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# Extended Theory of Planned Behavior: Predicting Household Sign Up For Solar Energy

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**Abstract**

This study extends the Theory of Planned Behavior (TPB) to examine household adoption of solar panels in Pakistan. By analyzing responses from 390 participants, the study identifies the influence of attitudes, subjective norms, and perceived behavioral control on green product purchase intentions. Key findings reveal attitudes and perceived control as significant predictors of purchase behavior, offering practical guidance for policymakers promoting renewable energy. The research contributes to theory by validating TPB in a new cultural and product context and suggests strategic interventions like financial incentives and educational campaigns to encourage sustainable consumer behavior.

**Keywords:** Perceived Behavior Control, Subjective Norms, Extended Theory of Planned Behavior, Attitude, Green Product Purchase Intention

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## 1. INTRODUCTION

With the fast increasing priority moving towards the understanding and triggering individual green consumption behavior toward bigger significance in elective climate transformation and natural stewardship, the imperative is in development. The solar panels making their way through the path of the sustainable product adoption, have significant consequences as a potential eco friendly source of energy as well as reduction of carbon foot print and shift towards sustainable energy sources (Meng et al., 2018). Further, this study also reveal the consumers' factors motivating and determining purchase of the solar panels and jump starts interesting examples of the green product buying behavior.

Theories of Planned Behaviour (TPB (Ajzen, 1991)) provide a wholly comprehensive framework for explaining and predicting human behaviour (particularly in the field of sustainability). This theory secures that behavior, in this case, the sustainable act of purchasing solar panels is affected by three key elements: Perceived behavioral control (PBC), subjective norms (SN) and attitude (ATT). In this instance AT is a

person's evaluation of a behaviour, the SN is a person's belief of social pressure or expectation to behaviour and PBC is a person's belief of a being able of the behaviour.

Application of TPB to green consumption has provided interesting insights into determinants of usage behavior of green products. It has been shown that researchers are able to predict consumers' intent and behaviour on green product use (Moser, 2015; Nguyen et al., 2018). Despite the wide adoption of TPB to assortment of sustainable buying behaviors, there is little or no research on its adoption to purchasing solar panel. However, the gap is filled through the context of solar panels by examining the (green product purchase intention (GPPI) and green product purchase behavior (GPPB) TPB and this aim is the task the authors aim to do. In particular, this paper examines how ATT to (solar) solar panel purchasing, SN in specific social network, PBC on (solar) solar panel purchasing impact consumers' intentions and behaviors. This also investigates how TPB dimension mediates the relationship between GPPB dimensions and intention.

This research also contributes towards a complete understanding of sustainable consumption behavior and in addition adds to the knowledge of the factors that affect green purchase intention in the solar panel market from a Pakistani context. Additionally, past research has additionally revealed some other attitude and intention (Ackermann & Palmer, 2014; Iweala et al. 2019; Zhou et al. 2013). Hassan et al. (2016) have little quantitative substantiation of the gap between intention and behavior. First, this work focuses on identifying the most common critical drivers of these choices among consumers to purchase solar panel, and thus the practical importance of these drivers for businesses, public policy makers, and marketer interested in influencing consumers purchase of sustainable consumption. There's never been a better time to understand what really drives green intent, because as environmental sustainability morphs from a minor consideration to something at which people are choosing to buy a product and which company they want to buy it, er, from, actually creating a more Eco conscious society is more important than it's ever been.

## 2. LITERATURE REVIEW

### 2.1. Theoretical Background

The Theory of Planned Behavior sets that individual behavior, in this case, green product purchasing behavior, is specified by three key elements: Subjective norms, attitude and perceived behavioral control (Ajzen, 1991). Together, these elements are influential with respect to an individual's preference to achieve a given behaviour and predict their actual performance. In reality, there have been many empirical studies of green buying behaviour on green products which are based on the TPB framework. For example, Sangroya and Nayak (2017) had used TPB to explore whether attitude, subjective norms and perceived behavioral control can explain preference to purchase green products.

