish Statistics Central Bureau (SCB). The distribution in our sample of the age of house owners and the construction year of houses is broadly consistent with data from Statistics Sweden (SCB), even if the number of older houses (i.e., built before 1931) looks somewhat underrepresented (Table 1). On the other hand, the number of houses built between 1961 and 1990 are slightly over-represented, which may have actually made our results more interesting as many of the houses built in that period have low energy standards, but better from similar buildings of an older age, and need to be renovated, and hence represent a crucial target for our purposes.

Table 1. Distribution (%) of age of house owners and house construction year in our sample compared to SCB data.

Age Group (Years)	<29	30–39	40–49	50–59	60–69	70–79	>79	
Survey	2.69	18.29	16.05	20.76	23.23	16.95	2.02	
SCB data	2.45	11.61	19.14	20.83	21.05	16.90	8.03	
Year built	<1940	1941–1950	1951–1960	1961–1970	1971–1980	1981–1990	1991–1900	>2001
Survey	19.53	6.65	6.54	17.24	29.91	10.18	3.84	6.13
SCB Data	31.44	7.18	8.29	15.76	22.28	6.73	2.41	5.9

4.2. Renovation Plans for the Near Future

Most house owners have planned to renew at least some parts of the house while only a small minority (about 5.5% of the respondents) declare that they will renew the whole house, in most cases step by step (Figure 2a). Most items to be renewed are related to the aesthetic aspects of the house—such as the kitchen, bathroom or indoor walls—while the windows are the most common item in this list having a significant impact on the building energy consumption (Figure 2b).

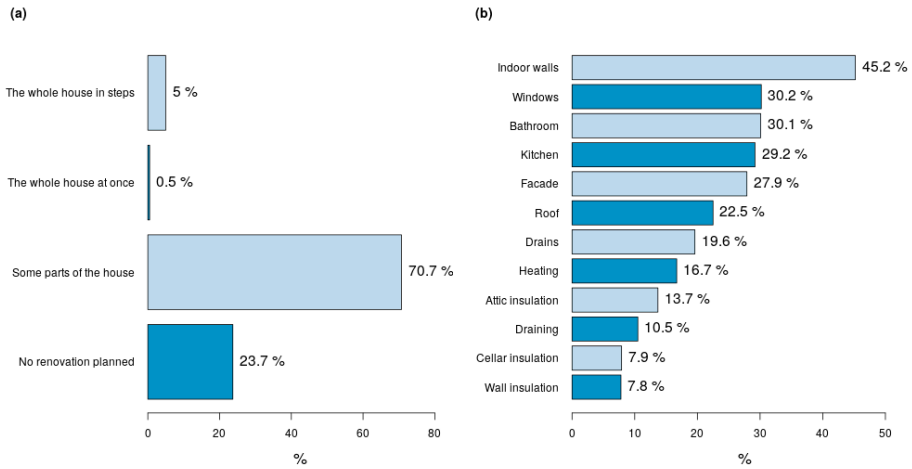

Figure 2. Frequency distribution for the renovation prospects as a whole (**a**) and the items that respondents are planning to renew (**b**).

To model the complex causal relationships leading to the decision for renovation, we estimated a PLSPM. The outcomes of interest for our model are latent construct reflecting comfort and physical renovation, respectively. They are supposed to be affected by several variables, both manifest and latent, which are derived from the survey answers. The resulting model structure is shown in Figure 3a, while a description of the variables included in the model is presented below.

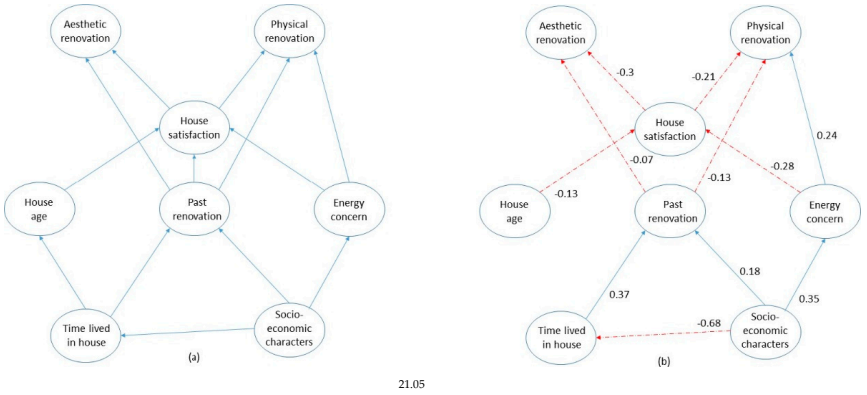

Figure 3. PLSPM analysis of physical and aesthetic renovation plans: (**a**) the model structure; and (**b**) the path coefficient estimates (paths with negative coefficients are dashed, and non-significant paths are omitted).

The time lived in the house, the house age and whether renovation works were performed in the past are included in the model as manifest variables, directly drawn from the survey data. The socioeconomic characteristics is instead a latent configuration based on data about the respondent's age, income and education and takes higher values for younger, higher income and higher education respondents (Dillon–Goldstein's (DG) r = 0.70; a DG coefficient ≥ 0.7 is usually considered good, while coefficients ≥ 0.6 are considered acceptable). The energy concern construct was estimated based on questions about the importance for the house owners to save energy and their willingness to adopt technical and behavioral measures to do so (DG r = 0.79). The house satisfaction construct derived from a battery of questions on different aspects concerning the current satisfaction with the house, such as size, aspect, energy costs, etc. (DG r = 0.87). The comfort renovation construct reflects works to renovate the kitchen, bathroom and indoor walls (DG r = 0.80). The physical renovation construct instead reflects works linked to the attic, cellar or wall insulation, draining, windows, roof, facade, drains, and the heating system (DG r = 0.84).

Figure 4b shows the resulting model, with path coefficient estimates, while Table 2 reports the direct, indirect and total effect of each variable. The overall goodness of fit of the model is 0.25. Bootstrap validation was performed, confirming the robustness of the effect estimates. The physical renovation of the house is affected positively by the socioeconomic characteristics and the energy concern of the respondent, while having already done some renovation in the past and being satisfied with the current house conditions (main effects only) negatively affect it. The comfort renovation of the house is only weakly positively affected by the house age, energy concerns and socioeconomic characteristics, while it is affected negatively by past renovations and, especially, house satisfaction.

Table 2. Direct, indirect and total effects in the renovation model.

Relationships	Direct	Indirect	Total
Socioeconomic characters -> Time lived in house	−0.68	0.00	−0.68
Socioeconomic characters -> Energy concern	0.35	0.00	0.35
Socioeconomic characters -> Past renovation	0.18	−0.25	−0.08
Socioeconomic characters -> House age	0.00	−0.002	−0.02
Socioeconomic characters -> House satisfaction	0.00	−0.09	−0.09
Socioeconomic characters -> Physical renovation	0.00	0.11	0.11
Socioeconomic characters -> Aesthetic renovation	0.00	0.03	0.03
Time lived in house -> Past renovation	0.37	0.00	0.37
Time lived in house -> House age	0.02	0.00	0.02
Time lived in house -> House satisfaction	0.00	−0.01	−0.01
Time lived in house -> Physical renovation	0.00	−0.04	−0.04
Time lived in house -> Aesthetic renovation	0.00	−0.02	−0.02
Energy concern -> House satisfaction	−0.28	0.00	−0.28
Energy concern -> Physical renovation	0.24	0.06	0.29
Energy concern -> Aesthetic renovation	0.00	0.08	0.08
Past renovation -> House satisfaction	−0.03	0.00	−0.03
Past renovation -> Physical renovation	−0.13	0.01	−0.12
Past renovation -> Aesthetic renovation	−0.07	0.01	−0.07
House age -> House satisfaction	−0.13	0.00	−0.13
House age -> Physical renovation	0.00	0.03	0.03
House age -> Comfort renovation	0.00	0.04	0.04
House satisfaction -> Physical renovation	−0.21	0.00	−0.21
House satisfaction -> Comfort renovation	−0.30	0.00	−0.30

4.3. Interest for the One-Stop-Shop (OSS) Concept

The survey included a question about the interest for energy renovation of the house in the case a single entrepreneur would offer a comprehensive package for the work. The possible responses were coded on a scale from 1 to 5, where 1 means not at all interested and 5 very interested. About 15% of the respondents indicated a value of 4, and 6% indicated 5, showing an appreciable interest for the one-stop-shop concept. This 21% of interested house owners corresponds to the 16% of innovators/early adopters required for innovation diffusion [87]. The distribution of socioeconomic characteristics of this group shows that middle-aged, high-educated and high-income owners (Table 3) are interested in one-stop-shop.

Among the aspects that the most interested respondents marked as more important for the success of a comprehensive package for energy renovation are the guarantee of the work quality (with an average mark of 4.7/5), clear work costs and estimations of future energy savings (4.6/5) and careful inspections and suggestions before starting the work (4.4/5). The least important aspects instead were the provision of alternative lodging opportunities during the renovation work (2.8/5) and the possibility of getting a loan as part of the package (3.6/5). The respondents that were not interested in one-stop-shop mentioned higher cost (3.4/5) and the freedom to choose different companies for different tasks themselves (3.2/5) as main reasons for their answer.

To understand better the factors affecting the interest for comprehensive energy renovation, we estimated a PLSPM model similar to the one above, although with just one terminal node reflecting the question about the respondents' interests in the one-stop-shop concept (Figure 3a).

Table 3. Distribution (percentage) of socioeconomic characteristics for high interested respondents.

Age (years)	**<30**	**30–50**	**50–70**	**>70**	
	4.5	47.7	36.4	11.4	
Education	Primary school	High school	University	Other	
	8.3	35.2	55.4	1.0	
Household income	<300K SEK	300K–400K SEK	400K–600K SEK	600K–750K SEK	>750K SEK
	9.4	15.7	23.0	22.5	29.3

The time lived in the house, the house age and whether renovation works were performed in the past entered the model as manifest variables. The socioeconomic characters (Dillon– Goldstein's r = 0:70), the energy concern (DG r = 0:79) and the house satisfaction (DG r = 0:87) were instead estimated as latent constructs as above.

Figure 4b shows the resulting model, with path coefficient estimates, while Table 4 reports the direct, indirect and total effect of each variable. The overall goodness of fit (the "goodness of fit" of a PLSPM is a composite measure taking into account both the capacity of the model to predict the data and the reliability of the latent variables [79]) of the model is 0.25. Bootstrap validation was performed, confirming the robustness of the effect estimates. The main driver of the interest towards the one-stop-shop concept are the socioeconomic characteristics of the respondent (i.e., being young, highly educated and with a high income) and, to a much lower extent, the age of the house. People who are highly satisfied with the current condition of their current house tend to be less interested in the concept.

Table 4. Direct, indirect and total effects in the one-stop-shop (OSS) model.

Relationships	**Direct**	**Indirect**	**Total**
Socioeconomic character. -> Time lived in house	−0.68	0.00	−0.68
Socioeconomic characters -> Energy concern	0.35	0.00	0.35
Socioeconomic characters -> Past renovation	0.17	−0.24	−0.07
Socioeconomic characters -> House age	0.00	−0.01	−0.01
Socioeconomic characters -> House satisfaction	0.00	−0.09	−0.09
Socioeconomics characters. -> Interest in OSS	0.00	0.12	0.12
Time lived in house -> Past renovation	0.35	0.00	0.35
Time lived in house -> House age	0.02	0.00	0.02
Time lived in house -> House satisfaction	0.00	−0.01	−0.01
Energy concern -> House satisfaction	−0.27	0.00	−0.27
Energy concern -> Interest in OSS	0.33	0.02	0.35
Past renovation -> House satisfaction	−0.02	0.00	−0.02
House age -> House satisfaction	−0.16	0.00	−0.16
House age -> Interest in OSS	0.00	0.01	0.01
House satisfaction -> Interest in OS	−0.09	0.00	−0.09

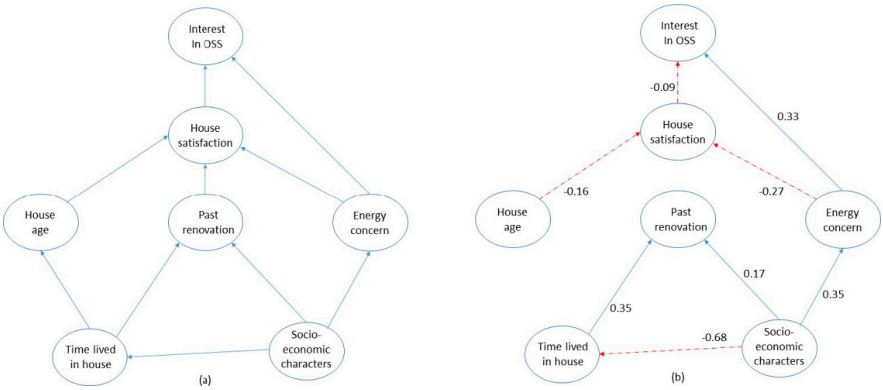

Figure 4. PLSPM analysis of the interest towards the one-stop-shop concept: (**a**) the model structure; and (**b**) the path coefficient estimates (paths with negative coefficients are dashed, and non-significant paths are omitted).

5. Discussion and Conclusions

This study analyzed the complex casual relationships among several variables leading to house owners planned renovation in the near future, and identified the attributes that positively or negatively affected those decisions. Furthermore, it provided us with information about the attitude of house owners towards a one-stop-shop service for renovations, which includes consulting, independent energy audit, renovation work, independent quality control and commissioning, and financing offered by a single actor. The findings show that more than 50% of examined house owners were positively inclined to perform a renovation project in their dwellings in the near future. In their majority, they prefer to renovate only individual components of their dwelling. For those planning to renovate their whole house, they preferred to perform such a project following a step wise approach, rather than renovating their house at once.

The analysis shows that, if any kind of renovation (physical or aesthetic) has already been carried out in the past, it negatively influences the decision of house owners to perform any type of renovation in the future. For those who are planning to perform a renovation in the future, the plan is to renovate only individual components of their dwelling addressing the immediate needs of their household.

House owners with higher income and higher education are more inclined towards performing physical renovations that improve the energy performance of the house. Additionally, those house owners are of younger age, and they show interest for the environment. Their interest on the environment was found to be an important motive for them, and it is an indicator to show that their decision to adopt energy efficient measures is connected to a broader environmental protection goal. On the other hand, satisfaction of house owners with the current state of their dwelling is an attribute that negatively affects their decision to perform a renovation in the future. That satisfaction can possibly derive from the outcomes of a previously performed renovation.

Our findings show that the age of the house affects positively, yet weakly, the decisions of house owners to perform changes that will improve the aesthetics and comfort of their dwelling. Such a decision is further connected to the energy concerns of the owners, as well as their financial capacity, age and educational level.

The one-stop-shop concept for the renovation of single-family houses that presently does not exist in Sweden. Answers regarding intention on the hypothetical one-stop-shop concept showed that 21% of the respondents have a significant interest for this concept. This segment consists of middle-aged house owners (aged 30–50), with higher income and high-level of education. The age of the house did

not have significant influence on the decision on one-stop-shop. Again, those house owners who are satisfied with the condition of their dwelling show no interest in such a concept.

For those house owners interested in one-stop-shop, it can facilitate their renovation decision process. By considering the individual characteristics of each household and the socio-economic conditions of household, one-stop-shop can offer customized renovation package solutions with proper sequencing adopting the necessary measures to improve their quality of life, and enable them to perform physical or deep renovation in steps.

Those respondents who showed interest for one-stop-shop posed some interesting arguments that could act as guidelines for the further development of this concept. Parameters such as the quality of work, clearly defined costs and energy savings and the suggestion of specific measures to adopt play an important role towards deciding to buy such a service. Financial incentives, for example loans, were considered as of lower importance for those interested in one-stop-shop. Such loans however could act as a motive for house owners who are yet unsure of choosing an one-stop-shop for the renovation of their dwelling, and the role of such a financial incentive need to be further examined. Another parameter that could be the subject of further research for the development of a one-stop-shop concept relates to the expressed desire of house owners to be able to choose the different companies that will perform the renovation works. The level of their involvement on one-stop-shop and how this could affect the final renovation could be further researched.

This study has some limitations. The potential of self-selection bias in the analysis exists with respect to aspects that have not been taken under consideration. Additionally, since the analyzed sample consists of house owners living in Kronoberg Region, it reflects the perceptions within this specific geographic area, which may be different to those of people living in other regions in Sweden. Furthermore, we need to consider that house owners were asked to express their interest in a concept that presently does not exist in the Swedish market.

To sum up, the process leading to the decision for renovation in the future is the product of several variable interacting with each other to the outcome. Taking into account the multiple factors affecting such a decision, we have identified a target group, consisting of house owners aged between 30 and 50 years of age, with university education and medium-high and high income, which has a higher inclination to adopt energy efficiency measures in the renovation of their dwelling. That same group also shows significant interest for one-stop-shop renovation services for their dwelling. Financial incentives and participatory acts from house owners' side can increase the interest for one-stop-shop. Those can be the subject of study for policy-makers to manage to mobilize more house owners to the direction of energy efficiency, achieving that way the realization of a part of national goals for environment in the future. Moreover, even though the analysis concerned a sample of house owners living at a specific geographical area, we were able to extract statistically strong results, providing interesting insights about house owners' plans for renovation, and their perceptions over a holistic service for that renovation, which could be relevant for international audiences.

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References

1. Birol, F. *World Energy Outlook Special Report 2013: Redrawing the Energy-Climate Map*; IEA: Paris, France, 2013.

2. Levesque, A.; Pietzcker, R.; Baumstark, L.; Luderer, G. How will buildings' energy demand look in 2100? Quantifying future energy service demand from buildings. In *European Council for an Energy Efficient Economy (ECEEE) Summer Study*; ECEEE: Hyeres, France, 2017.
3. Directive, E.E. Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32. *Off. J.* **2012**, *L315*, 1–56.
4. European Commission. Directive 2018/844/EU of the European Parliament and of the Council of 30 May 2018 on the energy performance of buildings (amending Directive 2010/31/EU). *Off. J. Eur. Union* **2018**, *L156*, 75–91.
5. Energimyndigheten. *Renovera Energismart*; Energimyndigheten: Eskilstuna, Sweden, 2012.
6. Swedish Energy Agency. Energy in Sweden: Facts and Figures. 2017. Available online: http://www.energimyndigheten.se/en/facts-and-figures/publications/ (accessed on 16 February 2019).
7. Swedish Energy Agency. Summary of Energy Statistics for Dwellings and Non-Residential Premises for 2014 (1654–7543). 2015. Available online: www.energimyndigheten.se (accessed on 11 November 2018).
8. Sköldberg, H.; Ryden, B. *The Heating Market in Sweden-an Overall View*; Sverige Värmemarknad: Stockholm, Sweden, 2014.
9. SABO. *Home for Millions: Conditions for Renovation of the Million-Year-Record-Years' Housing*; KTH: Stockholm, Sweden, 2009.
10. Stenberg, E. Recycle the Million Program—Individual Solutions for All. In *Urbanism: Today's Urban Construction in Rhetoric and Practice*; Nordic Academic Press: Lund, Sweden, 2016.
11. Elsinga, M.; Lind, H. The effect of EU-legislation on rental systems in Sweden and the Netherlands. *Hous. Stud.* **2013**, *28*, 960–970. [CrossRef]
12. Johansson, P.; Femenías, P.; Thuvander, L.; Wahlgren, P. Pending for renovations: Understanding the conditions of the multi-family housing stock from before 1945. *Energy Procedia* **2016**, *96*, 170–179. [CrossRef]
13. Gustafsson, M. Energy Efficient Renovation Strategies for Swedish and Other European Residential and Office Buildings. Ph.D. Thesis, KTH Royal Institute of Technology, Stockholm, Sweden, 2017.
14. Gram-Hanssen, K. Existing buildings–Users, renovations and energy policy. *Renew. Energy* **2014**, *61*, 136–140. [CrossRef]
15. Galvin, R. Why German homeowners are reluctant to retrofit. *Build. Res. Inf.* **2014**, *42*, 398–408. [CrossRef]
16. Meijer, F.; Itard, L.; Sunikka-Blank, M. Comparing European residential building stocks: Performance, renovation and policy opportunities. *Build. Res. Inf.* **2009**, *37*, 533–551. [CrossRef]
17. Nair, G. Implementation of Energy Efficiency Measures in Swedish Single-Family Houses. Ph.D. Thesis, Mid Sweden University, Östersund, Sweden, 2012.
18. Bartiaux, F.; Gram-Hanssen, K.; Fonseca, P.; Ozolina, L.; Christensen, T.H. A practice–theory approach to homeowners' energy retrofits in four European areas. *Build. Res. Inf.* **2014**, *42*, 525–538. [CrossRef]
19. Galvin, R.; Sunikka-Blank, M. The UK homeowner-retrofitter as an innovator in a socio-technical system. *Energy Policy* **2014**, *74*, 655–662. [CrossRef]
20. World Business Council for Sustainable Development. *Energy Efficiency in Buildings. Business Realities and Opportunities*; Worls Business Council for Sustainable Development: Geneva, Switzerland, 2010.
21. World Energy Council. *Energy Efficiency: A Recipe for Success*; World Energy Council: London, UK, 2010.
22. Jaffe, A.B.; Stavins, R.N. The energy-efficiency gap What does it mean? *Energy Policy* **1994**, *22*, 804–810. [CrossRef]
23. Sorrell, S.; O'Malley, E.; Schleich, J.; Scott, S. The Economics of Energy Efficiency: Barriers to Cost-Effective Investment. *Energy Stud. Rev.* **2006**, *14*, 186.
24. Reddy, B.S. Barriers and drivers to energy efficiency—A new taxonomical approach. *Energy Convers. Manag.* **2013**, *74*, 403–416. [CrossRef]
25. Haavik, T.; Tommerup, H.M.; Vanhoutteghem, L.; Svendsen, S.; Paiho, S.; Ala-Juusela, M.; Mahapatra, K.; Gustavsson, L.; Aabrekk, S.E. Renovation of single-family houses–an emerging market. In Proceedings of the SB10 Finland Sustainable Building Conference: Sustainable Community-building SMART, Espoo, Finland, 22–24 September 2010.
26. Mahapatra, K.; Gustavsson, L.; Haavik, T.; Aabrekk, S.; Svendsen, S.; Vanhoutteghem, L.; Paiho, S.; Ala-Juusela, M. Business models for full service energy renovation of single-family houses in Nordic countries. *Appl. Energy* **2013**, *112*, 1558–1565. [CrossRef]

27. Risholt, B.; Berker, T. Success for energy efficient renovation of dwellings—learning from private homeowners. *Energy Policy* **2013**, *61*, 1022–1030. [CrossRef]
28. Bjørneboe, M.G.; Svendsen, S.; Heller, A. Using a One-Stop-Shop Concept to Guide Decisions When Single-Family Houses Are Renovated. *J. Archit. Eng.* **2017**, *23*, 05017001. [CrossRef]
29. Bravo, G.; Pardalis, G.; Mahapatra, K.; Mainali, B. Physical vs. Aesthetic Renovations: Learning from Swedish House Owners. *Buildings* **2019**, *9*, 12. [CrossRef]
30. Baumhof, R.; Decker, T.; Röder, H.; Menrad, K. Which factors determine the extent of house owners' energy-related refurbishment projects? A Motivation-Opportunity-Ability Approach. *Sustain. Cities Soc.* **2018**, *36*, 33–41. [CrossRef]
31. Achtnicht, M.; Madlener, R. Factors influencing German house owners' preferences on energy retrofits. *Energy Policy* **2014**, *68*, 254–263. [CrossRef]
32. Abreu, M.I.; Oliveira, R.; Lopes, J. Attitudes and practices of homeowners in the decision-making process for building energy renovation. *Procedia Eng.* **2017**, *172*, 52–59. [CrossRef]
33. Kløckner, C.; Sopha, B.M.; Matthies, E.; Bjørnstad, E. Energy efficiency in Norwegian households-identifying motivators and barriers with a focus group approach. *Int. J. Environ. Sustain. Dev.* **2013**, *12*, 396–415. [CrossRef]
34. Das, R.; Richman, R.; Brown, C. Demographic determinants of Canada households' adoption of energy efficiency measures: Observations from the Households and Environment Survey, 2013. *Energy Effic.* **2018**, *11*, 465–482. [CrossRef]
35. Bjørneboe, M.G.; Svendsen, S.; Heller, A. Initiatives for the energy renovation of single-family houses in Denmark evaluated on the basis of barriers and motivators. *Energy Build.* **2018**, *167*, 347–358. [CrossRef]
36. Pomianowski, M.; Antonov, Y.I.; Heiselberg, P. Development of energy renovation packages for the Danish residential sector. *Energy Procedia* **2019**, *158*, 2847–2852. [CrossRef]
37. Benigna, Bo.; Paolo, B. *One-Stop-Shops for Energy Renovations of Buildings*; European Commission: Ispra, Italy, 2018.
38. Energikontor Sydost. *Climate and Energy Strategy for Kronoberg County and the Region of Southern Småland*; Energikontor Sydost: Växjö, Sweden, 2010.
39. Friege, J.; Chappin, E. Modelling decisions on energy-efficient renovations: A review. *Renew. Sustain. Energy Rev.* **2014**, *39*, 196–208. [CrossRef]
40. Jakob, M. *The Drivers of and Barriers to Energy Efficiency in Renovation Decisions of Single-Family Home-Owners*; Center for Energy Policy and Economics CEPE, Department of Management, Technology and Economics: ETH Zurich, Switzerland, 2007; Available online: http://www.cepe.ethz.ch/publications/workingPapers/CEPE_WP56.pdf (accessed on 29 August 2018).
41. Ebrahimi, S.; Qian, Q.K.; Meijer, F.M.; Visscher, H.J. Unravelling Dutch homeowners' behaviour towards energy efficiency renovations: What drives and hinders their decision-making? *Energy Policy* **2019**, *129*, 546–561.
42. Weiss, J.; Dunkelberg, E.; Vogelpohl, T. Improving policy instruments to better tap into homeowner refurbishment potential: Lessons learned from a case study in Germany. *Energy Policy* **2012**, *44*, 406–415. [CrossRef]
43. Guy, S.; Shove, E. *The Sociology of Energy, Buildings and the Environment: Constructing Knowledge, Designing Practice*; Routledge: Abingdon, UK, 2014.
44. Maller, C.J.; Horne, R.E. Living lightly: How does climate change feature in residential home improvements and what are the implications for policy? *Urban Policy Res.* **2011**, *29*, 59–72. [CrossRef]
45. Karvonen, A. Towards systemic domestic retrofit: A social practices approach. *Build. Res. Inf.* **2013**, *41*, 563–574. [CrossRef]
46. Judson, E.P.; Maller, C. Housing renovations and energy efficiency: Insights from homeowners' practices. *Build. Res. Inf.* **2014**, *42*, 501–511. [CrossRef]
47. Wilson, C.; Pettifor, H.; Chryssochoidis, G. Quantitative modelling of why and how homeowners decide to renovate energy efficiently. *Appl. Energy* **2018**, *212*, 1333–1344. [CrossRef]
48. Gamtessa, S.F. An explanation of residential energy-efficiency retrofit behavior in Canada. *Energy Build.* **2013**, *57*, 155–164. [CrossRef]
49. Alberini, A.; Banfi, S.; Ramseier, C. Energy efficiency investments in the home: Swiss homeowners and expectations about future energy prices. *Energy J.* **2013**, *34*, 49–86. [CrossRef]

50. Banfi, S.; Farsi, M.; Filippini, M.; Jakob, M. Willingness to pay for energy-saving measures in residential buildings. *Energy Econ.* **2008**, *30*, 503–516. [CrossRef]
51. Grösche, P.; Schmidt, C.M.; Vance, C. Identifying free-riding in home renovation programs using revealed preference data. *Jahrbücher Natl. Stat.* **2013**, *233*, 600–618. [CrossRef]
52. Palmer, K.; Walls, M.; Gordon, H.; Gerarden, T. Assessing the energy-efficiency information gap: Results from a survey of home energy auditors. *Energy Effic.* **2013**, *6*, 271–292. [CrossRef]
53. Murphy, L.C. 2016. Policy instruments to improve energy performance of existing owner-occupied dwellings. *A+ BE| Archit. Built Environ.* **2016**, *17*, 1–242.
54. Mundaca, T.L.; Mansoz, M.; Neij, L.; Timilsina, G.R. Transaction costs analysis of low-carbon technologies. *Clim. Policy* **2013**, *13*, 490–513. [CrossRef]
55. März, S. Beyond economics—Understanding the decision-making of German small private landlords in terms of energy efficiency investment. *Energy Effic.* **2018**, *11*, 1721–1743. [CrossRef]
56. Friedman, C.; Becker, N.; Erell, E. Retrofitting residential building envelopes for energy efficiency: Motivations of individual homeowners in Israel. *J. Environ. Plan. Manag.* **2018**, *61*, 1805–1827. [CrossRef]
57. Salo, M.; Nissinen, A.; Lilja, R.; Olkanen, E.; O'Neill, M.; Uotinen, M. Tailored advice and services to enhance sustainable household consumption in Finland. *J. Clean. Prod.* **2016**, *121*, 200–207. [CrossRef]
58. Nair, G.; Gustavsson, L.; Mahapatra, K. Factors influencing energy efficiency investments in existing Swedish residential buildings. *Energy Policy* **2010**, *38*, 2956–2963. [CrossRef]
59. Kahneman, D. Maps of bounded rationality: Psychology for behavioral economics. *Am. Econ. Rev.* **2003**, *93*, 1449–1475. [CrossRef]
60. Wilson, C.; Dowlatabadi, H. Models of decision making and residential energy use. *Annu. Rev. Environ. Resour.* **2007**, *32*, 169–203. [CrossRef]
61. Ameli, N.; Brandt, N. Determinants of households' investment in energy efficiency and renewables: Evidence from the OECD survey on household environmental behaviour and attitudes. *Environ. Res. Lett.* **2015**, *10*, 044015. [CrossRef]
62. Achtnicht, M. Do environmental benefits matter? Evidence from a choice experiment among house owners in Germany. *Ecol. Econ.* **2011**, *70*, 2191–2200. [CrossRef]
63. Earl, P.E.; Peng, T.C. 10 Home improvements. In *Handbook on the Economics of Leisure*; Edward Elgar Publishing: Cheltenham, UK, 2011; p. 197.
64. Murphy, L. The influence of energy audits on the energy efficiency investments of private owner-occupied households in the Netherlands. *Energy Policy* **2014**, *65*, 398–407. [CrossRef]
65. Buser, M.; Carlsson, V. What you see is not what you get: Single-family house renovation and energy retrofit seen through the lens of sociomateriality. *Constr. Manag. Econ.* **2017**, *35*, 276–287. [CrossRef]
66. Fan, K.; Qian, Q.K.; Chan, E.H. Transaction Costs (TCs) in Building Regulations and Control for Green Buildings: Case Study of Hong Kong. *Creat. Built Environ. New Oppor.* **2016**, *1*, 818.
67. Hongjuan Wu Qian Queen, K.; Visscher Henk Straub, A. Improving the Supply Chain of Housing Industrialization from Transaction Costs Perspective. In Proceedings of the World Sustainable Built Environment Conference (WSBE17), Hong Kong, 5–7 June 2017; pp. 2792–2797.
68. Frondel, M.; Vance, C. Heterogeneity in the effect of home energy audits: Theory and evidence. *Environ. Resour. Econ.* **2013**, *55*, 407–418. [CrossRef]
69. Wilson, C.; Crane, L.; Chryssochoidis, G. Why do homeowners renovate energy efficiently? Contrasting perspectives and implications for policy. *Energy Res. Soc. Sci.* **2015**, *7*, 12–22. [CrossRef]
70. Christensen, T.H.; Gram-Hanssen, K.; de Best-Waldhober, M.; Adjei, A. Energy retrofits of Danish homes: Is the Energy Performance Certificate useful? *Build. Res. Inf.* **2014**, *42*, 489–500. [CrossRef]
71. Nauleau, M.L. Free-riding on tax credits for home insulation in France: An econometric assessment using panel data. *Energy Econ.* **2014**, *46*, 78–92. [CrossRef]
72. Baumhof, R.; Decker, T.; Röder, H.; Menrad, K. An expectancy theory approach: What motivates and differentiates German house owners in the context of energy efficient refurbishment measures? *Energy Build.* **2017**, *152*, 483–491. [CrossRef]
73. Zundel, S.; Stieß, I. Beyond profitability of energy-saving measures—Attitudes towards energy saving. *J. Consum. Policy* **2011**, *34*, 91–105. [CrossRef]
74. Parnell, R.; Larsen, O.P. Informing the development of domestic energy efficiency initiatives: An everyday householder-centered framework. *Environ. Behav.* **2005**, *37*, 787–807. [CrossRef]

75. Mlecnik, E.; Cre, J.; Kondratenko, I.; Hilderson, W. Innovations in very low energy retrofit projects. In Proceedings of the PLEA 27th Conference on Passive and Low Energy Architecture, Louvain-la-Neuve, Belgium, 13–15 July 2011; pp. 601–606.
76. Mahapatra, K.; Gustavsson, L.; Haavik, T.; Aabrekk, S.; Tommerup, H.M.; Svendsen, S.; Paiho, S.; Ala-Juusela, M. *Possible Financing Schemes for One-Stop-Shop Service for Sustainable Renovation of Single-Family Houses*; Nordic Innovation Centre: Oslo, Norway, 2011.
77. Baruch, Y.; Holtom, B.C. Survey response rate levels and trends in organizational research. *Hum. Relat.* **2008**, *61*, 1139–1160. [CrossRef]
78. Team, R.C. *R: A Language and Environment for Statistical Computing*; R Foundation for Statistical Computing: Vienna, Austria, 2018; Available online: https://www.R-project.org/ (accessed on 12 March 2019).
79. Esposito Vinzi, V.; Russolillo, G. Partial least squares algorithms and methods. *Wiley Interdiscip. Rev. Comput. Stat.* **2013**, *5*, 1–19. [CrossRef]
80. Lohmöller, J.B. *Latent Variable Path Modeling with Partial Least Squares*; Springer Science & Business Media: Berlin, Germany, 2013.
81. Hair, J.F.; Sarstedt, M.; Ringle, C.M.; Mena, J.A. An assessment of the use of partial least squares structural equation modeling in marketing research. *J. Acad. Mark. Sci.* **2012**, *40*, 414–433. [CrossRef]
82. Wong, K.K.K. Partial least squares structural equation modeling (PLS-SEM) techniques using SmartPLS. *Mark. Bull.* **2013**, *24*, 1–32.
83. Sarstedt, M.; Ringle, C.M.; Hair, J.F. Partial least squares structural equation modeling. In *Handbook of Market Research*; Springer International Publishing: New York, NY, USA, 2017; pp. 1–40.
84. Do Valle, P.O.; Assaker, G. Using partial least squares structural equation modeling in tourism research: A review of past research and recommendations for future applications. *J. Travel Res.* **2016**, *55*, 695–708. [CrossRef]
85. Xiong, B.; Skitmore, M.; Xia, B. A critical review of structural equation modeling applications in construction research. *Autom. Constr.* **2015**, *49*, 59–70. [CrossRef]
86. Afthanorhan, W.M.A.B.W. A comparison of partial least square structural equation modeling (PLS-SEM) and covariance based structural equation modeling (CB-SEM) for confirmatory factor analysis. *Int. J. Eng. Sci. Innov. Technol.* **2013**, *2*, 198–205.
87. Rogers, E.M. *Diffusion of Innovations*, 5th ed.; Free Press: New York, NY, USA, 2005.

