Influence of innovation attributes with preventive nature of innovation on intent to adopt: the case of photovoltaic systems in mass markets

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***Abstract*— Diffusion studies have focused on multiple areas of innovation and innovations have been given various classifications. However, a type of innovation that is not widely covered in diffusion studies yet and which is relevant for multiple contemporary applications is preventive innovation. Preventive innovations are those that individuals adopt to reduce the probability of an unwanted event in the future or to mitigate the severity of the consequences of an unwanted event. In this study, we explored if the preventive nature of innovations influenced the intent to adopt the innovation with a survey study. In our study, photovoltaic (PV) systems were identified as preventive innovations as they serve various underlying goals of prevention. The dependent variable, intent to adopt was identified as the "period when the respondent is planning to purchase a photovoltaic system" and independent variables were either demographic, household-related, or based on diffusion of innovations theory. We ran a statistical analysis with our survey responses, and it yielded three linear regression models out of which one (Model 2) was selected as the best fit. The selected model identifies four significant variables associated with the intended period of PV system adoption: one related to relative advantage, one related to social compatibility, and two related to technical compatibility. Our results do not confirm that the preventive nature of innovations would be important to mainstream customers and hence, we derive that prevention-specific attributes merit further investigation with other adoption groups as well.**

***Keywords*— preventive innovation, photovoltaic systems, diffusion of innovations**

I. Introduction

An innovation is an idea, practice, or object that is perceived as new by a unit of adoption, be it an individual, a group of individuals, or an organization [1]. The newness of the idea depends on the potential adopters' perceptions, therefore, whether the idea is objectively 'new', or not, does not matter. Furthermore, newness does not only denote knowledge about the innovation but can also be identified in terms of the decision to adopt it [1].

The diffusion of an innovation refers to the process by which an innovation is communicated to a social system, over time, through certain channels [1]. Thousands of diffusion studies have focused on myriad areas of innovation including technology, agricultural practices, policies, and educational and health promotion programs [2]. Furthermore, innovations have been given various classifications depending on the type of innovation (product vs process) or newness of the technology (radical vs incremental) [1].

However, there is another type of innovation that is not widely covered in diffusion studies yet is relevant for multiple contemporary problems: preventive innovation. Preventive innovations are those that individuals adopt to reduce the probability of an unwanted event in the future [1] or to mitigate the severity of the consequences of the unwanted event.

Nowadays, prevention seems timelier than ever. Preventive behavior is needed in various aspects of our lives such as health decisions, sustainability choices, and business decisions. Preventive behavior is difficult to foster because it requires individuals to be future-oriented and motivated toward an underlying goal in prevention [3].

While preventive behavior has been studied widely, the focus of research has mostly been on public health, and only a few studies (e.g. [4]–[6]) in the innovation diffusion tradition have studied the preventive innovation. Hence, this paper highlights the need to conceptualize preventiveness as a part of the construction of innovation conceptualization. We report results from a survey research that analyzes a series of concepts that make up the construct of preventive innovation. This contribution is expected to build grounds for further studies that can facilitate the understanding of the concept.

The purpose of this study is to explore if the preventive nature of innovations, present in attributes of innovations, has a positive or negative influence over the intent to adopt. There are two objectives in this study. First, this study highlights the attributes of innovations that can be classified as preventive as discussed in diffusion studies. Second, this study seeks to identify the influence of preventive attributes on the intent to adopt photovoltaic systems (identified as preventive innovations) by mass markets.

The remainder of this paper is organized as follows. The next section sets a theoretical ground for this study and highlights the main attributes of preventive innovations as identified in diffusion studies theory. We then discuss the methodology for data gathering and analysis utilized in the study and report the results of our analysis by identifying predictors in the intent to adopt PV systems. Next, we discuss the limitations of our study and finalize this paper by identifying future research opportunities and implications for literature and practice.

