

THE EXTENT OF BARRIERS AND DRIVERS TO ENERGY EFFICIENT RETROFITS IN RESIDENTIAL SECTOR: A BIBLIOMETRIC ANALYSIS

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Current research

- Factors impacting energy-efficient retrofits in the residential sector: The effectiveness of the Slovenian subsidy program (Dolšak, Hrovatin, and Zorić, 2020; *Energy and Buildings*)
- Estimating the Efficiency in Overall Energy Consumption: Evidence from Slovenian Household-level Data (Dolšak, Hrovatin, and Zorić, 2022; *Energy Economics*)
- Analysing behaviour of consumers in energy markets with emphasis on energy efficiency (Dolšak, 2020; doctoral dissertation)
- The extent of barriers and drivers to energy efficient retrofits in residential sector: a bibliometric analysis (Dolšak)



Motivation (1)

- The residential sector in industrialized countries is responsible for almost 25% of final energy consumption
- The building stock is relatively old as about 35% of buildings is more than 50 years old
- The progress of energy efficiency is slow as only 0.4-1.2% of buildings are retrofitted each year
- **Housing renovation** is **one of the key factors of improving energy efficiency (EE)** and in recent years has been gaining ever more importance in the EU (EED and EPBD):
 - It stipulates that each member state should decrease its final energy consumption in the period 2024-2030 by 1.5% each year (currently 0.8% each year)
 - Member states should renovate at least 3% of public sector and decrease its energy use by 1.7% every year.



Motivation (2)

- Huge **energy saving opportunities** lie in retrofitted roof and wall insulation of buildings as well as improved appliances and other energy-using equipment
- Despite the availability and economic viability of energy efficiency measures, the realization is far below the required rate to meet the EU energy savings targets
- The discrepancy between the potential for cost-effective measures and their realization has been labelled as “**energy efficiency gap**”, which is mainly caused by market imperfections that hinders the diffusion of these measures (Jaffe and Stavins, 1994; Reddy, 2007)
- There are wide range of potential benefits beside energy savings such as the increase in asset value and in disposable income, energy poverty alleviation, decrease in unemployment rate and many others

Motivation (3)

- Implementation of EE investments in residential sector is hindered by various barriers
- Several energy-efficiency instruments have been introduced by the EU member states to tackle these issues
- In order to design effective policy measures to enhance future energy saving measures in residential sector, policy-makers must be informed about ...
- Therefore, the **objective** of this study is to **identify which determinants have the most important influence on decisions for energy-saving renovations** and what are the relations between studies identifying these determinants



Literature review (1)

- There are several different categorizations of barriers and drivers to energy efficient building retrofits and related measures in the literature on barriers and drivers
- Some studies categorise them according to their **role** in the decision-making process, e.g. (Broers et al., 2019), others according to their **type** e.g. (Hrovatin & Zorić, 2018; Bravo et al., 2019; Bjørneboe et al., 2018)
- According to the first approach, six stages in the decision-making process can be identified: Raising interest, gaining knowledge, forming an option, making a decision, implementing the measure, and experiencing the measure (Broers et al., 2019)

Literature review (2)

- On the other hand, barriers and drivers can be categorised according to their type:
 - Bravo et al. (2019) focused on identifying socioeconomic attributes and attitudes and categorised barriers and drivers into three categories: financial, attitudinal, and social
 - Bjørneboe et al. (2018) also classified them into three categories, namely informational, financial, and process barriers and drivers
- Hrovatin and Zorić (2018) provide an extended version of the categorization with five categories:
 - Information and Policies,
 - Economic factors,
 - Household Socioeconomic Characteristics,
 - Technical factors - Building Characteristics, and
 - Behavioural Drivers

Information and policy measures

Information and policy measures	Positive effect	Neutral effect	Negative effect
Regulations	(1): Green deal (GD)	(4): Insufficient or lax regulation; the lack of supervision and enforcement, GD, EPC	(0)
Fiscal support	(13): Rebates, tax credits, loans with low-interest rates, subsidies	(8): Not aware of grant scheme	(6): Free-riding effect
Energy audits	(25): A tailored face-to-face audit, tailored to homeowner preferences, qualified auditor	(10): Inability to afford it, lack of information about the existence and the type, too general advice	(4): Lack of information and expert advice
Information	(5): Information (availability), personal background – interest in technology	(2): Owners did not criticize a lack of information	(13): Lack of adequate knowledge or information, low or misperceived salience
Social network	(31): Friends, family, neighbours; interpersonal communication, social norms, social media, grass-root community	(2): Social networks (lack of research)	(6): Conflict with local or national building protection agencies or with neighbours
Informing homeowners	(8): Trust and reliability of the company	(0)	(10): Unreliable, non-transparent, lack of knowledge