III

Chapter 4
Future Energy-Related House Renovations in Sweden: One-Stop-Shop as a Shortcut to the Decision-Making Journey

Georgios Pardalis, Krushna Mahapatra, Brijesh Mainali, and Giangiacomo Bravo

Abstract Based on an online survey, this paper analyzes the attitude of detached house owners in Sweden toward future renovations and their perception over a one-stop-shop (OSS) service for deep renovation of these dwellings. With the aid of a house owners' renovation decision-making journey for renovation, personal and contextual variables have been analyzed to identify those house owners having renovation plans in the near future, what they are going to renovate, and which needs to lead them to that decision. Furthermore, we examine if there is an interest in OSS concept and the factors affecting positively or negatively the choice for such a concept. Results suggest that deep renovation is not yet prioritized. The priority for house owners is to change specific components of their dwelling and follow a step-wise approach. Aesthetic renovations are high on the agenda, with some structural and energy-related renovations following them. House owners between 29 and 49 years of age are those mostly interested in more comprehensive renovations. The OSS concept appears to be interesting to a number of house owners capable to verify a business potential. House owners up to the age of 45 years, with dwellings built from 1960 and above and with environmental awareness, are the market segment that can act as early adopters of the OSS concept. When it comes to the decision-making journey for renovations, house owners' future plans, and the factors affecting their

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choice for an OSS provider, we can claim that OSS can act as a guide for house owners from the early stages of their decision-making journey and provide them with a shortcut that will make this journey more secure, while triggering renovation decision of greater extent. In terms of financing, incentives related to energy performance are also suggested as means that could boost greater interest for more comprehensive renovations.

Keywords Future renovations · Energy-related renovations · One-stop-shop · House owners · Renovation journey

1 Introduction

The European Union has a goal of 32.5% energy efficiency in 2030 compared to the levels of 2005 as referred to the Directive 2018/844/EU [1]. Sweden has set an ambitious cross-sectoral target of reducing energy intensity 20% by 2020 compared to 2008 levels and 50% by 2030 compared to the levels of 2005 [2]. For the building sector, Sweden has a national goal to reduce energy consumption by 20% compared to the 1995 level by the year 2020 [3], a goal that seems ambitious considering that several EU member states have already revised their energy efficiency targets to 16.9% by the same year [4]. The Swedish residential sector could be a major contributor to achieve the national goals for reduction of energy consumption, as it is responsible for 22% of the total energy consumption, from which 12% coming from single-family houses [5]. Out of 4.7 million residential dwellings, 51% (2.4 million) are one- or two-family houses (from here onward "detached houses"), and they account for 293 million square meters of floor area, which is larger than that of multifamily houses [6].

According to Statistics Central Bureau (SCB) in Sweden, 86% of the one- and two-family dwellings are about 30 years old. They have poor energy standard and need of renovation. The most common practice in Swedish renovation market is to renovate kitchens and bathrooms (aesthetic type of renovations) as was observed in a recent survey of owners of detached houses in Kronoberg region of Sweden [7, 8].

The adoption of energy-efficient measures or deep renovation for improvement of the energy performance is rather low due to various socioeconomic barriers [9]. Also, house owners in general are not aware of where to seek information regarding deep renovation or which craftsmen offer such a service [10]. The renovation market is dominated by small and locally based craftsmen-owned companies who are interested to offer individual solutions and sell their own product, which leads to lack of trust between them and the house owners [11]. Moreover, the current building code in Sweden (BBR26) obliges the energy performance of a deep renovated house to reach the levels of a newly built one [12]. Regardless of location, the investment cost for such a renovation is relatively high, and this can act as a demotivating factor for many house owners. Additionally, the existing tax incentive does not differentiate between

deep renovation and aesthetic renovation [13]. Moreover, the financing mechanisms that could boost deep renovations (green loans) are yet to be developed.

To address those challenges, Mahapatra et al. [11] proposed the one-stop-shop (OSS) concept, in which a single actor could offer a full-service renovation package to house owners. One-stop-shop is a product-service system (PSS) concept, which could address some of the factors that prevent the house owners to renovate their dwellings [14]. In this concept, a single actor coordinates all the involved actors in the renovation process to offer a comprehensive package on energy-efficient renovation. In that concept, house owners deal with a unique contact point, and participating actors work together in a way that redefines their activities and increases their resource efficiency [15]. House owners would receive consulting services for renovation, including energy audit and recommendations for upgrades, facilitation in getting building permits (where it is required), renovation packages with financial schemes based on house owners specific needs and financial situation, supply of quality material and technical re-sources in the value chain, and post-renovation quality checks and guarantees. With OSS, house owners receive a guided journey throughout their renovation and get a renovated dwelling that truly satisfies their needs.

OSS concept has been emerging in several parts of Europe [16] and in Scandinavian countries, such as Norway [17] and Denmark [18]. In Sweden, the concept is yet to be tested, although the turnkey ("totalentreprenad" in Swedish) concept exists in the construction of all types of new buildings and renovation of multifamily buildings.

In this study, we analyze the future plans of Swedish house owners to renovate their houses. We analyze the underlying reasons leading them to take that decision, the influence of their socioeconomic background, and their preferred type of renovation. Furthermore, we examine to which extent they have knowledge of the renovation services offered and their perceptions over a full-renovation package as envisioned in the OSS concept.

2 Background and Related Work

The low level of adoption of energy-efficient measures by the house owners when they renovate their dwellings is a subject widely examined by literature. A significant number of studies identified factors motivating or preventing house owners toward energy-efficient solutions. They are categorized in related literature as economic [19–22], behavioral [19, 23–27], social [28–30], regulatory [31], and factors related to the physical condition of the dwelling [19, 28, 31–35]. To better understand how all those different factors affect the level of adoption of energy-efficient measures, it is important to understand the "journey" of house owners in deciding to renovate their dwelling.

2.1 The Context of Renovation Decisions

The changing demands of domestic life and the need to adapt to those changes influence the house owners in their decision to renovate and the specific improvements they chose. According to Karvonen [36], "Domestic retrofit is not an activity of changing a house from poor energy performance to exceptional energy performance, but an intervention into the rhythms of domestic habitation". Judson and Maller [28] observed that adoption of energy efficiency measures is usually combined with improvements of other parts of the dwelling. Hence, the decision to adopt energy efficiency measures is not independent or static, but a journey over time in a broader context of renovating the property.

The innovation-decision model of Rogers [37], which has been applied in different contexts like adoption of heating systems [38–40] and solar photovoltaic systems [41, 42], posits that decision to adopt an innovation passes through five stages. The upper part of Fig. 1 represents those stages starting from initial awareness to a final decision. In our conceptual framework, we have adapted those stages to the renovation journey of house owners, which is presented in the lower part of Fig. 1. The decision-making journey of a house owner starts from the point of reflection over the dwelling's situation (step 0). On that step, house owner is not thinking that it is time to renovate. A previous study [41] has found that satisfaction with the physical condition, thermal performance, and aesthetics of the dwelling are the reasons for that decision. When the house owner.

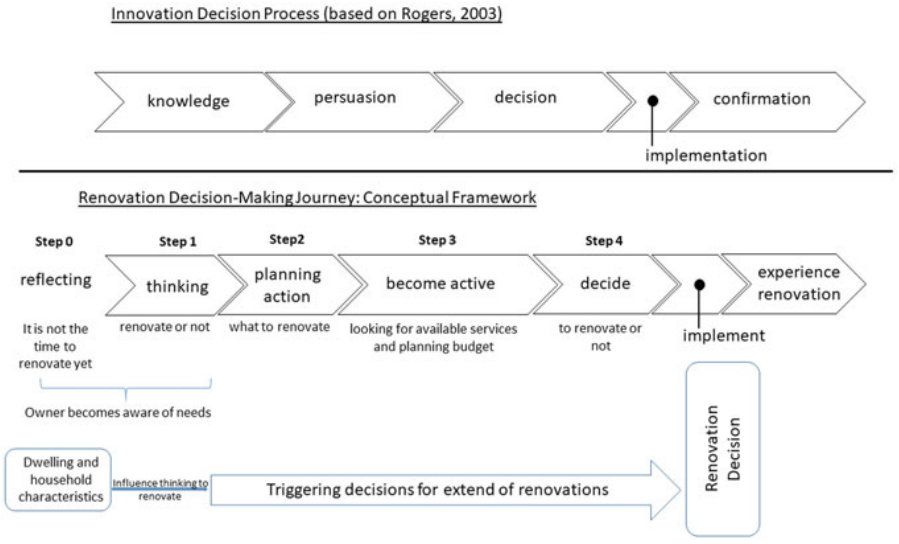

Fig. 1 Decision-making journey for house renovations

becomes aware of a need, like the dwelling itself or a component is old and dysfunctional, energy cost is high, etc., or when he/she becomes more environmentally concerned, proceeds in step 1. In that step, house owner makes an initial decision on whether the dwelling needs renovation or not. If it needs renovation, then step 2 follows where house owner starts to investigate what exactly needs to get renovated. At a later stage, house owner starts becoming active (step 3), looking for available services and planning his/her budget before reaching the "final decision" step (step 4), where after considering all the parameters described on the previous steps proceeds or not in the renovation. There is also the stage of "experience renovation" that relates to how house owners adapt and react to the renovations performed in their dwellings, but this stage is not considered in this paper since, as previously mentioned, we analyze future plans, not actual implementation of renovations. Dwelling's and household's characteristics are influences explaining why house owners start thinking of renovation and typically are not included in decision-making models [43, 44]. Instead, they are used as triggers for personal and contextual influences on renovations.

2.2 One-Stop-Shop Concept for Deep Renovation

One-stop-shop is currently advocated by the energy performance of buildings Directive (EPBD) 2018/844/EU [1], which amends the earlier EPBD 2010/31/EU [45] and Directive 2012/27/EU [46] on energy efficiency (EED). The Article 2A of the 2018 EPBD calls for a long-term renovation strategy, and member states "are required to facilitate access to mechanisms, such as one-stop-shops, which are considered as advisory tools here to inform and assist consumers in relation to energy efficiency renovations and financing instruments" [47]. According to the Article 20(2), "member states shall provide the information through accessible and transparent advisory tools such as renovation advice and one-stop-shops" [45]. Examining the potential interest of Swedish house owners on OSS will allow us to understand the market potential for such a service and to point out which parts of this service need to be reconsidered to reach a broader customer base.

3 Materials and Methods

The analytical framework in this paper is based on a preliminary stage of a larger-scale research project about the renovation-related practices of owners of detached houses in Sweden and the development of an OSS concept offering full-service renovation packages to them. To gain in-depth understanding regarding house "owners'" perception regarding energy consumption in their dwellings and toward renovation, we have designed an online survey in late spring 2017. The questionnaire for that survey was based on literature review and existing theories and pretested with a limited number of house owners, prior to its distribution. Later, the survey was sent to

Gender	Freq. (%)
Men	74.1
Women	25.6
Other	0.3

Age (years)	Freq. (%)
< 30	0.9
30–49	26.0
50–65	33.2
> 65	40.0

Education	Freq. (%)
Other	2.1
Primary	9.6
High school	32.7
University	55.6

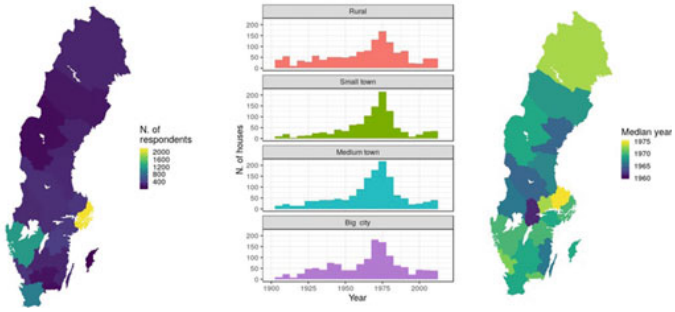

Fig. 2 Basic info on the survey respondents and their dwellings

144,660 members of Villaägarna, which is a non-profit and party-politically unbound consumer and interest organization for residents and owners of single-family houses in Sweden. In total, 12,194 house owners answered, after one reminder, which corresponds to a response rate of 8.43%, which is considered normal for such kind of surveys [48]. 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. Some basic information regarding the respondents and the dwellings can be found in Fig. 2.

The research is built on abductive approach, moving between theory and reality or observation in a systematic way. What will be presented in the following section is a preliminary analysis of the survey findings. The results were analyzed and interpreted in the theoretical context to derive conclusions [49].

4 Preliminary Survey Findings

4.1 Future Renovation Plans (Step 0)

The respondents were asked to share if they had planned to renovate their dwelling in the near future with the possible alternative answers: (a) I have no plans to renovate, (b) Yes, I plan to renovate my whole house at once, (c) Yes, I plan to renovate my whole house but gradually, and (d) Yes, I plan to renovate only a few parts of my house (Fig. 3). We have analyzed the respondents' answers per age and income groups to better understand the influence of socioeconomic attributes on their future renovation plans. Analysis showed that 25% of the respondents had no plan to perform a renovation in the nearest future. The main reasons for not planning a renovation in the future were satisfied with the current state of the dwelling, which confirms the findings of previous studies, and the time lived in the house. House owners living in their dwelling for a few years appear to be less willing to renovate in the close future.

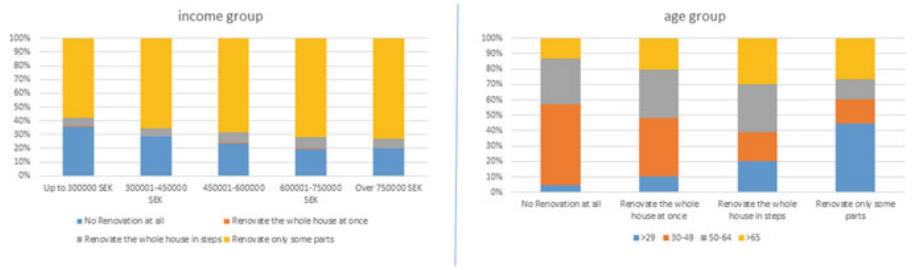

Fig. 3 Percentage of respondents planning to renovate their dwellings per income and age group

From the rest, 7% plan to renovate their whole house in stages, only 0.3% are interested to renovate their house at once, while the remaining are interested in renovation only some components of their dwelling. House owners between 29 and 49 years of age showed the greatest willingness to renovate their dwellings, at least some components, while owners over 50 years of age have shown greater willingness only to renovate parts of their dwelling or rejected the idea of renovation. Medium and high-income groups were more willing to renovate, but this was not the case when looked at the willingness to renovate the whole house at once or in stages. Additionally, houses built before the 1980s were more likely to be renovated.

4.2 Needs Leading to Renovation (Step 1)

The respondents were asked a question about the reasons for them to consider renovating their dwelling. The respondents were given 12 different alternative reasons (e.g., "house is old", "I want to improve indoor environment", etc.), with the possibility to indicate their level of agreement to each alternative on a Likert scale of 1–5, where 1 = disagree, 5 = agree. Their answers are presented in Fig. 4.

The analysis showed that the age of the house and the need to improve its aesthetics are very important reasons for house owners to begin thinking of a renovation project. Furthermore, the perception of increased value of the renovated house and the desire to reduce the energy cost are high on their priority list. On the other hand, parameters like improved indoor environment or influences from the social environment seem not to be reasons leading to the need for renovation.

4.3 Preferred Type of Renovation (Step 2)

Survey participants were asked to specify the type of renovation they were planning to perform. As seen in Fig. 5, they were given a variety of renovation measures to choose, which we have classified into energy, structural, and aesthetic renovations.

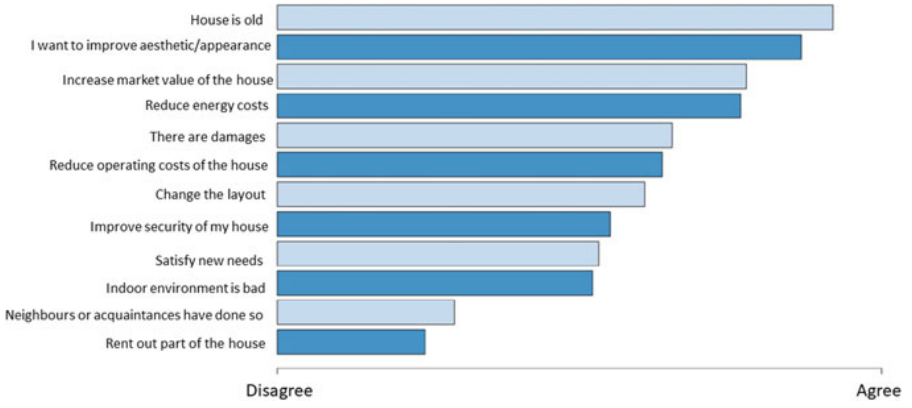

Fig. 4 Trends regarding reasons for considering renovating the dwelling

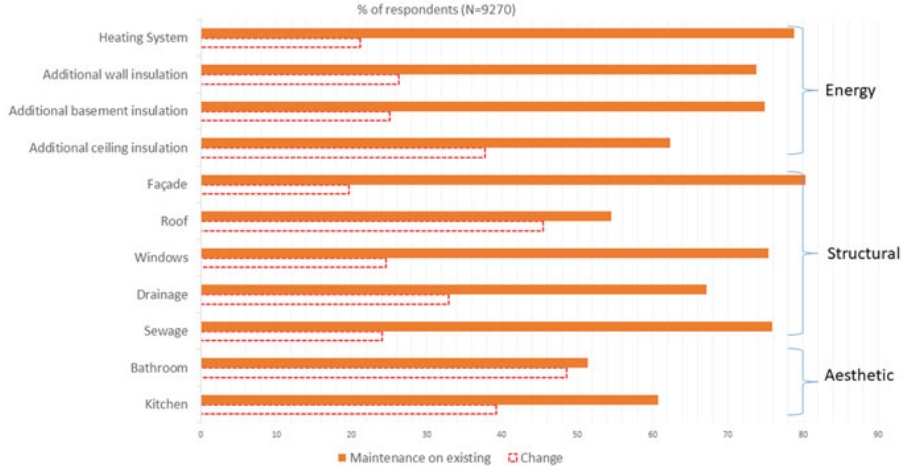

Fig. 5 Depiction of plans to perform maintenance or change house components

Respondents were asked to specify if they planned to perform a maintenance of existing building component or change them completely. Performing a maintenance appears to be the most common plan for the future, especially related to energy or structural renovations. Results regarding complete changes show that a greater number of respondents were willing to perform aesthetic renovations (changing kitchen and bathroom) than energy or structural renovations. Among structural renovation, roof and drainage were more attractive, while ceiling insulation was the most preferred option among energy-related renovations. 20% of the respondents intended to perform only one energy-related renovation (including in combination with structural or aesthetic renovations), while 43% of the respondents planned to implement multiple energy-related measures.

4.4 Awareness of Services and Interest in OSS (Steps 3 and 4)

Without introducing the phrase one-stop-shop, the respondents were asked if they were aware of actors offering full-service renovation packages in their area. Only 18% of them answered that they were aware of such actors in their area. Additionally, the respondents were asked to express their opinion on which actor could offer a full-service renovation package. The majority answered that local craftsmen and small construction/renovation companies could offer such a package, and some of them answered that large construction companies could offer such a package. A considerable number of respondents answered that someone else could be able to offer such a renovation package without specifying who that others could be.

Moreover, house owners were asked to express their interest on a full-service renovation package offered by a single contractor, as one-stop-shop concept suggests if that was offered in their area. More than 1/4 of the respondents answered that are interested or very interested to buy such a package if existing, while almost half of the respondents showed low or no interest at all. Results showed that both men and women owners, up to the age of 45 years and with university or high school education showed greater interest for that type of renovation package (Figs. 6 and 7). Moreover, those house owners own dwellings built from 1960 and above and show greater environmental concern, while they are willing to take action to protect the environment (Fig. 7).

Additionally, house owners were asked about the factors that are important for them to choose and actor offering a full-service renovation package. Respondents were given 16 different factors, and they were asked to evaluate them on a 1–5 Likert scale, where 1 = not important and 5 = important. Guarantees on cost/benefits, guarantees on delivery according to the agreed time schedule, and guarantees on quality of renovation work are the main qualities that house owners look after in order to choose such a package (Fig. 8).

To understand better why almost 50% of the respondents showed low or no interest in the OSS concept, we asked "how important are the following facts for not choosing one-stop-shop". Four different options were given in a 3-point Likert scale, where 1 = not important for me and 3 = very important for me. The main reasons for low or

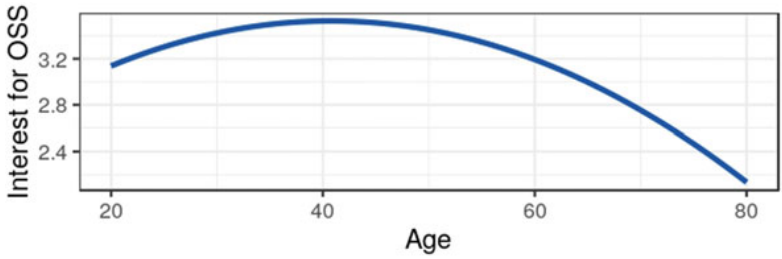

Fig. 6 Correlation of interest for OSS with the age of house owner

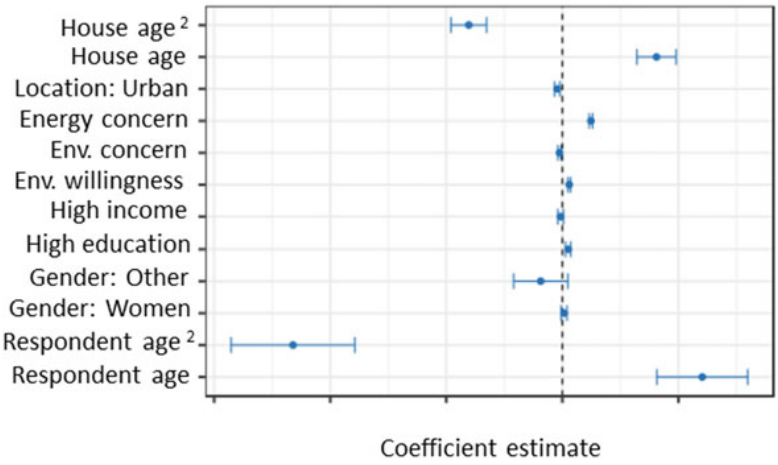

Fig. 7 Variables affecting interest on OSS

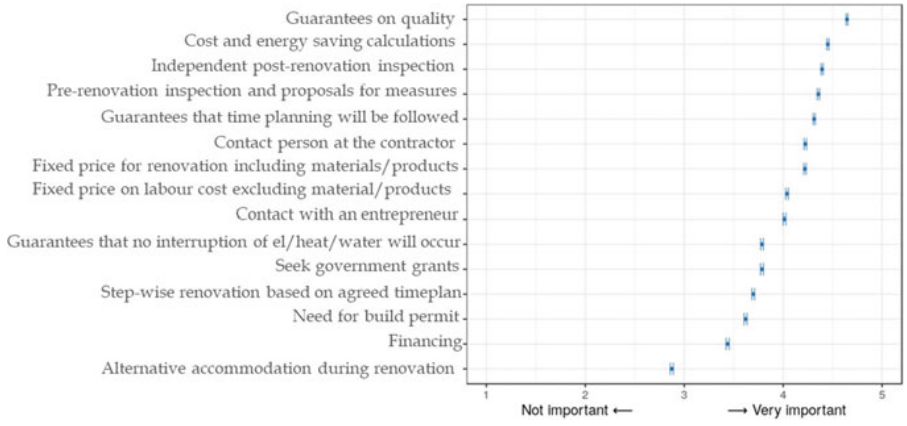

Fig. 8 Factors affecting choice of an OSS provider

no interest in OSS were the perceived high cost of it and the house owners' preference to choose different contractors to perform the different parts of renovation (Fig. 9).

4.5 Financing the Renovation

One of the questions asked to house owners was how they were going to finance their planned renovation in the near future. Respondents had to select between three different alternatives, namely own savings, mortgage loan, and private loan. The vast majority.

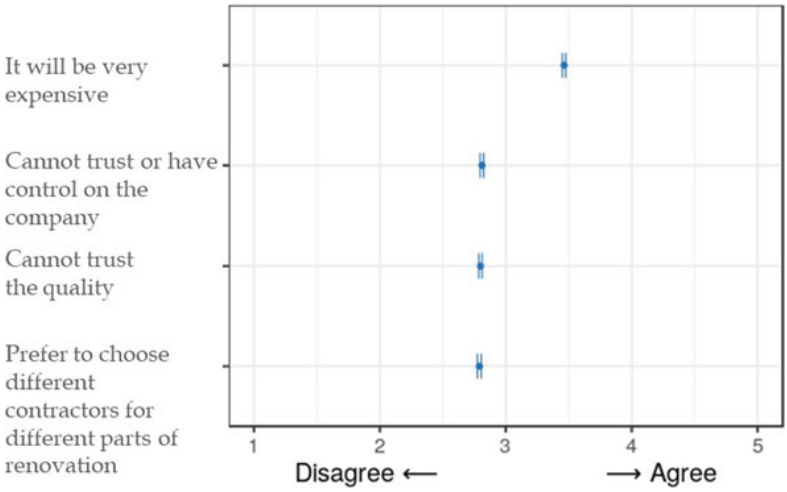

Fig. 9 Factors affecting lack of interest for OSS

of respondents (67.8%) would fund the renovation from their own savings, while very few (3.6%) would choose a personal loan, which usually has a higher interest rate than house mortgage loan. Additionally, house owners were asked to express their opinion on different financial incentives that could affect their interest to perform energy renovation.

Respondents were called to express their positive, neutral, or negative opinion on four preselected financial incentives for energy renovation (Fig. 10). According to them, connection of tax subsidies with energy reduction and the introduction of energy loans could positively incline them toward performing energy renovations.

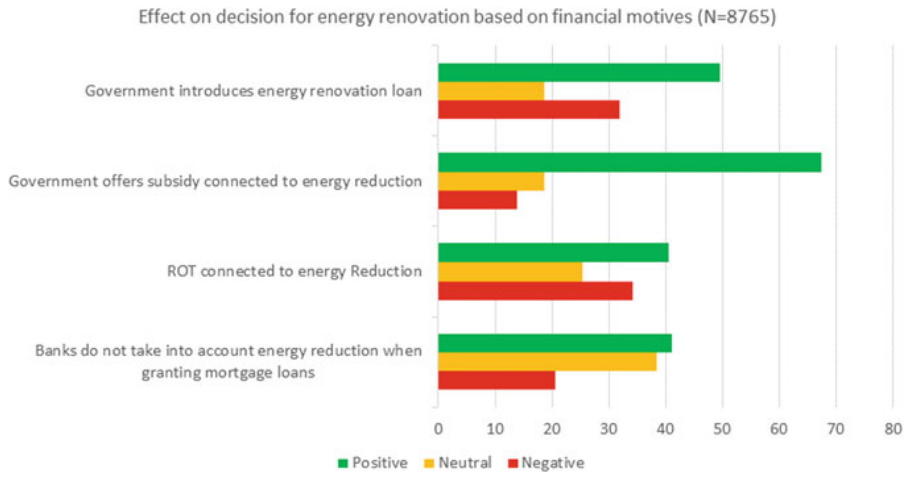

Fig. 10 Opinions on financial incentives that may motivate house owners for energy renovations

On the other hand, return on investment connected to energy deduction after renovation, and mortgage loans which consider the energy reduction post-renovation are financing measures that would lead to less positive inclination among house owners toward energy renovations.

5 Discussion and Conclusions

In this paper, we have analyzed the future plans of Swedish house owners toward renovating their dwellings. We have identified the underlying reasons leading them to take that decision and the influence of their socioeconomic background on it. Furthermore, we have identified the extent of the renovation they would prefer to perform and the components of their dwellings that they consider maintaining or change. Additionally, we have examined to which extent they have knowledge of the renovation services offered and their perceptions over a full-renovation package as envisioned in the OSS concept, as well as the financial incentives that would motivate them to invest in a more comprehensive renovation of their property (adoption of both energy and non-energy-related measures).

Our analysis showed that house owners between ages 29 and 49 years are the most positively inclined to perform renovations, while people aged 50 years and above show lower interest to perform renovations (with those aged 65+ years of age to be the least interested). The most preferable option is to renovate parts of the house. The number of people planning to renovate their whole house at once or in steps is still low. Aesthetic renovations are prioritized, but there is also a significant interest for structural changes (roof) with accompanying energy measures (additional ceiling insulation). Energy-related renovations are part of the house owners' future plans, but not from a holistic perspective (deep renovation). It should also be noted that energy-related renovations are not decided as an only renovation, but as a part of a broader renovation plan.

One-stop-shop appears to be interesting for an amount of house owners capable to verify a business potential for that concept. House owners up to the age of 45 years, with dwellings built from 1960 and above, are the market segment that can act as early adopters of the OSS concept. Additionally, those house owners show greater environmental interest and willingness to take action to protect the environment.

The perceived high cost of OSS and the interest to hold power to select the craftsmen appear to be important hindrances to market for OSS. Own savings are the most preferable option for house owners to finance renovations. Energy loans from financial institutions and tax subsidies linked to energy renovations are suggested to encourage them to perform energy renovations.