II. Theoretical Background

A. Definitions and Interpretations

According to Rogers, "A preventive innovation is a new idea that an individual adopts now to lower the probability of some unwanted future event"[1]. The concept was first introduced by Rogers in 1983 in the 3rd edition of *Diffusion of Innovations* and further elaborated in the 4th edition in 1995. In this paper, we argue that preventive innovations are those that individuals adopt to reduce the probability of an unwanted event in the future [1] or to mitigate the severity of the consequences of the unwanted event as some unwanted events are unavoidable, for example, natural disasters.

Two important elements that should be highlighted yet aren't commonly discussed in diffusion studies are the probability and severity of the unwanted event. Probability refers to the extent to which an unwanted event is likely to occur; in nontechnical contexts, the probability of an unwanted event that may or may not occur is referred to as 'risk' [8]. In insurance economics, the probability is associated with a loss of a certain size [9], which we identify to as severity, referring to how harmful the event and its consequences might be. The measures of probability and severity are frequently utilized when modeling expected loss [10].

Probability and severity can be affected by potential adopters' subjective perceptions. While there might be standard scales to determine the severity of certain unwanted events, such as scales to determine the magnitude of natural disasters, individuals might still have different perceptions of how severe an event can be. Furthermore, an unwanted event may have an impact on various domains, for which it is difficult to objectively assess severity. Furthermore, the probability of an unwanted event can be estimated at times; individuals know whether they are cautious or careless drivers, or whether they lead healthy lifestyles or not [9] and thus can be expecting or denying the possibility of an unwanted event. Alongside, probability and severity influence potential adopters' attitudes toward prevention.

B. The Innovation

Preventive innovations are those that individuals adopt to reduce the probability of an unwanted event in the future [1, p. 234] or to mitigate the severity of the consequences of the unwanted event. According to diffusion studies, innovations can be identified as 'preventive' by focusing on two of the four elements in the diffusion of innovations: the innovation and time. Particularly, the preventive nature of the innovation is evident when analyzing five attributes of the innovation: relative advantage, compatibility, complexity, trialability, and observability.

1) Relative advantage

Relative advantage is the degree to which an innovation is considered better than the previous idea [1, p. 15] and it is considered the strongest predictor of the adoption of innovations [1, p. 232]. Existing literature identifies that preventive innovations have low relative advantage as benefits are delayed in time and difficult to observe [6]. This idea can be further explored by incorporating subdimensions of relative advantage [1, p. 232] such as economic profitability, social prestige, decrease in discomfort, and time and effort savings.

The degree of relative advantage is commonly expressed as economic profitability; economic motivators are assumed as the main triggers for an individual's adoption of an innovation [11, p. 115]. For preventive innovations, economic profitability is challenged when compared to non-prevention, for example, paying for a health screening versus getting no screening.

Social prestige from adopting an innovation is another important factor [11, p. 115]; for certain innovations, such as fashionable clothing, social prestige may be the sole benefit received. However, preventive innovations might hinder social prestige, as is the case for wearing protective equipment in extreme sports where, despite the obvious advantages, the use of safety equipment is poor as it is still regarded as unfashionable and portrays inexperience [12, p. 174].

A decrease in discomfort may also be an important motivator to adopt an innovation, particularly for potential adopters that are less profit-oriented [11, p. 233]. Many preventive actions are commonly associated with discomfort when compared to non-adoption. Preventive efforts are known to have a direct impact on the adopter's daily life such as controlling sugar and fat consumption to prevent health issues, a behavior associated with negative emotions [3].

Finally, an innovation that can provide time and effort saving yields a greater relative advantage. Time and effort savings might not be achievable for preventive innovations when compared to non-adoption and evaluating present-time savings. Preventive innovations such as prophylaxis require continuous effort to prevent future negative consequences [4].

2) Compatibility

Compatibility is the degree to which an innovation is perceived as being consistent with existing values, past experiences, and needs of potential adopters [1, p. 15]. Preventive innovations are often not very compatible with individuals' values, attitudes, or lifestyles [13]. Low compatibility can be identified in the slow adoption rate of various preventive innovations, such as seatbelts, which took decades of public campaigns to get most of the population to adopt, [1, p. 235], use of contraceptive methods in countries where religious beliefs discourage family planning [1, p. 15] or the diffusion of HPV vaccine among young women, affected by their attitudes toward the vaccine [14].