Economic factors

Economic factors	Positive effect	Neutral effect	Negative effect
Retrofit costs	(0)	(3): Cost estimations	(22): inability to afford, lack of financial means
Savings in energy expenses	(19): Expected energy savings, energy consumption/energy cost perception	(6): Expectations of impacts (positive or negative); households consuming high levels of energy	(7): Uncertainty about benefits, underestimation of energy savings
Economic viability	(6): Profitability	(3): Investment size vs energy savings	(2): Investment size vs energy savings
Energy prices	(5): Energy price expectations, rising energy prices	(2): Energy price expectations, uncertainty about energy prices or the future supply	(4): Not sufficient stimulus
Time horizon	(4): Expecting a payoff within a reasonable time frame	(0)	(6): Too long payback period
Other economic factors	(5): Retained market value of the house, Guarantee period (long), a positive attitude towards taking a loan	(1): Lack of effect on property prices	(2): Economic concerns (unemployment, economic crisis), presence of loan for the house purchase

Socio-economic characteristics

Socio-economic characteristics	Positive effect	Neutral effect	Negative effect
Income	(11)	(5)	(1)
Age of the homeowner (older)	(0)	(1)	(12)
Education	(7)	(3)	(1)
Other socio-economic factors	(3) : Presence of children; Employment type (status)	(6) : Number of family members; Presence of children; Gender; Occupation (longer)	(9) : Number of family members; Occupation (longer); Not owning a dwelling; Split incentives; Uncertainty about how long one will stay living in the house

Technical – building characteristics

Technical – building characteristics	Positive effect	Neutral effect	Negative effect
Age of the building (older)	(12): Necessity	(2)	(1)
Location of the building	(2): Region; colder areas	(2): Urban, rural	(1): Large city areas
Technical parameters	(9): Floor area (larger); enhancing aesthetics; as a part of integrated process; planning to change the layout of the house anyway; changing needs of families; salient events	(1): Floor area (larger)	(5): Building is still in good condition; floor area (larger)
Better expected living conditions	(9)	(0)	(0)
Expected thermal comfort improvement	(13)	(0)	(0)

Behavioural factors

Behavioural factors	Positive effect	Neutral effect	Negative effect
Awareness	(20): A good understanding of the effect of energy use on the environment; awareness, motivations, goals, strategies	(3)	(3): Lack of engagement in energy-efficiency; energy efficiency not being a priority; awareness, attitude, strategy.
Lifestyle	(11): As part of DIY project, or as part of a lifestyle	(0)	(13): Disruption to everyday life, stress, and inconvenience; inertia, renovation is complex and irreversible; heritage values
Other behavioural factors	(2): Renovation skills	(0)	(6): Timing (feeling that right time had not come yet); opportunity costs (crowding out of more vital investments decision); transaction costs (of information seeking); time to make decision (not having time to deal with this decision)

Bibliometrics (1)

- In last decades the amount of available **data** grew rapidly offering researchers the opportunity to resort themselves to deductive reasoning
- Despite the large volume of work describing and categorising the determinants of residential energy efficiency, there is a lack of comprehensive **quantitative** analysis of this literature
- Therefore, in addition to a literature review that led to a description and categorization of the determinants of energy efficiency in residential buildings, a **bibliometric analysis** of the determinants of energy efficient behaviour was carried out, which allows to better understand the evolution of knowledge in this area

Bibliometrics (2)

- Bibliometric analysis consists of four main bibliographic methods, namely:
 - citation analysis,
 - co-citation analysis,
 - co-authorship analysis, and
 - co-word analysis.
- By analysing the content of the abstracts of the selected literature, I generated a visualised knowledge of the barriers and drivers of energy efficiency in residential sector
- This type of analysis also allows for the creation of a network of determinants that provides information on the co-occurrence of determinants in the literature