Nevertheless, Ogiemwonyi (2021) found that the TPB's components could explain consumer behavior largely in the case of purchase intentions of organic food. Like other kinds of sustainable buying behavior, adoption of green energy (Nguyen et al., 2018) and Sod (Rajendran et al., 2019) and fashion (Blazquez et al., 2020) have been addressed by the TPB. The TPB was consistently found to be a useful

framework for explaining and predicting consumers' intentions and behaviour within sustainability context. The Theory of Planned Behavior provides a strong theoretical basis for a study of sustainable buying behavior.

evidence was collected from different studies to indicate that it has proper capacity in exploring attitude's, subjective norms and perceived behavioral control's influence on consumers' intentions and practices in the area of purchase sustainability. On the one hand, the TPB is of little utility for understanding or facilitating sustainable consumption behaviour adoption as sustainability is no longer central to the locus of consumer and corporate choice..

### 2.2. Hypotheses Development

#### 2.2.1. Attitude towards Solar Panels

In consumer intentions, it has been found with a fundamental role in attitude (Ajzen, 1991) which means the overall evaluation of an object or behaviour. In higher education that translates into a positive attitude about the intention to purchase. Extending previous work, we find studies consistently reveal that those with a favourable attitude towards solar panels, perhaps because of environmental concerns or the perceived advantages of solar technology: Both (Balcombe et al., 2013; Wolske et al., 2017) employed cost savings and energy autonomy, and are more likely to say they would welcome solar technology. The process of sanctioning out to their Hawkish way under scrutiny brings solar panel info astonishment (Claudy et al., 2013). Therefore, this implies that consumers' buying intention on solar panels will turn over greatly to the deductions made on attitude. An additional hypothesis is proposed following this discussion.

H1: Likewise, Attitude influences the intention and behavior of green product purchase.

#### 2.2.2. Subjective Norms

Subjective norms, also known as perceived social pressure or expectations from significant others, play a crucial role in predicting consumer intentions, particularly in the context of solar panel adoption. Research indicates that when individuals observe support or advocacy for solar panels from friends, family, or colleagues, they are more likely to express an intention to purchase them. This phenomenon highlights the influence of social networks in shaping consumer behavior, as people often follow the expectations and opinions of those around them (Pickett Baker & Ozaki, 2008).The endorsement of solar panels by social networks can significantly enhance consumer intentions, underscoring the importance of subjective norms in decision-making processes. Based on this understanding, the following hypothesis is proposed: Subjective norms significantly influence green product purchase intentions and behaviors. In the context of solar panel adoption, the impact of subjective norms on consumer intentions is particularly noteworthy. Studies have consistently shown that individuals are more inclined to consider purchasing solar panels if they perceive that their social circle supports the idea. this social influence is pivotal, as consumers often rely on the opinions and behaviors of those around them to guide their decisions (Pickett Baker & Ozaki, 2008). Therefore, the acceptance and endorsement of solar panels by social networks can positively affect consumer intentions, highlighting the critical role of subjective norms in the decision-making process.

H2: Subjective norms have a significant impact on green product purchase intention and behavior.