According to Rogers [1, p. 15], the adoption of an innovation with low compatibility often requires the adoption of a new value system, which is a fairly slow process. However, external factors such as social influence can expedite the adoption of a new value system. For example, when peers within a social system have adopted a preventive innovation, individuals might feel compelled to adjust their value system and adopt the innovation, as it happened with solar water heaters in neighborhood clusters in California [1, p. 16].

3) *Trialability and Observability*

Trialability is the degree to which an innovation might be experimented on a limited basis [1, p. 15]. Preventive innovations are often characterized by their difficult or impossible trialability [13]. These innovations seek to reduce the probability of an unwanted or to mitigate the severity of the consequences of the unwanted event; therefore, how to try out what adopters hope to avoid?

Another aspect of trialability refers to divisibility, referring to trying out innovations on a limited basis [1, p. 15]. While it might be impossible to experience the trialability of some preventive innovations (for example, one cannot wear a seatbelt halfway nor get a small dose of a vaccine), it is possible to experience other preventive innovations on a limited basis, for example, opting for a 30-day free trial of antivirus software.

Similarly, observability is the degree to which the results of an innovation are visible to others [1, p. 16]. As the results of a preventive innovation are delayed, they are not very observable [13] and some preventive innovations might have non-observable benefits until implemented, such as insurance policies or contingency plans [4]. However, the preventive innovation itself can be visible and stimulate peer discussion in a social system. For example, solar water heaters can be found in neighborhood clusters in California, where there are various adopters within the same block, while there can be areas of the city with no such heaters [1, p. 16].

When an unwanted event has a high probability of happening trialability and observability of preventive innovations can be experienced. Examples of unwanted events with high occurrence include earthquakes in seismic hazard zones, flooding in high-risk areas, or crashing in an elite cycling race. Once the unwanted event has been experienced, the preventive innovation can be sampled, and its benefits observed, the adopter can decide whether to keep the innovation or make a change. This was the case with crop insurance adoption in India, where there was a higher probability of adoption for farmers who had already experienced crop loss [15].

4) *Complexity*

Finally, complexity refers to the degree to which an innovation is perceived as difficult to understand and use [1, p. 16]. While preventive innovations are not necessarily more complex to understand and use than other innovations, the cause-and-effect relationships involved are complex [13]. Therefore, it might be difficult for potential adopters to understand the reasons behind prevention. This is commonly the case for the diffusion of vaccines, such as the HPV vaccine, where low vaccination rates can be explained by a lack of understanding regarding the transmission of the human papilloma virus and its role in cervical cancer [16].

III. Methods

A. *Photovoltaic Systems*

A photovoltaic system converts light directly into electricity; its main components are various kinds of photovoltaic cells interconnected to create a photovoltaic module, a mounting structure for the module, an inverter, a storage battery, and a charge controller [17, p. 4]. For this study, we consider PV systems preventive in nature as they serve various underlying goals of prevention, including reduction of greenhouse gas emissions, protection against volatile electricity prices, and lowering dependence on unreliable fossil fuel markets [18]. While PV systems are not new in the market, the newness of the technology depends on the potential adopters' perceptions, therefore, whether the idea is objectively 'new', or not, does not matter.

B. *Data Collection*

Our data was generated through an online survey, distributed through the website of a local electricity company in central Finland during 22.6. – 16.8.2021. Out of the 365 responses altogether respondents with missing values and individuals who had already purchased a PV system were excluded from the study as their intention to adopt cannot be compared with those who are in earlier stages of the adoption-decision process. Furthermore, factors that provide value after the adoption of technology may differ from factors that provide value before adoption.