Bibliometrics – search query

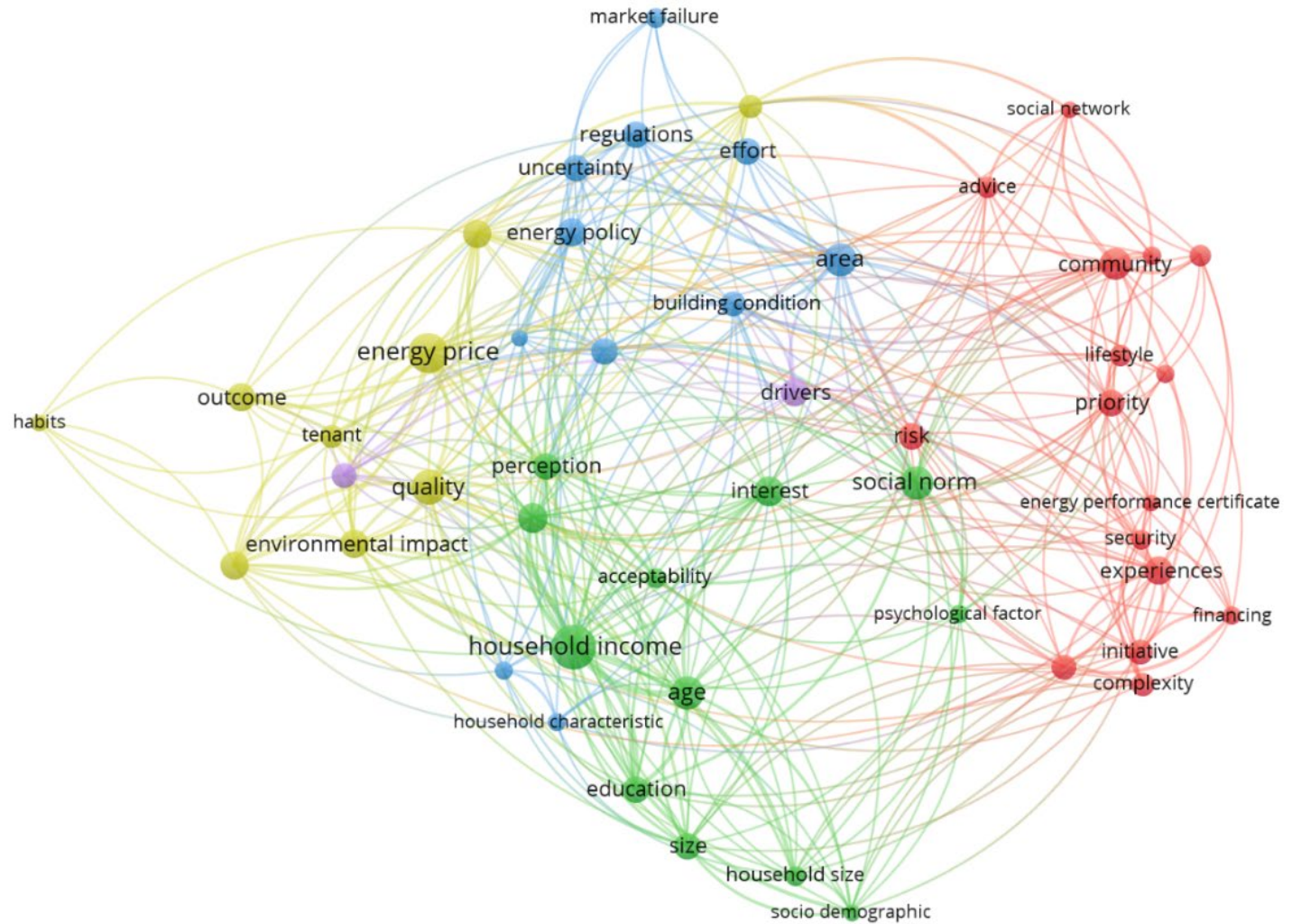
Parameters	Selection
Author keywords 1	residential* OR dwelling* OR building* OR home* OR hous* OR household* OR domestic* OR occupant* OR owner* OR owner-occupied
Author keywords 2	renovation* OR retrofit* OR uptake* OR refurbish* OR maintenance* OR intervention* OR invest* OR adoption* OR improve* OR measure* OR install* OR repair* OR upgrade* OR modernis*
Abstract 1	energy efficient* OR energy efficiency OR energy-efficient* OR energy-efficiency OR energy saving OR energy conservation OR reduce energy consumption OR lower energy consumption OR saving energy
Abstract 2	determinant* OR factor* OR barrier* OR obstacle* OR driver* OR facilitat* OR decision* OR behaviour* OR behavior* OR stimul* OR motiv* OR preference* OR promote* OR enhance* OR psychol* OR socio*
Document type	Articles, Proceeding Papers, Review Articles, Book Chapters
Citation Index	SSCI, SCI-EXPANDED, ESCI, AHCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH
Language	English

Bibliometrics – results (1)

- The results show that different clusters of determinants of energy efficient and energy saving behaviour have been identified in the literature
- While firm characteristics are mainly associated with barriers to energy savings, behavioural aspects such as pro-environmental attitudes co-occur with other drivers
- In addition to the thorough examination of selected papers, the bibliometric analysis provides interesting aspects of the evolution of these determinants
- The term map with determinants that occurred 10 times or more in papers' abstracts, presumably believed to be an indicator of the determinant relevance



Bibliometrics – results (2)



Conclusions

- First, I am able to identify key research streams based on the historical development of published work in this area
- Second, analysis of co-citations provides me with the network of influences between authors
- Finally, an analysis of the content of the papers' abstracts allows me to visualise the current state of knowledge on the determinants of energy efficient and energy saving behaviour in the literature
- Since this type of analysis is usually equipped with a large collection of data and analytical approaches, it can support the development of effective strategies for retrofitting residential buildings in the future

Thank you for your time!

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