It becomes evident that an optimal OSS concept for detached house renovation should allow house owners to have an active participation in the whole process. Having in mind the decision-making journey for house renovations presented in Fig. 1, in the adoption of OSS, house owners are likely to be very engaged in the decision-making process right from step 1. That concept can provide solutions in the

direction of making the right decisions on which house components need to be renovated, taking under consideration house owners' desires, but also the necessities in each individual dwelling. Moreover, OSS provides house owners with a feasible work and time schedule for the renovation of their house and with a group of craftsmen capable to deliver quality work. That enables to a great extent the decision of house owners to renovate and creates opportunities for the adoption of energy efficiency measures, within the given budget for renovation. Overall, we can claim that one-stop-shop can become the shortcut of the renovation decision-making journey for house owners and the vehicle for a smoother renovation process. Exempting house owners from the pains of renovation can become the trigger for them to further the extent of renovation and orient themselves to the adoption of more energy-efficient measures, despite the expressed financing doubts. Ways to finance a more comprehensive renovation need further research. There are though insights from house owners' side that highlight what needs to be addressed. The existing subsidies for house improvements should be linked with improved energy performance of those houses, to create an extra motive to invest in energy-efficient solutions. Own savings are, for nonce, the main financing mechanism of renovations. That makes the need for the development of financing products, like "green loans", imperative, as such loans could create a more favorable environment for investments in comprehensive renovation solutions.

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References

1. European Parliament (2018) Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency. Off J Euro Commu 61:75–91
2. Ministry of the Environment and Energy (2019) Sweden's draft integrated national energy and climate plan. Government Offices of Sweden, Stockholm. Published 17 January 2019. Available at: https://www.government.se/reports/2019/01/swedens-draft-integrated-national-energy--and-climate-plan/. Accessed on 18 July 2019
3. SE Agency (Energimyndigheten) (2012) Renovera Energismart Energimyndigheten. Eskilstuna, , Sweden
4. European Environment Agency (2017) Trends and projections in Europe 2017. Tracking progress towards Europe's climate and energy targets. 10.1016/j.watres.2007.01.052
5. Swedish Energy Agency (2017) Energy in Sweden: facts and figures. Available online: https://www.energimyndigheten.se/en/facts-and-figures/publications/. Accessed on 16 Feb 2019
6. Swedish Energy Agency (2015) Summary of energy statistics for dwellings and non-residential premises for 2014 (1654–7543). Available online: www.energimyndigheten.se. Accessed on 11 April 2019
7. Mahapatra K, Mainali B, Pardalis G (2019) Homeowners' attitude towards one-stop-shop business concept for energy renovation of detached houses in Kronoberg, Sweden. Energy Procedia 158:3702–3708. https://doi.org/10.1016/j.egypro.2019.01.888

8. Bravo G, Pardalis G, Mahapatra K, Mainali B (2019) Physical vs. Aesthetic renovations: learning from Swedish house owners. Buildings 9(1):12. https://doi.org/10.3390/buildings9010012
9. Friege J, Chappin E (2014) Modelling decisions on energy-efficient renovations: a review. Renew Sustain Energy Rev 39:196–208. https://doi.org/10.1016/j.rser.2014.07.091
10. Klöckner CA, Nayum A (2017) Psychological and structural facilitators and barriers to energy upgrades of the privately owned building stock. Energy 140:1005–1017. https://doi.org/10.1016/j.energy.2017.09.016
11. Mahapatra K, Gustavsson L, Haavik T, Aabrekk S, Svendsen S, Vanhoutteghem L, Ala-Juusela M (2013) Business models for full service energy renovation of single-family houses in Nordic countries. Appl Energy 112:1558–1565. https://doi.org/10.1016/j.apenergy.2013.01.010
12. Ekström T (2017) Passive house renovation of Swedish single-family houses from the 1960s and 1970s: Evaluation of cost-effective renovation packages.
13. Agency ST (Skatteverket), (2015) Taxes in Sweden (2015) An english summary of tax statistical year-book of Sweden. Swedish Tax Agency, Solna
14. Pardalis G, Mahapatra K, Mainali B (2020) Swedish construction MSEs: simply renovators or renovation service innovators? Build Res Inf 48(1):67–83. https://doi.org/10.1080/09613218.2019.1662713
15. Mlecnik E, Straub A, Haavik T (2019) Collaborative business model development for home energy renovations. Energ Effi 12(1):123–138. https://doi.org/10.1007/s12053-018-9663-3
16. Innovate Project Report (2018) Inventory of best practices for setting up integrated energy efficiency service package including access to long-term financing to homeowners: extensive analysis of the existing energy efficiency services operators and long-term financing schemes. Available at: https://www.financingbuildingrenovation.eu/wp-content/uploads/2017/08/Innovate_Inventory-of-best-practices_public-version.pdf. Accessed on 4th March 2019
17. Risholt B, Berker T (2013) Success for energy efficient renovation of dwellings—learning from private homeowners. Energy Policy 61:1022–1030. https://doi.org/10.1016/j.enpol.2013.06.011
18. Bjørneboe MG, Svendsen S, Heller A (2018) Initiatives for the energy renovation of single-family houses in Denmark evaluated on the basis of barriers and motivators. Energy Build 167:347–358. https://doi.org/10.1016/j.enbuild.2017.11.065
19. Achtnicht M, Madlener R (2014) Factors influencing German house owners' preferences on energy retrofits. Energy Policy 68:254–263. https://doi.org/10.1016/j.enpol.2014.01.006
20. Murphy LC (2016) Policy instruments to improve energy performance of existing owner occupied dwellings. A+ BE| Arch Built Environ (17):1–242. ISSN 2214–7233
21. März S (2018) Beyond economics—understanding the decision-making of German small private landlords in terms of energy efficiency investment. Energ Effi 11(7):1721–1743. https://doi.org/10.1007/s12053-017-9567-7
22. Friedman C, Becker N, Erell E (2018) Retrofitting residential building envelopes for energy efficiency: motivations of individual homeowners in Israel. J Environ Planning Manage 61(10):1805–1827. https://doi.org/10.1080/09640568.2017.1372278
23. Ameli N, Brandt N (2015) Determinants of households' investment in energy efficiency and renewables: evidence from the OECD survey on household environmental behaviour and attitudes. Environ Res Lett 10(4):044015
24. Murphy L (2014) The influence of energy audits on the energy efficiency investments of private owner-occupied households in the Netherlands. Energy Policy 65:398–407. https://doi.org/10.1016/j.enpol.2013.10.016
25. Das R, Richman R, Brown C (2018) Demographic determinants of Canada's households' adoption of energy efficiency measures: observations from the households and environment survey, 2013. Energ Effi 11(2):465–482. https://doi.org/10.1007/s12053-017-9578-4
26. Buser M, Carlsson V (2017) What you see is not what you get: single-family house renovation and energy retrofit seen through the lens of sociomateriality. Const Manage Econ 35(5):276–287. https://doi.org/10.1080/01446193.2016.1250929

27. Nair G (2012) Implementation of energy efficiency measures in Swedish single-family houses (Doctoral dissertation, Mid Sweden University)
28. Judson EP, Maller C (2014) Housing renovations and energy efficiency: insights from homeowners' practices. Build Res Inf 42(4):501–511. https://doi.org/10.1080/09613218.2014.894808
29. Mlecnik E, Kondratenko I, Cré J, Vrijders J, Degraeve P, van der Have JA, Svendsen S (2012) Collaboration opportunities in advanced housing renovation. Energy Procedia 30:1380–1389. https://doi.org/10.1016/j.egypro.2012.11.152
30. Mahapatra K, Gustavsson L, Haavik T, Aabrekk S, Tommerup HM, Svendsen S, Paiho S, Ala-Juusela M (2011) Possible financing schemes for one-stop-shop service for sustainable renovation of singlefamily houses. Nordic Innovation Centre. Nordic Call on Sustainable Renovation NICe, No. 08191 SR
31. Weiss J, Dunkelberg E, Vogelpohl T (2012) Improving policy instruments to better tap into homeowner refurbishment potential: lessons learned from a case study in Germany. Energy Policy 44:406–415. https://doi.org/10.1016/j.enpol.2012.02.006
32. Guy S, Shove E (2014) The sociology of energy, buildings and the environment: constructing knowledge, designing practice. Routledge, Abingdon, UK
33. Wilson C, Pettifor H, Chryssochoidis G (2018) Quantitative modelling of why and how homeowners decide to renovate energy efficiently. Appl Energy 212:1333–1344. https://doi.org/10.1016/j.apenergy.2017.11.099
34. Christensen TH, Gram-Hanssen K, de Best-Waldhober M, Adjei A (2014) Energy retrofits of Danish homes: is the energy performance certificate useful? Build Res Inf 42(4):489–500. https://doi.org/10.1080/09613218.2014.908265
35. Baumhof R, Decker T, Röder H, Menrad K (2017) An expectancy theory approach: what motivates and differentiates German house owners in the context of energy efficient refurbishment measures? Energy Buildings 152:483–491. https://doi.org/10.1016/j.enbuild.2017.07.035
36. Karvonen A (2013) Towards systemic domestic retrofit: a social practices approach. Build Res Inf 41(5):563–574. https://doi.org/10.1080/09613218.2013.805298
37. Rogers EM (2005) Diffusion of innovations, 5th edn. Free Press, New York, NY
38. Madlener R (2007) Innovation diffusion, public policy, and local initiative: the case of wood-fuelled district heating systems in Austria. Energy Policy 35(3):1992–2008. https://doi.org/10.1016/j.enpol.2006.06.010
39. Michelsen CC, Madlener R (2013) Motivational factors influencing the homeowners' decisions between residential heating systems: an empirical analysis for Germany. Energy Policy 57:221–233. https://doi.org/10.1016/j.enpol.2013.01.045
40. Mahapatra K, Gustavsson L (2008) An adopter-centric approach to analyze the diffusion patterns of innovative residential heating systems in Sweden. Energy Policy 36(2):577–590. https://doi.org/10.1016/j.enpol.2007.10.006
41. Nair G, Gustavsson L, Mahapatra K (2010) Owners' perception on the adoption of building envelope energy efficiency measures in Swedish detached houses. Appl Energy 87(7):2411–2419. https://doi.org/10.1016/j.apenergy.2010.02.004
42. Wilson C, Crane L, Chryssochoidis G (2013) The conditions of normal domestic life help explain homeowners' decisions to renovate. ECEEE Summer Study (European Council for an Energy Efficient Economy), Toulon, France
43. Dodds PE (2014) Integrating housing stock and energy system models as a strategy to improve heat decarbonisation assessments. Appl Energy 132:358–369. https://doi.org/10.1016/j.apenergy.2014.06.079
44. Rommel K, Sagebiel J (2017) Preferences for micro-cogeneration in Germany: policy implications for grid expansion from a discrete choice experiment. Appl Energy 206:612–622. https://doi.org/10.1016/j.apenergy.2017.08.216
45. Recast European Parliament (2010) Directive 2010/31/EU of the European parliament and of the council of 19 May 2010 on the energy performance of buildings (recast). Off J Euro Union 18(06)

46. European Parliament (2012) Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32. Off J L 315:1–56.
47. Boza-Kiss B, Bertoldi P (2018) One-stop-shops for energy renovations of buildings. Ispra: European Commission, JRC113301
48. Baruch Y, Holtom BC (2008) Survey response rate levels and trends in organizational research. Hum Relat 61(8):1139–1160. https://doi.org/10.1177/0018726708094863
49. Voss C, Johnson M, Godsell J (2016) 5 Case research. Res Meth Oper Manag 165

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Swedish construction MSEs: simply renovators or renovation service innovators?

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ABSTRACT

To address the renovation needs of detached house stock in Sweden, micro and small-sized enterprises (MSEs), a subgroup of small and medium-sized enterprises, are expected to introduce more comprehensive house renovation solutions. One-stop-shop (OSS) is an innovative Product-Service System model that can enable MSEs to offer comprehensive renovation packages instead of existing fragmented solutions. We have applied a conceptual framework for innovation adoption in organizations and conducted an interview of 21 construction MSEs in three different geographical areas in Sweden to examine their perceptions and preparedness to adopt the OSS business concept. Findings showed that the examined MSEs are positive towards OSS as it could address the needs for the comprehensive renovation of detached houses. However, presently, are not prepared to take the coordinator's role in such a concept mainly due to the perceived business risks, the lack of flexibility to organizational restructuring, and lack of resources and management competency to coordinate multiple tasks and actors. Those organizations lacked awareness of existing policy support and access to funding mechanisms to try new business models. As a solution, they proposed an external coordinator to be the provider of OSS, on the trial phase, whose role and characteristics need to be further examined.

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Innovation adoption; construction MSEs; one-stop-shop; organizational innovation; business model; detached houses

Introduction

One and two-family houses (from here onward referred to as 'detached houses') account for more than 50% of the total building stock in Sweden and are responsible for 12% of the total energy consumption (Swedish Energy Agency, 2017). About 80% of those houses are more than 30 years old and in need of renovation (Boverket, 2015). This provides a unique opportunity for micro and small-sized construction companies (MSEs) to implement energy efficiency measures during the renovation. The MSEs are a subset of SMEs (small and medium enterprises) according to the criteria of the European Commission. A small enterprise has less than 50 employees and an annual turnover of up to €10 million, while micro enterprises have less than 10 employees and an annual turnover of up to €10 million (European Commission, 2018). Following the classification of number of employees, 99% and 92% of the construction companies in different segments of the Swedish construction sector are micro and small enterprises, respectively (Table 1). The MSEs typically offer fragmented services in their area of expertise, e.g. plumbing, carpentry, replace windows, insulation, roof, etc. A similar situation exists in other Nordic countries and several European countries (Mlecnik, Straub, & Haavik, 2019).

An EU-wide definition for the term 'energy renovation' does not exist. It is widely accepted though that energy renovation includes the adoption of all those measures that create long-lived reduction in energy use, after the intervention work is carried out, and which are not dependent on human behaviour (Clark, Gibson, Barth, & Bonato, 2019). In order to realize the business opportunities of energy renovation and to develop further in the market, the construction MSEs are required to address multiple renovation needs of the house owners and offer them more complete and advanced renovation solutions. For this to happen, the MSEs are expected to partner with other actors in the market (Rødsjø, Prendergast, Mlecnik, Haavik, & Parker, 2010) and form collaborative business models for the services they provide (Mlecnik, 2013). The attractiveness and importance of those new business models is highlighted by various researchers (Abuzeinab, Arif, Quadri, & Kulonda, 2018; Aho, 2013; Artola, Rademaekers, Williams, & Yearwood, 2016).

A product-service systems (PSS) business concept has been proposed for the construction MSEs to better satisfy

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Table 1. Structure of construction-related companies in Sweden.

	% of companies in different segments of construction sector					
No. of employees	**Building projects developer**	**Contractors for new building construction**	**Demolition and site preparation contractors**	**Contractors for electrical, plumbing and other construction installation activities**	**Contractors for building completion and finishing**	**Contractors for other specialised construction activities**
0	74	55	58	46	60	55
1–4	22	32	30	37	30	29
5–9	2	6	6	9	5	8
10–19	1	3	3	5	3	5
20–49	1	2	2	3	1	2
50–99	0	1	0	0	0	0
100–199	0	0	0	0	0	0
200–499	0	0	0	0	0	0
500+	0	0	0	0	0	0
Total	100	100	100	100	100	100

Source: Statistics Central Bureau Sweden (2019).

customer needs, increase efficiency, minimize general expenses, and maximize the profit margin (Tukker & Tischner, 2017). Product-service system (PSS) is an emerging business concept, which provides for cohesive delivery of products and services with the aim of pro-environmental outcomes. To adopt such a PSS, the MSEs are expected to change their existing structures and routines, and engage in a joint effort with other companies and with their customers under a common goal of delivering a functional service (Mont, 2002). The one-stop-shop business model for house renovations (Boo, Dallamaggiore, Dunphy, & Morrissey, 2016) is one such PSS concept. In this model, a single actor will coordinate or collaborate with other actors to offer comprehensive renovation packages on energy-efficient renovation. The benefit of this model is that it offers the house owners a unique contact point for all the services involving an energy renovation project, and that participating actors can join together, redefine their activities, and increase their resource efficiency (Mlecnik et al., 2019). It provides a holistic approach, simplifies the planning process, and offers advice on the most appropriate technical solutions and financial schemes. Furthermore, a one-stop-shop (OSS) organization may

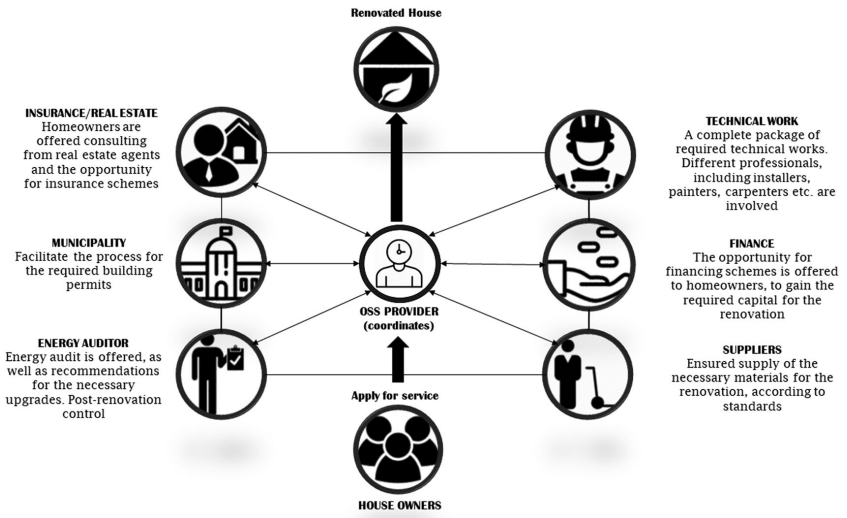

Figure 1. Notional OSS business model.

carry out its services and receive a pre-agreed price depending on the scope of the contract (Boo et al., 2016). Figure 1 offers an illustration of a notional OSS concept for house renovation.

There has been emerging examples of OSS business models for detached houses in the Nordic counties (Mahapatra et al., 2013) and in Europe (Boza-Kiss & Bertoldi, 2018). In Sweden, this is best illustrated by the concept of 'totalentreprenad', i.e. turnkey contract. Such a concept is typically offered by large or medium-size companies, which possess the capability to offer construction management (CM) services as they have internally project management competence that can oversee the planning, design and construction of a project, from its beginning to its end. MSEs in the majority of cases work either as subcontractors to a turnkey contractor or diffuse their manpower in individual small scale projects. According to Swedish Project Management Forum (2019) they have low ability to manage projects.

In Sweden, the application of the turnkey contract concept is known in the construction or renovation of multifamily residential buildings and construction of new detached houses, but not for renovation of detached houses. OSS model is still in its infancy and there is no known company that currently offers such a service. There has been though theoretical studies on OSS business model development (Haavik et al., 2012; Mahapatra et al., 2013; Mahapatra & Gustavsson, 2011; Mlecnik et al., 2019; Vanhoutteghem et al., 2011) and studies about attitudes and perceptions among house owners (Bjørneboe, Svendsen, & Heller, 2018; Bravo, Pardalis, Mahapatra, & Mainali, 2019). Most of these studies highlight the need of OSS to enable scaling up the comprehensive renovation. However, there is a lack of studies on how the MSEs perceive the OSS concept and are prepared to adopt it, especially in the Swedish context. Hence, the aim of this paper is to examine the perceptions and level of preparedness of Swedish construction MSEs regarding their adoption of innovations in general and OSS in particular. From this we will first gain a better understanding of how these firms see their position in the market of house renovations, and secondly, to what extent they believe that the adoption of an innovative business concept will improve their current business practice and benefit them, and thirdly, make an overall evaluation of the proposed concept based on their current organizational state.

Though this is a case study of Swedish construction MSEs, the results can be applicable to the broader context with similar market conditions. This is because construction MSEs in Europe appear to have a set of common characteristics such as limited information and awareness about new technological trends and opportunities, lack of management expertise as they mostly consisted of one person (owner) or a small group of people (family), and lack of financial resources to invest in innovations (Sexton & Barrett, 2003). Moreover, the European Commission through the 'Smart financing for smart buildings' initiative and through the 'new' Energy Performance of Buildings Directive (EPBD) has advocated OSS (Boza-Kiss & Bertoldi, 2018). According to the directive, 'Member States are required to facilitate access to appropriate mechanisms for accessible and transparent advisory tools, such as OSS for consumers and energy advisory services, on relevant energy renovations and financing instruments.' Since OSS models in the EU are in the initial phase of market development and the future is rather unknown (Boza-Kiss & Bertoldi, 2018), empirical analyses are needed to the overall understanding of the OSS market.

Literature review

Innovation is considered as the introduction of new products, processes or services (Dodgson & Gann, 2018; Drucker, 2014; Kahn, 2018). Innovations are classified as 'incremental' or 'radical' depending on whether the innovation is an improvement of an existing technology or a totally new technology (Ringberg, Reihlen, & Rydén, 2019). Innovations have also been classified as radical, incremental, modular, architectural and system innovations (Slaughter, 1998). Goverse, Hekkert, Groenewegen, Worrell, and Smits (2001) classified innovations into six different types based on various combinations of two dimensions of innovation, namely technical radicality and organizational complexity. Garcia and Calantone (2002) also applied similar criteria, which they term technological and/or marketing discontinuities at the micro (firm or customer) and/or macro (market, industry or world) level to classify innovation into radical, really new, and incremental innovations.

Applying this latter typology of Garcia and Calantone (2002), OSS for detached house renovations can be classified as a 'really new innovation', due to marketing discontinuity at macro level (European level). Marketing discontinuity includes lack of services, risk perceptions, business models, etc. There is no technological discontinuity as technology for energy renovation exists.

Innovation in the construction industry

The construction industry in general is traditional (Bennett, 2013) and suffers from lack of innovation (Iranmanesh & Kamal, 2015). Innovation is key for the success of firms regardless of their size (Kyrgidou & Spyropoulou,

2013; Turk, 2016; Zubizarreta, Cuadrado, Iradi, García, & Orbe, 2017). Past research indicates that the adoption of new technologies and practices by the construction firms leads to improved firm performance (Russell, Tawiah, & Zoysa, 2006), increased range of capabilities, sustainable market share (El-Mashaleh, O'Brien, & Minchin Jr, 2006), and organizational competitive advantage (Salunke, Weerawardena, & McColl-Kennedy, 2011). However, compared to large construction firms, SMEs (and therefore MSEs) experience different barriers preventing them to innovate (Reichstein, Salter, & Gann, 2008). They lack the capacity to invest in R&D initiatives (Jung & Andrew, 2014) or in the improvement of their processes. They usually operate in a highly competitive environment, which makes it difficult for them to keep on investing and succeed to innovate over time, especially when their resources for such activities are limited (Iliescu & Ciocan, 2017). That inevitably drives those small firms to try achieve innovation based on their existing financial resources and organizational capabilities, in order to remain competitive. The success of this though remains unclear (Xue, Zhang, Wang, Skitmore, & Wang, 2018).

Factors affecting innovation in organizations

Innovation adoption helps organizations to become more effective and competitive (Damanpour & Wischnevsky, 2006), gain new perspectives and knowledge on existing problems they face (Pérez-Luño, Wiklund, & Cabrera, 2011), and adapt to new situations. However, innovation patterns for the large construction industry are not necessarily appropriate for SMEs and vice versa (Barrett & Sexton, 2006). Studies have shown that many of those SMEs are unfamiliar with existing renovations within their sector, and that they face difficulties when required to work together with other similar companies on whole building solutions (Mlecnik et al., 2019).

There exists a vast literature on factors influencing adoption of innovation in organizations in general (Anderson, Potočnik, & Zhou, 2014; Arpaci, Yardimci, Ozkan, & Turetken, 2012; Damanpour & Schneider, 2006; Frambach & Schillewaert, 2002; Gumusluoglu & Ilsev, 2009) and in specific sectors, e.g. health sector (Adler-Milstein, Kvedar, & Bates, 2014; Hamilton et al., 2014; Wisdom, Chor, Hoagwood, & Horwitz, 2014), automotive (Zailani, Govindan, Iranmanesh, Shaharudin, & Chong, 2015), lodging (Nieves, Quintana, & Osorio, 2014), and construction (Bygballe & Ingemansson, 2014; Martin & Perry, 2019).

Figure 2 presents a conceptual framework for innovation adoption, i.e. the OSS concept in this paper. This framework combines different variables found in the innovation adoption models of Rogers (2005) and Frambach and Schillewaert (2002). These models describe and incorporate the two types of organizational adoption decision that can be identified, i.e. the decision made by an organization and the decision made by an individual within the organization (in our case the construction MSEs owners). The organization's level of preparedness i.e. the degree to which an entity is quicker to take an adoption decision (Rogers, 2005) is an outcome of different parameters related to the nature of innovation itself, the organizational capability, and external factors, which, to a certain extent, affecting the organization's capability to innovate.

Nature of innovation

The nature or characteristics of an innovation as perceived and evaluated by an organization influence the inclination to adopt it (Anderson et al., 2014; Rogers, 2005). Such characteristics are related to the relative advantage (improvement of what already exists in the market), compatibility (consistency with existing organizational values), complexity (how easy innovation is to be understood and used), observability (visibility of results to others) and trialability (existence of an experimenting phase) of innovations (Rogers, 2005). Since deep renovation is complex in nature, including multidisciplinary tasks requiring huge capital investment and time, perceived risk behind trailing innovation in deep renovation by MSEs seems high. Furthermore, perceived risks, like for example market uncertainties and customers' reactions can create a less safe environment for innovation adoption (Freel, 2005). Moreover, the perceived cost-effectiveness from adopting an innovation compared to the current practice provides organizations with an advantage that makes them more likely to adopt it (Damanpour & Schneider, 2006; Graham & Logan, 2004). The perceived innovation characteristics can be considered as subjective indicators reflected in an attitude towards the innovation (Le Bon & Merunka, 1998).

Organizational capability

In many studies, the effect of organizational capability in the preparedness of organizations to innovate has been controverted (Kannebley Jr, Porto, & Pazello, 2005; Rahmouni, Ayadi, & Yıldızoğlu, 2010). A variety of studies have examined relationships between organizations' size, age, structure, business culture and vision, and their inclination to innovate. Some studies found a significant positive relationship between the size of the organizations and its willingness to innovate (Ganotakis & Love, 2010), while some other found this relationship

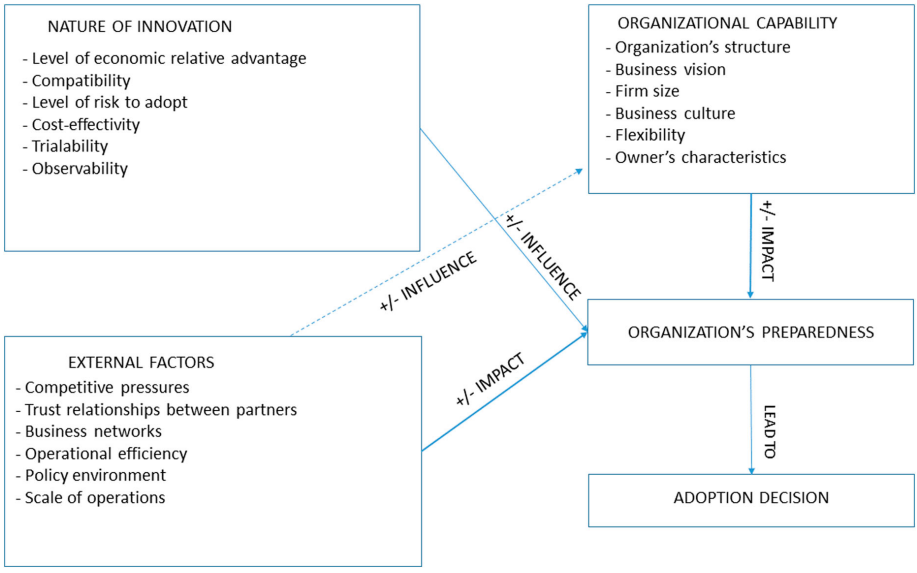

Figure 2. Conceptual framework for OSS innovation adoption. Adaption from Rogers (2005) and Frambach and Schillewaert (2002).

to be weak (Heimonen, 2012). Smaller organizations are considered more flexible and thus it is more probable for them to innovate. However, the size of an organization might be correlated to other variables, such as structure, vision and culture (Bock, Opsahl, George, & Gann, 2012). Smaller organizations usually have a simple structure and therefore are more willing to initiate an adoption decision (Anderson et al., 2014), but they are less prepared to implement an innovation. Regarding culture, organizations with an open mind towards new ideas will be positively influenced to adopt an innovation (Auernhammer & Hall, 2014). As far as it concerns the business vision of organizations, it is important to examine their general attitude regardless of their size (Goffee & Scase, 2015). The need to renew the way they do business and their willingness to enter new markets, positively influence the adoption of innovations. Huergo and Jaumandreu (2004) found a positive relationship between the age of the company and innovativeness, but Coad, Segarra, and Teruel (2013) dispute this relationship. When it comes to SMEs, inclination towards innovations are heavily influenced by the owners, as they can be those initiating innovation activities in the firm (Teirlinck & Spithoven, 2013). Their work experience and broader professional competency facilitate efficient management of the change that the innovation brings within the firm. Moreover, their personality and willingness to take business risks influence the decision for innovation adoption (Gronum, Verreynne, & Kastelle, 2012; Kickul & Gundry, 2002).

In general, organizations go through several stages of development during their life-cycle. Organizations that are at an early stage of their life-cycle are able to grow and become more mature by being innovative, while older firms that are more reluctant towards innovation may experience a period of stagnation or even a decline over time (Hansen, 2009). Nevertheless, older organizations that review the way they operate and remain innovative continue to have an exceptional market performance (Huergo & Jaumandreu, 2004).

Construction MSEs operate in limited geographical areas. Their ability to recognize the value of an innovation, the assimilation of it, and its application to their way of conducting business is very much influenced by their individual internal characteristics. Those organizations usually have no specific goal towards the development of human resources, and strategic adoption of the required innovations. Furthermore, the adoption of an innovation is highly dependent on how individuals are able to acquire, understand and implement new knowledge (Kamal & Flanagan, 2014).

External factors

MSEs lack resources, which act as a barrier towards adopting innovations. Integration with other actors

within the limits of their network is important towards growing their organizational capability to innovate. The existence of networks gives the MSEs the opportunity to complement their own resources, and to mitigate the risks and costs of innovation adoption (Gronum et al., 2012). For effective use of networks, MSEs should be able to identify suitable partners, create and maintain collaborative relationships with them, and identify which elements of their collaborators required to implement successfully their set goals (Forsman, 2011).

Apart from network influences, the business environment affects the adoption of innovations in different ways (Baker, 2012). A potential adopter may gain an understanding of the potential risks associated with the adoption of the innovation from the fact that other partners within a business network have adopted the innovation in the past (Lee, Leong, Hew, & Ooi, 2013). It is more likely that an organization will adopt an innovation if a number of other linked organizations in the market environment have adopted the same or a similar innovation (Wu & Chiu, 2015), or due to the pressure of market competition (Aydalot & Keeble, 2018; Bossle, de Barcellos, Vieira, & Sauvée, 2016; Kirzner, 2015). However, the probability of a competitive disadvantage depends on the strategic importance of the innovation and its effect on the functioning of the organization. Local markets are rather competitive as well, since many MSEs operate in that space. Therefore, the adoption of innovation can become the vehicle for them to achieve the desired business growth (Andersson & Tell, 2009).

Another important external factor affecting innovation adoption is the existing policy environment. Especially for the pre-adoption stage, there are indications that external policies and regulations are positively related to innovation adoption, including specific application of policies, legislation and regulations that facilitate innovation adoption (Aarons, Hurlburt, & Horwitz, 2011; Rogers, 2005). In addition, Bossle et al. (2016) show that if there is a potential market that organizations could penetrate, and there are governmental incentives for companies to develop innovative products and services to address the needs of that market, then it becomes very attractive for many companies engage in innovation. Studies have shown that in organizational settings, characteristics of attitude components (e.g. owner's characteristics and business vision) intervene the influence of external variables, like policy environment, on behavioural intention (Park, Song, Yoon, & Kim, 2014). Furthermore, attitude theory (Fishbein & Ajzen, 1977; Triandis, 1971) presumes that beliefs intercede the impact of external influences, such as persuasive communication and/or active participation on decisions.