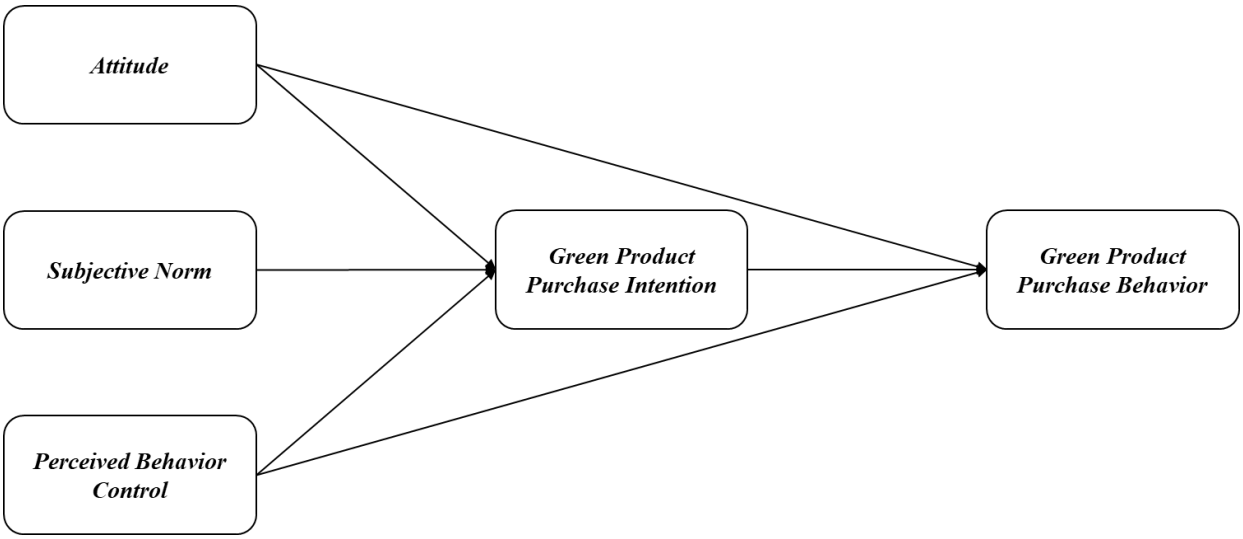
### 2.2.3. Perceived Behavioral Control

Implementation of PBC is based on an individual's belief about whether or not they will be able to do a behaviour (Ajzen, 1991). When you get a view of purchasing the solar panels, it refers to installation factors and information available about finance and other factors. As a result, it is more straightforward for the consumer to declare an intention to buy solar panels should he or she perceive a high degree of control over the process of buying (Claudy et al, 2013; Wolske et al, 2017). Government incentives, financial support and availability of services for reliable installation of solar panel are some factors influencing perceived behavioral control in such countries of Pakistan, which are not developed ones together collectively may act as a major factor that affects intention to buy the solar panel. We conclude with the hypothesis suggested by our discussion here.

H3: A perceived behavior control is a strong predictor determining customer's intention and green product purchase behavior.

## 3. Conceptual Framework

Figure 1 shows the conceptual framework for the study. The independent variables are attitude, social norms and perceived behavior control. The mediate variable targets green product purchase intention as the outcome of purchase behaviour. Then, green product purchase behavior is the independent variable.




