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Factors Affecting the Adoption of Photovoltaic Systems in Rural Areas of Poland

Marek Angowski [1,*], Tomasz Kijek [1], Marcin Lipowski [2] and Ilona Bondos [3]

1 Department of Microeconomics and Applied Economics, Faculty of Economics, Maria Curie-Sklodowska University in Lublin, Pl. M. Curie-Skłodowskiej 5, 20-031 Lublin, Poland; tomasz.kijek@mail.umcs.pl
2 Department of Marketing, Faculty of Economics, Maria Curie-Sklodowska University in Lublin, Pl. M. Curie-Skłodowskiej 5, 20-031 Lublin, Poland; marcin.lipowski@mail.umcs.pl
3 Department of IT Systems and Logistics, Faculty of Economics, Maria Curie-Sklodowska University in Lublin, Pl. M. Curie-Skłodowskiej 5, 20-031 Lublin, Poland; ilona.bondos@mail.umcs.pl
* Correspondence: marek.angowski@mail.umcs.pl

Abstract: The paper aims to identify and explain the factors influencing the decision-making process on the behavioural intention to use home photovoltaic systems by Polish households and potential buyers. The survey was conducted in 2021 on a sample of 521 participants. The research used a random sample of households without PV systems located in the rural areas in Poland, where the adoption of innovative technologies related to obtaining energy from renewable sources is especially important. Structural equation modelling (SEM) was applied to measure structural relationships. The main finding indicates that consumer innovativeness has the strongest impact on the intention to purchase a photovoltaic installation. The perceived value also affects the intention to purchase a photovoltaic installation. The perceived value is affected by perceived economic benefits and indirectly by the subjective knowledge of PV. Surprisingly, environmental concerns negatively affect the intention to use PV installations.

Keywords: PV systems; renewable energy resources; rural areas; economic value; consumer behaviour; consumer innovativeness

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1. Introduction

For several years there has been much interest in renewable energy, which also includes solar energy. Among these technologies is photovoltaics (PV), i.e., converting solar energy into electricity, considered one of the most promising and environmentally friendly energy sources. Photovoltaics guarantees energy obtained completely naturally. Any amount of energy produced from the sun reduces CO_2 emissions, which significantly impacts the environment [1]. A significant advantage of solar radiation is its availability and the daily and annual variability—an equally important disadvantage. The development of energy storage methods should minimise the limitations related to converting solar energy into energy useful for humans and its wider use [2,3]. In Poland, there are generally good natural and spatial conditions for the use of solar radiation energy. Satisfactory results can be achieved by adapting the type of systems and the properties of solar devices to the nature, structure and time distribution of the solar radiation. The basis for the development of photovoltaics in Poland is the introduction of appropriate legal regulations that guarantee the investor the profitability and predictability of the investment. Opportunities should also be seen in prosumer energy, where the main assumption should be the production of energy for one's own needs, and in the case of producing excess energy, the possibility of selling it at a favourable price [2,4]. The large increase in investments in photovoltaic systems in Poland is related primarily to the decrease in installation costs with the simultaneous increase in energy costs for end-users. Therefore, photovoltaics becomes a better alternative in terms of reducing energy costs, both in households and companies [3,4].

The issue of photovoltaics as a renewable energy source finds a place as a new area of activity both in the national energy policy and the EU energy policy. The EU policy supports the development of renewable energy to ensure energy security in the conditions of sustainable development and competitiveness [5]. Therefore, the EU provides significant financial resources for implementing investments related to the development of renewable energy sources. The selection of the appropriate source of financing depends on the type of beneficiary and the scale of the investment. RDP is the available form of financing for applicants located in rural areas. So far, investors of solar PV systems have benefited from support under the financial perspective for 2014–2020. This support will be continued in the coming years as part of the Act on renewable energy sources [2], which is to enter into force, and introduce new regulations, to a greater extent supporting the development of renewable energy sources in photovoltaic systems. In Poland, the development of photovoltaic systems in rural areas may also be favoured by the environmentally neutral nature of this type of investment, which, unlike wind farms or agricultural biogas plants, is more socially acceptable. What is important, is that rural areas encompass more than 93% of Poland and are inhabited by almost 40% of the country's population. The high consumers' demand for energy in rural areas combined with increased use by agriculture result in the need for energy security in these areas. Due to convenient conditions (geographical location and climate zone), the countryside has the real potential to increase the share of green energy in Poland's energy mix [6]. Owing to the enormous financial aid from the European Union for Polish agriculture, there is a great alternative in the form of installation of photovoltaics, which may contribute to the improvement of the economic situation of individual regions and households located there [3,7]. Therefore, it can be concluded that in the longer term of activities undertaken for the use of solar energy as an energy source, photovoltaics is not only a new direction in meeting energy needs but also a way of professional activation (activating entrepreneurship) of the population and rural development.