Research methods

This research is based on semi-structured interviews with owners of 21 SMEs, out of which 19 are micro and small (MSE) construction enterprises, form the three Swedish counties, namely Kronoberg, Västra Götaland and Kalmar. Interviews were used as a data collection tool with an aim to get detailed information from the interviewees on the subject of our research, which would not be possible with a questionnaire survey (Collis & Hussey, 2013). Data from the interviews were complemented by information collected from the web pages and brochures of the examined companies regarding their structure, the products and services they offer and any potential innovative initiatives they are involved in. For confidentiality purposes, any direct quotes from these brochures or websites are given in an interpretative way. The reason for choosing construction MSEs as an actor to examine are related to their importance in renovation projects. Those companies are expert in their field of work and the have the technical capacity to perform renovation related works. Furthermore, the nature of their operations brings them in direct contact with other professionals in the same field (e.g. suppliers, other small construction contractors, etc.) with whom they might have developed some sort of professional relationship. Moreover, since they interact with house owners, within the limits of their business, they have a better picture of customer needs.

The interviewed companies were randomly selected from online yellow pages based on their size and activities. The keywords used to identify them were 'construction works' (byggarbeten) and 'renovation works' (renoveringsarbeten). Out of the 65 companies approached via telephone calls, 21 agreed to be interviewed. All the 21 companies are or have been actively involved, according to information deriving from the examination of their websites and brochures advertising their services, in the detached house renovation market. No more companies were approached due to the fact that during data analysis similar information appeared from the interviewees. It was reasonable to feel assured that further data collection would yield similar results and would confirm the existing themes and conclusions (Faulkner & Trotter, 2017). Table 2 provides general information about the interviewed companies.

For the interviews, an exploratory approach was used as this places emphasis on examining participant interpretations and takes account of the research context (Bryman, 2008). The interviewer was not allowed to record the interviews electronically, so the proceedings of the interviews were captured through detailed notes

Table 2. Construction-related MSEs interviewed in this study.

Company	Owner's age group	Number of employees	Age of company	Area of operations
1	40–50	2	9	Roof and floor construction and renovation
2	40–50	8	10	Ventilation systems
3	60+	23	43	Heating systems
4	50–60	15	5	Solar panels
5	30–40	4	12	Carpentry
6	40–50	35	16	General house renovations
7	30–40	4	3	Heating systems installations
8	40–50	5	20	Plumbing and electricity services
9	30–40	10	5	Heating and ventilation systems
10	30–40	6	7	Carpentry
11	40–50	4	14	Architect
12	40–50	2	12	General house renovations
13	50–60	2	18	Roof and flooring
14	40–50	24	15	Heating systems
15	40–50	12	10	installations
16	50–60	68	27	Total renovation services
17	40–50	6	20	Flooring and tiling
18	30–40	52	13	New construction, renovation services
19	40–50	18	16	Stairs, remodelling and façade services
20	30–40	4	15	Bathroom renovations
21	30–40	20	10	Heating systems installations

including written comments from the interviewees. Those notes were examined thoroughly by the first author, who conducted all the interviews at the interviewees' place of work. On an average, each interview lasted 95 min.

A funnel approach (Figure 3) was applied for the interviews (Roller & Lavrakas, 2015) with a goal to build trust, affinity, and questions were presented in a way to minimize biases from both the interviewer and interviewee (Hutchings, 2005). Stylistically, open-ended questions in simple language were used to get descriptive answers from the interviewees. Examining the perceptions of interviewees during all the stages of this funnel approach was important, as it provided the researcher with interviewees' individual observations, understanding, interpretations, and evaluation of the discussed subjects (Bennett, 2016). Examining those perceptions allowed the interviewer to gain a clearer picture of those things that should be done for the development of the market of house renovations.

The data from the interviews were analysed following a mix of both a deductive and inductive approach in a sequential way. A deductive approach was applied to draw a list of factors (or codes) from the existing literature on the topic of innovation adoption (like e.g. trialability of innovation, business vision of the company, operational efficiency, etc.). The deductive approach assumes that certain substantial concepts are in the data based on knowledge gained after examining the existing literature on the topic (Bradley, Curry, & Devers, 2007; Thomas, 2006). Data were coded into categories using a start list. After developing clusters of data from the deductive analysis, an inductive analysis was conducted by engaging detailed readings of interviews' data, not only to gain comprehensive understanding of what interviewees said (Gale, Heath, Cameron, Rashid, & Redwood, 2013), but also to make sure that all

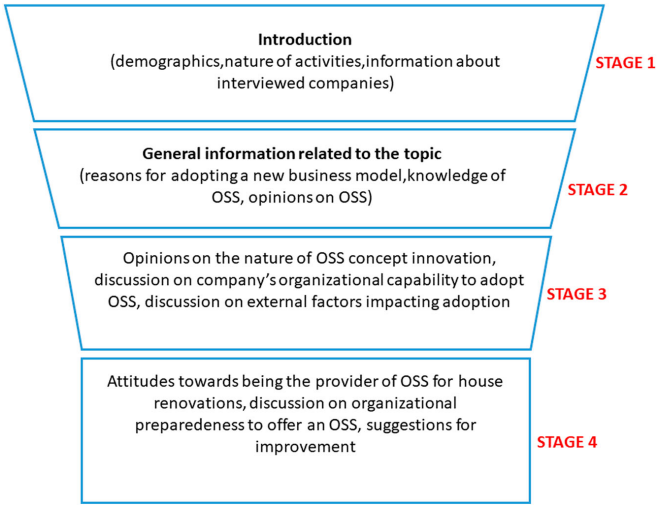

Figure 3. Funnel approach of interviewing. Adaption from Roller and Lavrakas (2015).

important aspects of data were captured. The authors after examining thoroughly the notes from interviews, assigned codes to paragraphs or segments of texts relevant to the parameters of the framework of organizational innovation adoption of Figure 2. Key concepts and themes were identified using those parameters as lenses. Deriving themes from the raw data using the inductive approach prevented the possibility authors to lead to subjective conclusions (Bradley et al., 2007). The sequential approach using deductive and inductive analysis resulted in two categories of data sets, which were reduced to manageable sizes by creating bigger categories including similar ones (e.g. the bigger category of owner's characteristics includes the sub-categories business behaviour, management style, commitment, etc.). The preparation and organization of data and the stages of the analysis process can be seen in Figure 4.

The data collected in this research were validated with the employment of triangulation strategy (Flick, 2018), and more specifically the employment of multiple investigators from different disciplines (Merriam & Tisdell, 2015). Apart from the authors, two additional individuals from social science discipline analysed the same data, resulting in similar conclusions. Additionally, findings from the examined MSEs websites and brochures confirmed the testimonies of their owners in subjects like i.e. future vision, collaborative culture and so on. Moreover, as previously mentioned, during the analysis, similar information appeared from the interviewees, which indicates that our data is saturated, and thus more reliable.

Research findings

General perception on OSS

Interviewees were asked to comment on the model presented in Figure 1, and share their opinion about the OSS concept as a whole. Their responses were largely homogeneous. The majority of the interviewees showed a keen interest in OSS. They claimed that it opens space for collaborations with professionals from other fields of business, which could provide a great opportunity to strengthen their position in the market and expand their networks. They firmly believed that they could learn a lot from their collaborators and improve the way they do business. Furthermore, learning from experts from different business segments would provide them with an opportunity to adopt a more extrovert business approach and possibly reach a new customer base. Some of the interviewees mentioned that a more simplified version of the concept exists in the market. They described that if a customer needs to perform more than one technical work in their house, then usually they sign a single contract with the company having the largest share of work, and the rest are employed as sub-contractors. They all agreed, that the concept given to them does not exist, to their knowledge, at the moment in their local markets.

According to the interviewees, the OSS concept seems to be compatible to their current way of delivering work, and its adoption would result in reaching a new market that potentially could increase their profit. A common response and conviction of all the respondents was that the one who

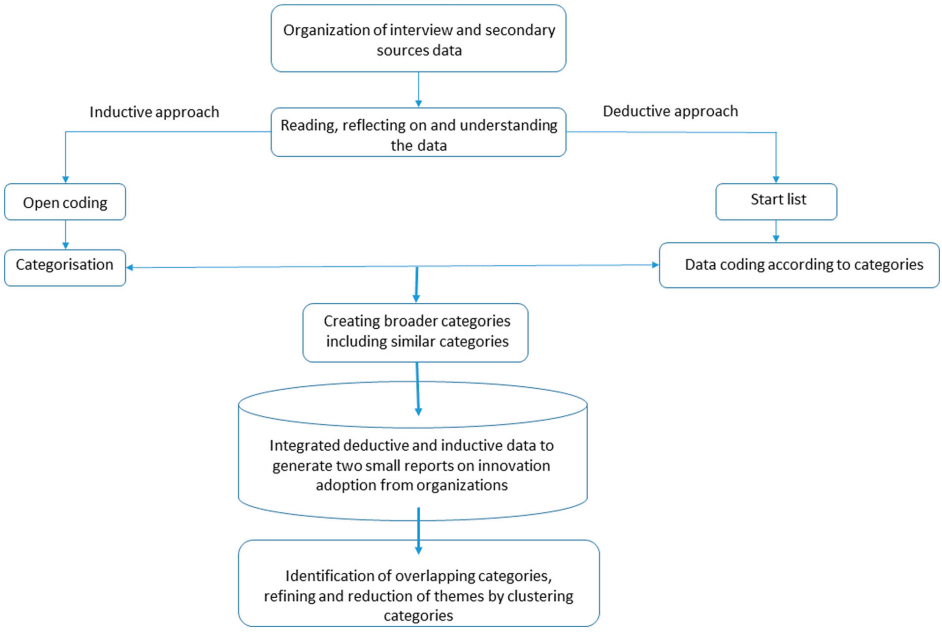

Figure 4. Preparation, organization and data analysis process. Adapted from Azungah (2018).

will bring such a holistic approach in house renovations would gain the ability to lead the market. But they claimed though that this would probably take some time, since at the moment the greatest focus is placed upon new constructions. As one of the interviewees pointed out:

> … it is certain that an integrated service for house renovations would have been very attractive for the customers, and would definitely challenge us and the way we do business at present, setting an example for the future. Do not expect though this to happen immediately, especially when we talk about a local market. People are used to the current market situation and it will take time to accept something new …

External factors

While discussing the business environment in which they currently operate, all interviewees agreed that local markets are limited in terms of share for their business. For example, one interviewee quoted that:

> If you consider how many companies can offer the same service as you, then you realize that your market share is limited and you need to offer your product in a more attractive way to choose you.

According to them, there is high competition in the local markets in which they operate, where every company tries to sell their own product or service to the same customer base, which in some cases leads to great conflicts of interest. 'The market for heating systems is good, but at the same time it makes it more difficult for us to convince people to make changes in the façade of their house' stated one of the interviewees. Another said:

> Most of the smaller size companies have a craftsman that they know from previous collaborations, which they offer to the customers for additional renovation services for attractive prices. To deal with that I need to lower the cost for my services to remain competitive. You understand that this creates certain problems to me and my business

Despite the competition, they admit that, in general, companies respect each other and that no great volatility exists. Most of those companies are usually called to work together as sub-contractors to larger firms, which allows them to develop business relationships and to exchange knowledge in projects. Through those relationships, they admit, they gain access to more customers, as word of mouth is their main advertising strategy, and getting good references from past collaborators help them to work in new projects. Moreover, the vast majority of interviewees claimed that it is a common practice, when they are called to perform a technical work, the customer asks them for additional works that

could be performed to improve their house. For those extra works, usually they propose artisans within their network of collaborators.

> Before installing a new heating system, I always propose to my customers to proceed to more changes, like for example windows or additional ceiling insulation. I have worked with a company delivering such services, and I know they can deliver good work at an affordable price. They also give reference to me to their clients,

Answered one of the interviewees, confirming that 'word of mouth' promotional practice for services for companies operating in the same geographical area. The same principle applies to a lesser or greater extent for the rest of the examined MSEs.

Policy environment, and especially the new Energy Performance of Building Directive from EU (Directive E.E., 2018), creates a fertile ground for more business according to all interviewees. Using different expressions, all came to the same conclusion that there are many houses across the country that are in definite need for some type of renovation, and that creates opportunities for them to sign more contracts and have an increased amount of job. Surprisingly, however, this market is not their present priority, since they are busy working in new construction, and have limited time and human resources to deploy in renovation projects. Some of the respondents argued that if there was a more favourable tax environment for small companies, they could recruit more staff, so they can take advantage of the business opportunities that the house renovation sector offers. Moreover, in the direction of opportunities to create new jobs, five of the respondents argued that they have knowledge of state funding opportunities for the development of small businesses and the development of new sustainability-related products and services. According to them, however, both they and most businesses in their sector do not know how to access these funds. In the case of construction MSEs in Sweden though, those favourable policies, even if they exist, they remain unreachable for those type of entrepreneurs. The end result is entrepreneurs preferring to continue with what they call 'business as usual', rather than investing resources to innovate.

Organizational capability

In the discussion regarding business culture and innovation, the interviewees had different perceptions on how they will achieve growth of their company. Those companies are owner-centred organizations, where the owner has in most of cases the final word for every decision related to organizational changes and innovation adoption. The common feature of those owners is that they consider themselves entrepreneurs and business persons, who want to be at the forefront of trends and developments in their field. All of them showed an open-minded attitude towards new ideas, which in combination with their entrepreneurial attitude, are aligned to the personality characteristics that can positively influence innovation adoption. However, they are somewhat conservative while implementing an innovation in their current practice.

MSEs operating in the market for longer time (up to 15 years) stated that it is their goal to grow their business and enter new markets in the near future.

> There are still unexplored areas in the building industry, which we should consider exploring in the future …

Claimed one of the respondents, while another stated that:

> I have inherited this business from my father, and I believe that as a younger person I can see more ways to conduct business than he did.

Another interviewee took it a step further, claiming that:

> At the moment we have the knowledge and networks that allow us to expand beyond the limits of our current area of operations.

It becomes evident from their answers that the age of the company cannot act as a motivating factor only by itself, but in combination with the personality and characteristics of the owner. For older companies in the market (operating for more than 15 years), the opportunity for business growth is not a strong motive to innovate. They act in a reserved way, and they are not willing to change the way they operate, feeling safer within the limits of their current operations. For them, exceptional market performance is connected with the offering of the latest technology within the area of their expertise. Characteristic of that attitude were the words of the owner of a MSE offering plumbing and electricity services who said:

> I feel pleased with the amount of work I deal with at the moment. New construction is blooming and smaller projects are always on the run. I see no reason to try to swim in dark waters

While another stated:

> I am focusing on offering to my clients the latest technology existing. That makes me differ from my competitors. People can find through me products that nobody in the area is able to offer.

When discussing potential changes in their organizational structure due to the adoption of an innovation,

the vast majority of the examined companies suggested that such an incident would be 'bad for business'. The need of owners to have control of their organization, and potential changes in the way they have formed their business, or the way they deliver their services makes them feel insecure and not taking risks that could harm what they have achieved so far. Even if they understand that adopting an innovation could help them grow and require sacrifices, their personality and the lack of a risk-taking attitude act as a deterrent on their decision to innovate. Potential changes in organizational structure and way of delivering services can also lead to financial and time planning inefficiencies according to the interviewees. For example, one interviewee observed:

> … changing organizational structure requires hiring new competent people to deliver. It is my company and I feel more secure when I can control how this company operates …

However, two MSE owners had a different opinion on this issue. According to them, taking risks and changing the organization structure is the driving force for growth, but before taking such risks, a careful and thorough investigation of all involved parameters is required. Moreover, in terms of having control of their own business, both of them stated:

> I have no problem sharing control of the company's activities. I would prefer though to do that with a person that we share common views.

All the interviewed MSE owners seem not convinced that the adoption of OSS would be a good decision for them. According to them, the size of their company does not leave space for complex business structures. They were worried that the adoption of such a model would cause a great disturbance to the balance they have managed to achieve in their business, and disappoint their employees, whose satisfaction is considered the key for companies' success. They insisted that investing in changing their business model is valued less than investing in creating opportunities for an improved working environment and training of their personnel.

Construction SMEs as providers of OSS

In the last part of the interview, interviewees were asked to express their opinion regarding the probability of them offering OSS service for house renovation, as presented in Figure 1. All of them saw potential in the concept and had a general interest, but were hesitant to offer such a service due to certain concerns. They all recognized that offering such a service to customers will provide them with a definite relative advantage in the market. All of them actually perceived OSS as a

> … certainly more efficient and complete way to offer an attractive renovation package …

With one of them paralleling OSS with Walmart's 'pay less, live better' concept. Concerns were raised regarding the complexity of the model with most of them referring to the risk factors. Perceived risks related to the adoption of an innovation have been found as a parameter that creates a negative decision environment for them. That applies to the case of the examined construction MSEs in this study, as they seem to feel worried of the impact that those risks can have in their current operations. This was expressed like:

> '… who will be responsible for what.', '… it is important the contract to state clearly who is responsible for potential problems and malfunctions …' or '… signing a contract with a client is OK, but having to sign contracts with several technicians worries me as they would probably want to lower their risk …'

The complexity factor also appeared in the concern for coordination of an OSS renovation project. The lack of project management competence among most of the MSEs owners makes them concerned for whether they would be able to deliver efficiently what would be promised to the customer. Furthermore, the interviewees connected efficient coordination with their ability to understand the work of each technician. The vast majority of MSEs owners claimed that their work is '… rather specialized and unique in each project …', and that they were unable to '… fit in someone else's working schedule, when having ongoing projects … .' Additionally, they felt that the effort to coordinate different professionals and try to bridge the gaps between different working cultures would bother them.

Another important element that was raised was related to the uncertainties around OSS. All respondents stated that the market now is mostly oriented towards new buildings, and the taxation environment limits their opportunities to try some-thing new, while they have to ensure adequate capital flow in their business. They were uncertain regarding the quality of the new service they might offer. Even though they can guarantee the quality of work performed by themselves, they feel unable to offer the same guarantees for the work delivered by other actors involved in the renovation. Even though they trust those actors, they have little knowledge of their expertise, and that may lead to a poor service and quality of renovation. Potential failures to deliver what they promise will harm their business and their reputation in the market. They were not against participating in such a business if someone else took the lead.

They have proposed that during a trial period of application of this OSS concept there should be an entrepreneur, who has knowledge of the building industry and managerial competence, could take the role of the project manager and coordinate all the different actors involved. The entrepreneur would ensure the quality of the final product to be delivered on promised time and agreed-upon cost. Taking into account the consultation of the interviewees on how OSS concept should be applied during the trial period of implementation, it would have a form as illustrated in Figure 5.

Discussion and conclusions

The main findings of the interview, when visualized in relation to the conceptual theoretical framework we used, would look like Figure 6. Different pattern lines indicate the positive, negative, or neutral influence of various variables on the organizational preparedness for OSS adoption.

This paper has analysed the perceptions of construction MSEs regarding OSS business model for the holistic renovation of detached houses, and has examined their level of preparedness to offer such a service. The results showed that the examined MSEs consider OSS concept as appealing with obvious future benefits for their business. Even if turnkey contractor concept exists in the market, OSS is might be more appropriate for construction MSEs to lead the market of detached house renovations. However, they are not yet ready to adopt the OSS, at least at present, mainly due to the perceived complexity of the model, the likely need to change the existing business structure, and the ensuing perceived business risks.

The age of the companies affects their willingness to innovate as found by Aarons et al. (2011). MSEs that are at their initial stage, or are not fully mature, see a new innovative way to offer their services as a strategic step towards expanding their business. Such a step is considered as an opportunity to explore new business potentials and gain a better position in the market. They are a bit reserved though, fearing that the changes accompanying the introduction of an innovative service delivery in their current business practice, might harm their current operations. Any such eventual change is seen as a danger to their ability to deliver services, and a potential cause of further inconsistencies in their overall business operation. Therefore, even if they recognize the benefits from adoption such an innovation, and it was clear to them that this would help in the growth of the company, the risks and uncertainties prevail over the potential adoption. On the other hand, mature organizations, with longer experience in the market, consider that their position in the market will be enforced and maintained if they offer the latest technology within their area of expertise, and thus decline to adopt innovations in the way they deliver their services. The certainty with which the owners of those mature MSEs expressed this view, shows that we cannot talk about a period of stagnation towards innovation adoption for

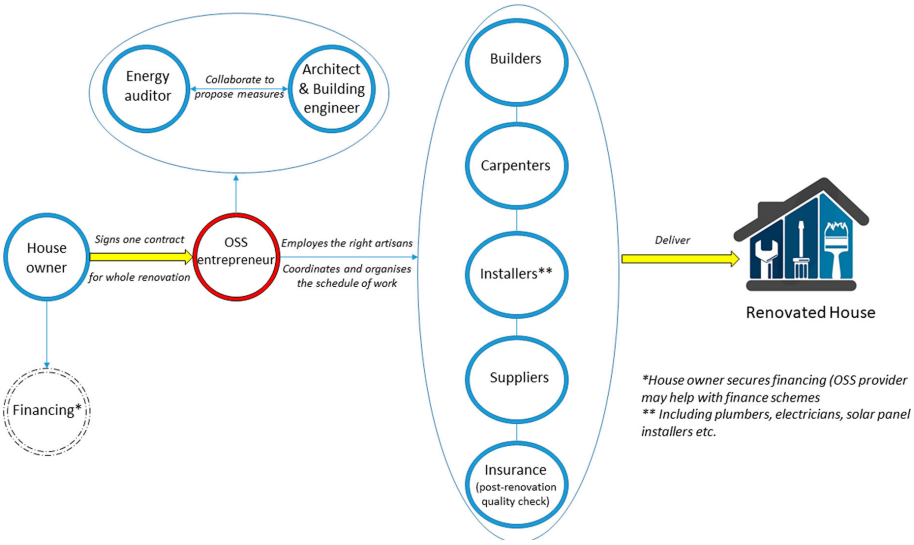

Figure 5. OSS concept for detached house renovation. Illustration developed after consultation of interviewees.

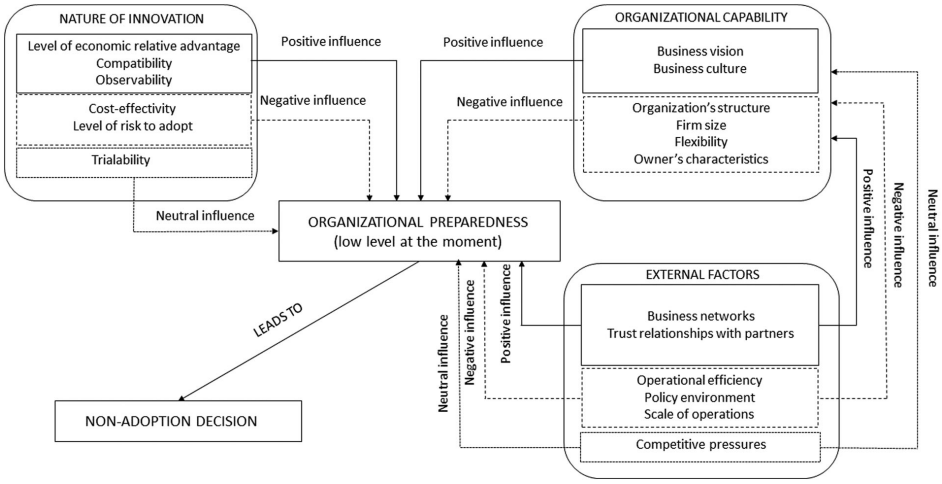

Figure 6. Reasons for non-adoption of OSS concept.

them, as described by Hansen (2009), but an absolute decline. Moreover, for those MSEs exceptional market performance is not connected with a desire to remain innovative, contradicting the findings of Huergo and Jaumandreu (2004). Additionally, their small size and the controlling nature of their owners makes most of the examined MSEs less flexible and less probable to innovate, a finding that opposes that of Tolbert and Hall (2015).

The internal characteristics of the organizations such as their business vision and culture dictate that they should strive for future growth, thus be more inclined to innovate. OSS though, entails changes in organizational structure, which the examined firms did not support due to their size and limited flexibility. Moreover, the lack of managerial and coordination skills (in projects requiring the collaboration of different actors) of the examined MSE owners have a negative impact on organizations' preparedness to innovate. External factors, such as existing business networks and trust relationships between the potential partners have a positive impact on the examined organizations preparedness to adopt OSS concept. This limits their scale of operations, and creates problems in their ability to expand their business in the field of detached house renovations, as they currently use all their resources to work in new constructions as sub-contractors to larger companies. Additionally, the examined construction MSEs feel that there is no competitive pressure regarding OSS, since it is a concept with no actual market application yet.

A positive policy environment supports the adoption of innovations (Aarons et al., 2011). Especially, policies that overcome business risks may promote a really new innovation. In Sweden, opportunities exist for the MSEs to avail capital incentives, which may overcome their concern for the risks of adopting new business concepts. The examined companies perceive such support mechanism as something appealing, but they lack knowledge on how and where to seek such opportunities. For the examined MSEs there is only a small point of disagreement with current policies that has to do with the taxation on small businesses, which, according to them, can be improved.

The MSEs consider their business environment as highly competitive, but they seem to work well together when working under the coordination of turnkey contractors. Additionally, owners of these MSEs perceived working with other professionals as a great opportunity to strengthen their competencies. Unlike turnkey contractors though, they lack competencies that will allow them to tackle potential conflicts of interest among involved actors, and mitigate the risks that a renovation project entails.

The perception that OSS is compatible with the MSEs' current operations, the observability they will gain in the market, and the perceived economic advantage they will gain from OSS have a positive influence on their organizational preparedness. On the other hand, the risks related to OSS adoption and the uncertainty that an investment on OSS will pay back, negatively influences the MSEs. When it comes to offering OSS, that risk avoidance behaviour of MSEs, combined with the lack of managerial competencies, makes them hesitant to take-in charge. They have a clear view that a new type of actor should act as

an OSS entrepreneur and be responsible for the coordination of a renovation project, at least on the trial phase of the application of such a model. For them, such an entrepreneur has the role of a safety measure to notice how this concept works and which problems in their interaction with the other involved actors need to be addressed. Additionally, that external entrepreneur is thought to bridge the competency gap those MSEs have, and will allow them to understand better what they are missing internally, setting the framework for the smooth operation and further development of OSS for them in the future. Therefore, we can safely assume that such an entrepreneur is not affecting the level of preparedness of those MSEs to innovate.

The research has conducted in a specific geographical location, coverage of larger geographical regions and examining a larger sample of construction SMEs could have been better in capturing different perspectives. Furthermore, since the data was collected through a series of interviews there are limitations related to data collection approach. The researchers tried to keep a distance and to interpret the answers they received in a way that would ensure objectivity and scientific validity. However, that interpretation might not fully reflect the views expressed. Moreover, since the interviews were not allowed to be recorded electronically, some of the comments might not be noted.

Concluding, we can claim that the variables having negative influence are of greater importance for the organizational preparedness of the examined MSEs as they affect the core of how they conduct business. That results in low level of organizational preparedness, and consequently lack of inclination, to adopt the OSS concept, at least for nonce. Nevertheless, the examined MSEs are interested to be a part of the OSS concept, but not as coordinators of the whole house renovation process. The role of the coordinating, the examined MSEs owners suggest, should be undertaken by an external entrepreneur, during the trial phase of the OSS concept application. The role of that external entrepreneur needs to be further investigated to define accurately his role on the OSS model and the required competencies one must possess to successfully address the needs of that role. In overall, capacity building activities and studies are deemed necessary to support MSEs journey towards the OSS market development and identifying their roles within it.

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References

Aarons, G. A., Hurlburt, M., & Horwitz, S. M. (2011). Advancing a conceptual model of evidence-based practice implementation in public service sectors. *Administration and Policy in Mental Health and Mental Health Services Research*, *38*(1), 4–23.

Abuzeinab, A., Arif, M., Quadri, M. A., & Kulonda, D. (2018). Green business models in the construction sector: An analysis of outcomes and benefits. *Construction Innovation*, *18* (1), 20–42.

Adler-Milstein, J., Kvedar, J., & Bates, D. W. (2014). Telehealth among US hospitals: Several factors, including state reimbursement and licensure policies, influence adoption. *Health Affairs*, *33*(2), 207–215.

Aho, I. (2013). Value-added business-models: Linking professionalism and delivery of sustainability. *Building Research & Information*, *41*(1), 110–114.

Anderson, N., Potočnik, K., & Zhou, J. (2014). Innovation and creativity in organizations: A state-of-the-science review, prospective commentary, and guiding framework. *Journal of Management*, *40*(5), 1297–1333.

Andersson, S., & Tell, J. (2009). The relationship between the manager and growth in small firms. *Journal of Small Business and Enterprise Development*, *16*(4), 586–598.

Arpaci, I., Yardimci, Y. C., Ozkan, S., & Turetken, O. (2012). Organizational adoption of information technologies: A literature review. *International Journal of eBusiness and eGovernment Studies*, *4*(2), 37–50.

Artola, I., Rademaekers, K., Williams, R., & Yearwood, J. (2016). Boosting building renovation: what potential and value for Europe?, Study for the Policy Department A: Economic and Scientific Policy, European Parliament, European Union.

Auernhammer, J., & Hall, H. (2014). Organizational culture in knowledge creation, creativity and innovation: Towards the Freiraum model. *Journal of Information Science*, *40*(2), 154–166.

Aydalot, P., & Keeble, D. (2018). High-technology industry and innovative environments in Europe: An overview. In *High technology industry and innovative environments* (pp. 1–21). Oxon: Routledge.

Azungah, T. (2018). Qualitative research: Deductive and inductive approaches to data analysis. *Qualitative Research Journal*, *18*(4), 383–400.
Baker, J. (2012). The technology–organization–environment framework. In *Information systems theory* (pp. 231–245). New York, NY: Springer.
Barrett, P., & Sexton, M. (2006). Innovation in small, project-based construction firms. *British Journal of Management*, *17* (4), 331–346.
Bennett, J. (2013). *Construction the third way: Managing Cooperation and competition in construction*. Oxon: Routledge.
Bennett, N. J. (2016). Using perceptions as evidence to improve conservation and environmental management. *Conservation Biology*, *30*(3), 582–592.
Bjørneboe, M. G., Svendsen, S., & Heller, A. (2018). Initiatives for the energy renovation of single-family houses in Denmark evaluated on the basis of barriers and motivators. *Energy and Buildings*, *167*, 347–358.
Bock, A. J., Opsahl, T., George, G., & Gann, D. M. (2012). The effects of culture and structure on strategic flexibility during business model innovation. *Journal of Management Studies*, *49*(2), 279–305.
Boo, E., Dallamaggiore, E., Dunphy, N., & Morrissey, J. (2016). How innovative business models can boost the energy efficient buildings market. *International Journal for Housing Science and Its Applications*, *40*(2), 73–83.
Bossle, M. B., de Barcellos, M. D., Vieira, L. M., & Sauvée, L. (2016). The drivers for adoption of eco-innovation. *Journal of Cleaner Production*, *113*, 861–872.
Boverket. (2015). Förslag till Utvecklad Nationell Strategi för Energieffektiviserande Renovering Boverket [Proposal to develop national strategy for energy efficient renovation]; Boverket Publikationsservice: Stockholm, Sweden.
Boza-Kiss, B., & Bertoldi P. (2018). *One-stop-shops for energy renovations of buildings*. Ispra: European Commission, JRC113301.
Bradley, E. H., Curry, L. A., & Devers, K. J. (2007). Qualitative data analysis for health services research: Developing taxonomy, themes, and theory. *Health Services Research*, *42*(4), 1758–1772.
Bravo, G., Pardalis, G., Mahapatra, K., & Mainali, B. (2019). Physical vs. aesthetic renovations: Learning from Swedish house owners. *Buildings*, *9*(1), 12.
Bryman, A. (2008). *Research methods and organization studies*. Abingdon, UK: Routledge.
Bygballe, L. E., & Ingemansson, M. (2014). The logic of innovation in construction. *Industrial Marketing Management*, *43*(3), 512–524.
Clark IIW. W., Gibson, R., Barth, J., & Bonato, D. (2019). Finance, Economics, and sustainability. In *Climate Preservation in Urban Communities case studies* (pp. 245–289). Oxford, UK: Butterworth-Heinemann.
Coad, A., Segarra, A., & Teruel, M. (2013). Like milk or wine: Does firm performance improve with age? *Structural Change and Economic Dynamics*, *24*, 173–189.
Collis, J., & Hussey, R. (2013). *Business research: A practical guide for undergraduate and postgraduate students*. London: Macmillan International Higher Education.
Damanpour, F., & Schneider, M. (2006). Phases of the adoption of innovation in organizations: Effects of environment, organization and top managers 1. *British Journal of Management*, *17*(3), 215–236.
Damanpour, F., & Wischnevsky, J. D. (2006). Research on innovation in organizations: Distinguishing innovation-generating from innovation-adopting organizations. *Journal of Engineering and Technology Management*, *23* (4), 269–291.
Dodgson, M., & Gann, D. (2018). *Innovation: A very short introduction*. Oxford, UK: Oxford University Press.
Drucker, P. (2014). *Innovation and entrepreneurship*. Abingdon, UK: Routledge.
El-Mashaleh, M., O'Brien, W. J., & Minchin Jr, R. E. (2006). Firm performance and information technology utilization in the construction industry. *Journal of Construction Engineering and Management*, *132*(5), 499–507.
European Commission. (2018). What is an SME? Retrieved from http://ec.europa.eu/growth/smes/business-friendly-environment/smedefnition_en
European Parliament. (2018). Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency. *Official Journal of the European Communities*, *61*, 75–91.
Faulkner, S. L., & Trotter, S. P. (2017). Data saturation. In J. Matthes, C. S. Davis, & R. F. Potter (Eds.), *The international encyclopedia of communication research methods* (pp. 1–2). Hoboken, NJ: John Wiley & Sons.
Fishbein, M., & Ajzen, I. (1977). *Belief, attitude, intention, and behavior: An introduction to theory and research*. Reading: Addison-Wesley Publication Company.
Flick, U. (2018). *Triangulation in data collection. The SAGE handbook of qualitative data collection*. London: SAGE.
Forsman, H. (2011). Innovation capacity and innovation development in small enterprises. A comparison between the manufacturing and service sectors. *Research Policy*, *40*(5), 739–750.
Frambach, R. T., & Schillewaert, N. (2002). Organizational innovation adoption: A multi-level framework of determinants and opportunities for future research. *Journal of Business Research*, *55*(2), 163–176.
Freel, M. S. (2005). Perceived environmental uncertainty and innovation in small firms. *Small Business Economics*, *25* (1), 49–64.
Gale, N. K., Heath, G., Cameron, E., Rashid, S., & Redwood, S. (2013). Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC Medical Research Methodology*, *13*(1), 117.
Ganotakis, P., & Love, J. H. (2010). R&D, product innovation, and exporting: Evidence from UK new technology based firms. *Oxford Economic Papers*, *63*(2), 279–306.
Garcia, R., & Calantone, R. (2002). A critical look at technological innovation typology and innovativeness terminology: A literature review. *Journal of Product Innovation Management: An International Publication of the Product Development & Management Association*, *19*(2), 110–132.
Goffee, R., & Scase, R. (2015). *Corporate realities (Routledge revivals): The dynamics of large and small organisations*. Originally published 1995. London: Routledge.
Goverse, T., Hekkert, M. P., Groenewegen, P., Worrell, E., & Smits, R. E. (2001). Wood innovation in the residential construction sector; opportunities and constraints. *Resources, Conservation and Recycling*, *34*(1), 53–74.
Graham, I. D., & Logan, J. (2004). Innovations in knowledge transfer and continuity of care. *CJNR (Canadian Journal of Nursing Research)*, *36*(2), 89–103.