When developing the survey, we were guided by theory-based survey items and by the practical experience in survey design of members of our research team. Survey questions sought to measure variables from a diffusion of innovations (DOI) theory, which could contribute to the adoption of PV systems. Survey items included various types of questions: demographic questions to gather demographic data, multiple choice questions to assess household characteristics, and 5-point Likert scale questions (from 5= strongly agree to 1= strongly disagree with an additional option to specify don't want to say) for other variables related to the intent to adopt. We will now discuss the DOI variables that were utilized in survey items.

Relative advantage. Relative advantage is considered the strongest predictor of the adoption of innovations [1, p. 232]. Four questions on the survey measured the perceived relative advantage of PV based on the subdimensions of relative advantage, including economic profitability, decrease in discomfort, and conveyed social prestige.

Trialability and observability. Innovations are more likely to be adopted if they can be experimented out on a limited basis, and if they can observe the results of the technology [1, p. 16]. Three questions assessed trialability and observability, by considering peer experience, social influence, and availability of information.

Compatibility. Innovations that are compatible with existing values, experiences, and needs of potential adopters are more likely to be adopted [1, p. 15]. For our study, we assessed technical compatibility with two variables (compatibility with technical aspects of PV) and social compatibility with five variables (social system's compatibility with the use of PV in terms of values and norms).

Complexity. Complexity identifies the degree to which an innovation is perceived as difficult to understand and use [1, p. 16], and innovations with higher complexity are less likely to be adopted. We sought to measure complexity through four questions that assessed the difficulty of utilizing PV systems from accessing information about the systems to installing them.

Preventiveness. For this study, we consider PV systems preventive in nature as they serve various underlying goals of prevention, including reduction of greenhouse gas emissions, protection against volatile electricity prices, and lowering dependence on unreliable fossil fuel markets [18]. Therefore, we included four questions that measured each of these aspects of prevention.

Control variables. We included a series of socio-demographic and household-specific items to measure characteristics that could affect the dependent variable: the period when the respondent is planning to purchase a PV system. Socio-demographic questions assess decision-maker characteristics; these include gender, age, and income levels. Household-specific questions identify household characteristics including type and size of the dwelling, and type of household management (self-owned, renting, subletting, etc.)

Dependent variable. We used one main measure to identify the intent to adopt PV technologies: the period when the respondent is planning to purchase a PV system. This variable measures behavioral intention, with an underlying belief, that intentions are predictors of behavior [19]. The scale included plans to adopt a PV system within a year, within two years, within five years, after a long time, and no intention to adopt. Those who already had installed a PV system were excluded since their intention to adopt was not considered comparable to those still deciding. The factors seen as most important after the adoption and use of technology can be different from those perceived and valued before adoption.

C. *Data analysis*

We ran our statistical analysis on SPSS. The dependent variable met the normality assumption per acceptable skewness and kurtosis values, which allowed for linear regression analysis. We ran three linear regression models. Model 1 included only demographic control variables. Model 2 included only the variables associated with relative advantage, compatibility, trialability, observability, complexity, and preventiveness. All variables from models 1 and 2 were included in model 3. Removing answers with missing values yielded 239 responses accounting for all variables in regression model 3. Regression models 2 and 3 with smaller subsets of variables included 243 and 239 responses respectively. Multicollinearity issues were not detected as only one variance inflation factor (VIF) exceeded 3 but remained below 3,3 in models 2 and 3 for the "I feel an obligation to reduce the negative consequences of my energy consumption" variable.

IV. Results

A. *Descriptive Statistics and Regression Analysis*

In Table 1 we present descriptive statistics and correlations for all measures in the regression analysis. Table 2 displays the results of the performed regression analysis with non-standardized coefficients and their standard errors.