Despite the potential of photovoltaic systems, the dynamics of the development and implementation of these solutions are still limited. The literature identifies several barriers to the adoption of photovoltaics on the market. Key barriers include consumer passivity, high initial costs, the long payback period for investments, planning and installation pains, various information gaps, and customer concerns about the ability to use PV [1,8]. Additionally, it is possible to indicate the motivations and priorities shaping the behaviour of consumers, which differ and depend on their knowledge, personality, preferences, values and attitudes towards ecology or innovation [9]. For example, open-minded users and looking for novelty (innovation) are more likely to take risks despite the technical complexity and lack of short-term benefits of modern solutions such as PV than other consumers [10]. Among the factors influencing the development of photovoltaics in rural areas, the following limitations can be indicated [11,12]: public reluctance (with regard to the location of these investments in the vicinity); low public awareness of the role and importance of renewable energy sources; lack of stable support systems for this area of economic activity; the need to adapt the applied solutions to local conditions; problems with connecting new installations to energy and heating networks; lack of appropriate, time-stable legal solutions regarding the functioning of various groups of entities dealing with renewable energy on the energy market; poorly developed energy network in rural areas.

Despite the development barriers, the photovoltaic sector has enormous potential and is able to meet the growing global demand for energy in the near future. With the current trends in technology and market development, photovoltaics will significantly improve the natural environment, ensure energy security, and contribute to protecting the global economy from energy crises. As a result, this sector is increasingly becoming an area of interest for analysts and scientists from various fields. The research and publications conducted so far in the field of the photovoltaic sector have focused mainly on the analysis and assessment of technical parameters, R&D activity and the possibilities of increasing their efficiency [12,13]. The economic publications are dominated by items related to the analysis of costs and investment efficiency. Some empirical studies apply the technology acceptance model (TAM) to explain the adoption of PV solar technologies by consumers [14]). Unfortunately, using the TAM model in the context of PV adoption is questionable since this model focuses on the limited number of factors affecting consumers' decisions. Therefore, it seems important to explore the issues of using innovative photovoltaic technologies, emphasising the aspects of a buyers' behaviour in the purchasing process. In recent years, analyses of the issue of prosumerism have appeared more and more frequently. On the other hand, the issue of buyers' behaviour in relation to the process of selecting and purchasing photovoltaic installations seems to be still insufficiently explored.

In order to close this research gap; our contribution is twofold. First, to the best of our knowledge, this study is the first attempt to take into account the broad set of factors (i.e., environmental concerns, consumer innovativeness, subjective knowledge on PV, perceived economic benefits of PV, perceived risk of PV, the perceived value of PV) influencing the decision-making process on the selection and implementation of investments in home photovoltaic systems. Such an approach allows us to model and empirically verify the complex hypothetical relationships between the buyer's characteristics, beliefs, attitudes and knowledge, and their behaviour in the process of purchasing photovoltaic installations. Second, the paper considers the specificity of consumers living in rural areas, where the development of innovative technologies related to obtaining energy from renewable sources is important, because the energy sector in these regions, away from agglomeration and industrial centres, is often characterised by: isolation, high dispersion population centres, limited supply as well as the lagging behind in technical and business infrastructure.

We consider it also important that the research was carried out in a country with a specific energy culture—the coal culture. Poland is one of these countries where the coal market is particularly relevant as coal is the first choice to meet energy demand in this country. From 2019 to 2020, the percentage change of hard coal and lignite generation (bars) production was −8.0%, while the average decline for the EU was −18.0 [15]. In 2020, 83% of electricity came from fossil fuels (to samo źródło) in Poland. While the trend to move away from coal in the power sector is increasing, the Polish government aims to maintain coal as a dominant energy source until at least 2050. This position is in clear contradiction with the European and global climate and energy policy. [16,17]. What is more, according to the forecasts, the legislative changes planned for 2022 by the Ministry of Climate and Environment will reduce the profitability of PV installations in Poland. Therefore, it is worth analysing other factors influencing the intention to use PV than just those related to the perceived profitability of such a solution.