Gronum, S., Verreynne, M. L., & Kastelle, T. (2012). The role of networks in small and medium-sized enterprise innovation and firm performance. *Journal of Small Business Management*, *50*(2), 257–282.

Gumusluoglu, L., & Ilsev, A. (2009). Transformational leadership, creativity, and organizational innovation. *Journal of Business Research*, *62*(4), 461–473.

Haavik, T., Aabrekk, S., Mlecnik, E., Cré, J., Kondratenko, I., Paiho, S., & Mostad, K. (2012). Guideline: How to develop a business model for one stop shop house renovation. *Segel, Nordfjordeid*.

Hamilton, A. B., Oishi, S., Yano, E. M., Gammage, C. E., Marshall, N. J., & Scheuner, M. T. (2014). Factors influencing organizational adoption and implementation of clinical genetic services. *Genetics in Medicine*, *16*(3), 238.

Hansen, B. J. (2009). Small business growth and non-growth over the long-term (Unpublished master's thesis). University of Canterbury, Christchurch.

Heimonen, T. (2012). What are the factors that affect innovation in growing SMEs? *European Journal of Innovation Management*, *15*(1), 122–144.

Huergo, E., & Jaumandreu, J. (2004). How does probability of innovation change with firm age? *Small Business Economics*, *22*(3-4), 193–207.

Hutchings, K. (2005). Examining the impacts of institutional change on knowledge sharing and management learning in the people's Republic of China. *Thunderbird International Business Review*, *47*(4), 447–468.

Iliescu, M., & Ciocan, R. (2017). Modern technologies innovation in use for quality control on construction site. *Procedia Engineering*, *181*, 999–1004.

Iranmanesh, M., & Kamal, E. M. (2015). Innovation practices in construction firms. *Advances in Environmental Biology*, *9* (5), 124–126.

Jung, K., & Andrew, S. (2014). Building R&D collaboration between university-research institutes and small medium-sized enterprises. *International Journal of Social Economics*, *41*(12), 1174–1193.

Kahn, K. B. (2018). Understanding innovation. *Business Horizons*, *61*(3), 453–460.

Kamal, E. M., & Flanagan, R. (2014, April). Model of absorptive capacity and implementation of new technology for rural construction SMEs. *Australasian Journal of Construction Economics and Building-Conference Series*, *2* (2), 19–26.

Kannebley Jr, S., Porto, G. S., & Pazello, E. T. (2005). Characteristics of Brazilian innovative firms: An empirical analysis based on PINTEC – industrial research on technological innovation. *Research Policy*, *34*(6), 872–893.

Kickul, J., & Gundry, L. (2002). Prospecting for strategic advantage: The proactive entrepreneurial personality and small firm innovation. *Journal of Small Business Management*, *40*(2), 85–97.

Kirzner, I. M. (2015). *Competition and entrepreneurship*. Chicago, IL: University of Chicago press.

Kyrgidou, L. P., & Spyropoulou, S. (2013). Drivers and performance outcomes of innovativeness: An empirical study. *British Journal of Management*, *24*(3), 281–298.

Le Bon, J., & Merunka, D. (1998). The role of attitude in competitive intelligence activities of salespersons: Evidence and consequences of the mediating effect. *ISBM Report*, *22*.

Lee, V. H., Leong, L. Y., Hew, T. S., & Ooi, K. B. (2013). Knowledge management: A key determinant in advancing technological innovation? *Journal of Knowledge Management*, *17*(6), 848–872.

Mahapatra, K., & Gustavsson, L. (2011). Full service energy efficient renovation business for Swedish single-family houses. In *World Sustainable Building Conference, 18-21 October, Helsinki, Finland*.

Mahapatra, K., Gustavsson, L., Haavik, T., Aabrekk, S., Svendsen, S., Vanhoutteghem, L., & Ala-Juusela, M. (2013). Business models for full service energy renovation of single-family houses in Nordic countries. *Applied Energy*, *112*, 1558–1565.

Martin, L., & Perry, F. (2019). Sustainable construction technology adoption. In *Sustainable construction technologies* (pp. 299–316). Oxford, UK: Butterworth-Heinemann.

Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation*. Hoboken, NJ: Wiley.

Mlecnik, E. (2013). Opportunities for supplier-led systemic innovation in highly energy-efficient housing. *Journal of Cleaner Production*, *56*, 103–111.

Mlecnik, E., Straub, A., & Haavik, T. (2019). Collaborative business model development for home energy renovations. *Energy Efficiency*, *12*(1), 123–138.

Mont, O. K. (2002). Clarifying the concept of product–service system. *Journal of Cleaner Production*, *10*(3), 237–245.

Nieves, J., Quintana, A., & Osorio, J. (2014). Knowledge-based resources and innovation in the hotel industry. *International Journal of Hospitality Management*, *38*, 65–73.

Park, Y. K., Song, J. H., Yoon, S. W., & Kim, J. (2014). Learning organization and innovative behavior: The mediating effect of work engagement. *European Journal of Training and Development*, *38*(1/2), 75–94.

Pérez-Luño, A., Wiklund, J., & Cabrera, R. V. (2011). The dual nature of innovative activity: How entrepreneurial orientation influences innovation generation and adoption. *Journal of Business Venturing*, *26*(5), 555–571.

Rahmouni, M., Ayadi, M., & Yıldızoğlu, M. (2010). Characteristics of innovating firms in Tunisia: The essential role of external knowledge sources. *Structural Change and Economic Dynamics*, *21*(3), 181–196.

Reichstein, T., Salter, A. J., & Gann, D. M. (2008). Break on through: Sources and determinants of product and process innovation among UK construction firms. *Industry and Innovation*, *15*(6), 601–625.

Ringberg, T., Reihlen, M., & Rydén, P. (2019). The technology-mindset interactions: Leading to incremental, radical or revolutionary innovations. *Industrial Marketing Management*, *79*, 102–113.

Rogers, E. M. (2005). *Diffusion of innovations* (5th ed.). New York, NY: Free Press.

Roller, M. R., & Lavrakas, P. J. (2015). *Applied qualitative research design: A total quality framework approach*. New York, NY: Guilford Publications.

Rødsjø, A., Prendergast, E., Mlecnik, E., Haavik, T., & Parker, P. (2010). From demonstration projects to volume market. Market development for advanced housing renovation, report of the IEA SHC Task 37. Retrieved from http://task37.iea-shc.org/Data/Sites/1/publications/Advanced_Housing_Renovation.pdf,

Russell, A. D., Tawiah, P., & Zoysa, S. D. (2006). Project innovation-a function of procurement mode? *Canadian Journal of Civil Engineering*, *33*(12), 1519–1537.

Salunke, S., Weerawardena, J., & McColl-Kennedy, J. R. (2011). Towards a model of dynamic capabilities in innovation-based competitive strategy: Insights from project-oriented service firms. *Industrial Marketing Management*, *40*(8), 1251–1263.

Sexton, M., & Barrett, P. (2003). Appropriate innovation in small construction firms. *Construction Management and Economics*, *21*(6), 623–633.

Slaughter, E. S. (1998). Models of construction innovation. *Journal of Construction Engineering and Management*, *124* (3), 226–231.

Statistics Central Bureau Sweden. (2019). Enterprises (FDB) by industrial classification SNI 2007 and size class. Year 2008–2018. Retrieved from http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START__NV__NV0101/FDBR07N/

Swedish Energy Agency. (2017). Energy statistics for one- and two-dwelling buildings in 2016 ES 2001-2017:06.

Swedish Project Management Forum (Svenskt Projektforum). (2019). Private communication.

Teirlinck, P., & Spithoven, A. (2013). Research collaboration and R&D outsourcing: Different R&D personnel requirements in SMEs. *Technovation*, *33*(4-5), 142–153.

Thomas, D. R. (2006). A general inductive approach for analyzing qualitative evaluation data. *American Journal of Evaluation*, *27*(2), 237–246.

Tolbert, P. S., & Hall, R. H. (2015). *Organizations: Structures, processes and outcomes* (10th ed.). Oxon: Routledge.

Triandis, H. C. (1971). *Attitude and attitude change (Foundations of social psychology)*. Hoboken, NJ: Wiley.

Tukker, A., & Tischner, U. (Eds.). (2017). *New business for old Europe: Product-service development, competitiveness and sustainability*. Oxon: Routledge.

Turk, Ž. (2016). Responsible research and innovation in construction. *Procedia Engineering*, *164*, 461–466.

Vanhoutteghem, L., Tommerup, H. M., Svendsen, S., Paiho, S., Ala-Juusela, M., Mahapatra, K., & Aabrekk, S. E. (2011). Full-service concept for energy efficient renovation of single-family houses. In *SB11 Helsinki World Sustainable Building Conference*.

Wisdom, J. P., Chor, K. H. B., Hoagwood, K. E., & Horwitz, S. M. (2014). Innovation adoption: A review of theories and constructs. *Administration and Policy in Mental Health and Mental Health Services Research*, *41*(4), 480–502.

Wu, L., & Chiu, M. L. (2015). Organizational applications of IT innovation and firm's competitive performance: A resource-based view and the innovation diffusion approach. *Journal of Engineering and Technology Management*, *35*, 25–44.

Xue, X., Zhang, X., Wang, L., Skitmore, M., & Wang, Q. (2018). Analyzing collaborative relationships among industrialized construction technology innovation organizations: A combined SNA and SEM approach. *Journal of Cleaner Production*, *173*, 265–277.

Zailani, S., Govindan, K., Iranmanesh, M., Shaharudin, M. R., & Chong, Y. S. (2015). Green innovation adoption in automotive supply chain: The Malaysian case. *Journal of Cleaner Production*, *108*, 1115–1122.

Zubizarreta, M., Cuadrado, J., Iradi, J., García, H., & Orbe, A. (2017). Innovation evaluation model for macro-construction sector companies: A study in Spain. *Evaluation and Program Planning*, *61*, 22–37.

V

To be or not to be: What does it take to launch One-Stop-Shop for Energy Efficient Renovations?

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Abstract

Residential energy efficient renovations have high potential to reduce emissions, however organizing such renovation is riddled with high transaction costs. In response, scholars and policy makers (e.g., European Commission) have advocated a One-Stop-Shop (OSS) concept to simplify house owners' access to complex renovation solutions. However, adoption of the concept still remains slow. So far, research has focused on the positive impact of OSS at the end customer interface, paying little attention to the governance challenges among supply side actors. We perform abductive research that combines insights from 45 supply-side actor interviews with transaction cost economics and resource-based theory toward developing a conceptual framework that outlines the conditions for supply-side actors' uptake of the OSS model. The study explains the reasons for the slow adoption of OSS, and discusses the implications for the most prominent actors who might take up the OSS provider role and the conditions under which the OSS model might run successfully.

Keywords: renovation, one-stop-shop, business strategy, transaction cost economics

1. Introduction

In most advanced economies, buildings, especially one- and two-family houses (henceforth: detached houses), are the largest single consumers of energy and producers of carbon emissions Scholars have reported on the applications of OSS for Energy Efficient Renovations (henceforth: EER) of detached houses in the Nordic countries [5] and mapped the progress of existing and emerging OSS cases in Europe [15]. Furthermore, several studies have been conducted towards developing the OSS concept [4, 16-18], adapting it to national contexts [12, 19], as well as testing house owners' perception of it [20]. Moreover, OSS has been prioritized by the European Commission as an important element of the 'Smart financing for smart buildings' initiative , according to which, member states are encouraged "to develop dedicated local or regional one-stop-shops for project developers, covering the whole customer journey from information, technical assistance, structuring and provision of financial support, to the monitoring of savings." Similarly,

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OSS is advocated by the Directive 2018/844/EU which calls upon EU Member States to establish a long-term renovation strategy, as part of which Member States are required to facilitate access to mechanisms, such as one-stop-shops, which are considered advisory tools here to inform and assist consumers in relation to energy efficiency renovations and financing instruments.

However, scholars and policy-makers alike have mainly focused on the (positive) implications of the OSS concept at the end customer interface and little attention has been paid to the necessary governance of the supply side network of actors behind that one customer-facing contract. From this perspective, while OSS promises to notably simplify the access of households to complex renovation solutions, the structure within which supply-side actors should operate in order to deliver these gains remains vague. Furthermore, neither the conditions and requirements nor the profile of the actors that are applicable in the OSS set-up are clearly established. It is also unknown if relevant supply-side actors see this as an attractive opportunity. Indeed, Boza-Kiss and Bertoldi [15] found that some early attempts regarding OSS for detached houses have already discontinued and adoption on the supply side was slower than anticipated. In proposing OSS as a means of encouraging EER renovations, we should, therefore, take into account not only how the perceived TC is brought down for households, but also *who (if anyone)* and *under what conditions* could assume that role and create a governance structure (cf. [21]) that optimally serves to reduce costs enough to justify bringing the OSS into the equation.

In this paper, we examine the conditions that lead to the emergence of OSS, as well as those required for it to become successful in practice. In addition, we explore which market participants would have the will and the ability to bring about such conditions so that the OSS would materialize as a wide- spread governance model on the EER marketplace. To gain insight into these questions, we perform an abductive analysis [22] where we develop a conceptual framework about the conditions of OSS emergence by iteratively drawing from previous literature and from empirical data originating from 45 interviews with four classes of supply-side actors that could, in principle, develop the OSS concept: construction-related micro, small and medium enterprises (MSMEs), real- estate agents, banks and municipalities. With regard to previous literature, we draw on two prominent theories in organization science — transaction cost economics [21, 23, 24] and resource-based theory [25-27] — which together form the basis for explaining the strategy of organizations with respect to the type of business they choose to perform and the way they behave in relation to markets [28] .

In particular, we report that, while actors in all aforementioned classes of supply-side participants are willing and able to *be governed* by an OSS, *becoming the governor* of an OSS model is not considered an immediately desirable strategic prospect by any of the four actor classes. Our analysis indicates that the underlying causes converge well with the predictions of transaction cost economics and resource-based theory. We argue further that these theories, besides explaining why none of the actor classes are likely to take up the OSS role right away, might further serve to inform how and by whom the OSS could, nevertheless, be established as a successful market role.

The study makes three contributions. Firstly, we report on how a wide range of supply-side market participants perceive OSS in relation to their own organizations. This focus

on supply-side actors is distinctly different from either the end-user or the policy-maker perspective on the OSS concept featured elsewhere. Secondly, related to the previous, we contribute to economic analysis in renovation studies by turning attention to organizational economics on the supply side. In this regard, we develop a theoretical framework that outlines the conditions in which an actor is likely to take up being the OSS as well as executing the model successfully. Finally, extending upon the finding that the four studied actor classes are unlikely to adopt the OSS concept at a sufficient scale, we draw further from the two theoretical perspectives (i.e., transaction cost economics and resource-based theory) to discuss possible supply-side governance approaches for establishing a detached house OSS for EER.

The outline of this paper is as follows. Section 2 provides a literature review on transaction costs in EER and organizational strategy in adopting new exchange-based business models, such as OSS. These serve to create an initial theoretical framework to be used in our empirical work. In section 3, we introduce the methodology on how we perform abductive research in analyzing the conditions of OSS emergence. The results of the analysis, and discussion of the results and implications are presented in sections 4 and 5 respectively.

2. Literature Review

2.1. How transaction costs are holding back the EER market

Transaction cost economics (henceforth: TCE) is a branch of economics and organization science that explains how an economic exchange is organized as a function of the costs caused by market inefficiencies around that exchange [29]. These so-called 'transaction costs' are a natural part of trade — so, to know the true cost of any exchange, one would include both the cost of the goods that are being exchanged, and the transaction costs associated with the exchange. Think, for example, back to the pre-Airbnb era and consider how inefficient it would have been for people to find strangers, validate their reliability, negotiate prices, organize payment, and troubleshoot any issues in arranging a peer-to-peer short term stay in a foreign city. In fact, due to the implied very high transaction costs that exchange was hardly considered. TCs can, in that sense, restrict an entire market from emerging.

Similarly, major inefficiencies currently burden the market of EER of detached houses with recent studies [6, 7, 30, 31] quoting the proportion of TC in total project costs as high as 20%. Considering EER of detached houses from the point of view of transaction cost economics [24, 29] at least three reasons for high TC in this context stand out. Firstly, with transactions occurring when 'a good or service is transferred between technologically separable stages' [28], EER projects as integrations of a number of products and services from different suppliers entail not one but several different transactions. Furthermore, though projects have standard elements, every detached house is nevertheless different in their particularities requiring their own planning [19,32,33]. Consequently, the project, as well as organizing its components involve search, contracting, monitoring and enforcement costs [23] that are project-specific TC.

Secondly, knowledge asymmetry between the supply and demand side actors on this market is high. This asymmetry is further enforced by the default option of house owners to do nothing [34] and avoid renovation, as it is perceived to be both complex and irreversible [35]. Another factor that enforces this asymmetry is related to the attitude of house owners, which has a major impact on their decision to renovate. House owners lack an understanding of the effect of energy use on the environment [30, 35], while others see renovation not as a need, but as part of a do-it-yourself culture [36,37]. Furthermore, owners have insufficient information regarding qualified artisans able to perform more comprehensive renovations and limited knowledge or awareness of the benefits, in terms of maintenance costs and improved living environment that a renovated house can offer them [5]. Supply side actors on the renovation market contribute to the knowledge asymmetry by using the influence they have on customers – on mostly small localized markets – to promote their own products, often offering sub-optimal energy efficiency solutions [5]. Moreover, negative experience from previous renovation projects can lead to a certain level of mistrust between house owners and artisans [38], which becomes even greater when services offered are perceived as overpriced [39]. In that sense, if house- holds were to enter the process on their own, they risk incoherent choices both technologically and relationally, as well as the possibility to get ripped off. Consequently, their hesitation towards EER projects is high by default [5]. Third, as noted by D'Oca et al. [40], due to the contextual nature of each project, there are often considerable discrepancies between intended and achieved project outcomes. Owners, however, seek to lower their uncertainty by assuming a guarantee that the aggregate energy-efficiency effects of the renovation project are indeed achieved. This being hard for suppliers to ensure, they are incentivized to add to the service cost a margin for potential post-project claims and rework. While potentially masked under production costs, effectively this buffer is a TC also.

With inefficiencies of that magnitude, if an intervention such as OSS can indeed facilitate significant reduction of TC in this market, EER adoption is likely to be boosted considerably [41]. Nevertheless, this effect is predicated on the OSS role emerging in the first place.

2.2. Conditions for OSS to emerge

The argument for OSS as put forth by scholars and policy-makers is fundamentally an argument on the reduction of TC, achieved by restructuring the relationships of different supply-side actors and of supply and demand. As such, we recognized considerations from TCE as central to analyze how an OSS might emerge.

A central part of TCE explains what the most efficient governance form would be, given a transaction is embedded in a specific economic context [42]. This means that if we assume OSS to be present, TCE would explain to what extent the OSS organization would integrate necessary activities within their own boundaries and to what extent they would contract external market-based actors to perform them [24]. In regard to that, it would be possible for an OSS provider to choose to individually perform all relevant project activities from planning and execution to monitoring and involve no other actors on the supply side, except in buying materials (i.e., a full integration strategy). At the other end of the spectrum, an OSS could, in principle, do nothing else but organize the one customer-oriented contract

and procure all other activities from external parties (i.e., strategy of full market-based governance). According to TCE, prospective OSS organizations would make a choice about where on this spectrum they wish to be, by considering the internal production and control costs of each activity required by the renovation cycle and whether such costs are below or above the combination of the price of that service/product on the market and the transaction costs associated with acquiring it from other parties [24]. Activities where the aggregate cost is lower internally, they would perform themselves; all others, they would attempt to acquire from the market.

Nevertheless, while this template makes it possible to evaluate how an actor would systematize the OSS around their organization, it cannot yet sufficiently predict *if* or *under what conditions* an actor is likely to assume the role of OSS in the first place. Two conditions appear necessary for (an) OSS to emerge.

First, assuming OSS as a cost-reduction mechanism, it is necessary that the sum of production (PC) and transaction costs (TC) in the OSS model indeed be lower than the respective one in a market without OSS. This condition can be represented by the following formula:

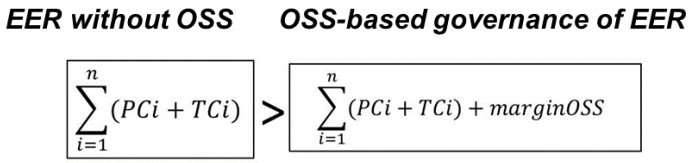

Figure 1: Condition for OSS to be assumed as a cost reduction mechanism

Drawing from TCE, that condition would be brought about if (a) an OSS is able to reduce TC among the suppliers, *ceteris paribus;* and/or if (b) an OSS is able to reduce production costs (PC) among the suppliers, *ceteris paribus*, by more than the emergence of the OSS role costs for the end customer (in terms of TC and profit margin). For condition (a) in particular, TC is reduced in inter-organizational relationships, for example, if the transacting parties have had (frequent) previous successful transactions [43], perceive each other as having a track record in relevant production areas [43] , or grant each other acts of goodwill [44] , all leading to increased trust and commitment between the transaction partners [45]. Trust and commitment, conjointly, reduce the likelihood of opportunistic behavior and uncertainty in partner behavior [46]. In that sense, and particularly regarding the OSS, their ability to reduce TC depends on having an existing network of repeat collaborators for the greatest possible coverage of the comprehensive list of necessary externally procured activities.

For condition (b), the OSS creates most cost reduction if it chooses not only the comparatively most advantageous party (i.e., themselves, or another supplier) to supply a relevant product/service into the project, but seeks also to further improve that advantage by enabling additional economies of scale for that component. This means that even if the OSS maintains production capabilities, the economics of the model may be better off procuring their competitors, which can be psychologically difficult. Furthermore, condition (b) further implies that OSS as a business model likely becomes more valuable the higher the number of projects it governs and the more standardized these projects are;

although, this not without limitations. Namely, with the exception of movable goods installed during the project (e.g., insulation material), renovation services are largely geographically bounded [47]. For all activities needing physical presence of the supplier(s), any particular geographical region of the OSS should include economies of scale (relatively) independently. Furthermore, in order to fulfill condition (a), the geographical restraint means that the OSS should maintain a partner network in the vicinity of the customer. In that regard, if the region does not provide enough projects, the OSS organization itself might struggle to find economies of scale in their governance (and production) activities.

Second, looking back at the two idealized strategies for being an OSS (i.e., full integration vs. full market-based governance), only in the full integration strategy would the OSS organization rely entirely on the capability to produce without needing to govern other supply-side actors. In all other strategies where the OSS would procure at least some activities from the market, they would have to coordinate and take responsibility toward the end customer over the contributions of other actors on the supply side [21]. This means that to be a successful OSS, unless the organization has internal cost advantage in all activities of the renovation project, they need to possess some level of exchange governance capability. Furthermore, TCE would argue that the costs of performing OSS governance would need to be lower than within other prospective OSS organizations; otherwise, it would be more advantageous for some other organization to become OSS instead [21] . In that sense, it is not only the pre-OSS state of the market that serves as a competitive benchmark for prospective OSS organizations in deciding whether to take up the role, but also the perception on whether there might be other parties better fit for the role. It is here that resource-based theory provides a complementary analytical lens.

Resource-based theory, at its core, argues that organizations are heterogeneous because they have (access to) heterogeneous resources and capabilities [25]. Organizations seek to perform activities as per their available resources and capabilities, or risk being outperformed by other organizations that have an advantage in the respective activity area [27]. Resources, but capabilities in particular are developed generally in long, path-dependent learning processes [48], which entail carrying out related activities repeatedly [49]. Therefore, strategic options of an organization are at any one moment largely limited by the past choices of that organization. One would thus expect that among any set of market participants, the most interested and able to take up the OSS role are those that in doing so can re-use existing resources and capabilities more than their peers. In this regard, the ability to transact and govern transactions with others should be thought of as a particular capability in itself [48] which organizations have to a varied extent depending on whether they have previously performed and knowledgeably routinizing the learning in this area into steady capabilities [50]. It is possible to acquire additional resources and to develop new capabilities. However, doing so for the sake of a new business model would imply increased reward expectations, as compared to a situation when the company implements a new business model based on existing resources and capabilities. Furthermore, setting out to acquire new resources and develop new capabilities in order to establish a new business model is likely to place the organization under competitive threat from actors already in possession of such resources and capabilities. In short, the second necessary condition for a particular organization to take up being the OSS for residential EER renovations is that

they possess necessary resources and capabilities comparatively more than other prospective OSS candidates; or that becoming the OSS is perceived as an opportunity attractive enough to develop such specific governance assets while knowing that these might not be reusable elsewhere [51] and doing so might lead the organization to a competitive disadvantage with regard to other actors in possession of such resources/capabilities.

These conditions of OSS emergence as informed by TCE and resource-based theory are summarized in Figure 2 as black-colored components marking our initial theoretical framework.

3. Methodology

For this research, we adopted the abductive approach, performing what Dubois and Gadde [22] refer to as 'systematic combining' of previous theory and empirical evidence into an evolving framework. We chose the abductive approach because, on the one hand, organizational economics and strategy have been thoroughly studied in a wide array of industries, resulting in well-grounded theories that explain the strategic behavior of organizations. On the other hand, the applicability of these theories to the OSS concept in EER has not yet been tested. Furthermore, what makes the OSS concept stand out from standard strategy studies is that its emergence has so far been proposed mainly by scholarly and legislatively efforts, which is not typical to how commercial strategies emerge. Therefore, while a deductive approach might have enabled us to test the applicability of organization theory in this context, this being the first research taking an in-depth look at the supply-side strategies to OSS in EER, we chose to be more explorative and open-ended than a fully deductive approach would have implied.

Meanwhile, the existence of established organization theory that at least in principle appears fit for explaining the behavior of organizations in this context led us to conclude that a fully inductive approach where new theory is generated (mostly) from empirical data would have been inappropriate also. Thus, we chose to draw from the tradition of abductive research and its principle of iterating between previous theory and empirical evidence in order to further *develop* (as opposed to *generate* new) theory [22] on the conditions of OSS emergence. Abductive research has previously been employed in similar situations, for example, by Edvardsson, Holmlund, and Strandvik [52], Kindström, Kowalkowski, and Sandberg [53] and Storbacka [54]. In the following paragraphs, we introduce the empirical context of the study and describe our research approach.

3.1. Empirical context

The context of this research is Kronoberg province in Sweden. Sweden, which has been the context of multiple earlier studies on EER [55-59], is argued to be among the markets where OSS would be most relevant for two reasons. First, the market is currently dominated by micro and small construction companies that typically offer fragmented services in their area of expertise [60]. Second, in Sweden there is a lack of regulatory framework that guarantees the post-renovation quality of more comprehensive renovations projects, while trust in the companies offering renovations services is relatively low. That leads house owners to take the role of coordination, even in projects where many different actors are

involved, bearing that way the risks and responsibilities concerning the quality of work delivered. Studies by Mahapatra et al. [61] and Pardalis et al. [20] in Kronoberg province, and Pardalis et al. [62] in Sweden overall, have also showed an interest from the house owners' side to use OSS-like services for the renovation of their whole dwelling, or of specific elements in it. This, in theory, could indicate business potential for supply-side actors to offer such services. Nevertheless, progress in establishing the OSS model has so far been slow in Sweden. In this regard, Sweden is a prototypical case which we believe is well suited as a benchmark to other Nordic countries, and much of Europe in general. Similar market conditions have so far been reported in at least the countries of Belgium, Denmark, Finland, the Netherlands, Norway, and Latvia.

3.2. Data collection

We collected empirical data by means of semi-structured interviews with market participants. To provide diverse perspectives on the perceptions and behavior of actors with regard to the OSS concept, we sampled actors from four distinct classes of market participants: construction-related micro, small and medium enterprises (MSMEs), banks, municipal authorities, and real estate agents. In total, we conducted 45 semi-structured interviews spanning the period of 2017 to 2019 (see Appendix A). We sampled the construction-related MSMEs randomly from online yellow pages based on their activity descriptions including 'construction works' (*byggarbeten*) and 'renovation works' (*renoveringsarbeten*). We sampled real estate agents to include both bigger firms with local branches in the entire country, and smaller family-owned firms. We sampled banks to include the four biggest financial institutions in Sweden, interviewing in each case loan officers responsible for bank products for housing and renovation. Finally, we interviewed energy advisors of Kronoberg province municipalities.

In the abductive approach the aim is to iterate between insights drawn from existing theory and the empirical context. Therefore, we started the project by surveying organization science literature to distinguish organizational considerations in adopting a new business model. We quickly realized that, depending on context, such considerations can be grounded in a number of different theoretical perspectives (e.g., [42]). Therefore, instead of potentially priming interviewees to some theoretically driven perspective, we decided to perform data collection in an open-ended fashion [63] with focus on interviewees reflecting on their standpoint with regard to the OSS concept. In this light, we asked interviewees to explain how their own organization relates to the concept, assume their possible roles within an OSS network, provide a perspective on which other parties and how they would be included in the OSS operational model, and articulate strategic considerations around initiating the OSS model. The interviews were performed in a semi-structured fashion where the interviewer followed up on the answers given to the protocol-based questions. All interviews were performed by the lead author of the paper. Where possible, the interviews were recorded for later transcription. Where recording was not allowed, extensive notes were taken during the interviews. All interviews were conducted in person at the workplaces of the interviewees. The interviews lasted, on average, 95 minutes.