Model 1 with demographic control variables reveals household income, size of the dwelling, and the type of household management as significantly associated ($p < 0,05$) with the intended period of PV system adoption. These results suggest that higher-income respondents with larger living spaces are considering adopting a PV system within a shorter timeframe. However, we interpret model 2 since its adjusted R2 value is the same as for model 3, yet the F-value for model 2 is better and none of the demographic variables in model 3 are significant ($p < 0,05$). In model 2 variables that are associated with compatibility are significant predictors of adoption: Living quarters well suited for fitting a PV system and a sunny location predict a shorter timeframe for adoption from the technical compatibility side. Regarding social compatibility, being able to freely choose to adopt a PV system is a very significant ($p < 0,001$) predictor of faster adoption. This suggests that those who are free to do so are more likely to have active plans for installing a PV system. Out of variables concerning relative advantage, a good mood is the only significant one, signifying that those who have plans for installing a PV system hope to derive emotional benefits from it for themselves. In model 3 the social compatibility variable and the mood advantage remain significant predictors.

B. *Intent to adopt Photovoltaic Systems*

Our results suggest that PV systems, which can be classified as preventive innovations, provide non-financial forms of relative advantage and are compatible with existing decision-making mechanisms and with technical energy requirements. These two attributes are traditionally considered "low" for preventive innovations.

Through four variables we measured the role of PV systems in the reduction of greenhouse gas emissions, protection against volatile electricity prices, and lowering dependence on unreliable fossil fuel markets [18]. As depicted in Table 2, neither of these variables is strongly correlated with the intended period of PV system adoption. Therefore, it appears that prevention-specific attributes are not significant in the intent to adopt PV systems in mass markets.

However, factors that provide value after the adoption of a technology may differ from factors that provide value before adoption; therefore, we went through the responses of participants that had already installed a PV system. We noticed that prevention-specific attributes had a higher presence for respondents that had already purchased a PV system. This finding suggests that adopters of PV systems find attributes of prevention more important than individuals who are still in the adoption-decision process. However, we could not build a regression model from respondents who had already purchased a PV system as their intention to adopt was not considered comparable to those still deciding. Furthermore, the sample size for those who had already purchased a PV system was small and not normally distributed.