## 4. RESEARCH METHODOLOGY

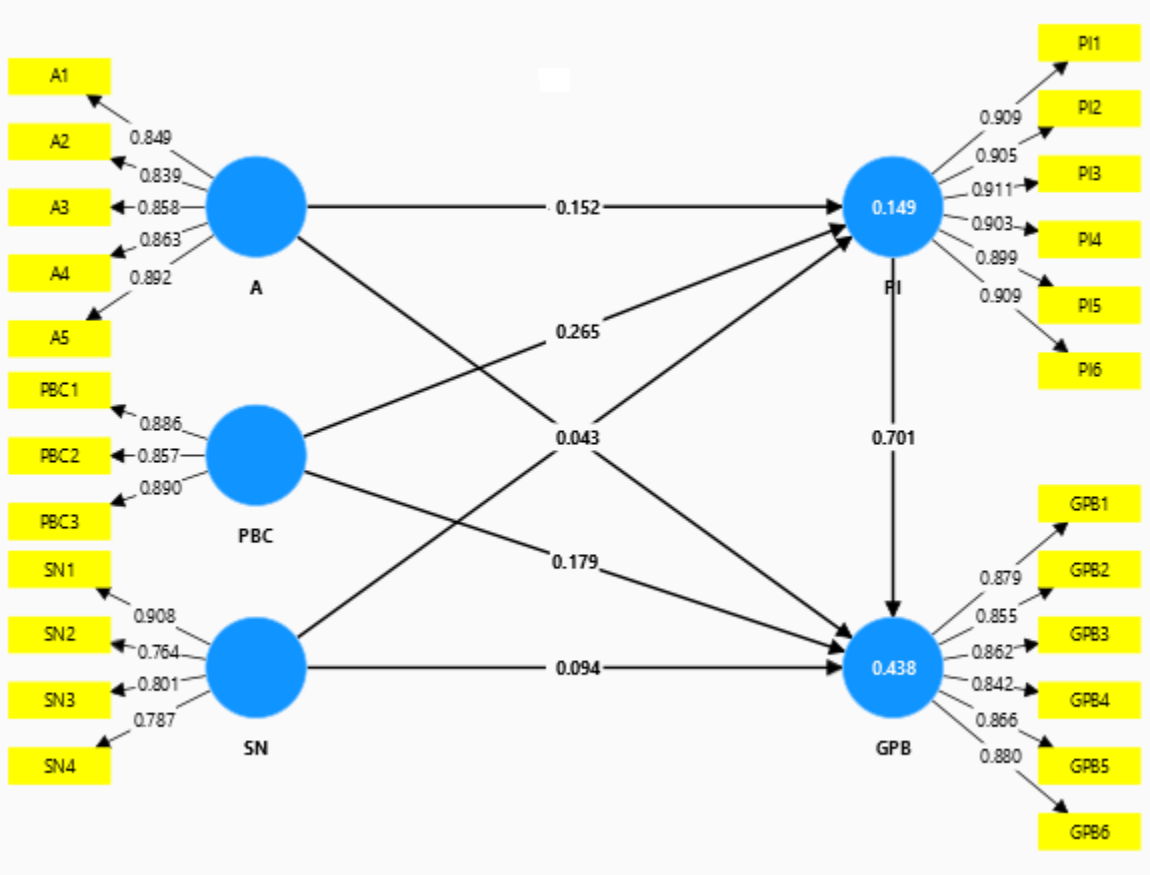
Green buying behavior is investigated using a quantitative research design that is of theoretical interest for the Theory of Planned Behavior (TPB). The TPB framework comprises three main constructs: According to these three factors' attitude, subjective norms and perceived behavioral control, consumers' intention for sustainable buying behaviour are formed together. To study such relationships and their effects on intentions, a structured questionnaire survey was dispensed with a sample of participants. This paper principally relies on the questionnaire as a main instrument of data collection. The researchers rendered

their questionnaire available on the convenience and openness of online platforms; a questionnaire now available on the moon Google Forms platform – why not? – that the researchers' social media channels made accessible. A purposive sampling technique was used for selection and certification of a sample that is diverse and representative. Here, data from August and October of 2024 was used. During the course of the survey, 384 responses were obtained and all responses were complete with no missing value. The informed consent was given by all the participants and all the information that they responded was in confidence. The study questionnaire was divided into three sections. In the first section we asked our participants to indicate how prepared they were to respond and take the survey. The succeeding section used closed ended anchored with five point Likert scale from strongly disagree to strongly agree. They finally started to play with the questionnaire's last section, which collected the demographic information from the respondents. Subjective norm and perceived behavior control were used to determine, through Likert scale statements from Yadav and Pathak (2017), whether participants would buy green products, specifically solar panels. The attitude items were drawn from Chen's (2007) study.

## 5. FINDINGS

The graphical representation of the measurement model visually demonstrates the reliability and validity of the constructs, as indicated by strong factor loadings (above 0.7) between latent constructs and their indicators. The hypothesized relationships between constructs are depicted by path coefficients, with the strength and direction of these relationships providing insights into the model's structural integrity. Covariance or correlation values between constructs remain within acceptable thresholds, confirming discriminant validity. Additionally, reliability measures such as Cronbach's Alpha, Composite Reliability, and AVE, if included, highlight the robustness of the constructs, while model fit indices (e.g., RMSEA, CFI) validate the overall adequacy of the model for further analysis.