2. Theoretical Background

Beliefs and attitudes about the natural environment are translated into actions or behaviour. Some studies indicated the lack of strong impact of environmental beliefs on environmental behaviours; the main reason is that general opinions are not strong enough to pro-social acting—Gadenne et al. [18] called it the value-action gap. Nevertheless, it was also acknowledged that environmental concerns impact behavioural intention [19,20]. Additionally, Thi Khanh and Phong [21] noted that consumers' beliefs and awareness of the natural environment could create environmentally responsible behaviour.

Therefore, we proposed the hypotheses:

Hypothesis 1 (H1). *Environmental concerns positively impact intention to use PV;*

Hypothesis 2 (H2). *Environmental concerns positively impact the perceived value of PV.*

Consumer innovativeness is seen as an important part of personality. It refers to the tendency of purchasing and using new products more quickly and more often than other people [22]. The relation between consumer innovativeness and behavioural intention became the main research topic in reference to many offers such as robotic restaurants [23], a drone food delivery service [24], smart toys [25], smartwatches [26], autonomous cars [27].

Consumer innovativeness is vital to create a positive response towards new products and positively impacts willingness to pay [25].

Therefore, we proposed the hypotheses:

Hypothesis 3 (H3). *Consumer innovativeness positively impacts intention to use PV;*

Hypothesis 4 (H4). *Consumer innovativeness negatively impacts perceived risk.*

As stated by Buratti and Allwood [28], not only an individual's objective knowledge but also subjective knowledge (consumers assessment of the level of their knowledge) can influence consumers risk perception and actions. According to researchers, subjective knowledge plays a bigger role in predicting environmental behaviour than other knowledge types [29]. In our study, we concentrated on subjective (environmental) knowledge that is defined as people's perceptions of how much they know about a particular environmental issue [30]. Subjective knowledge can be identified as the result of highly objective knowledge and previous experience [31]. According to much research, people exhibit overconfidence when assessing their knowledge within many different kinds of domains. It is important to emphasise that the research on the impact of subjective knowledge on risk perception or risk behaviour provide mixed results—positive influence, negative influence or no influence [28]. Using the example of smart home technologies, Wilson et al. [32] noted that early adopters acquire greater knowledge. Their positive perceptions of benefits are strengthened, but greater knowledge does not significantly weaken early adopters' perceptions of risks. Zhu et al. [33] tried to prove that the greater the perceived knowledge, the lower the perceived risk. As a result of their research model, it turned out not be supported the research hypothesis. Additionally, Dursun et al. [34] could not find support to the assumption that high subjective environmental knowledge will decrease the tendency to deny the problem.

Therefore, we proposed the hypotheses:

Hypothesis 5 (H5). *Subjective knowledge of PV negatively impacts perceived risk;*

Hypothesis 6 (H6). *Subjective knowledge of PV positively impacts perceived benefits.*

The concept of 'perceived value' emerged as the defining business issue of the 1990s and has continued to receive extensive research interest in the 21st century [35]. El-Adly [36] noted that the definition of customer perceived value has changed over time. The perceived value has received much attention from academics and practitioners due to its close relationship with customer satisfaction and competitive advantages. However, the concept of perceived value was seen by Khalifa [37] as one of the most overused and misused concepts in the social sciences in general and in the management literature in particular. Among many definitions, one of the more commonly cited is that supplied by Zeithaml [38], who proposed a general perspective where perceived value is the consumer's overall assessment of the utility of a product based on what is obtained and provided. Her conceptualisation of perceived value was one of the first. Monroe's [39] research approach was similar; he defined perceived value as "a trade-off between the quality or benefits they perceive in the product relative to the sacrifice they perceive by paying the price". Simply, the perceived value is a difference between the benefits obtained and the sacrifices made; it is a trade-off between benefits acquired and perceived costs. In our study, the concept of perceived value was adapted in the context of PV installation offer. As it was stated by Slovic [40], a risk–benefit trade-off is used in order to evaluate specific technology to accept it or reject it. The most promising technologies generate both risk and benefits [41], and the PV system is no different. In our study, two separated variables were identified as main components of perceived value—perceived risk and perceived benefits.

Perceived benefits can be identified in the scientific literature in many different ways—functional, experiential, symbolic [42], functional benefits [43], utilitarian, emotional [44], hedonic. Although PV installation can provide its users with multiple benefits, only perceived economic benefits were included as an extremely strong incentive in our study. Santos [45] noted the importance of financial aspects for potential adopters of PV systems due to their deep interests in economic benefits when installing a photovoltaic system. We defined perceived economic benefits of PV installation by analogy to economic benefits from participating in sharing economy analysed by Lee et al. [46]. Kim [47] considered the general idea of perceived benefits and showed a positive impact of perceived benefit on the value.