TABLE 1. DESCRIPTIVE STATISTICS AND CORRELATION OF VARIABLES

		Mean	SD	N	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)
(1)	Dependent variable	2.07	0.86	239	1.00																												
(2)	Reladv_1	3.68	0.84	239	0,16**	1.00																											
(3)	Reladv_2	3.95	0.88	239	0,35**	0,59**	1.00																										
(4)	Reladv_3	4.06	0.83	239	0.04	-0.04	-0.05	1.00																									
(5)	Reladv_4	3.26	0.99	239	-0.09	-0.11	-0,11*	0,13*	1.00																								
(6)	Observ_1	3.07	1.50	239	0,19**	0.07	0.06	0.01	-0.02	1.00																							
(7)	Trial_1	3.84	0.99	239	0.08	0.06	0,17**	0,11*	0.04	0,17**	1.00																						
(8)	Trial_2	3.07	1.39	239	0,20**	-0.01	-0.02	0.06	-0,13*	0,30**	-0,19**	1.00																					
(9)	CompTech_1	3.61	1.16	239	0,25**	-0.02	0.08	0,12*	0.00	0,12*	0,11*	0,19**	1.00																				
(10)	CompTech_2	3.04	1.11	239	-0,21**	-0.03	-0,13*	0.06	0,19**	0.07	0.07	-0.09	0.01	1.00																			
(11)	CompSoc_1	3.07	1.08	239	0,32**	0.10	0,27**	0.01	-0.01	0,35**	0,23**	0,23**	0,20**	0.04	1.00																		
(12)	CompSoc_2	2.51	1.60	239	0,33**	-0.08	-0.07	0,26**	-0.04	0,30**	-0.07	0,40**	0,27**	-0.08	0,21**	1.00																	
(13)	CompSoc_3	4.34	0.96	239	0.09	0,15*	0,24**	-0.05	-0.01	-0.04	0.02	0.03	0,12*	-0,12*	0.08	-0,12*	1.00																
(14)	CompSoc_4	4.30	0.80	239	0,21**	0,34**	0,46**	0.04	-0.09	-0.02	0,19**	0.03	0.07	-0,12*	0,15*	-0.07	0,42**	1.00															
(15)	CompSoc_5	3.83	1.06	239	0,21**	0,38**	0,45**	-0,11*	-0.07	-0.01	0.09	0.00	0.04	-0.10	0,16**	-0.08	0,51**	0,61**	1.00														
(16)	Complex_1	3.44	0.76	239	0,27**	0,18**	0,17**	0,22**	-0.08	0,21**	0.02	0,31**	0,23**	-0.07	0,21**	0,32**	-0.09	0,15**	0.02	1.00													
(17)	Complex_2	3.23	0.81	239	-0.08	0.05	0.00	-0,12*	0,32**	0.06	-0.01	-0.05	0.04	0,12*	0.10	-0.08	0.09	-0.03	0.02	-0.10	1.00												
(18)	Complex_3	3.19	0.92	239	0,13*	-0.06	0.01	0.07	-0.09	0,26**	0.00	0,22**	0.09	0.09	0,11*	0,19**	-0.01	-0.06	-0.02	0,21**	0.00	1.00											
(19)	Complex_4	3.79	0.73	239	0,14*	0.07	0,15**	0,17**	-0,16**	0.07	-0.02	0,26**	0,12*	-0,17**	0.08	0,16**	0,14*	0,22**	0.07	0,40**	-0,16**	0,20**	1.00										
(20)	Prevent_1	4.05	0.77	239	0,18**	0,25**	0,42**	0,15*	-0,12*	-0,13*	0,15*	-0,12*	0.10	-0.07	0,13*	-0.07	0,15**	0,22**	0,16**	0.06	-0.10	0.00	0.10	1.00									
(21)	Prevent_2	4.20	0.98	239	0,27**	0,39**	0,58**	-0.05	-0,14*	0.01	0,22**	-0.02	0.09	-0,14*	0,28**	-0.09	0,44**	0,56**	0,57**	0.08	-0.02	0.10	0,16**	0,44**	1.00								
(22)	Prevent_3	4.07	0.77	239	0.04	0,17**	0,34**	0,11*	-0.02	0.01	0,24**	-0.06	0.01	0.04	0.08	-0,15**	0,26**	0,33**	0,18**	0.03	-0.01	0.00	0.05	0,47**	0,39**	1.00							
(23)	Prevent_4	3.84	1.05	239	0,20**	0,39**	0,45**	-0.09	-0.08	0.02	0,15**	0.03	0,13*	-0,15*	0,20**	-0.05	0,46**	0,58**	0,78**	0.08	0.04	-0.04	0.05	0,18**	0,56**	0,20**	1.00						
(24)	Demographics_gender	1.35	0.48	239	0.10	-0,11*	-0,19**	0,20**	-0.07	0.03	-0,20**	0,34**	0.09	-0,13*	-0.06	0,22**	-0,15**	-0,11*	-0,26**	0,17**	-0.03	0,12*	0,24**	-0,17**	-0,18**	-0,22**	-0,23**	1.00					
(25)	Demographics_age	3.83	1.39	239	-0.05	0.02	-0,16**	-0.08	0.00	0,13*	-0,15*	0.07	0,16**	0.10	-0.05	0.08	-0.07	-0,14*	-0.08	0.07	-0.01	-0.01	-0.01	-0.04	-0,16**	-0.05	-0.07	0,13*	1.00				
(26)	Demographics_income	3.14	1.84	239	0,23**	-0.04	0.08	0.08	-0,12*	0.08	0.07	0,16**	0,14*	-0,13*	0,20**	0,24**	-0.04	0.10	0.03	0,12*	-0.05	0.05	0,11*	0.10	0,15**	0.01	0.10	0,15*	-0.02	1.00			
(27)	Household_type	1.83	1.02	239	0,14*	-0.04	0.05	0,19**	0.00	0.06	-0.01	0.10	0,17**	-0,12*	0.05	0,21**	-0.04	-0,14*	-0.07	0,19**	-0.01	0.02	0.04	-0.04	-0.07	-0.03	-0.04	0,17**	0,12*	0,12*	1.00		
(28)	Household_size	99.71	63.26	239	0,29**	-0.07	-0.05	0,23**	0.02	0,17*	-0,17**	0,27**	0,19**	-0,20**	0.08	0,51**	-0,14*	-0.01	-0.05	0,32**	-0,11*	-0.03	0,16**	-0.06	-0.08	-0,16**	-0.03	0,22**	0,14*	0,29**	0,23**	1.00	
(29)	Household_mngmt	1.46	0.68	239	-0,23**	0.10	0.10	-0,21**	0.01	-0.07	0.08	-0,17**	-0,26**	0.07	-0.09	-0,40**	0.09	0.02	0.07	-0,14*	0,15*	-0.06	-0.03	-0.01	0.06	0,15**	0.05	-0,11*	-0,17**	-0,17**	-0,25**	-0,45**	