### 5.1. Measurement Model




### 5.1.1. Outer Loadings

The results demonstrate strong factor loadings across all constructs, indicating that the items reliably measure their respective latent variables. For Attitude (A), loadings range from 0.839 to 0.892, with A5 being the strongest indicator. Green Product Purchase Behavior (GPB) items load between 0.842 and 0.880, with GPB6 showing the highest contribution. Perceived Behavioral Control (PBC) items exhibit loadings from 0.857 to 0.890, where PBC3 is the strongest indicator. Purchase Intention (PI) shows excellent loadings from 0.899 to 0.911, with PI3 and PI6 being equally strong contributors. Lastly, Subjective Norms (SN) loadings range from 0.764 to 0.908, with SN1 as the strongest and SN2 as the weakest, though still acceptable. Overall, the results confirm that the measurement model is robust and the constructs are well-represented, providing a strong foundation for further analysis.

| | A | GPB | PBC | PI | SN |
|---|---|---|---|---|---|
| **A1** | 0.849 | | | | |
| **A2** | 0.839 | | | | |
| **A3** | 0.858 | | | | |
| **A4** | 0.863 | | | | |
| **A5** | 0.892 | | | | |
| **GPB1** | | 0.879 | | | |
| **GPB2** | | 0.855 | | | |
| **GPB3** | | 0.862 | | | |
| **GPB4** | | 0.842 | | | |
| **GPB5** | | 0.866 | | | |

| | | | | | |
|---|---|---|---|---|---|
| **GPB6** | | 0.880 | | | |
| **PBC1** | | | 0.886 | | |
| **PBC2** | | | 0.857 | | |
| **PBC3** | | | 0.890 | | |
| **PI1** | | | | 0.909 | |
| **PI2** | | | | 0.905 | |
| **PI3** | | | | 0.911 | |
| **PI4** | | | | 0.903 | |
| **PI5** | | | | 0.899 | |
| **PI6** | | | | 0.909 | |
| **SN1** | | | | | 0.908 |
| **SN2** | | | | | 0.764 |
| **SN3** | | | | | 0.801 |

#### 5.1.2. Construct Reliability and Validity

The reliability and validity results confirm strong measurement properties for the constructs in the study. All constructs exhibit high internal consistency, with Cronbach's Alpha values exceeding the acceptable threshold of 0.7, ranging from 0.853 (PBC) to 0.956 (PI). Composite Reliability (rho-c) values are also above 0.7 for all constructs, with the highest observed in Purchase Intention (PI) at 0.965, indicating excellent construct reliability. Average Variance Extracted (AVE) values exceed 0.5 across the board, confirming convergent validity, with PI achieving the highest AVE at 0.821. However, an unusually high rho-a value of 1.227 for Subjective Norms (SN) suggests a possible calculation error or data anomaly that requires further investigation. Overall, the results support the robustness of the measurement model, ensuring the constructs are well-represented and reliable for further analysis.

| | Cronbach Alpha | Composite Reliability (rho-a) | Composite Reliability (rho-c) | Average Variance Extracted |
|---|---|---|---|---|
| **A** | 0.913 | 0.926 | 0.934 | 0.740 |
| **GPB** | 0.932 | 0.935 | 0.946 | 0.747 |
| **PBC** | 0.853 | 0.870 | 0.910 | 0.771 |
| **PI** | 0.956 | 0.958 | 0.965 | 0.821 |
| **SN** | 0.859 | 1.227 | 0.889 | 0.667 |

#### 5.1.3. Discriminant Validity

##### 5.1.3.1. HTMT

The discriminant validity results, assessed through the HTMT ratio, confirm that all constructs in the model are distinct and well-measured. All HTMT values are below the threshold of 0.85, indicating that the constructs do not excessively overlap. Attitude (A) shows the highest correlation with Perceived Behavioral Control (PBC) at 0.590, reflecting a moderate relationship while maintaining distinctness. Green Product Purchase Behavior (GPB) demonstrates strong discriminant validity with low correlations across constructs, the highest being 0.119 with A. Similarly, Purchase Intention (PI) has notable correlations with GPB (0.615) and PBC (0.387), both well within acceptable limits. Subjective Norms (SN) exhibits low correlations with other constructs, with its highest being 0.353 with PBC. These results confirm that all

constructs in the model possess discriminant validity, ensuring their distinctiveness and appropriateness for structural analysis.