Therefore, we proposed the hypothesis:

Hypothesis 7 (H7). *Perceived economic benefits positively impact the perceived value.*

By analogy to smart retail technology [48], the benefits offered by PV are not without potential risks, uncertainties and adverse consequences. In this study, we decided to resign from focusing on price perception aspects due to the vital financial support provided to potential PV buyers. Instead of analysing perceived costs in general, we put our research attention to risk perception. Impacts risk is seen as one antecedent of a perceived value [48]. Perceived risk was conceptualised by Raymond Bauer in 1960 in the context of consumer behaviour and is based on the notion that any buying activity includes risk. The perceived risk works when consumers are unsure whether the intended purchase will permit them to accomplish their buying purposes [49]. Scholars defined perceived risk as a kind of subjective, expected, possible loss when pursuing a prospective outcome [50]. It was usually defined as the subjective expectation of a loss [51] and the consequences of such a loss if it occurs [52]. What is important, this loss can have both monetary and non-monetary nature [53]. These negative consequences are expected to emerge from particular technology/innovation adoption or use [54]. In our study, by analogy to Chin et al.'s [55] definition, perceived risk referred to the consumer's subjective belief in the possibility of loss or harm emerging from the PV installation in a consumers' household. The information asymmetry to the sellers' advantage is the main reason most buyer–supplier relationships are characterised by risks [56]. Understanding elements that can decrease perceived risk is truly vital [57]. Different risk reducers can be useful depending on the specific type of perceived risk (risk factors) [58]. Perceived risk is well explained in literature; however, it is still an important avenue of research [59], such as PV installation as an innovative environmentally friendly technology in consumers' households.

Therefore, we proposed the hypothesis:

Hypothesis 8 (H8). *Perceived risk negatively impacts the perceived value of PV.*

Perceived value is highly relevant to marketers as it has been found to positively affect behavioural intention [60]. A series of studies confirmed that perceived value increases purchase intention. The impact of perceived value on behavioural intention has been studied in various interesting trendy areas such as online group buying [61], private labels [62], smart retail technology [48], green branding [63]. The positive impact on behavioural intention is connected with the psychological explanation of the perceived value that involves an attraction toward the outcome of the goal pursuit [64].

Purchasing intention indicates an individual's readiness to buy a product that one has preferred for oneself after some evaluations on the basis of personal experience, perception, attitude, subjective norm [65]. Green purchase intention refers to the probability and individual inclination to choose environmentally friendly energy products over the conventional products in their purchase decision [66]. In line with previous research findings, it is reasonable to predict that consumers' perceptions of PV installation value may increase their purchase intention towards PV installation.

Therefore, we proposed the hypothesis:

Hypothesis 9 (H9). *Perceived value positively impacts intention to use PV.*

3. Materials and Methods

Our research used a random sample consisting of households without PV systems located in the rural areas in Poland. A survey instrument was developed to understand the factors that shape households' use intention of PV technology in Poland. A total of 526 questionnaires were collected, of which five respondents reported that they used PV systems. These were removed from the sample, leading to a final sample size of 521 participants. Of the respondents, 53 per cent were male, and 47 per cent were female. Their ages varied from 18 to 81 years, with a mean of 40.5 years. The dominant household's size was four persons. In terms of the average monthly amount of a household's electricity bill, the largest group of respondents reported that they paid between EUR 22 and 44 (Table 1).

Table 1. Sample characteristics.

Characteristics		Number of Respondents	Percentage of Sample
Gender	Female	245	47
	Male	276	53
Age (years)	18–24	96	18.4
	25–34	133	25.5
	35–44	93	17.9
	45–54	101	19.4
	Over 55	98	18.8
Average monthly energy bills (euro)	Below 22.0	49	9.4
	22.0–44.0	241	46.3
	45.0–66.0	140	26.9
	67.0–89.0	58	11.1
	Over 90.0	33	6.3
Household size (number of persons)	1	29	5.6
	2	108	20.7
	3	136	26.1
	4	138	26.5
	5 or more	110	21.1

For the purpose of this study, the endogenous and exogenous constructs were adapted from prior research (Appendix A). Six constructs represented the influential factors (i.e., environmental concerns—EC, consumer innovativeness—CI, subjective knowledge on PV—SK, perceived economic benefits of PV—PEB, perceived risk of PV—PR, the perceived value of PV—PV). The remaining construct is related to the use intention of PV—UI. In total, 28 questions were applied to operationalise these constructs. All questions were measured on a seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree).