3.3. Data analysis

Considering the open-ended approach in data collection, our first step in data analysis was to prioritize potentially useful theoretical perspectives that appear to provide the best explanatory power with regard to the context at hand. Toward that end, we extensively surveyed organization science literature, identifying that empirically provided arguments appear to match two theoretical perspectives in particular: transaction cost economics [21, 23, 24] and resource-based theory [25, 26, 27]. We proceeded by developing the initial theoretical framework by means of a scoped literature survey within these two literature streams (see Chapter 2 and Figure 2 for parts marked in black). The initial theoretical framework provided us with the first coding scheme for data analysis which we used to perform the initial round of data analysis. Meanwhile, as per abduction, we were also explicitly searching for arguments in the data that went beyond the initial theoretical framework. The first round of coding entailed the lead author coding the entire database of interviews and both of the other authors independently coding a sample of 100 excerpts from the interviews to test the reliability of the first coder. Fully transcribed interviews and interview notes were used as the basis for data analysis. Analysis was performed separately per actor class to distinguish different perspectives of the different market participants.

After the first round of coding, we adjusted the scheme by including newly found additional categories not yet included in the initial theoretical framework. The updated coding scheme was discussed and agreed in a research meeting, leading to a new iteration of coding of the entire database. To perform parallel independent coding and estimate agreement of the coders, we distinguished in the data a total of 207 statements which were independently coded across the entire coding scheme by two co-authors. The entire coding scheme can be seen in Table 1. Across the 18 individual dimensions (across 5 main categories), we achieved an average Cohen's Kappa of 0.54, which is near the upper bound of a 'moderate' agreement [64]. In particular, 7 of the codes resulted in 'substantial' (0.6 – 0.8), 8 in 'moderate' (0.4 – 0.6), 2 in 'fair' (0.2 – 0.4) and 1 in 'slight' (0.0 – 0.2) agreement. A series of research meetings were then held to align the coding between the raters.

3.4. Data synthesis

Based on the agreed-upon coding of all statements in the 18 lower-level categories, we proceeded to synthesize the codes into narratives that each explain the standpoint of an actor class as per a higher-level category (Table 1).

Table 1: Coding scheme at performing final coding

Category	**Dimension**	**Empirical indicators**
Access to trusted partners	Previous collaborations in accomplishing projects	Working together in previous projects (municipal or private)

		Working together with local actors
	Appreciation of the craftsmanship of others	Rumors of good work/skill of others Showing mutual respect
	Acts of goodwill	Client referrals to one another Reciprocal provision of favors to one another
	Dedicated network-building activities	Presenting at/organizing industry events Networking as firm strategy Researching the background of other supply actors
	Sharing similar philosophy/vision	Speaking the same 'language' Sharing similar philosophy and/or vision
Creating economies of scale	Local market limitations	(High) opportunity costs to EER activities in the region (Lack of) willingness to pay by customers in the region Losing face with customers for proposing expensive services (Lack of) suitable local partners (Delays in) customer acceptance
	Local market opportunities	Involving owners' associations to increase scale Local support schemes to boost demand Numbers of similar dwellings in the region Increased role of municipalities in supporting OSS emergence
	Multi-locality	Ambition/opportunity to scale beyond local context
Exchange governance capabilities	Own capabilities with respect to governing others	Availability of resources/capabilities to govern others Availability of structures and legal entities to govern others Fit with overall profile of the organization
	Experience in governing others	References to previous instances of governance performed by the organization and to the profile of those governed over
	Experience in end customer interaction	References to previous instances of customer contract

		governance and the complexity of those projects
	Opportunities for standardizing the offering	References to innovative approaches (technology) that enables standardizing renovation offerings
	Fears concerning transactions costs and governing of others	Willingness to guarantee the quality of others' work Conflicts arising from supply-side actors not aligning with each other Delays caused by coordination challenges Costs associated with ensuring profitability for all
	Financial attractiveness of performing governance	References to margin (expectations) and/or profitability of serving the OSS role
Production capabilities	Production profile of the organization	References to the extent of own production capabilities, and the corresponding scale of internalization (integration) of EER services
Perceived attractiveness of OSS opportunity	Belief in market emergence	Perceived alignment of OSS with broad societal/market trends Perceived influence on industry growth Perceived match of OSS model with local context
	Strategic interest in being OSS	Overall conclusion and rationale on how the organization sees themselves with regard to OSS – as coordinator, supplier, or else
	Perception of others' fit for becoming OSS	References and rationale for proposing other actors to become OSS

4. Findings

The research identifies five categories, namely access to trusted partners, ability to create local economies of scale, transaction capabilities, production capabilities, and perceived attractiveness of OSS opportunity, which apply to all the examined supply side actors and allow us to examine the suitability of each examined actor to become the OSS provider, as well as identify the underlying reasons that lead those actors in the decision to adopt OSS at sufficient scale. Additionally, we draw information on potential other actors that could

lead the OSS concept.

The findings are discussed first as per each examined actor with the construction companies divided further into two sub-categories: micro/small and medium-sized. Each narrative in this section is sup- ported by a respective synthesis table in Appendix B that includes a selection of quotations supporting each synthesis.

4.1. Banks

Based on our research, banks appear to have the clearest picture regarding their role in the OSS concept. Despite perceiving OSS as an attractive opportunity overall, such a concept is not related to their area of operations. Therefore, becoming an OSS coordinator is not seen as a strategic option for them. Nevertheless, banks offered several key insights that can contribute to the effective development of OSS. Banks see financing schemes such as green loans and energy efficiency funds (focused in the renovation of the building stock) as interventions that can create local economies of scale and pave the way for the emergence of the OSS concept. They additionally refer to the commitment and collaboration of local actors as a condition for OSS success. In fact, for banks, any single actor might not be the best fit for the role of OSS coordinator. In their perception, a more powerful governing body would consist of municipalities, regional and central governments, as well as house owners' associations and regional energy agencies. That constellation is seen as the appropriate coordinator since it is perceived to have both the competence and the trust of local communities and businesses. Both are required conditions for the successful development of OSS.

That overall position of banks appears well articulated by the following quotation:

> "..Even with the loans existing in the market such a concept could have great potential if all the players were willing to dedicate time and resources for this scope. Municipalities or the Energy Agency, in collaboration with house owners associations, could provide free-of-charge energy auditing of the properties and post-renovation quality control. That would minimize to some extent the total cost for such a comprehensive renovation and the results from this auditing would be difficult to be challenged by the other actors involved."

4.2. Medium-sized construction companies

In principle, the OSS concept appears attractive to the majority of the interviewed medium-sized construction companies who see it as possible opportunity for future growth. They are in fact active in broadening their network of collaborations, with the purpose to offer customers more integrated services and achieve better economies of scale in their activities. Furthermore, as far as exchange governance capabilities are concerned, medium-sized construction companies report to having some experience in coordinating external parties in renovation projects before.

Nevertheless, several aspects of the assumed OSS model are seen as potentially problematic. First, medium-sized construction companies recognize that participation in OSS might entail cooperating with partners they have no previous experience of working with or that do not belong to their network of trust. That creates concerns regarding how the relationship network will evolve if OSS is to be adapted alongside other business

activities. One of the interviewees referred this issue as follows:

> ". . . working in such a concept means that we potentially have to break business relationships with partners we have worked with for long. That affects our network, and creates implications in the rest of our operations."

Furthermore, according to the medium-sized construction companies, significant quality and budgeting risks are likely to emerge because craftsmen in different areas of renovation do not 'speak the same language', so their integration to a coherent project is seen as a major task. To succeed as an OSS, the companies see a need to address the risks related to renovation work, budget and timing, which would require a comprehensive contract among the supply-side parties. Still, the coordinator is ultimately responsible in the face of the customers, so to ensure that the OSS is covered for any risk, it is proposed that the coordinating party charges the customer with an additional risk mitigation margin on the final price. This, however, might be problematic considering the high uncertainty associated with finding enough customers for a total renovation due to its high cost. Overall, the interviewed medium-sized construction companies remained hesitant to take action toward a fully integrated service:

> "…you will see lots of conflicts and lots of mistrust, especially between those people that have never worked together before. That can make even the most competent underperform. It is a challenge to make all of them feel safe and appreciated, and I do not know if any of us could take the responsibility to deal with that challenge."

Therefore, although these companies seem to have many traits qualifying them for an OSS, they too appear to assume that some other actors are more appropriate to take the role of OSS coordination. In particular, municipalities and house owners' associations, newly graduated engineers and architects and experienced consultants with backgrounds in the construction industry are mentioned. A relevant quotation indicates that:

> ". . . the municipality and house owners' associations could easily sit with us and discuss the needs for renovation. The Municipality could even organize smaller renovation projects, which, according to availability and skill demand, we could bid on them. . ."

In that sense, the move toward an OSS is seen as a gradual process with public involvement in the first stages.

4.3. Micro- and small-sized construction companies

Micro- and small-sized construction companies perceive the OSS concept as overall attractive, but rather than bringing it on the market they see themselves predominantly participating as suppliers to some other OSS. Five main reasons for this standpoint are noted, each by at least two different construction companies: a) it needs supply-side parties to significantly change their attitude and ways of working, b) the concept is seen as too costly for most house owners, so the market is limited and one risks losing face with customers by

offering the service at actually necessary price levels, c) there are presently more attractive opportunities for craftsmen in the new-build market, d) to become successful, the concept needs to start at scale so one needs to invest significantly up front, and e) although they are confident that any missing production capabilities can be procured from well-established local networks, the need to coordinate and take responsibility over the work of other suppliers is not seen as feasible. Two example quotations characteristically bind these considerations:

> "The customer will expect an equal level of performance from all the actors involved. Thus, we are expected to formulate a common working culture and ethics. Each of us work in different ways, and have their own norms and performance standards. Many will feel like they need to change habits and behavior. They will feel they are in doubt and that their work is perceived as crap. Nobody really wants to change for the sake of something that will not be the 100% of their business."

> ". . . technical capacity can be found in the market. As a coordinator, though, I must be able to offer the customer an affordable price, while at the same time ensuring that I will not have to bare severe risks. Time I can guarantee. Quality, though, is another story. Immediately I have either to increase my price or guarantee a third party like an insurance company that will cover the risk. Difficult equation to solve."

Nevertheless, micro- and small-sized construction companies assume that there are specific segments in the market that may become interested in an OSS service, especially if the outcome significantly in- creases the value of their property. Thus, providing clear return on investment is seen as an important metric in outlining and negotiating with that segment. Still, for performing the marketing and coordination, micro- and small-sized construction companies assume that other types of parties are better positioned. These potentially better positioned include established (larger) construction companies, energy authorities, municipalities and independent consultants. The expectation for legislative push is frequently mentioned.

4.4. Real-estate agents

Real estate agents see OSS as an attractive concept with potential to differentiate buildings and improve the state of the building stock in general. However, they emphasize the strong influence of local conditions (e.g. climate and property value) for the attractiveness of the concept to building owners, creating large differences between regions of the country. As such, real-estate agents see it important for the state to take a leading role in developing a national strategy for energy efficiency. A representative quotation reads:

> ". . . The first step has already been made when they introduced mandatory energy certificates for houses on sale. Investments in energy efficiency should rise, but we must keep in mind the great differences on climate and property value in Sweden. If you look at certain markets, like for example in the north

> of the country, investing 1.5 million SEK to renovate a house is more or less impossible to give your money back. We need as country to formulate a strategy that will provide answers to those challenges, and OSS could be a part of that strategy."

Real-estate agents also perform dedicated networking activities, turning attention foremost to good collaborations with financial institutions and energy advisors. Both of these parties are likely necessary collaborators in making OSS possible. However, though they are familiar with construction companies in their region, their network is still limited to frequent collaborators on small-scale projects. Such projects include renovations which aim to short-term improve the value of a property (i.e. kitchen, bathroom etc.). This is also the category of projects they have experience in managing. The weak- ness of real-estate agents derives from a lack of deeper knowledge and understanding of the technical parameters of construction work and construction processes. That makes them considering their role within an OSS as supporting rather than leading. Real-estate agencies in Sweden are frequently also nation-wide organizations where local branch strategy is limited by the overall strategy of the mother company. Therefore, the adoption of new business models such as OSS are reported to require an overall change in corporate strategy.

Real estate agents seem to assume that actors who have deep knowledge of construction work and processes, and the network of suppliers and construction companies, are better positioned to uptake the OSS provider role. As expressed during one of the interviews:

> "…you need someone that is experienced in that environment. Someone who knows the processes, has an idea of construction work, and at the same time can deal with PM issues. On top of that, this person must have some sort of experience of contracting with suppliers and sub-contractors."

Some examples given by real estate agents for the role of OSS coordinator include independent consultants, well-established construction companies and government agencies related to the construction and energy sector.

4.5. Municipalities

As articulated in previous sections, municipalities are frequently brought up by other actor classes as potential leaders to developing an OSS. However, our results seem to indicate that municipalities themselves have low inclination to perform commercial integration on the supply side. This is true for a number of reasons. First, municipalities currently perceive demand for energy related renovations in the detached house market to be limited. They also report to having a lack of resources to dedicate to the coordination of renovation projects, alongside legal limitations to doing so on a commercial basis. In particular, municipalities perceive the necessary coordination to open them up to the risk of being accused of promoting unfair competition. As such, the possibility of municipalities to procure services based on TC-reducing heuristics such as trust and previous positive experience is limited.

Nevertheless, municipalities seem to have the potential to boost economies of scale for

the OSS concept, as they maintain ties with diverse local actors including house owners' associations and regional energy agencies. Furthermore, the topic of building energy efficiency is already found at the core of their sustainability agenda. Additionally, and despite the fact they do not engage in deliberate network building activities, municipalities have knowledge of these local construction companies that have earlier provided services to municipal projects. As such, municipalities would not mind being involved in a supportive role without taking the lead themselves. In particular, they refer to potential actors as including house owners' associations, experienced consultants from the building sector, and professionals with legal and technical knowledge of the construction industry as each perhaps finding enough business opportunity to start the OSS. Characteristic to the standpoint of municipalities is the quote:

> "…I personally believe that there is space for new people to enter this market. A person that has knowledge of the construction laws and procurement act can effectively deal with all the actors involved in the concept…."

5. Discussion

Figure 2 represents the framework we developed on the conditions of OSS emergence as informed both by TCE and resource-based theory (developed on section 2 of this paper), and the empirical work performed in this study. In particular, the theoretical framework serves as a template to estimate the fit of *any* particular actor (class) to become the coordinator/governor of the OSS model.

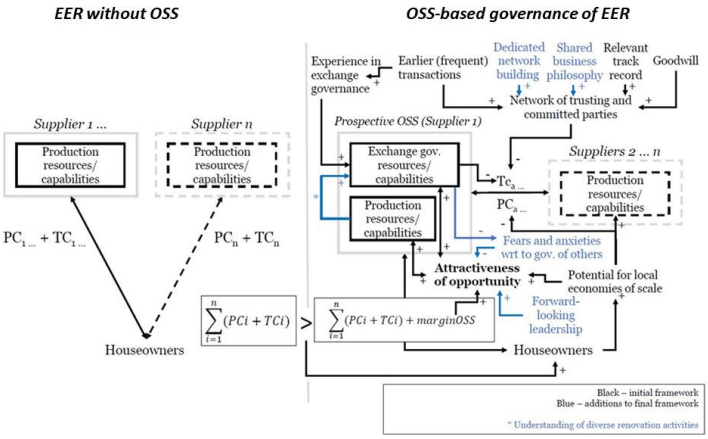

Figure 2: Theoretical framework for estimating the attractiveness for an actor to become the OSS for EER in detached houses

Applying this template on the actor classes explored in this study, we come to the conclusion that, although the reasons vary from one class to the other, each of them appear unlikely to adopt the OSS model. Micro- and small-sized construction companies applied predominantly to possessing specialized production capabilities, but very low capabilities

and resources with performing formal exchange governance. Consequently, they see themselves as participating in the OSS concept as a supplier, but not as the governor. Medium-sized construction companies can, in principle, see themselves as the OSS coordinator and report having both the resources and the exchange governance capabilities for the successful delivery of the concept. However, for them, the main argument against OSS appeared to lie in the limitations of their network of partners. In the OSS concept, the assumed necessity to collaborate with (unknown) partners weakens significantly their perceived capability to govern the whole concept, and creates additional fears and anxieties on the implications that the collaborations with such partners will bring. This is, in particular, linked to regulating the warranty and rework risk which the OSS is expected to bear at the end customer interface. Furthermore, it was questioned if the margin necessary to reduce that risk would not diminish the number of potential customers and result in companies losing face with their market. Municipalities have traits that would boost their involvement in the OSS. In particular, they can drive economies of scale on the local level by connecting a broad network of supply-side collaborators with systemic actors on the demand side (e.g., owners' associations). However, with regard to the OSS, they reduce their perspective to a supporting role at most, mentioning the legal restrictions to participating in market transactions, lack of immediate resources to dedicate to developing the concept, and the unwillingness to carry the actual transactional risk on behalf of commercial actors. Real-estate agents is another actor class which superficially might have potential to become an initiator of the OSS. Though seeing the concept as attractive overall and reporting managerial capacity for coordination, their standpoint not to proceed in the development of an OSS derives from a lack of strategic interest at the corporate level, and a lack of deeper knowledge regarding the technical parameters of the renovation process. This is seen as a significant shortcoming to efficiently governing other supply-side actors. Finally, banks opt out from becoming the OSS be- cause of a perceived lack of supply-side network, of governance, and of production capabilities in the renovation sector. Banks saw their future relationship with the OSS concept as close to their current core business: in providing financial services.

6. Conclusions and Policy Implications

Our paper contrasts from earlier works around the OSS concept, both from policy and from scholarly origin, where focus has been on the perception of end customers of the OSS concept [12, 62, 65], or on reducing TC at the end customers interface [6, 7]. We turned explicit attention to the supply-side of the OSS, examining organizations (not) becoming the OSS as a strategic choice driven by certain conditions within their organization and the environment. In doing so, we revealed that the barrier to the OSS emerging are likely higher than anticipated so far. Furthermore, while previous research, when computing the TCs that are visible from the end customer perspective, has estimated TC to constitute perhaps as much as 20% of the total cost of renovation [6, 9], our limited investigation into the supply-side economics of the OSS would indicate that this proportion may be significantly higher. In particular, we found that additional TC can be hidden into the transactions on the supply-side as part of at least two other components: a) margins added by actors in the value chain to mitigate the quality/coordination risk of previous actors' work; and b)

previous network ties causing imperfect competition in the cost-efficiency of sub-sections of work. It was beyond the scope of this research to quantify these elements for a truer estimate of total TC in renovation cost, but we see that as a critical task for future research. Indeed, even in instances where OSS-like business models have been attempted [5], their scale has so far been limited. In this regard, our results converge with previous research [59, 66, 67, 68, 69] arguing that, for owners, total cost and long payback time are probably the single biggest inhibitors of holistic renovation solutions. In reducing this, tackling the hidden TC on the supply side appear at least as important as interventions like educating the public or procuring at scale (via owners' associations) that have been suggested elsewhere [6].

Our theoretical framework also makes it possible to hypothesize about potential other candidates for taking up the governance of an OSS and the (inter-)organizational structures that would have to emerge in providing the service. Following our framework, the most likely OSS would either be an actor that has either a widespread portfolio of internal production capabilities (therefore needing little external governance) or the combination of a) an extensive background and underlying capabilities to coordinate other parties in executing various types of renovation work down to technical detail, b) a trusted network of partners with production capabilities across the categories of renovation work, c) an ability to drive local economies of scale, and d) strategic interest to commit to OSS as a path of growth for the actor. Based on these criteria two particular actor profiles surface as potential OSS adopters. With a profile of (almost) entirely internalizing the renovation work necessary in holistic renovation would be large construction companies. So far, however, these companies have shown little interest in small-scale residential renovations as the associated production and transaction costs are higher compared to those of renovation of a multi-family residential building or construction of a new building [39, 70] With a combined profile of criteria a) — d), there is potential also for either energy efficiency or engineering consultants to adopt the OSS, perhaps as a spin-off from their current business. Their perspective on the matter remains for future research to investigate, but based on our framework, if they were to become the OSS, we expect these actors to rely on the strategy of an almost complete market-based governance with limited in-house production activities (with the likely exceptions of initial inspection and composition of renovation plan), because that structure would fit best their current resource and competence profile.

This research serves also as a contribution to the literature on business model innovation in companies in the construction industry. Unlike previous research which has focused on the functional logic of novel business models [5, 71], our research has focused on the conditions that hinder or support the adoption of a particular business model. In particular, we have made a link between superficial business model features (e.g., resources, partnerships, and revenue model) as they would be described according to component-based business model frameworks (e.g., [72]) and their underlying organizational economics as explained by the combination of TCE and resource-based theory. We believe that grounding our theoretical framework on OSS adoption conditions in prominent base theory in organization studies increases its explanatory power and possibility for generalization of the framework beyond the investigated sample of organizations and their context.

Finally, our research indicates that since significant components of TC lie in

inefficiencies of transactions in the supply-side network, policy-support to EER might benefit from adding supply-centric support schemes to the current approaches where support focuses on end-customers (e.g., renovation subsidy, or special condition loans), and the customer-OSS interface (e.g., information meetings, or demonstrator projects). One such approach might be to support OSS via systemic intermediation services [73] that can provide the structure for aligning various supply actors; and, in some conditions, even temporarily internalize a novel business model, make it operational and then divest [74].

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References

[1] Edenhofer, O. (Ed.). (2015). Climate change 2014: mitigation of climate change (Vol. 3). Cambridge University Press.

[2] Rosenow, J., Leguijt, C., Pato, Z., Eyre, N., & Fawcett, T. (2016). An ex-ante evaluation of the EU Energy Efficiency Directive—Article 7. Economics of Energy & Environmental Policy, 5(2), 45-64. https://doi.org/10.5547/2160-5890.5.2.jros

[3] Artola, I., Rademaekers, K., Williams, R., & Yearwood, J. (2016). Boosting Building Renovation: What Potential and Value for Europe? Study. European Parliament.

[4] Mlecnik, E., Straub, A., & Haavik, T. (2019). Collaborative business model development for home energy renovations. Energy Efficiency, 12(1), 123-138. https://doi.org/10.1007/s12053-018-9663-3

[5] Mahapatra, K., Gustavsson, L., Haavik, T., Aabrekk, S., Svendsen, S., Vanhoutteghem, L., ... & Ala-Juusela, M. (2013). Business models for full-service energy renovation of single-family houses in Nordic countries. Applied energy, 112, 1558-1565. https://doi.org/10.1016/j.apenergy.2013.01.010

[6] Kiss, B. (2016). Exploring transaction costs in passive house-oriented retrofitting. Journal of Cleaner Production, 123, 65-76. https://doi.org/10.1016/j.jclepro.2015.09.035

[7] Ebrahimigharehbaghi, S., Qian, Q. K., Meijer, F. M., & Visscher, H. J. (2020). Transaction costs as a barrier in the renovation decision-making process: A study of homeowners in the Netherlands. Energy and Buildings, 215, 109849. https://doi.org/10.1016/j.enbuild.2020.109849

[8] Ang, S, & Straub, D. W. (1998). Production and Transaction Economies and IS Outsourcing: A Study of the U. S. Banking Industry. MIS Quarterly, 22(4), 535-552. https://doi.org/10.2307/249554

[9] Ürge-Vorsatz, D., Eyre, N., Graham, P., Harvey, D., Hertwich, E., Jiang, Y., Kornevall, C., Majumdar, M., McMahon, J. E., Mirasgedis, S., Murakami, S., Novikova, A., Janda, K., Masera, O., McNeil, M., Petrichenko, K. & Herrero, S. T. (2012). Energy end-use: buildings. In Global Energy Assessment: Toward a Sustainable Future (pp. 649-760). Cambridge University Press. https://doi.org/10.1017/CBO9780511793677.016

[10] Valentová, M., Lízal, L., & Knápek, J. (2018). Designing energy efficiency subsidy programmes: The factors of transaction costs. Energy Policy, 120, 382-391. https://doi.org/10.1016/j.enpol.2018.04.055

[11] Mlecnik, E. (2012). One Stop Shop: Development of Supply Chain Collaboration for Integrated Housing Retrofit. In Paper for: International Comparative Urban Retrofit Workshop: Purpose, Politics and Practices 13th–14th September 2012, Manchester UK.

[12] Bjørneboe, M. G., Svendsen, S., & Heller, A. (2017). Using a One-Stop-Shop Concept to Guide Decisions When Single-Family Houses Are Renovated. Journal of Architectural Engineering, 23(2), 05017001. https://doi.org/10.1061/(ASCE)AE.1943-5568.0000238

[13] Pardalis, G., Mahapatra, K., & Mainali, B. (2020). Swedish construction MSEs: simply renovators or renovation service innovators? Building Research & Information, 48(1), 67-83. https://doi.org/10.1080/09613218.2019.1662713

[14] de Groote, M., & Lefever, M. (2016). Driving transformational change in the construction value chain. Reaching the untapped potential. Buildings Performance Institute Europe (BPIE), Brussels, Belgium.

[15] Boza-Kiss, B., & Bertoldi P. (2018). One-stop-shops for energy renovations of buildings. Ispra: European Commission, JRC113301. Available at: https://e3p.jrc.ec.europa.eu/publications/one-stop-shops-energy-renovations-buildings

[16] Haavik, T., Aabrekk, S., Mlecnik, E., Cré, J., Kondratenko, I., Paiho, S., & Mostad, K. (2012). Guideline: How to develop a business model for one stop shop house renovation. Segel, Nordfjordeid. Available at: https://www.buildup.eu/en/practices/publications/guidelines-how-develop-business-model-one-stop-shop-house-renovation

[17] Mahapatra, K., Gustavsson, L., Haavik, T., Aabrekk, S., Svendsen, S., Vanhoutteghem, L., Paiho, S. & Ala-Juusela, M. (2013). Business models for full-service energy renovation of single-family houses in Nordic countries. Applied energy, 112, 1558–1565. https://doi.org/10.1016/j.apenergy.2013.01.010

[18] Vanhoutteghem, L., Tommerup, H. M., Svendsen, S., Paiho, S., Ala-Juusela, M., Mahapatra, K., & Aabrekk, S. E. (2011). Full-service concept for energy efficient renovation of single-family houses. In SB11 Helsinki World Sustainable Building Conference.

[19] Risholt, B., & Berker, T. (2013). Success for energy efficient renovation of dwellings: Learning from private homeowners. Energy Policy, 61, 1022-1030. https://doi.org/10.1016/j.enpol.2013.06.011

[20] Pardalis, G., Mahapatra, K., Bravo, G., & Mainali, B. (2019). Swedish House Owners' Intentions Towards Renovations: Is there a Market for One-Stop-Shop?. Buildings, 9(7), 164. https://doi.org/10.3390/buildings9070164

[21] Madhok, A. (2002). Reassessing the fundamentals and beyond: Ronald Coase, the transaction cost and resource-based theories of the firm and the institutional structure of production. Strategic management journal, 23(6), 535-550. https://doi.org/10.1002/smj.247

[22] Dubois, A., & Gadde, L. E. (2002). Systematic combining: an abductive approach to case research. *Journal of business research*, *55*(7), 553-560. https://doi.org/10.1016/S0148-2963(00)00195-8

[23] Dyer, J. I. (1997). Effective interfirm collaboration: How firms minimize transaction costs and maximize transaction value." Strategic Management Journal, 18 (7): 535-556. https://doi.org/10.1002/(SICI)1097-0266(199708)18:7<535::AID-SMJ885>3.0.CO;2-Z

[24] Williamson, O. E. (1989). Transaction cost economics. Handbook of industrial organization, 1, 135-182.

[25] Barney, J. (1991). Firm resources and sustained competitive advantage. Journal of Management, 17(1), 99-120. https://doi.org/10.1177/014920639101700108

[26] Penrose, E. (1959). The Theory of the Growth of the Firm. John Wiley, New York.

[27] Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. Strategic Management Journal, 18(7), 509-533. https://www.jstor.org/stable/3088148

[28] Williamson, O. E. (1999). Public and private bureaucracies: a transaction cost economics perspective. The Journal of Law, Economics, and Organization, 15(1), 306-342. https://www.jstor.org/stable/3554953

[29] Coase, R.H. (1937). The Nature of the Firm. Economica, 4(16), 386-405.

[30] Wilson, C., Crane, L., & Chryssochoidis, G. (2015). Why do homeowners renovate energy efficiently? Contrasting perspectives and implications for policy. Energy Research & Social Science, 7, 12-22. https://doi.org/10.1016/j.erss.2015.03.002

[31] Mundaca T, L., Mansoz, M., Neij, L., & Timilsina, G. R. (2013). Transaction costs analysis of low-carbon technologies. Climate Policy, 13(4), 490-513. https://doi.org/10.1080/14693062.2013.781452

[32] Owen, A., & Mitchell, G. (2015). Outside influence–Some effects of retrofit installers and advisors on energy behaviours in households. Indoor and built environment, 24(7), 925-936. https://doi.org/10.1177/1420326X15600775

[33] Hrovatin, N., & Zoric, J. (2018). Determinants of energy-efficient home retrofits in Slovenia: The role of information sources. Energy and Buildings, 180, 42-50. https://doi.org/10.1016/j.enbuild.2018.09.029

[34] Wilson, C., & Dowlatabadi, H. (2007). Models of decision making and residential energy use. Annual Review of Environment and Resources 32, 169–203.

https://doi.org/10.1146/annurev.energy.32.053006.141137

[35] Knudsen, H. N., & Jensen, O. M. (2014). Indoor climate perceived as improved after energy retrofitting of single-family houses. In 13th International Conference on Indoor Air Quality and Climate, Indoor Air 2014International Conference on Indoor Air Quality and Climate. ISIAQ.

[36] Gram-Hanssen, K. (2014). Existing buildings–Users, renovations and energy policy. Renewable Energy, 61, 136-140. https://doi.org/10.1016/j.renene.2013.05.004

[37] Zundel, S., & Stieß, I. (2011). Beyond profitability of energy-saving measures—attitudes towards energy saving. Journal of Consumer Policy, 34(1), 91-105. https://doi.org/10.1007/s10603-011-9156-7

[38] Klöckner, C. A., & Nayum, A. (2016). Specific barriers and drivers in different stages of decision-making about energy efficiency upgrades in private homes. Frontiers in psychology, 7, 1362. https://doi.org/10.3389/fpsyg.2016.01362

[39] Buser, M., & Carlsson, V. (2017). What you see is not what you get: single-family house renovation and energy retrofit seen through the lens of sociomateriality. Construction Management and Economics, 35(5), 276-287. https://doi.org/10.1080/01446193.2016.1250929

[40] D'Oca, S., Ferrante, A., Ferrer, C., Pernetti, R., Gralka, A., Sebastian, R., & Op't Veld, P. (2018). Technical, financial, and social barriers and challenges in deep building renovation: Integration of lessons learned from the H2020 cluster projects. Buildings, 8(12), 174. https://doi.org/10.3390/buildings8120174

[41] North, D. C. (1992) Transaction costs, institutions, and economic performance. San Francisco, CA: ICS Press.

[42] Amit, R., & Zott, C. (2001). Value creation in e-business. Strategic management journal, 22(6-7), 493-520. https://doi.org/10.1002/smj.187

[43] Ring, P. S. and A. H. Van de Ven (1989). 'Legal and managerial dimensions of transactions'. In A. H. Van de Ven, H. Angle and M. S. Poole (eds.), Research on the Management of Innovation: The Minnesota Studies, Ballinger/Harper Row, New York, pp. 171-192

[44] Dore, R. (1983). Goodwill and the spirit of market capitalism. The British Journal of Sociology, 34(4), 459-482. doi:10.2307/590932

[45] Williamson, O.E. (1983). Credible commitments: using hostages to support exchange. American Economic Review, 73(4), 519–40. http://www.jstor.org/stable/1816557

[46] Kim, S. M., Mahoney, J. T. (2006). Mutual Commitment to Support Exchange: Relation-Specific IT System as a Substitute for Managerial Hierarchy. Strategic Management Journal, 27(5), 401-423. https://doi.org/10.1002/smj.527

[47] European Commission (2016). Accelerating clean energy in buildings. Annex to the Clean Energy for All Europeans. Brussels, 30.11.2016. COM (2016) 860 final. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52016DC0860

[48] Winter, S. G. (1988). On Coase, competence, and the corporation. JL Econ. & Org., 4, 1. https://www.jstor.org/stable/765019

[49] Nonaka, I. and Takeuchi, H. (1995) The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation, Oxford University Press, New York.