*p < .05
**p < .01

TABLE 2. REGRESSION ANALYSIS RESULTS

Variable	*Model 1 B (Std. Err)*	*Model 2 B (Std. Err)*	*Model 3 B (Std. Err)*
(Constant)	2,054 (0,297)**	0,239 (0,578)	0,007 (0,649)
Demographics_gender: Gender_num	0,057 (0,115)		0,210 (0,122)
Demogrphcs_age: Age_group_num	-0,070 (0,039)		-0,036 (0,038)
Demographics_income What is your household's total gross income (income before tax) per year_num	0,061 (0,030)*		0,018 (0,029)
Household_type: What is the house type of your dwelling_num	0,032 (0,054)		0,003 (0,053)
Household_size: What is the floor area of your dwelling?	0,002 (0,001)*		0,002 (0,001)
Household_mngmt: What is the type of management of your dwelling_num	-0,187 (0,087)*		-0,098 (0,086)
Reladv_1: [The introduction of a solar power system makes a good impression on other people.]		-0,049 (0,074)	-0,030 (0,076)
Reladv_2: [Solar PV makes me feel good.]		0,262 (0,081)*	0,265 (0,085)*
Reladv_3: [Solar photovoltaic systems have high purchase costs.]		-0,035 (0,065)	-0,092 (0,069)
Reladv_4: [Solar photovoltaic systems have high operating costs.]		0,016 (0,054)	0,013 (0,054)
Observ_1: [I know more than one person who has a photovoltaic system.]		0,032 (0,038)	0,032 (0,039)
Trial_1: [Before purchasing a photovoltaic system, I would like to talk to someone who has a photovoltaic system.]		0,008 (0,055)	0,033 (0,057)
Trial_2: [I have enough information about photovoltaic systems to make a decision about purchasing one.]		0,003 (0,041)	-0,013 (0,043)
CompTech_1: [My house is suitable for installing a PV system (no shadows from trees, chimneys, other buildings, or historic building).]		0,093 (0,045)*	0,075 (0,047)
CompTech_2:[My location is not sunny enough for solar panels to produce well.]		-0,126 (0,046)*	-0,088 (0,048)
CompSoc_1: [Many people who are important to me think it would be good if I installed a solar PV system.]		0,102 (0,053)	0,100 (0,053)
CompSoc_2: [It is entirely up to me to decide whether or not to install a solar PV system.]		0,128 (0,037)**	0,088 (0,040)*
CompSoc_3: [It is important for me to protect nature.]		0,002 (0,063)	0,029 (0,064)
CompSoc_4: [It is important to use renewable energy to reduce emissions.]		0,058 (0,086)	0,021 (0,089)
CompSoc_5: [I feel an obligation to reduce the negative consequences of my energy consumption.]		0,089 (0,079)	0,109 (0,081)
Complex_1: [I find it easy to install a photovoltaic system.]		0,092 (0,076)	0,084 (0,079)
Complex_2: [I think it takes a lot of time to install a photovoltaic system.]		-0,069 (0,065)	-0,061 (0,066)
Complex_3: [I think that the support procedures for installing a photovoltaic system are clear.]		0,044 (0,056)	0,052 (0,058)
Complex_4: [I think it would be easy to learn how to use a PV system.]		-0,069 (0,076)	-0,083 (0,078)
Prevent_1: [I consider it important that installing a solar system helps to protect against future electricity price increases.]		0,073 (0,080)	0,092 (0,081)
Prevent_2: [I consider it important that installing a solar system will allow me to save natural resources and reduce greenhouse gas emissions.]		0,031 (0,0756)	0,009 (0,077)
Prevent_3: [I consider it important that the introduction of a solar system will allow me to be independent from energy producers.]		-0,089 (0,076)	-0,050 (0,078)
Prevent_4: [People like me should do everything possible to reduce emissions and prevent climate change.]		-0,076 (0,077)	-0,071 (0,078)
N	245	243	239
Adj. R^2	0,10**	0,28**	0,28**
F	5.64	5.31	4.37