The measurement model was verified via construct reliability and validity tests. To measure the scale's reliability, we applied Raykov's reliability coefficient—RRC. This coefficient is preferred over Cronbach's alpha since it relaxes the assumption of tau-equivalent measures. Other reliability tests used in our study include Loevinger's H coefficient and Ferguson's delta coefficient. The former provides information on scalability. The latter allows us to verify scales discrimination. Convergent validity was measured by average variance extracted (AVE). Finally, structural equation modelling (SEM) was applied to measure structural relationships [67]. SEM can be regarded as a combination of several traditional multivariate procedures such as factor analysis, regression analysis, discriminant analysis or canonical correlation.

SEM consists of the structural model and the measurement model [68]. The structural model with latent variables takes the form:

$$\eta_i = \alpha_y + \mathrm{B}\eta_i + \Gamma\xi_i + \zeta_i \quad (1)$$

where η_i is a vector of latent endogenous variables for unit i, α_y is a vector of constants for the equations, B is the matrix of coefficients showing the expected impacts of the latent endogenous variables (η) on each other, ξ_i is the vector of latent exogenous variables, Γ is the coefficient matrix showing the expected impacts of the latent exogenous variables (ξ) on the latent endogenous variables (η) and ζ_i is the vector of disturbances.

The measurement model has two equations:

$$y_i = \alpha_y + \Lambda_y \eta_i + \varepsilon_i \quad (2)$$

$$x_i = \alpha_x + \Lambda_x \xi_i + \delta_i \quad (3)$$

where y_i and x_i are vectors of the observed responses of η_i and ξ_i, accordingly, α_y and α_x are constant vectors, Λ_y and Λ_x are matrices of factor loadings showing the effect of the latent η_i and ξ on y_i and x_i, accordingly, and ε_i and δ_i are the unique factors of y_i and x_i.

Prior to the measurement model verification and the SEM analysis, the multivariate normality assumption was checked by the Doornik–Hansen test. Its outcome resulted in the application of Satorra–Bentler adjustment after maximum likelihood.

4. Results and Discussion

Table 2 shows the results of the reliability and validity tests. All of the RRCs are higher than the lowest acceptable level (0.7). Moreover, Loevinger's H coefficients for the seven scales are higher than 0.3, indicating good scalability. Regarding the generalised delta index of scale discrimination, it meets a threshold level (0.9) for all scales. The results of Confirmatory Factor Analysis show that all constructs can explain more than an average amount of 50% variance of its indicators. In other words, convergent validity is demonstrated since the average variance extracted (AVE) exceeds the cut-off value (0.5). There is no problem with discriminant validity, as AVE values of all constructs are larger than their squared correlations (SC) with other constructs in the model. All except one of the standardised factor loadings are above 0.5. This means that they are considered satisfactory items. Consequently, the item from the construct of subjective knowledge on PV with low loading was dropped in further analysis. CFA outcomes reveal that the entire measurement model indicates acceptable goodness of fit as RMSEA = 0.06 and CFI = 0.93 meet satisfactory thresholds [69].

Table 2. Reliability and validity of measurement model.

Construct	Items	Loadings Range	RRC	H	Delta	AVE
Environmental concerns—EC	4	0.75–0.92	0.93	0.67	0.94	0.76
Consumer innovativeness—CI	4	0.71–0.85	0.88	0.80	0.96	0.65
Subjective knowledge on PV—SK	3	0.63–0.95	0.88	0.74	0.97	0.74
Perceived economic benefits of PV—PEB	4	0.79–0.89	0.92	0.81	0.96	0.74
Perceived risk of PV—PR	4	0.62–0.91	0.88	0.76	0.96	0.65
Perceived value of PV—PV	4	0.88–0.93	0.96	0.73	0.95	0.82
Use intention of PV—UI	4	0.94–0.98	0.98	0.74	0.93	0.91

The standardised path coefficient between EC and UI did not confirm a positive relationship between the environmental concerns and the intention to use PV installations; thus, H1 has been rejected (Figure 1). Such a relation can be influenced by the increasing controversy over the possible environmental impact of environmentally friendly technologies, such as electric cars or wind farms [70]. Solar photovoltaic installations are also not free from this type of controversy, especially regarding the "end of life" panel and hazardous materials used in PV [71]. Apart from the factors related to recycling, the negative impact of PV installations on the environment may be associated with visual pollutions, especially in the case of large installations or the exclusion of the land from agricultural crops [72]. These effects can be especially felt in rural areas [73]. For this reason, respondents' environmental concerns do not have to positively affect the installation of voltaic panels, and even—as in the results of the conducted research—can have a negative effect on installing intention. A high level of environmental concerns can create a wider perspective of the effects of PV technology and its potential long-term impact on the household and its surroundings.

