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Determinants of residential photovoltaic adoption intention – A meta-analysis

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1. Introduction

For reaching global goals to reduce carbon emissions to a net zero by 2050, the decarbonisation of the residential sector is of central importance [1–3]. As this process largely depends on individual decision-making to adopt low-carbon energy sources, and residential photovoltaic (PV) systems are a central component of this transition [4], the antecedents of residential adoption of PV systems have been researched widely to help accelerate diffusion [5]. The roles of socio-demographic and general personal motivations, such as environmental concern and innovativeness, have been investigated frequently, and theories capturing beliefs about PV, or the innovative and pro-environmental aspects of the product are used as theoretical backgrounds to understand adoption decisions. However, due to the different theoretical perspectives and explanatory variables, questions remain regarding the role of predictors for PV adoption [5]. Aggregating empirical evidence is further hampered by inconsistencies among studies concerning the use and operationalization of predictors, different sampling procedures and contexts.

To advance research from the existing literature body, a statistical meta-analysis is performed that aims to reveal patterns of relationships among explanatory variables and residential PV adoption. Theory development is advanced by determining point estimates of relationships between adoption intention and socio-demographic variables, the typical Theory of Planned Behavior (TPB) constructs, and additional variables related to environmental attitudes and innovativeness. Furthermore, following the meta-analytical structural equation modelling (MASEM) approach as outlined by [6] and applied by [7,8], the suitability of an (extended) TPB model to replicate the extracted data is assessed. In addition, implications for future studies to enhance future aggregation of scientific evidence are derived.

2. Methodology

To include only commensurable literature, peer-reviewed scientific articles written in English that had conducted a quantitative survey on residential PV adoption intention and reported bivariate correlations were selected. A literature search with a fixed set of keywords was conducted in August 2020 using Web of Science, Scopus and PsychINFO. The search yielded 946 results, of which 653 remained after doublets removal. The screening procedure was conducted by two independent screeners and encompassed title screening (205 remain), abstract screening (110 remain), and full-text screening. From the 24 identified papers, only five report correlation tables [9–13]. The remainder was contacted via e-mail, and three more correlation matrices were gathered [14–16].

Conceptually similar constructs among and within primary studies were grouped by two independent researchers to ensure reliability. In case of conceptually similar constructs within one study, the composite was computed. To compute the meta-analytically pooled correlation table, the meta-package in Stata was used, and a random-effect model with inverse-variance weighting using the REML (restricted maximum likelihood) method was applied [17]. Using the correlation table as input, four structural equation models were computed, using a maximum likelihood estimator.

3. Results

The meta-analytically pooled correlation table reveals medium to high significant correlations between environmental concern (p = .343**[i]), novelty seeking (p = .475**), perceived benefits (p = .530**), subjective norm (p = .326**) and intention to adopt a residential PV system respectively, whereas socio-demographic variables and barriers were uncorrelated with intention. Particularly large correlations were furthermore found between environmental concern (p = .693**), novelty seeking (p = .636**), social norm (p = .491**) and benefits respctively, and novelty seeking and social norm (p = .504**).

The four subsequently computed structural equation models were statistically significant and could explain around 30% of the variance in intention, with benefits being the strongest predictor of intention. Benefits in turn can be explained by the decision-makers environmental concern, novelty seeking and perceived subjective norm, leading to a coefficient of determination around 70%.

4. Discussions and Conclusions

In this study, we attempted to make sense of the vast amount of data that already is available on residential adoption of PV. However, the empirical evidence is in large parts far from being similar enough to meaningfully combine results, and lack of reporting standards further

[i] Significance levels: * $p<.1$; ** $p<.05$

aggravate the problem. Therefore, only 8 studies could be included in the final meta-analysis, which limits its informative value. Only small portions of the heterogeneity among effect-size estimates in single studies could be explained by sampling error, typically around 8%. The results of the MASEM analysis support the findings of [5,18] that socio-demographic variables are no good predictors of adoption decisions. The most important predictor for adoption intention is the decision units perception of personal and environmental benefits of PV systems. Results are furthermore in line with the idea that general dispositions, such as environmental concern and novelty seeking, determine how a product is perceived in the first place, rather than determining adoption intention directly [11,19]. Consequently, we propose to use a slightly modified version of the TPB in future studies, in which attitudes are explained by environmental concern, novelty seeking, and social norms. To enhance future aggregation of scientific evidence, we furthermore recommend the use of consistent predictors and measures for adoption, the systematic collection of contextual variables, and compliance with reporting standards.

Overall, our results imply that policy measures should focus on enhancing the perception of benefits instead of the reduction of perceived barriers. Measures aimed at increasing the financial benefits of PV installations could include options to reduce initial costs. Promotion strategies for the measures can focus on environmental benefits or the innovativeness of PV systems, with the latter playing a particularly large role in regions with low diffusion stages. As the perception and importance of personal and environmental benefits depend on the characteristics of the decision-maker, promotion strategies could additionally be tailored to consumer segments representing groups of like-minded people rather than socio-demographic groups, to account for the interchangeable or complementary effects of psychographic determinants.

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