ADOPTION OF ENERGY EFFICIENCY MEASURES AND RENEWABLE ENERGY BY HOMEOWNERS ACROSS THREE MAJOR DUTCH CITIES

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Overview

Household investment decisions regarding energy efficiency measures (EEM) and renewable energy (RE) adoption have an untapped potential for reducing energy consumption and carbon emissions. There can be significant regional differences in the uptake of EEM and RE, which suggests that understanding the local context is essential in studying energy renovation diffusion. Cities are responsible for a large share of emissions from the operation of residential buildings and have many contextual factors in common such as high density. With this study, we contribute to the literature by conducting a comparative analysis across three major Dutch cities: Amsterdam, Rotterdam, and Groningen. This can be insightful for local policies on accelerating the uptake of EEM and RE. For the empirical analysis, logistic regression models are estimated using data from the Dutch Housing Survey, with explanatory variables grouped into socio-demographic, dwelling-related and socio-psychological factors. The results indicate that dwelling characteristics have a larger impact on heating system replacement, while the socio-psychological factors are more significant for PV adoption and insulation. The analysis also shows that socio-demographic factors are rarely associated with energy-related investment decisions.

Methods

To investigate what characteristics of households are associated with their energy-related investment decisions, we use the latest release of the Dutch Housing Survey – WoonOnderzoek Nederland (WoON) 2018[1] [4]. The survey provides data on households' characteristics including current and desired living situation, housing costs and incomes, and energy-related information [4]. We examine the characteristics of 6417 owner-occupied households (i.e., a sample after cleaning the data for missing information) in Amsterdam, Rotterdam, and Groningen with the focus on their socio-demographic, dwellings', and socio-psychological characteristics related to energy. The logistic regression models are run to estimate the factors that are in association with the decision of homeowners to adopt each type of EEM and RE implemented in the last 5 years (sometime between 2012 and 2018): (1) *insulation*, i.e., improving the insulation of roof, wall, floor or walls; (2) *PV adoption*, i.e., installing or replacing solar panels; (3) *heating system replacement*, i.e., renewing the central heating boiler or other installations. The probability of having implemented a respective measure is calculated from the formula:

$$p = \frac{1}{1 + e^{-(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k)}}$$

where, p denotes the odds of the measure uptake (in the past 5 years), and x corresponds to the explanatory variables. The performance of models, or their fit, were evaluated by conducting the Chi-squared test. Test for coefficients shows that the Chi-squared test is statistically significant across all conducted models. This indicates that the full model is significant and fit.

Results and Conclusions

The findings suggest that consistent with the existing literature [4,10], dwelling features (e.g., building construction year and dwelling type) are essential for the heating system replacement and insulation measures, while the socio-psychological factors (e.g., willingness to implement more EEM and perception of energy efficiency of house) are more central for PV adoption and insulation. In contrast, socio-demographic factors have weaker association with energy-related investment decisions in general, which is in line with the findings of Kastner & Stern [16]. Most of the socio-demographic factors found significant are distinct for each energy-related decision and each city, except the length of occupancy being essential for heating system replacement across all three cities. The outcomes of the logit model estimations are summarized in Table 1.

[1] Data collected between mid-August 2017 and the end of April 2018.

Table 1. Summary of the logit models' outcomes[2]

	In all three cities	**Amsterdam**	**Rotterdam**	**Groningen**
Insulation	*dwelling features:* building construction year, dwelling type; *socio-psychological factors*: willingness to implement more EEM, perception of energy efficiency of house	*socio-psychological factors*: satisfaction with home, contact with neighbors, perception of energy efficiency *socio-demographic factors:* length of occupancy, household size	*socio-psychological factors*: perception of energy efficiency	-
PV adoption	*dwelling features:* dwelling type; *socio-psychological factors*: willingness to implement more EEM, perception of energy efficiency of house	*dwelling features:* living area size *socio-demographic factors:* education, age *socio-psychological factors*: contact with neighbors	*socio-demographic factors:* income, education, age	*socio-psychological factors*: satisfaction with home
Heating system renewal	*dwelling features:* building construction year, dwelling type; *socio-demographic factors:* length of occupancy	*dwelling features:* living area size *socio-psychological factors*: perception of energy efficiency, awareness about consequences for climate	*socio-demographic factors:* income, household size, age	*socio-demographic factors:* household size

Along with shared influential factors on the decisions regarding EEM and RE, we have also found significant differences across the cities. In Amsterdam, insulation decisions are also correlated to contact with neighbors and satisfaction. In particular, homeowners with more connections in the neighborhood tend to insulate more. This provides an indication that owner-occupiers lacking contact with neighbors are missing out from the exchange of information presumably based on their neighbors' insulation experience. Connectedness to neighbors is an important factor for PV adoption too. This is in line with the evidence from the literature [20,39,40] that demonstrates the positive impact of the peers in close geographical proximity on increasing likelihood of PV adoption. Improving the social connectedness of the neighborhoods in Amsterdam might be a beneficial strategy for increasing the uptake of EEM and RE in Amsterdam. In Rotterdam, income is a significant contributor in decisions of homeowners in Rotterdam regarding PV purchase and heating system renewal decisions. The data across European countries reveal that higher-income households are more likely to invest in energy-efficient improvements, not only because they can afford it, but because in this way they can maintain or improve their quality of life [41]. This observation suggests that subsidies would be more effective in Rotterdam than in Amsterdam and Groningen, and would, thus, contribute to reducing the barriers for implementing one of the measures. In Groningen, length of occupancy is correlated with PV adoption decisions, indicating that those homeowners who live longer in their dwelling are more likely to invest. As the majority of Groningen homeowners in the dataset live in detached and semi-detached houses, it might be that such homeowners are less likely to move and usually occupy their house for a long period, are more likely to invest in PVs.

References

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[2] The summary provides which factors are common across all three cities, and which ones are found to be unique in influencing the decision-making process for these three types of energy-related investments.