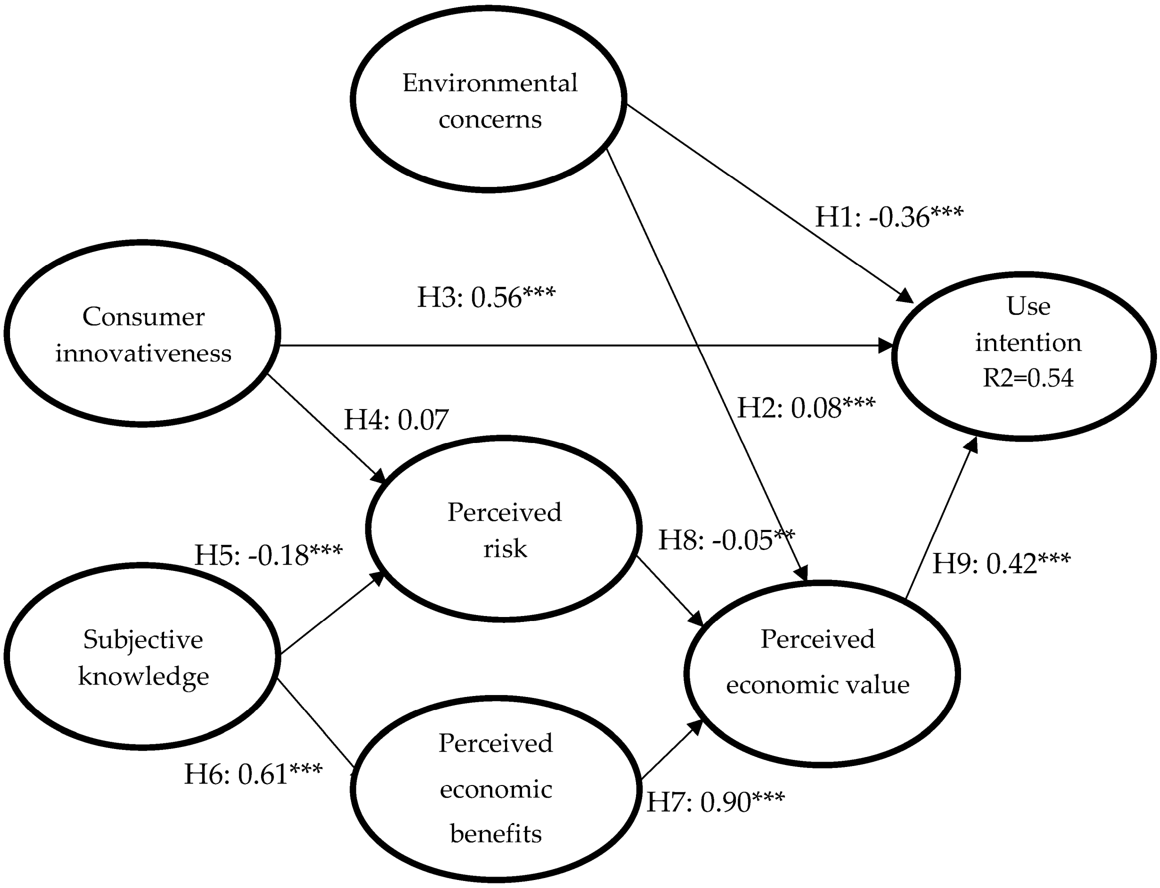

Figure 1. Results of structural model estimation. Note: *** $p < 0.01$, ** $p < 0.05$, RMSA = 0.08, CFI = 0.89.

The indirect and positive impact of the environmental concerns on the intention to use PV installation occurs via the perceived value (Table 3). Even though this dependence is weak, it has confirmed H2. The perceived value moderates the impact of environmental concerns on the intention to use PV installations. Thus, the perception of the photovoltaic installation value affects the intention to use this technology.

Table 3. Indirect effects of endogenous and exogenous variables on use intention.