*p < .05
**p < .01

V. DISCUSSION AND CONCLUSIONS

Our study sought to explore if the preventive nature of innovations, present in attributes of innovations, has a positive or negative influence over the intent to adopt.

Preventive innovations are considered to have low relative advantage as benefits are delayed in time and difficult to observe [6]. Previous studies on residential photovoltaics (RPV) [20] have identified elements of relative advantage (economic profitability) as negative attributes that directly reduce the intention to buy. However, our study indicates that PV systems can provide non-financial forms of relative advantage.

Furthermore, preventive innovations are identified as not very compatible with individuals' values, attitudes, or lifestyles [13]. Previous studies on solar technologies through the lens of DOI by Labay & Kinnear [21] have identified solar systems as compatible with the personal values of the general population in the state of Maine in the United States. Our findings reveal that PV systems are compatible with existing decision-making mechanisms and technical requirements for energy systems. Thus, our findings complement previous studies on this attribute of innovations.

Moreover, preventive innovations are considered to have low trialability and observability. Previous studies on observability in the diffusion of photovoltaic panels have found that the visibility of solar panels enhances peer effects, which are found to increase the amount and size of installations over a zip code [22]. Studies on trialability [21] indicate that even a small trial of solar systems represents a major financial commitment, for which these systems don't have a real possibility for a low-risk trial. While our study did measure trialability and observability variables, we did not detect any significant influence over intent to adopt.

Finally, preventive innovations are believed to have high complexity due to the cause-and-effect relationships involved and ease of use. Previous studies evaluating the complexity of renewable energy systems have found solar systems as less complex than other sources of energy [21], and have identified that perceived ease of use does not affect the purchase intention of renewable energy [23]. Our study did not detect any significant correlation between complexity-related variables and intent to adopt, which is in line with previous studies

The key finding from the analysis was that four variables: "Solar PV makes me feel good", "My house is suitable for installing a PV system (no shadows from trees, chimneys, other buildings, or historic building)", "My location is not sunny enough for solar panels to produce well", and "It is entirely up to me to decide whether to install a solar PV system" were associated with the intended period of PV system adoption. Furthermore, our research suggests that adopters of PV systems find attributes of prevention more important than individuals who are still in the adoption-decision process. However, statistical assumptions made between variables made it impossible to create a model for individuals who had already purchased a PV system.

Therefore, future studies should explore the preventive nature of innovations present in attributes of innovations, for actual adopters of preventive innovations. With this, we seek to understand if prevention is perceived and prioritized differently across adopter groups; this could shed light on different strategies to promote adoption. Additionally, future survey questions should be adjusted to directly measure the preventive nature of innovations, as our current survey setup seems to merely hint at a direction of preventiveness.

There were limitations in this study being the most evident, the fact that we could not create a model from respondents who had already purchased a PV system. Furthermore, this study was carried out in Finnish households, a culture with a high profile of uncertainty avoidance [24]; these societies adopt strict rules to minimize uncertainty and are risk averse [25]. Therefore, results may be different across cultures that are more risk-tolerant. Despite the limitations, the results of this study provide additional steps to unveiling the drivers for the adoption of preventive innovations.

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