[50] Kale, P., Dyer, J.H. and Singh, H. (2002) Alliance capability, stock market response, and long-term alliance success: The role of the alliance function. Strategic Management Journal, 23(8), 747–67. https://doi.org/10.1002/smj.248

[51] Williamson, O.E. & Ouchi, W.G. (1981). The Markets and Hierarchies and Visible Hand Perspectives. In Van de Ven, A. & Joyce, W. (eds.), Perspectives on Organization Design and Behavior, New York: Wiley.

[52] Edvardsson, B., Holmlund, M., & Strandvik, T. (2008). Initiation of business relationships in service-dominant settings. Industrial Marketing Management, 37(3), 339-350. https://doi.org/10.1016/j.indmarman.2007.07.009

[53] Kindström, D., Kowalkowski, C., & Sandberg, E. (2013). Enabling service innovation: A dynamic capabilities approach. Journal of business research, 66(8), 1063-1073. https://doi.org/10.1016/j.jbusres.2012.03.003

[54] Storbacka, K. (2011). A solution business model: Capabilities and management practices for integrated solutions. Industrial Marketing Management, 40(5), 699-711. https://doi.org/10.1016/j.indmarman.2011.05.003

[55] Thuvander, L., Femenias, P., & Meiling, P. (2011). Strategies for an integrated sustainable renovation process: Focus on the Swedish housing stock 'People's Home'. In Proceedings from the International Sustainable Building Conference SB11 in Helsinki 18-21October 2011.

[56] Brown, N. W., Malmqvist, T., Bai, W., & Molinari, M. (2013). Sustainability assessment of renovation packages for increased energy efficiency for multi-family buildings in Sweden. Building and Environment, 61, 140-148. https://doi.org/10.1016/j.buildenv.2012.11.019

[57] Palm, J., & Reindl, K. (2016). Understanding energy efficiency in Swedish residential building renovation: A practice theory approach. Energy Research & Social Science, 11, 247-255. https://doi.org/10.1016/j.erss.2015.11.006

[58] Johansson, T., Olofsson, T., & Mangold, M. (2017). Development of an energy atlas for renovation of the multifamily building stock in Sweden. Applied energy, 203, 723-736. https://doi.org/10.1016/j.apenergy.2017.06.027

[59] Azizi, S., Nair, G., & Olofsson, T. (2019). Analysing the house-owners' perceptions on benefits and barriers of energy renovation in Swedish single-family houses. Energy and Buildings, 198, 187-196. https://doi.org/10.1016/j.enbuild.2019.05.034

[60] Mahapatra, K., & Gustavsson, L. (2013). Energy renovation of single-family houses: Importance of economic aspects and suggested policy measures. In ECEEE 2013 Summer Study, June 3-8, BelambraLes Criques, France (pp. 529-536). European Council for an Energy Efficient Economy (ECEEE).

[61] Mahapatra, K., Mainali, B., & Pardalis, G. (2019). Homeowners' attitude towards one-stop-shop business concept for energy renovation of detached houses in Kronoberg, Sweden. Energy Procedia, 158, 3702-3708. https://doi.org/10.1016/j.egypro.2019.01.888

[62] Pardalis, G., Mahapatra, K., Mainali, B., & Bravo, G. (2021). Future Energy-Related House Renovations in Sweden: One-Stop-Shop as a Shortcut to the Decision-Making Journey. In Emerging Research in Sustainable Energy and Buildings for a Low-Carbon Future (pp. 37-52). Springer, Singapore. https://doi.org/10.1007/978-981-15-8775-7_4

[63] Galletta, A. (2013). Mastering the semi-structured interview and beyond: From research design to analysis and publication (Vol. 18). NYU press.

[64] Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. biometrics, 159-174. https://doi.org/10.2307/2529310

[65] Bjørneboe, M. G. (2017). Method for planning extensive energy renovation of detached single-family houses. Technical University of Denmark, Department of Civil Engineering.

[66] Bjørneboe, M. G., Svendsen, S., & Heller, A. (2018). Initiatives for the energy renovation of single-family houses in Denmark evaluated on the basis of barriers and motivators. Energy and Buildings, 167, 347-358. https://doi.org/10.1016/j.enbuild.2017.11.065

[67] Abreu, M. I., de Oliveira, R. A., & Lopes, J. (2020). Younger vs. older homeowners in building energy-related renovations: Learning from the Portuguese case. Energy Reports, 6, 159–164. https://doi.org/10.1016/j.egyr.2019.08.036

[68] Baumhof, R., Decker, T., Röder, H., & Menrad, K. (2018). Which factors determine the extent of house owners' energy-related refurbishment projects? A Motivation-Opportunity-Ability Approach. Sustainable cities and society, 36, 33-41. https://doi.org/10.1016/j.scs.2017.09.025

[69] Ebrahimigharehbaghi, S., Qian, Q. K., Meijer, F. M., & Visscher, H. J. (2019). Unravelling Dutch homeowners' behaviour towards energy efficiency renovations: What drives and hinders their decision-making? Energy Policy, 129, 546-561. https://doi.org/10.1016/j.enpol.2019.02.046

[70] Ekström, T. (2017). Passive house renovation of Swedish single-family houses from the 1960s and 1970s: Evaluation of cost-effective renovation packages. Licentiate Thesis, Department of Architecture and Built Environment Lund University Faculty of Engineering

[71] Mokhlesian, S., & Holmén, M. (2012). Business model changes and green construction processes. Construction Management and Economics, 30(9), 761-775. https://doi.org/10.1080/01446193.2012.694457

[72] Osterwalder, A., & Pigneur, Y. (2010). Business model generation: a handbook for visionaries, game changers, and challengers. John Wiley & Sons.

[73] Kivimaa, P. (2014). Government-affiliated intermediary organisations as actors in system-level transitions. Research policy, 43(8), 1370-1380. https://doi.org/10.1016/j.respol.2014.02.007

[74] Talmar, M., Walrave, B., Raven, R., Romme, A.G.L. (2019). Intermediary role dynamics in system-level transitions: A case from energy transition. Academy of Management Proceedings. Boston, MA. https://doi.org/10.5465/AMBPP.2019.11331abstract

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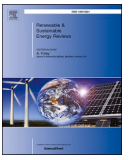

Strategies for deep renovation market of detached houses

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ABSTRACT

Deep renovation of the buildings is a key for sustainable development, however, the rate of deep renovation of residential buildings in the European Union (EU) is lower than what is required to meet the climate and energy goals. This paper analyses peculiarities and commonalities in market conditions and approaches to deep renovation of single-family (or detached) houses in Denmark and Sweden. The market analysis covers the Political, Economic, Social and Technical (PEST) dimensions and is based on systematic literature review and findings of market gap analysis. The PEST analysis is complemented with responses from 49 stakeholders/experts to examine the strengths, weaknesses, opportunities and threats (SWOT analysis) for deep renovation market. The synthesis of SWOT and PEST led to some strategies for deep renovation. Furthermore, policies and strategies adopted by some other countries have been discussed to place findings from this study in the regional and global context. Capacity building in designing and managing deep renovation with technological advancement and construction practices; and enforcement of quality assurance systems of artisans could avoid the perceived risk and inconveniences associated with renovation. Encouraging systematically planned stepwise deep renovation through One-Stop shop and linking such renovation with appropriate financing mechanism could attract more homeowners with financial limitations. Besides, clustering several houses in need of renovation and appropriate energy/carbon pricing mechanisms could make the renovation market more attractive for investors and construction companies. The findings of this paper are of interest for the construction companies, policymakers, investors, and analysts about deep renovation market.

1. Introduction

The building sector accounts for around 51% of electricity use, 51% of district heat energy use, and 19% of energy-associated greenhouse gas (GHG) emissions at the global level [1]. The deep renovation of the buildings is therefore a key sustainable development agenda to decrease these energy consumption and associated emissions. European Union has the goal to reduce energy efficiency by 32.5% within 2030 as compared to the year 2005. Buildings are accountable for 40% of total energy consumption and 36% of CO_2 emissions in the European Union [2]. Around 70% of homes across the EU are owner-occupied where homeowners precede the decision for renovations [3]. Around 1.6 million one-two family houses (also called detached houses) in Sweden [4], and around 0.45 million in Denmark [5], were built more than 30 years ago. A large part of them require major renovation providing unique opportunities for the implementations of energy efficiency measures to reduce primary energy use (up to 80%) and greenhouse gas emissions significantly [6]. Other than the direct energy savings and climate benefits, energy efficiency improvements in buildings improve comfort and indoor climate for the occupants and could deliver tangible co-benefits to the construction industries/businesses. EU Energy Efficiency Directive (Directive 2012/27/EU) under Article 4 directs the member states to set up national strategies for the renovation of the building stocks [7].

EU Energy Efficiency Directive has defined deep renovation as a refurbishment action that decreases both the delivered and the final energy consumption of a building by a significant percentage in comparison to the pre-renovation levels [8], however it does not specify what constitutes as “significant percentage”. The Buildings Performance Institute Europe (BPIE) has defined deep renovation as a package of measures applied together in a holistic approach resulting in reduction in final energy use by 60–90% [9]. However, it has been reported that hardly 1% of the renovations comply with this level of renovation [10]. The pace of deep renovation of buildings is very slow due to several challenges [8]. The aim of this research is to develop strategies to enhance deep renovation market of detached houses by analysing the market conditions in a holistic approach.

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List of abbreviations

SWOT	Strengths, Weaknesses, Opportunities and Threats
PEST	Political, Economic, Social and Technological
OSS	One-stop-Shop
EU	European Union
SMEs	Small and medium Entrepreneurs
kWh	Kilowatt hours
EED	European Union's Energy Efficiency Directives
EEO	Energy Efficiency Obligation

In this pretext, this paper analyses deep renovation market of detached houses with case examples from Sweden and Denmark exploring the political (policies), economic, social and technical (PEST) factors influencing the market, and proposes marketing strategies based on SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis. Both the countries have similar macroeconomic, climatic and housing stock conditions. They have aggressive climate and energy goals and are emerging leaders in renewable energy and energy efficiency sector. The deep renovation may not directly reduce significant GHG emissions as they are already in the low-carbon pathways in terms of energy generation but increased energy efficiency will reduce primary energy use, which is important for overall resource efficiency. Moreover, primary energy savings in these two Nordic countries could decrease non-renewable energy uses in other parts of EU, thus contributing to EU's energy efficiency and climate goals. It is therefore interesting to explore deep renovation market of these two country cases exploring the commonalities and peculiarities within their approach.

The paper is highly relevant as the enhancement of deep renovation market is instrumental in realizing the target associated with energy efficiency goal (SDG 7) and climate goal (SDG 13) while also contributing to meeting targets associated with employment in construction sector (SDG 8) and in addressing energy poverty issues in housing sector (SDG 1).

Various studies have explored the policy aspects and their role in boosting the deep renovation of buildings in Europe. Baek and Park [11] argues that market based approach adopted in Sweden and Denmark might not be sufficient to accelerate deep renovation market especially when the housing market is dominated by new construction. The paper highlights the need of appropriate financing policy for the deep renovation. Kiss et al. [12] discusses the role of policy instrument in the development and dissemination of technological innovations for renovation with the case examples from Sweden, Germany and United Kingdom. Mahapatra et al. [4] highlights the role of policy instruments in promoting deep renovation and suggests one-stop-shop (OSS) market-model that can provide the services as per customers' need in the process of deep renovation. Bjørneboe et al. [5] analysed the barriers and motivators behind the renovation market of single-family houses in Denmark and identifies financing schemes with subsidy as one of the policy instrument to overcome the market barriers. In contrast, Dubois and Allacker [13] argues for the abolishment of subsidies for renovation with minor energy savings and suggest for restructuring the subsidies in the favour of deep renovation or demolition and reconstruction project. A review of financial incentives for energy efficiency has shown that such measures increase the implementation of energy efficient measures in the residential sector, but the net energy saving and CO_2 reduction does not commensurate with the expectations due to free riding (see Ref. [14]) and rebound effects (see Ref. [5]).

Various studies have highlighted the economic aspects of the deep renovation market in Europe. Kragh and Rose [15] suggests long-term mortgage soft loans for energy renovation and equity investment as an economically attractive means to finance energy renovation of single-family houses in Denmark. Mata et al. [16] analysed cost effectiveness of various retrofit alternatives with different energy price scenario and at various discount rate. The deep renovations always have high upfront cost and may not always look attractive from economic perspective [16]. Ekström et al. [17] adopted a life cycle approach to evaluate the cost-effectiveness of renovating single-family houses at (i) shallow level (ii) deep level to meet new building regulation and (iii) passive house level. The paper shows that installation of a heat pump could be the most cost-effective individual renovation measure whereas the deep renovation (at passive house level) was cost effective only in the case with electric heating system.

Owners' perception and social attributes influencing the decision on deep renovation of the detached houses have been well discussed in the literature with case examples from Sweden and Denmark. Nair et al. [18] analysed the perceptions of homeowners in terms of adopting building envelop energy efficiency measures, whereas Buser and Carlsson [19] applied sociomateriality approach (also known as socio-material lens) to comprehend the slow expansion of the retrofit market of single-family houses. The paper argues that the importance of the old households' configuration and associated complexity with deep renovation perceived by the homeowners affect their decision for the deep renovation. Mortensen et al. [20,21] evaluated the level of thermal comfort and quality of indoor environment that the homeowners feel essential along with the level of architectural changes they would prefer during renovation. Tjørring [22] made anthropological investigation on gender role on decision of the energy renovation in Danish houses. The study has shown the decisions about energy renovations are affected by cultural norms and gender practices, male being the most interested in the energy renovation.

Alev et al. [23] discussed the technical dimension of deep renovation showing various alternatives in improving the energy performance of single-family rural houses with the case studies from Sweden, Estonia and Finland. The analysis showed that significant energy saving could be achieved with improvement in building energy service (heating and ventilation systems) and with the addition of renewable energy source without much more changes in the structure and appearances of the building. Kragh and Wittchen [24] analysed the appropriate and efficient technical alternatives in upgrading the energy performance of the building with the case example from Denmark. Table 1 summarizes the review of past work covering policy, economic, social and technical dimension of the deep renovation of single-family houses.

Most of these studies focused on and explored one of the dimensions of the deep renovation market while a holistic approach deemed necessary to evaluate the market critically [25]. Continuous effort in technological development as well as market innovations considering aforementioned dimensions are key for businesses to become more competitive [26]. The integration of the PEST analysis with SWOT analysis for the evaluation of deep renovation market conditions of detached houses and proposing strategies based on these analysis is the novelty within this paper.

2. Methodological framework

The research is based on the systematic literature review, expert consultation, and findings of market gap analyses of deep renovation in Sweden and Denmark conducted as a part of INNOVATE project under EU Horizon 2020 [6,27]. Defining the object under study and purpose of the study is the first step in defining the analytical framework. The object under this study is the deep renovation market and the purpose of the study is to analyse the existing market conditions and develop strategies for deep renovation market of single-family detached houses in Denmark and Sweden. Second step is to examine the existing market conditions (both supply-side and demand side) within Political, Economic, Social and Technical (PEST) dimensions. The political factors include e.g. housing regulation, tax regulation, procedural bureaucracy; economic factors include e.g. financial incentives, availability of credit finance, customers' economic gain; social factors include perceptions,

Table 1
Summary of Scientific literature covering Policy, Economic, Social and Technical dimensions of Deep renovation of Single-family houses.

Dimension	Authors/publication year	Country studied	Topics addressed
Policy	[11] Baek and Park, 2012	Denmark, Sweden, France, Germany	Evolution of renovation policies and political strategies.
	[12] Kiss et al., 2013.	Sweden, Germany, United Kingdom	Role of policy instrument in the development and dissemination of technological innovation for renovation
	[13] Dubois and Allacker, 2015	Europe	Evaluating effectiveness of 3 economic instruments: subsidies for (i) renovation, (ii) subsidies for demolition and (iii) reconstruction
	[14] Laes et al. (2016) [25] Bjørneboe et al., 2018	Europe Denmark	Review on financial incentives and subsidies in energy renovation Initiatives for the energy renovation of single-family houses in Denmark evaluated on the basis of barriers and motivators
Economic	[15] Kragh and Rose, 2011.	Denmark	Energy renovation of single-family houses utilizing long-term financing based on equity
	[17] Ekström et al., 2018	Sweden	Renovation alternative analysis for Swedish single-family houses with life cycle cost
	[4] Mahapatra et al., 2013	Denmark, Sweden, Finland, Norway	Market models for full service energy renovation of single-family detached houses.
	[16] Mata et al., 2015	Sweden	Cost effectiveness of various retrofit alternatives at different energy prices & discount rates
Social	[20] Mortensen et al., 2016	Denmark	Behaviour aspects of the house owners
	[18] Nair et al., 2010	Sweden	Behaviour aspects of the house owners
	[19] Buser and Carlsson, 2017	Sweden	Inter linkages of physical and social attributes and its influences in house renovation decision
	[21] Mortensen et al., 2018	Denmark	Customer perception on type and level of renovation
	[22] Tjørring, 2016	Denmark,	Gender and cultural attributes influencing renovation decision
Technical	[23] Alev et al., 2014	Sweden, Estonia, Finland	Technical renovation alternatives to improve energy performance
	[24] Kragh and Wittchen, 2014	Denmark	Appropriate and efficient technical alternatives in upgrading the energy performance

cultural and social conventions; and technological factors e.g. are technological advancement, synergy and trade-off among the technology/service providers. This is also known as PEST analysis.

After the PEST analysis, the market strengths, weaknesses, opportunities and threats (SWOT) were analysed following the steps as suggested by Chermack and Kasshanna [28]. Stakeholder consultation is an utmost important step for SWOT analysis. A broad consultation with 49 stakeholders (including consultant, municipality energy advisors, and professionals from construction SMEs, bankers, and real estate agents from Sweden and Denmark) were performed. The consultations were rather explorative and descriptive in nature with 33 face-to-face interviews and 11 online questionnaires surveys. During the survey the objective behind the study, definitions of SWOT elements have been well communicated with the respondents for the common understanding. Respondents were asked to describe three key strengths, weaknesses, opportunities and threats of the deep renovation market of detached houses in their country. The responses have been solicited and analysed in combination with PEST analysis [29]. This serves as a basis for developing appropriate market strategies for the deep renovation. Strategies are developed for (i) utilizing existing market strengths to reduce its vulnerability to external threats (ST-Strategies); (ii) tracing out the means to use strengths to take advantage of existing market opportunities (SO-Strategies); (iii) overcoming weaknesses to open new opportunities (WO-Strategies); and (iv) minimizing the weaknesses and prepare defensive plan making it less vulnerable to external threats (WT-Strategies).

Though combination of SWOT and PEST is commonly used method in marketing science but to the best of authors' knowledge, this has been adopted for the first time analysing deep renovation market. The paper has also discussed the strategies and policies adopted by some other countries to place findings from this study in the regional and global context.

3. PEST-analysis

PEST (Political, Economic, Social and Technological) Analysis is an analytical tool for examining major influential factors determining the decline or growth of the market and there by facilitate more effective strategic planning [30].

3.1. Political factors (policies)

3.1.1. Building regulation

Building regulations comprise of requirements on energy management as well as upper threshold for energy use. The existing building regulation (BBR 29) in Sweden demands that primary energy consumption should not exceed 90 kWh/m^2/year for both new and deeply renovated single family houses [31,32]. In Denmark, the building regulation (BR 18) has stricter requirements for new buildings than renovation of the existing buildings [33]. There is also a separate voluntary energy performance (EP) frameworks for existing buildings with different requirement for different classes of renovation. Renovation Class 1 requires EP-framework of 52.5 + 1650/heated floor area (kWh/m^2/year) equivalent to Energy label A_{2010}. Renovation class 2 requires an EP-framework of 110 + 3200/heated floor area (kWh/m^2/year) equivalent to Energy label C. Such a voluntary requirement provides flexibility to the house owners.

In both countries, there is a requirement of energy performance certificates (EPCs) while changing the ownership or tenant of a house. The EPC includes recommended potential energy efficient measures appropriate for the specific house. The assumption behind this regulation is that better information about the energy performance of the building will trigger energy renovation. EPC has been introduced in many EU states and in USA [1]. However, EPC has not been as effective as it was expected [34,35]. To make EPC more effective the energy performance criteria or indicators should be independent of owners or tenant behaviour related with building operation [36]. The quality of EPC plays a vital role on its impact realization [1].

3.1.2. Tax regulation

The existing housing tax policies in Sweden and Denmark are more favourable for the new constructions to meet the increasing housing demand than on renovating the existing building stock [33,37]. For example, in Sweden, the real estate fee for single-family houses is 7112 SEK/year (684 €[1]) but not exceeding 0.75% of the tax assessment value. However, such a fee is waived for newly built dwellings for first ten years encouraging new construction [38].

3.1.3. Energy efficiency regulation

The European Commission's directive on Energy Efficiency (EED)

[1] 1 € = 10.4 SEK as of Oct 2020 conversion rate.

endorses implementation of an energy efficiency obligation scheme (EEO) with tradable white certificates as an alternative for achieving the targeted energy savings. The EED provides sufficient space for the diversity of possible designs in such schemes [39]. Australia, Denmark, France, Italy, Poland, United Kingdom and USA have policy portfolio that includes EEO with different obligated parties based on specific local market conditions [40]. Savings through EEO was amounted to 12.2 PJ in Denmark for the year 2015, out of which 35% was from residential sector [41]. Danish EEO is perceived to be the strongest and most successful in comparison to other European countries [42]. There is no EEO scheme for the residential sector in Sweden, but an earlier study has suggested EEO as non-cost effective measure that overlaps with the EU Emissions Trading System (EU ETS) [43]. Recently Swedish Ministry of the Environment and Energy has set up a commission to investigate the possibility on some policy measures like white certificate for enhancing energy efficiency based on a broader framework agreement among major political parties [44]. White certificate if introduced may create some obligations to promote demand side intervention in the new building construction or for the renovation. Linking such white certificate system with a clear-cut energy efficiency goal and learning from experienced countries in the design of the policy instrument will contribute to effective implementation. Furthermore, the EDD requirements in Article 4 deemed to be more specific in addressing identified information gaps, as well as translating them in National Energy Efficiency Action Plans (NEEAPs) for the implementation and monitoring of energy savings in existing buildings [45].

3.2. Economic factors

3.2.1. Financial incentives

EU directives have emphasized to increase both the level and the rate of building renovation, and to promote the use of sustainable energy sources in heating and cooling through appropriate incentives. Government support in terms of grants and subsidies are generally required at the initial stage of the market when the investments required for energy renovation cannot be fully covered by the customers themselves. This kind of support should be taken as a means to overcome the upfront cost barrier. In Netherlands various sets of fiscal incentives viz. Capital subsidy for installing sustainable energy system and tax rebate are in place to enhance deep renovation [46]. Similarly, in the US, there exists more than 30 different on-bill financing programmes for upgrading to a high-efficiency air conditioner or adding insulation, as well as various kinds of federal and state-level grants for energy renovation [3].

However, both the Swedish and Danish National Energy Efficiency Action plans (NEEAPs) and latest annual reports pursuant to Article 24 (1) of Directive 2012/27/EU [5] are silent about public funds for energy efficiency. Danish EEO scheme is expected to deliver 100% of the mandatory EED target, and hence, there is no further consideration on investment subsidies. In Sweden, currently there is no specific subsidies for any action improving energy efficiency. There was one time investment support for installing Solar Panel and battery storage system for individual houses. The support was 60% of the investment cost but not exceeding a ceiling of 50,000 SEK (4808 €) which has been discontinued from July 2020 and instead, there is a provision for tax deduction on the installation of solar panel and energy storage system.

Besides, there is a provision of tax rebate (ROT) in Sweden on the purchase of household services, repairs and maintenance up to 4808 € per applicant per year [37]. However, main intension of such tax reduction is not the energy renovation, but to create jobs and to transfer jobs from the hidden to the registered economy in housing construction industry. In contrast, there is a provision of annual tax credits up to 2015 €[2] per capita per housing unit, and a maximum of 4030 € per home for encouraging the energy renovation in Denmark. Besides, there is also a provision of getting reimbursement against saved CO_2 from deep renovation [47].

3.2.2. Credit finance

Access to credit for energy efficiency measures could be a more sustainable means of financing as it provides liquidity and direct access to capital [48]. However, no soft loans specific for energy renovation is available in Denmark and Sweden. Most of the commercial banks in these countries are typically unfamiliar with energy renovation and perceive loans on this sector as high-risk investments [48]. Therefore, there exists financial constraints for deep renovation. However, some of the European banks viz. Triados Bank with its branches in Belgium, Germany, Netherlands, Spain and the UK, and Dutch Robo Bank are offering low-interest loans for energy renovation. The commercial banks in Denmark and Sweden could learn from the experiences from these banks.

Danish Pension Fund (PKA) has set a goal of investing 3.5 billion euro into energy efficiency and renewable energy by 2020. In 2015, it launched a 40 million euro fund called Sustain Solutions, which offers soft loans for renovations, which is paid back by the homeowners through savings on energy bills [49]. However, at present such loans are available only to housing companies. The accessibility of such credit finance by individual homeowners could be helpful in accelerating the deep renovation market.

3.2.3. Customers' economic gain

Economic gain from deep renovation needs to be considered going beyond gain of energy saving. Most often additionality issues are overlooked in economic analysis. The reduced energy demand after deep renovation would avoid the capital cost of building additional power plants and investments in new grid capacity, which will be eventually reflected in the electricity price and the grid tariffs paid by consumers [50]. A more indirect gain occurs through health benefits because of improved indoor climate and thermal comfort [51]. Deep renovation packages if planned along with scheduled major maintenance of the houses (most often done in the interval of 30–40 years), could be economically more attractive.

3.3. Social factors

3.3.1. Cultural and social conventions

Normally, house owners perform major renovation of their house once or twice in their lifetime, but such a decision is influenced by the know-how and habits [52,53]. A study in Denmark has shown that renovation decisions are strongly influenced by the knowledge networks (family members, friends and colleagues) and advice from the craftsmen or construction companies [54] who might have own interests and limitations of not promoting deep renovation. In some of the older buildings, the tendency to preserve the historical and cultural values limits the scope of deep renovation. The perceived cultural value of the exterior and interior architect will sometime make it impossible to add insulation in the building envelop [55].

3.3.2. Homeowners' perception

Social motives and barriers could be explained using a lifestyle-model also known as inertia model [56]. Bjørneboe [57] has used this concept to explain the social barriers in the deep renovation where it has been argued that the response of the people towards the same energy-saving measure may differ depending upon what signals it will deliver to their social surroundings. Thus, even an economically unattractive energy efficiency measure could still be attractive, if it is perceived to strengthen their social status, whereas an economically feasible measure might not be obvious choice if it does not have any signalling effect [58]. Pardalis et al. [27] has analysed homeowners' personal and contextual variables with a case study from Sweden, which indicates that people are interested more on aesthetic renovation than

[2] 1 € = 10.4 SEK = 7.4 DKK as of Oct 2020 conversion rate.

the energy renovation, which could be viewed as a barrier for the deep renovation market. In contrast, cross-country evidence from Netherland, UK and Ireland have shown that the buyers are paying more value for energy-renovated buildings. The possible reasoning behind a higher bid price for the house could be the expected yearly energy savings and the comfort value offered by the energy-renovated house. This gives an opportunity for banks to use the potential increased value of the building as a collateral for financing the up-front cost of the renovation which is also known as mortgage financing [59].

3.3.3. Enthusiasm, income and time (EIT)

There is always a challenge to have simultaneously (i) enthusiasm for making changes, (ii) enough income/savings, and (iii) appropriate time for carrying out deep renovation [27]. Among the Swedish population, youth under the age of 35 were found to be more willing to perform deep renovation [27]. Mortensen et al. [26] also reported that the youth are most interested in the deep renovation in Denmark. This customer segment has time and enthusiasm to try new things and ability to take risk [60]. However, they might have financial constraint to invest more on renovation on the top of their existing home loan. Middle-aged group (35–64 years) might have some enthusiasm for change and have stable income with some savings for financing the renovation but might have time constraint for renovation due to different priorities and being occupied with other family activities, specially related to children. Pensioners may have time availability, but may not have enough income/saving and they have the least interest for making major changes in the houses [27].

3.4. Technical factors

3.4.1. Building code/technological advancement

The development of codes and standards are falling behind the technological advancement, which has been perceived as a barrier for energy-efficient innovation [61]. Technological advancement in building materials and construction practices and other energy efficient home appliances have increased the technical capability of the market for deep renovation. However, innovations in energy-efficient building solutions are often not well adopted in the (Swedish and Danish) building renovation. Reluctant for change and lack of transformation pressure for adopting technological changes in the renovation are some challenges for integrating technological advancement in deep renovation [62].

3.4.2. Technical knowledge and resource gaps

The market for renovation of detached houses is fragmented, and dominated by Small and Medium Enterprises (SMEs) that promote their own products and services. Varied knowledge and conflicting interests of these actors are perceived as hindrance for deep renovation [63]. There is shortage of skilled and competent artisans in both countries. This shortage is projected to increase in the upcoming years due to increasing investments in new construction and high retirement rates of the workers in the sector [64,65]. This has affected the renovation market as priority of the large construction companies being more on the new construction. Specific skills are needed to enhance energy-efficiency in old buildings and sequencing and coordinating of various jobs within deep renovation process. This has been perceived as one of the major challenges by SMEs working in the renovation sector [66,67].

3.4.3. Technical solution, research and innovation

Technological innovation and solutions need to address the existing hurdles of the renovation market. Prefabricated renovation solution is an ongoing transition, which has potential to overcome renovation barriers combining product and process innovation [68]. This can significantly reduce the onsite renovation time, offering less disturbance for dwellers and possibly offering cost-effective solutions. Integration of ICT and automated solutions in the home renovation could make the house smart, energy efficient, increases thermal comfort and safety in homes [69]. In Sweden, there is a "construction innovation programme" supported by Swedish Innovation Agency VINNOVA with matching fund from the companies, which promote the commercialisation of research results by supporting the adoption of innovative ICT and green growth solutions [65]. Innovation Network for Energy efficient and Sustainable construction (InnoBYG), Danish Eco-innovation Programme are some initiatives in Denmark that supports energy efficient innovation in Construction sector [64].

4. SWOT analysis for deep renovation market

SWOT is a commonly used market analysing technique, which examines internal strengths and weaknesses of the market, and identifies the opportunities and threats due to the external environment [70]. SWOT analysis is instrumental in analysing market, policy sector or instruments, and business models. Muresan and Attia [71] and Liu et al. [72] analysed deep renovation market covering the case studies from Romania and China, respectively. SWOT analysis has also been applied for analysing business model for deep renovation market in Europe [73]; energy efficiency innovation adoption with case examples from Taiwan, South Korea, Indonesia, and Vietnam [74]; energy efficiency policy instruments with case examples from Europe [75]. Jiang et al. [76] have applied this tool for investigating China's off-site construction status quo under the backdrop of China's new urbanisation. This tool has also been applied in evaluating the national energy sector with case studies from Northern Macedonia [77] and Ethiopia [78].

Defining the market under study and identifying its competitors are crucial for conducting SWOT analysis. Competitors can be conceptually framed in three categories based on market commonality and resource similarity as proposed by Bergen and Peteraf [79]. That conceptual framework has been adapted to identify the direct, indirect and potential competitors in the context of deep renovation market (see Fig. 1).

Market commonality could be defined as the degree of presence or the domain of the deep renovation market that overlaps with the competing market/sector [80,81]. While the resource similarity is defined by the extent, to which a given competitor possesses strategic attributes comparable to the market/sector into consideration [79,82]. The market sector that possess high commonality in terms of both market and resource serving the same market needs with the same types of resources could be consider as *direct competitors*. For an example, single service providers such as façade installers or heat pump installers are direct competitors as they vie for similar customers and possess similar endowments. Aesthetic renovation is serving the same renovation market as deep renovation with different types of resources. In fact, renovation market is most often dominated by aesthetic renovation, which gets greater attention by the house owners. Therefore, aesthetic renovation is in *indirect competition* to the deep renovation market. New housing construction though do not serve the same customer needs but have resource similarity in terms of human resources, energy efficient equipment and material used for the construction. Therefore, new housing construction industries possess potential competition to the renovation market. In the competitive environment the goal is to overcome the competition and gain new customers with innovative market strategies [83].

SWOT is often considered as a static analytical tool and can risk ignoring dynamic conditions. This is considered as its limitation [84]. Political, economic, social and technical factors determine the external environment influencing the opportunities and threats (external characteristics) of the deep renovation market. However, these relationships are dynamic and, in a long run, indirectly may affect in shaping strength and weaknesses (internal characteristics) of the market. For example, in a long run the impact of government financial incentives or technical support, awareness campaigns, technological and market demonstrations, word of mouth communication, and technological innovations and diffusion could be internalized as its strength by the market [29].