Path	Coefficient
EC→UI	0.04 ***
PR→UI	−0.04 **
PEB→UI	0.48 ***
CI→UI	−0.003
SE→UI	0.28 ***

Note: *** $p < 0.01$, ** $p < 0.05$.

The hypothesis H3, indicating that consumer innovativeness has a positive effect on purchasing a photovoltaic installation, has been confirmed. Thus, the research results confirmed the conclusions provided by Zhang et al. [25]. In the analysed model, the impact of consumer innovativeness on the intention to purchase a photovoltaic installation is the strongest. Consumer innovation is a personal characteristic. The greater the consumer openness to innovative ecological technologies, the more likely they are to use PV installations. This consumer characteristic is even more important than the perceived value of the PV. According to the research model, the consumer's innovativeness does not affect the perceived risk of installing photovoltaic panels—the relationship is statistically insignificant (Figure 1). Therefore, hypothesis H4 has not been confirmed. The obtained results are consistent with the conclusions of Xue et al. [10]); in our research, consumer innovation does not affect the risk of the PV installation decision. The impact of consumer innovativeness on the perceived risk is irrelevant, probably due to the increasing usage of solar panels by households and the spread of this technology. As Sommerfeld et al. noted, PV technologies have already reached technological maturity, which is why they are perceived as low risky [74]

The subjective knowledge of PV installations reduces the perceived risk and increases the perceived economic benefits of PV panels (Figure 1). The results confirm the Alrashoud and Tokimatsu study [10], indicating that consumer knowledge impacts PV installation usage. Therefore, H5 and H6 have been verified. The impact of consumer knowledge on benefits is stronger than on the perceived risk. These results confirm the conclusions of Zhu et al. [33]. However, we agree that knowledge may have a different influence on the perceived risk depending on the type of technology and the stage of its acceptance, as shown by Wilson et al. [32].

The perceived value of PV in the research model depends on the perceived risk and the economic benefits (Figure 1). As Lewandowska et al. [75] noted, the use of renewable energy sources is innovative, and its implementation involves certain effects related not only to possible profits but also costs. The study confirmed that perceived risk lowers the perceived value while the economic benefits increase value perception. The positive impact of financial benefits on the perceived value in the case of PV installation is much stronger than the negative one on the value of the perceived risk. Another study showed that in the case of Polish households, the installation of PV brings some financial benefits [8]. Among some factors determining the profitability of PV investments in households, there can be indicated such as the level of electricity prices, the prices of electricity distribution, as well as the insolation condition. Despite the fact that energy prices for households in Poland are subsidised, they are constantly growing [8,76]. As a result, the homeowners who use more due to various systems (e.g., family farms) have greater economic benefits from using PV.

The research results have confirmed the hypotheses H7 and H8. Thus, both variables (perceived benefit and perceived risk) indirectly affect the intention of the photovoltaic installation. Importantly, the perceived economic benefits have the greatest positive impact on installation intention. Thus, the conclusions indicated by Santos [45] are confirmed by these findings. In the case of Poland, the value of PV installations is additionally supported by the support programs in the form of co-financing the PV installation from the European Union or domestic funds [4,77]. Some of these funds are dedicated to rural areas. The perceived value of a PV installation may also be increased by its declining cost and the possibility of obtaining income from selling surplus energy. This improves the ratio of expenditure to revenues.

The last of the hypotheses, H9, has also been confirmed (Figure 1). The perceived value affects the intention to purchase a photovoltaic installation. As expected, the perceived effect of using the installation determines its purchase, as are other studies on the impact of perceived value on the intention to purchase. This perceived value is greater for larger energy consumers, who often live in rural areas. They use the electricity for their own needs but also their family farm. They also have land for the location of slightly larger photovoltaic investments, which does not have to generate additional costs.

5. Conclusions

The development of PV installations is an issue that may combine the needs of individual consumers and the development factors of economies on a global, national or local scale. The impact of changes in the diversification of energy sources may contribute to changes in technical (development of technical infrastructure, innovation), economic (energy costs, new jobs) and improve the condition of the natural environment.

The objective of this study was to investigate the factors influencing the intention to install photovoltaics in the household. To achieve the set research goal, we collected data and used them to verify the proposed research model in this area. To the best of our knowledge, factors influencing the intention of PV installations in rural areas are not fully recognised. We believe that this issue deserves the interest of researchers also due to the largely untapped potential for PV installations in households as well as the European Union policy in the area of renewable energy sources.

The main finding shows that consumer innovativeness has the strongest impact on the intention to purchase a photovoltaic installation. The perceived value also affects the intention to purchase photovoltaic installation. The perceived value is affected by perceived economic benefits and indirectly by the subjective knowledge of PV. The surprising results of studies pointing to the negative impact of financial concerns on the intention to use a photovoltaic installation may be due to the greater sensitivity of rural residents to the possible negative ecological effects of PV installations. Currently, the issue of disposal of photovoltaic panels may be an important issue for potential customers. This issue seems vital because the lifetime of the panels is relatively short. The issue of disposal of PV panels can be treated as an important element of communication with customers. In rural areas, large solar farms can also be a concern by disturbing the natural landscape. The location of this type of farm should be regulated to a greater extent than just by the class of land on which farms are allowed to be located. It follows that consumers currently adopt a microeconomic perspective (the impact of installations on their immediate surroundings) and do not consider the macro perspective—improving the state of the natural environment in the country. This is important because Poland is one of the countries with very high environmental pollution and a dominant share of coal in energy production.

While encouraging the use of PV installations in rural areas, the economic benefits of such a solution should still be emphasised. The perceived value of PV installations increases along with the rising energy prices in the case of Polish households. Conclusions from the conducted research may indicate that communication may turn out to be a key element of the strategy for the development of photovoltaic systems in rural areas. Our results suggest that a well-disseminated information campaign must contain precise details on the economic benefits of PV (e.g., the sample calculation of energy cost reduction). Regarding environmental effects of PV, they should be presented in the context of the socio-economic framework since we found the indirect impact of environmental concern appeared to be positive and significant. What is more, to mitigate the perceived risk of PV evidence-based approach should be implemented in communication strategy. All government and local authority support/funding programs must be maintained as they increase the benefits of PV installations in rural areas.

Although the results of this study have useful implications, some limitations must be considered. These limitations offer three lines of further research. First, future research could extend empirical testing to these dependencies (the impact of environmental concerns as well as consumer innovativeness), which proved to be quite surprising and are not fully confirmed by the literature. The second limitation concerns the model specification. It seems necessary to incorporate other factors affecting the adoption of PV systems (e.g., PV system characteristics) into the research model. Finally, a limitation is the sample size and its composition. Although the sample consists of 521 respondents, there is a need to increase the sample size to improve the generalisability of the findings. It is worth noticing that the sample is limited to households located in rural areas. In order to conduct comparative analyses, it would be recommended to include respondents from the urban areas in future research.

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Appendix A

Latent Variables	Items
Environmental concern (EC) adapted from; Wung, Cao and Zhang [20]	EC1: I worry about air pollution. EC2: I am concerned about environmental problems. EC3: I think that environmental problems have become increasingly serious in recent years. EC4: I try to take care of the natural environment.
Consumer innovativeness (CI) adapted from Zhang et al. [25]	CI1: I know more about new ecological technologies than people around me. CI2: I eagerly reach for ecological products. CI3: I am interested in new energy-saving technologies. CI4: I believe that new green technologies are worth using.
Subjective knowledge on PV (SK) adapted from Dursun [34]	SK1: I know that photovoltaics is a good solution for obtaining energy from renewable sources (delated). SK2: I am interested in photovoltaics as a source of energy. SK3: I have much knowledge of photovoltaics. SK4: I have more knowledge about photovoltaics than the average person.
Perceived economic benefits of PV (PEB) adapted from Kim [47]	I'm able to save on energy expenses by installing photovoltaic panels. Nowadays, the installation of a photovoltaic installation is economically advantageous. Using photovoltaic installation could reduce my energy expenses. Taking into account financial support, the photovoltaic installation is financially beneficial.
Perceived risk (PR) adapted from Park et al. [78]	PR1: I believe that installing photovoltaics requires much effort. PR2: Using photovoltaic installation can cause problems. PR3: I perceive the installation of photovoltaics as risky. PR4: I am concerned that installing photovoltaics might be difficult.
Perceived value (PV) adapted from Oyedele et al. [79]	PV1: Installation of the photovoltaic system is cost-effective. PV2: Considering the benefits and costs, a photovoltaic installation is profitable. PV3: Production of energy from the photovoltaic system is more advantageous than buying it from the energy supplier. PV4: Considering the advantages and disadvantages, a photovoltaic installation is valuable.
Use intention of PV (UI) adapted from Li et al. [22]	UI1: I'm going to set up a photovoltaic installation in the near future. UI2: There is a high probability that I will install photovoltaics. UI3: Most likely, I will be installing a photovoltaic installation. UI4: I plan to use energy from a photovoltaic installation.

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