This dynamism needs to be considered while performing the SWOT analysis and hence the analysis need to be flexible and periodic subject to change in the situation in-order to address the limitation.

In this pre-text, the SWOT analysis has been performed based on the theoretical analysis of the market conditions using PEST and the stakeholder consultation to identify the key internal characteristics (strengths and weaknesses) and external influences (opportunities and threats) of the deep renovation market for detached house in Sweden and Denmark. During the consultations, stakeholders were asked to list down top three strengths, weaknesses, opportunities and risk associated with deep renovation market and discussed why they perceived so. The possible alternatives for accelerating deep renovation of detached houses were also discussed.

4.1. Strengths

Most of the stakeholders consulted highlighted that improved quality of life, better thermal comfort, and significant energy saving are some key strengths of deep renovation in Sweden and Denmark. Availability of high quality building insulation materials and construction practices, presence of competent construction companies are some of the strength for the deep renovation market in both countries. Besides, the existing free advisory services from municipality on energy renovation; financial support on energy audit have been perceived as strength. Financial incentives like rebate on tax (ROT) on energy renovation and a provision of getting reimbursement against saved CO_2 from deep renovation in Denmark have provided strong basis for the market to expand. However, tax rebate (ROT) in Sweden on the purchase of household repair and maintenance services could motivate to do the renovation work within the given rebate range every year rather than going for a systematic deep renovation. Linking the ROT with energy renovation could strengthen the deep renovation market.

Besides, Danish energy efficiency obligation scheme (EEO) with tradable white certificates has provided some assurance to the homeowners for return on their investment.

4.2. Weaknesses

Most of the respondents perceived that the existing building regulations in Sweden that mandates same energy performance requirements for both new and deeply renovated houses weaken the deep renovation market as this leads to a high cost renovation project. Since not all house owners can afford deep renovation with higher energy performance requirement, the demand for the deep renovation can go down weakening the market. Majority of the SMEs perceived this as a major challenge, especially in the absence of proper financing mechanism and in a situation where the financial incentives are not explicitly supporting energy renovation. However, in Denmark, voluntary energy performance requirement and availability of financial incentives encouraging energy renovation make the situation relatively better. Too tight or too loose energy performance requirement might not be effective and eventually less attractive for the deep renovation. Most of the respondents were emphasizing to set an appropriate/reasonable maximum allowed energy usage requirement for deep renovated buildings in order to promote energy refurbishment.

In both countries, most of the house owners cover the renovation cost from their savings, from home loan or from private loan. There is no specific loans available for the deep renovation of detached houses. The interviewed bankers said that there has been no documented demand for such specific loan from house owners' side and that they perceive high risk to provide additional loan to those houses who already have home loan.

Large construction companies are currently more interested in new construction with larger business volume rather than in renovation of individual houses. Mostly, small and medium scale construction companies are engaged in the renovation business. These companies are competent in some specific jobs but might have limited competence in deep renovation. Renovation market is fragmented and dominated by a craftsman-based approach lacking holistic knowledge about deep renovation in SMEs and homeowners [12]. Therefore, they are less proactive to reach the customers and seldom promote integrated deep renovation solutions. There is lack of necessary project management competence among SMEs to collaborate efficiently with proper sequencing of various tasks minimizing operational risks.

Besides, perceived inconvenience caused during the deep renovation, lack of confidence of homeowners on the contractor are also some of the weakness of the deep renovation market. Some of the respondents have argued that the deep renovation market has not been able to attract homeowners in terms of return on their investment.

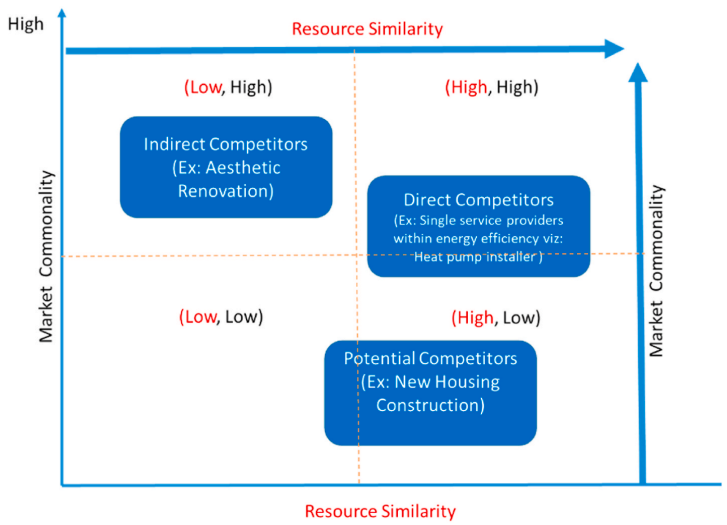

Fig. 1. Mapping the competitive landscape for deep renovation market.

Table 2
SWOT elements for Deep renovation market.

Strengths (S)	**Weaknesses (W)**
S1. Improved quality of life, better thermal comfort and significant energy saving S2. Large stocks of old inefficient detached houses needing renovation S3. Availability of high quality building insulation materials and competent construction practices. S4. Availability of quality certified energy efficient equipment S5. Free municipality advisory services on energy renovation. S6. Rebate on tax (ROT) on energy renovation and reimbursement provision against saved CO_2 from deep renovation in Denmark. S7. Financial support on energy audit in Denmark S8. Danish energy efficiency obligation scheme (EEO) with tradable white certificates. S9. Energy performance certificates requirement during renting or selling the house.	W1. High demanding building regulations, leading high cost renovation. W2. Cumbersome financial incentives policy and tax policies. W3. No specific loans available for the deep renovation of detached houses. W4. Companies' interest in new construction than renovation due to higher business volume. W5. SMEs with limited competence in deep renovation, lack of co-ordination. W6. Lack of holistic knowledge about deep renovation for the SMEs and house owners. W7. Lack of confidence of homeowners on the contractor W8. Perceived inconvenience caused during the deep renovation
Opportunities (O)	**Threats (T)**
O1. Public positive attitude towards climate change mitigation and sustainability **O2**. Targeted loans/incentives and taxation for deep renovation. **O3**. Increase in the energy prices and taxes **O4**. Easy access to information and counselling on energy efficiency. **O5**. A systematic renovation plan along with major periodic maintenance. **O6**. Innovation in the construction technology and practices.	**T1**. Construction companies have greater interest in new construction than renovation. **T2**. Scarcity of competent service providers in the renovation market. **T3**. Risk of lower energy savings attitude after renovation due to thermal comfort 'take-back'. **T4**. Perceived risk of poor quality work due to lack of coordination among various artisans. **T5**. The deep renovation might be less attractive when energy prices go down. **T6**. Perceived lower economic and social status gain from deep in comparison to aesthetic renovation.

4.3. Opportunities

Availability of soft loan and introduction of financial incentive specifically targeted for the deep renovation could create an opportunity for the expansion of the market. However, long experiences of financial incentives in US has provided very limited evidence that homeowners can be reliably motivated to renovate until there is a positive attitude towards climate and sustainability agenda [3]. Most Swedish and Danish people have positive attitude towards climate change mitigation and sustainability [66]. This provides an opportunity for deep renovation. However, homeowners mostly engage in habitual or low cost measures for motivating them in investment intensive deep renovation could be challenging without proper financial packages [16]. Most often, the return on deep renovation is looked in terms of energy saving. Therefore, increase in the energy prices (cost per unit electricity, heat and energy taxes) could make deep renovation more attractive economically and create more market opportunities. Besides, counselling on energy efficiency, easy access to information and guide/advice for systematic renovation could create a favourable opportunity for the deep renovation market. There is a common trend of having a major maintenance of houses in every 30–40 years. Counselling and advices could motivate the homeowners to have a systematic plan of deep renovation while performing such periodic maintenance. The deep renovation could be economically attractive to perform along with such major maintenance. Besides, innovation in the construction technology and practices viz. Prefabrication renovation has been perceived as opportunities in the expansion of the market.

4.4. Threats

Due to boom in new constructions in both the countries, competent large construction companies are currently more interested in new construction with bigger business volume rather than taking the renovation contract for individual houses. Therefore, this creates a threat of scarcity of competent service providers in the renovation market. The most indispensable ethical issues that businesses would face are integrity and trust on their services. Perceived risk of poor quality of the work during deep renovation due to lack of coordination among various craftsmen by the homeowners. Addressing the ethical barriers is very crucial for the market expansion. Deep renovation leads to energy saving and improved thermal comfort but not necessarily realize expected energy savings because of people's behaviour and thermal comfort 'take-back' after a renovation. Studies have discussed discrepancies between predicted and actual savings [62]. During the stakeholder consultation, risk of not attending potential savings after the execution renovation has been identified as one of the key risks for the market expansion. Besides, if the energy prices go down, then the people might be less motivated for deep renovation. In Sweden, average electricity price has gone down in the recent years (2012–2016) in comparison to average price in 2006–2012, which possess a hurdle for the expansion of deep renovation market. Deep renovations have advantages of energy savings and increased thermal comfort but such action have less visible (observability) and less impact in raising social status and property value in comparison to investment in aesthetic renovation. The Strength, Weaknesses, Opportunities and Threats for deep renovation have been tabulated in Table 2. They are applicable to both Denmark and Sweden unless specifically mentioned.

5. Recommended SWOT strategies for deep renovation market

The SWOT analysis combined with PEST analysis serves as a basis for developing appropriate strategies for the deep renovation market. Four distinct types of SWOT strategies have been developed matching the identified strengths and weaknesses with opportunities and threats.

5.1. S-T strategies (Identify the ways to use the strengths to reduce its vulnerability to threats)

- The existing technological advancement in the construction materials and competent construction practices (S3) could be utilized in training new human resources and for skill upgrading in the design and management of deep renovation. This will capacitate the supply side actors for renovation minimizing the scarcity of competent service provider (T2). Trained craftsmen could be mediators to reach out to the homeowners to motivate them for the deep renovation [85]. (S3→T2).[3]
- In addition to existing quality assurance system for the products with CE marking and energy labelling and guarantee period on the renovation work, enforcement of quality standards/certification systems for installers/artisans for deep renovation would assure

[3] S3→T2 means utilizing Strength (S3) to reduce the Threat (T2) summarized in Table 2.

quality of services and create confidence in homeowners to perform deep renovation (S4→T4).
- The existing generic tax rebate on labour cost of renovation (ROT) in Sweden should be linked to energy renovation and the maximum ceiling of such annual rebate be reviewed from a longer-term perspective to encourage deep renovation (e.g. increasing the ceiling for deep renovation or by permitting for adjustment of such tax rebate to some years after deep renovation). (S6→T6).

5.2. S–O strategies (Recognize the way to use strengths to take advantage of opportunities)

- Systematically planned and well thought out stepwise renovation packages that fit within the homeowners' yearly renovation budget could encourage those having positive attitude towards climate change mitigation and sustainability. The best available technological solutions and construction practices should be implemented in every step of renovation activities considering lifecycle approach [86] (S3→O1).
- Stepwise renovation could be even more attractive if linked with the appropriate annual financial incentives. The existing municipality support for advisory services, energy audit report, and energy certificates could be instrumental in promoting deep renovation. Furthermore, municipalities could create new entities or employ more people specifically to galvanize the deep renovation sector as is done in Frederikshavn, Denmark [6] (S5, S6, S7→O1, O2, O4).
- Making the existing property taxation system more progressive in terms of energy efficiency with tax rewards for buildings with high energy performance while penalizing buildings with poor performance could motivate many homeowners' to go for the deep renovation (S9→O2).
- Large stocks of the old inefficient detached houses could go through deep renovation in the presence of proper financing mechanism. Mortgage financing could be relatively of lower risk for the bank and one of the cost effective options encouraging more homeowners for deep renovation. A pragmatic country-by-country approach is deemed necessary in designing such financing mechanism to utilize the strengths and tap the opportunities and addressing the country-specific challenges (S2→O2).

5.3. W–O strategies (Overcome the weaknesses to take advantage of new opportunities)

- Increasing access to guidance/counselling from municipality will help to increase the awareness of the homeowners about the advantage of deep renovation, sequencing and prioritizing of the actions in the process of deep renovation. Sweden can learn from Danish 'Better Home' initiatives, which provides opportunity to obtain collective guidance from single source all the way in the renovation process [65] (W6→O4).
- Innovative business models such as a One-Stop-Shop (OSS) providing all the renovation services in the supply chain in a better-coordinated way could attract more homeowners for the deep renovation [87]. The OSS should have the necessary technical and managerial capabilities to design and coordinate the deep renovation project, avoiding the conflicts of interest between the parties involved, and mitigate the possible risks in the implementation of such projects [67]. The development of financial package (soft loan to be paid on instalments) on the product and service provided by one-stop-shop in collaboration with its suppliers could make energy renovation accessible to those homeowners having difficulties to obtain a bank loan (W5→O6). Renovation strategies should encourage technological innovation on prefabricated façade and roof and its implementation [88]. Circularity and resource efficiency must be closely looked at in such innovation to explore the economic and environmental benefits of prefabrication in terms of reduction, reusability, adaptability, and recyclability of its components [89]. Full or semi prefabricated technology (depending upon the site-specific requirement) could help to address the homeowners' perceived inconveniences, associated with deep renovation in both Sweden and Denmark (W8→O6).

5.4. W-T strategies (Minimize the weaknesses from making it highly exposed to threats)

- Renovation of detached houses in neighbourhood/integrated district approach could be an attractive business for medium and large construction companies whose current focus are rather on large-scale renovations or new construction. The neighbourhood approach might also be economic due to shared project management cost. Municipality and homeowners' associations may work together to encourage the homeowners for district renovation (W4→T1).
- Appropriate energy/carbon pricing mechanisms should be in place to offer the right economic signals to the market (W2→T5).

Synergies and trade-off among all these strategies suggested, their implementation modality are not covered within the scope of this paper but could be future research area to be explored.

6. Conclusion and way forward

Pragmatic country-by-country approach deemed necessary in designing strategies depending upon the market conditions determined by existing policy, economic, social and technical factors, which have been discussed and analysed in section 5. Despite of similar macroeconomic condition, climate, housing stock, energy and climate goals, and market-based approaches to deep renovation, there are some peculiarities in the instruments and approaches used to achieve the energy and climate goals. In Denmark, building regulations, together with measures such as high levels of energy taxation, various financial incentives (viz. Tax rebate, reimbursement against saved CO_2 from deep renovation), and energy performance requirements for building components, free advice/information on energy renovation, and energy efficiency obligation are some key initiatives encouraging deep renovation. In Sweden, building regulations, together with measures such as high levels of energy and carbon taxation, financial incentives like tax rebate on labour cost of renovation are in place. However, more targeted incentives are deemed necessary for promoting deep renovation. Energy Performance Certificates (EPCs) and energy audits should be further enhanced to make them more reliable and means of support in the decision-making process of homeowners regarding the renovation. The analysis also suggests some common strategies, which could be instrumental for the sustainable growth of deep renovation market in general, and for these two countries in particular.

Innovative business models such as One-stop shop model, and innovation on prefabricated renovation technology to address the homeowners' inconveniences with renovation are some WO-strategies identified. Neighbourhood/Integrated district approach in renovation to make the business attractive to the construction companies, and appropriate energy/carbon pricing mechanisms are some WT-strategies. Similar findings were also reported in another study within European Union [90].

Similarly, access to soft loan for deep renovation from banks or OSS services with financial package would enable more people to carry out extensive renovations overcoming the existing financial barriers for deep renovation. Training and skill upgrading of supply side actors; enforcement of quality standards/certification systems of installers for deep renovation as some ST-Strategies to avoid the perceived risk of poor quality of the renovation. Encouraging stepwise deep renovation, introducing the property taxation system linking with energy performance of the building, and mortgage refinancing are some of the SO-strategies to take advantage of potential opportunities using existing

strength. Deep renovation could increase market value of the property [91]. Thus, costs benefits analysis should go beyond the conventional energy saving estimations and should be well reflected in the process of property valuation.

These strategies could be equally applicable for the countries with similar market conditions. The strategies suggested under this paper may provide conducive environment for the market expansion by providing meaningful insights to the construction companies, policy-makers, investors.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] Pasichnyi O, Wallin J, Levihn F, Shahrokni H, Kordas O. Energy performance certificates — new opportunities for data-enabled urban energy policy instruments? Energy Pol 2019;127:486–99.
[2] Kangas HL, Lazarevic D, Kivimaaa P. Technical skills, disinterest and non-functional regulation: barriers to building energy efficiency in Finland viewed by energy service companies. Energy Pol 2018;114:63–76.
[3] Wilson C, Crane L, Chryssochoidis G. Why do homeowners renovate energy efficiently? Contrasting perspectives and implications for policy. Energy Res Soc Sci 2015;7:12–22.
[4] Mahapatra K, Gustavsson L, Haavik T, Aabrekk S, Svendsen S, Vanhoutteghem L, Paiho S, Ala JM. Business models for full service energy renovation of single-family houses in Nordic countries. Appl Energy 2013;112:1558–65.
[5] Bjørneboe MG, Svendsen S, Heller A. Case study: using a One-Stop-Shop concept to guide decisions when single-family houses are renovated. J Arch Eng 2017;23(2).
[6] Dehghan B. Market gap analysis. European Commission; 2020. p. 2018. Work Package 2, Deliverable 2.1, INNOVATE Project, Horizon.
[7] Directive 2012/27/EU of European parliament and of the Council of 25 october 2012 energy on efficiency, amending directives 2009/125/EC and 2010/30/EU and repealing directives 2004/8/EC and 2006/32/EC. Off. J. Eur. Union 2012;4:202–57.
[8] Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU. Directorate C, renewables, research and innovation, energy efficiency. 2019.
[9] Economidou M, Atanasiu B, Despret C, Maio J, Nolte I, Rapf O. Europe's buildings under the microscope. A country-by-country review of the energy performance of buildings. Build Perform Inst Eur (BPIE) 2011:35–6.
[10] The Economist. Investing in energy efficiency in Europe's buildings. A view from the construction and real estate sectors. A study commissioned by the Global Buildings Performance Network (GBPN) in collaboration with its European Hub, the Buildings Performance Institute Europe. BPIE); 2013.
[11] Baek CH, Park SH. Changes in renovation policies in the era of sustainability. Energy Build 2012;47:485–96.
[12] Kiss B, González MC, Neij L. The role of policy instruments in supporting the development of mineral wool insulation in Germany, Sweden and the United Kingdom. J Clean Prod 2013;48:187–99.
[13] Dubois M, Allacker K. Energy savings from housing: ineffective renovation subsidies vs efficient demolition and reconstruction incentives. Energy Pol 2015;86:697–704.
[14] Laes E, Mayeres I, Renders N, Valkering P, Stijn Verbeke S. How do policies help to increase the uptake of carbon reduction measures in the EU residential sector? Evidence from recent studies. Renew Sustain Energy Rev 2018;94:234–50.
[15] Kragh J, Rose J. Energy renovation of single-family houses in Denmark utilising long-term financing based on equity. Appl Energy 2011;88:2245–53.
[16] Mata E, Kalagasidis AS, Johnsson F. Cost-effective retrofitting of Swedish residential buildings: effects of energy price developments and discount rates. Energy Eff 2015;8:223–37.
[17] Ekström T, Bernardo R, Å Blomsterberg. Cost-effective passive house renovation packages for Swedish single-family houses from the 1960s and 1970s. Energy Build 2018;161:89–102.
[18] Nair G, Gustavsson L, Mahapatra K. Owners' perception on the adoption of building envelope energy efficiency measures in Swedish detached houses. Appl Energy 2010;87:2411–9.
[19] Buser M, Carlsson V. What you see is not what you get: single-family house renovation and energy retrofit seen through the lens of sociomateriality. Construct Manag Econ 2017;35(5):276–87.
[20] Mortensen A, Heiselberg P, Knudstrup M. Identification of key parameters determining Danish homeowners' willingness and motivation for energy renovations. Int J Sustain Built Environ 2016;5:246–68.
[21] Mortensen A, Heiselberg P, Knudstrup MA. Definition of specific comfort parameters, indoor environmental and architectural quality: evaluated by Danish single-family homeowners. Indoor Built Environ 2018;27(8):1085–104.
[22] Tjørring L. We forgot half of the population! the significance of gender in Danish energy renovation projects. Energy Res Soc Sci 2016;22:115–24.
[23] Alev Ü, Eskola L, Arumägi E, Jokisalo J, Donarelli A, Kai Siren, Broström T, Targo Kalamees. Renovation alternatives to improve energy performance of historic rural houses in the Baltic Sea region. Energy Build 2014;77:58–66.
[24] Kragh J, Wittchen KB. Development of two Danish building typologies for residential buildings. Energy Build 2014;68:79–86.
[25] Mlecnik E, Parker J, Ma Z, Corchero C, Knotzer A, Pernetti R. Policy challenges for the development of energy flexibility services. Energy Policy. Energy Pol 2020;137:111147.
[26] Bjørneboe MG, Svendsen S, Heller A. Initiatives for the energy renovation of single-family houses in Denmark evaluated on the basis of barriers and motivators. Energy Build 2018;167:347–58.
[27] Pardalis G, Mahapatra K, Bravo G, Mainali B. Swedish house owners' intentions towards renovations: is there a market for one-stop-shop? Buildings 2019;9:164.
[28] Chermack TJ, Kasshanna BK. The use and misuse of SWOT analysis and implications for HRD professionals. Hum Resour Dev Int 2007;10(4):383–99.
[29] Kalish S, Lilien GL. Optimal price subsidy policy for accelerating the diffusion of innovation. Market Sci 1983;2:407–19.
[30] Iglińskin B, Iglińska A, Cichosz M, Kujawski W, Buczkowski R. Renewable energy production in theŁódzkie Voivodeship. The PEST analysis of the RES in the voivodeship and in Poland. Renew Sustain Energy Rev 2016;2016(58):737–50.
[31] Boverket. Boverket's building regulations – mandatory provisions and general recommendations, BBR. In: Swedish National Board of Housing BaPB, editor. BFS 2011:6 with amendments up to BFS 2016:6; 2016. p. 165. Stockholm: Swedish National Board of Housing, Building and Planning (Boverket).
[32] Factsheet BPIE. Sweden Current use of EPCs and potential links to iBRoad (individual Building Roadmap). Buildings Performance Institute Europe; 2018.
[33] Danish Ministry of Transport, Building and Housing (BR18) Danish building regulations 2018. Available from: http://bygningsreglementet.dk/~/media/Br/BREnglish/BR18_Executive_order_on_building_regulations_2018.pdf. [Accessed 12 May 2019].
[34] Christensen TH, Gram-Hanssen K, de Best-Waldhober M, Adjei A. Energy retrofits of Danish homes: is the Energy Performance Certificate useful? Build Res Inf 2014;42:489–500.
[35] Hårsman B, Daghbashyan Z, Chaudhary P. On the quality and impact of residential energy performance certificates. Working paper series 429. KTH Sweden: Centre of Excellence for Science and Innovation Studies (CESIS); 2016.
[36] Allard I, Olofsson T, Nair G. Energy performance indicators in the Swedish building procurement process. Energy performance indicators in the Swedish building procurement process. Sustainability 2017;2017(9):1877.
[37] DKCESB. Energy Requirements of BR18: a quick guide for the construction industry on the Danish Building Regulations 2018. Danish Knowledge Centre for Energy Savings in Buildings; 2018.
[38] Swedih Tax Agency. Taxes in Sweden 2015. an English Summary of Tax Statistical Yearbook of Sweden; 2015.
[39] Bundgaard SS, Dyhr-Mikkelsen K, Larsen AE, Togeby M. Energy efficiency obligation schemes in the EU -lessons learned from Denmark. Int Assoc Energy Econ 2013:43–7. 3rd Quarter.
[40] Bertoldi P, Labanca N, Rezessy S, Steuwer S, Oikonomou V. Where to place the saving obligation: energy end-users or suppliers? Energy Pol 2013;63:328–37.
[41] Union European. Strategy for the energy renovation of buildings - European commission; annex B. Presentation to the commission of a long-term strategy for mobilizing investment in the renovation of residential and commercial buildings pursuant to Article 4 of the energy efficiency directive. 2017.
[42] Ecofys. Energy efficiency obligation scheme in Denmark. Factsheet developed for federal Ministry for the environment. Nature conservation and nuclear safety (BMU) and European climate initiative. EUKI; 2018.
[43] Swedish Energy Agency. Konsekvenser av kvotplikt för energieffektivisering. Kan ett svenskt kvotpliktssystem ge mindre energianvändning? Statens energimyndighet. Environ Rev 2012:2012. 07.
[44] Swedish Government Office. Framework agreement between the Swedish social democratic party, the moderate party, the Swedish green party, the centre party and the christian democrat. Swedish Government Homepage; 2018. . [Accessed 12 December 2018].
[45] Mata E, Kalagasidis AS, Johnsson F. Contributions of building retrofitting in five member states to EU targets for energy savings. Renew Sustain Energy Rev 2018;2018(93):759–74.

[46] Mainali B, Pardalis G, Mahapatra K. Criteria based approach for assessment of policy instruments for deep renovation of residential building in The Netherlands. ECEEE; 2019. p. 599–606.
[47] Cities Energy. Financing the energy renovation of residential buildings through soft loans and third-party investment schemes. Infinite Sol Guidebook; Energy Cities 2017:1–84.
[48] Union European. Financing building energy renovations: current experiences & ways forward. Science and policy report by the joint research centre. the European Commission; 2014.
[49] Financing Euroactv. Energy efficiency. Special report 8-12. 2017.
[50] Hansen MB, Danielsson CU. Multiple benefits of investing in energy efficient renovation of buildings: impact on Public Finances. Copenhagen Economics; 2012.
[51] Kerr N, Winske M. Household investment in home energy retrofit: a review of the evidence on effective public policy design for privately owned homes. Renew Sustain Energy Rev 2020;2020(123):109778.
[52] Karvonen A. Towards systemic domestic, retrofit: a social practices approach. Build Res Inf 2013;41(5):563–74.
[53] Bartiaux F, Gram-Hanssen K, Fonseca P, Ozoliņa L, Christensen TH. A practice–theory approach to homeowners' energy retrofits in four European areas. Build Res Inf 2014;42(No. 4):525–38.
[54] Nair G, Mahapatra K, Gustavsson L. Implementation of energy efficient windows in Swedish detached houses. Appl Energy 2012;89(1):329–38.
[55] Karlsson A, Lindqvist C, Wojtczak E, Stachurska-Kadziak K., Holm D, Sornes K, Schneuwly P, Tellado N, Rodriguez F. Common Barriers and Challenges in Current nZEB Practice in Europe; D1.1 Report; "Nearly Zero Energy Neighborhoods" project. http://zenn-fp7.eu.
[56] SBi Danish Building Research Institute, Jensen OM. Barrierer for realisering af energibesparelser i bygninger. 2004. p. 2004.
[57] Bjørneboe MG. Method for planning extensive energy renovation of detached single-family houses. Doctoral thesis. Technical University of Denmark, Department of Civil Engineering, Section of Building Energy; 2017.
[58] Gram-Hanssen K. Existing buildings – users, renovations and energy policy. Renew Energy 2014;61:136–40.
[59] Næss-Schmidt S, Jensen JB, Lumby BM. Kick-starting green mortgage finance-A pragmatic country-by-country approach. 2018. Copenhagen Economics.
[60] Rolison JJ, Hanoch Y, Wood S, Liu PJ. Risk-taking differences across the adult life span: a question of age and domain. J Gerontol B Psychol Sci Soc Sci 2013;69:870–80.
[61] Häkkinen T, Belloni K. Barriers and drivers for sustainable building. Build Res Inf 2011;39(3):239–55.
[62] Palm J, Reindl K. Understanding barriers to energy-efficiency renovations of multifamily dwellings. Energy Eff 2018;11(1):53–65.
[63] Persson J, Gronkvist S. Drivers for and barriers to low-energy buildings in Sweden. J Clean Prod 2015;109:296–304.
[64] European Commission. European construction sector observatory: policy measure fact sheet – Denmark. Better homes. BedreBolig) Scheme; 2018.
[65] European Commission. European construction sector observatory: country profile Sweden. 2018.
[66] Pardalis G, Mahapatra K, Mainali B. Swedish construction MSEs: simply renovators or renovation service innovators? Build Res Inf 2020;48:63–83.
[67] Pardalis G, Mainali B, Mahapatra K. One-stop-shop as an innovation, and construction SMEs: a Swedish perspective. Energy Procedia 2019;158:2737–43.
[68] Sandberg K, Orskaug T, Andersson A. Prefabricated wood elements for sustainable renovation of residential building façades. Energy Procedia 2016;96:756–67.
[69] Eloy S, Plácido I, Duarte J. Integration of information, communication and automation technologies in housing rehabilitation. IAHS World Congress on Housing; 2010.
[70] Valentin EK. Away with SWOT analysis: use defensive/offensive evaluation instead. J Appl Bus Res 2005;21(No 2):91–104.
[71] Muresan AA, Attia S. Energy efficiency in the Romanian residential building stock: a literature review. Renew Sustain Energy Rev 2017;74:349–63.
[72] Liu G, Zheng S, Xu P, Zhuang T. An ANP-SWOT approach for ESCOs industry strategies in Chinese building sectors. Renew Sustain Energy Rev 2018;93:90–9.
[73] Mlecnik E, Straub A, Haavik T. Collaborative business model development for home energy renovations. Energy Eff 2018;12(1):123–38.
[74] Chou JS, Kim C, Ung TK, Yutami IGAN, Lin GT, Son H. Cross-country review of smart grid adoption in residential buildings. Renew Sustain Energy Rev 2015;48:192–213.
[75] Trza A, Rucinska J. Energy labeling of windows – possibilities and limitations. Sol Energy 2015;120:158–74.
[76] Jiang R, Mao C, Hou L, Wu C, Tan J. A SWOT analysis for promoting off-site construction under the backdrop of China's new urbanization. J Clean Prod 2018;2018(173):225–34.
[77] Markovska N, Taseska V, Pop-Jordanov J. SWOT analyses of the national energy sector for sustainable energy development. Energy 2009;34:752–6.
[78] Tessema Z, Mainali B, Silveira S. Mainstreaming and sector-wide approaches to sustainable energy access in Ethiopia. Energy Strat Rev 2014;2:313–22.
[79] Bergen M, Peteraf MA. Competitor identification and competitor analysis: a broad-based managerial approach. Manag Decis Econ 2002;23:157–69.
[80] Chen MJ. Competitor analysis and interfirm rivalry: toward a theoretical integration. Acad Manag Rev 1996;21:100–34.
[81] Cooper LG, Inoue A. Building market structures from consumer preferences. J Market Res 1996;33:293–306.
[82] Peng Y-S, Liang I-C. A dynamic framework for competitor identification: a neglecting role of dominant design. J Bus Res 2016;69:1898–903.
[83] Hana U. Competitive advantage achievement through innovation and knowledge. J Competit 2013;5(1):82–96.
[84] Gurel E, Tat M. SWOT analysis: theoretical reviews. J Int Soc Res 2017;10(51):994–1006.
[85] Risholt B, Berker T. Success for energy efficient renovation of dwellings—learning from private homeowners. Energy Pol 2013;61:1022–30.
[86] Implementing EuroPHit. Deep energy step-by-step retrofits. Increasing the European potential. Germany: Passive House Institute; 64283 Darmstadt; 2016.
[87] Bravo G, Pardalis G, Mahapatra K, Mainali B. Physical vs. aesthetic renovations: learning from Swedish house owners. Buildings 2019;9(1).
[88] International Energy Agency. Prefabricated systems for low energy renovation of residential buildings. Retrofit strategies design guide, advanced retrofit strategies & 10 steps to a prefab module, energy conservation in buildings and community systems. International Energy Agency; 2011.
[89] Minunno R, O'Grady T, Morrison GM, Gruner RL, Colling M. Strategies for applying the circular economy to prefabricated buildings. Buildings 2018;2018(8):125.
[90] Kameni M, Antoinette N, Nishimwe MR, Reiter S. Towards nearly zero-energy residential neighbourhoods in the European Union: a case study. Renew Sustain Energy Rev 2021;135:110198 [Österbring M].
[91] Camarasa C, Nägeli C, Thuvander L, Wallbaum H. Prioritizing deep renovation for housing portfolios. Energy Build 2019;202:109361.