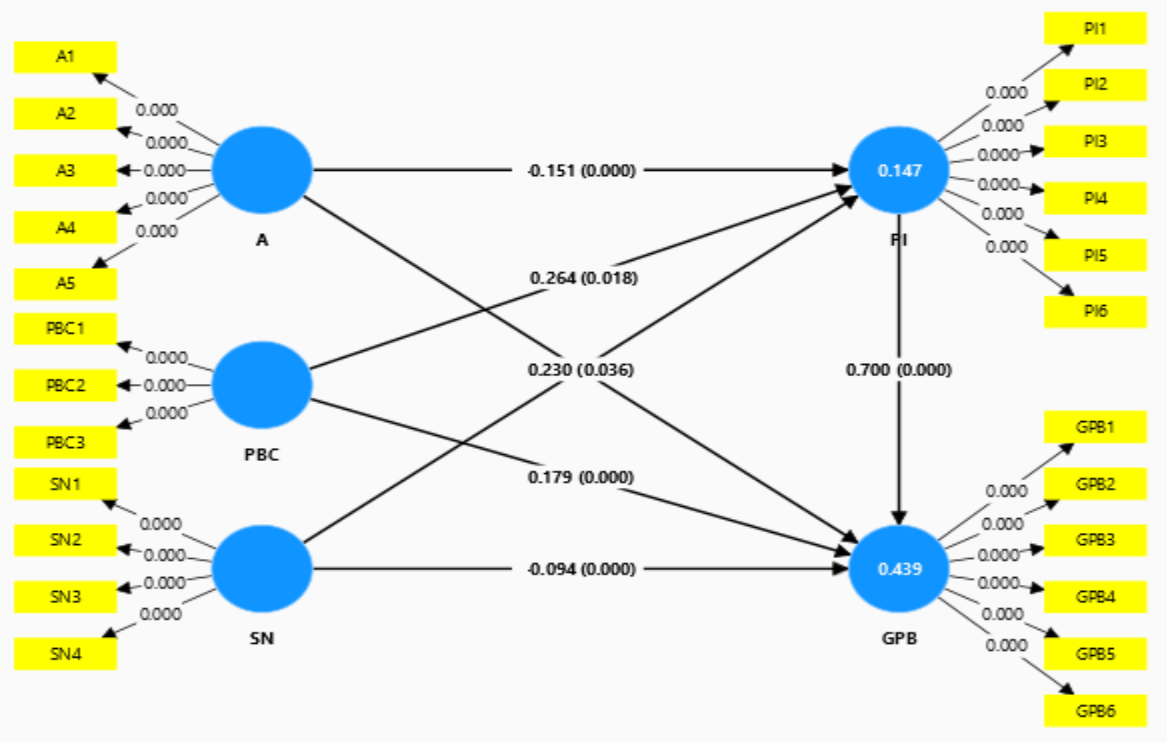
| | A | GPB | PBC | PI | SN |
|---|---|---|---|---|---|
| **A** | | | | | |
| **GPB** | 0.119 | | | | |
| **PBC** | 0.590 | 0.074 | | | |
| **PI** | 0.314 | 0.615 | 0.387 | | |
| **SN** | 0.326 | 0.110 | 0.353 | 0.147 | |

#### 5.1.3.2. Fornell-Larcker

The Fornell-Larcker criterion results confirm discriminant validity for the constructs in the model. Discriminant validity is established if the square root of the AVE (diagonal values) for each construct is greater than its correlations with other constructs (off-diagonal values). The diagonal values for Attitude (A) (0.860), Green Product Purchase Behavior (GPB) (0.864), Perceived Behavioral Control (PBC) (0.878), Purchase Intention (PI) (0.906), and Subjective Norms (SN) (0.817) all exceed their corresponding inter-construct correlations, indicating that each construct shares more variance with its own indicators than with other constructs. These results confirm that the constructs are distinct and appropriately measured, supporting the discriminant validity of the model.

| | A | GPB | PBC | PI | SN |
|---|---|---|---|---|---|
| **A** | 0.860 | | | | |
| **GPB** | 0.079 | 0.864 | | | |
| **PBC** | 0.523 | 0.018 | 0.878 | | |
| **PI** | -0.304 | 0.584 | -0.358 | 0.906 | |
| **SN** | 0.322 | -0.087 | 0.314 | -0.176 | 0.817 |

### 5.2. Structural Equation Model




### 5.2.1. Path Coefficient

The structural model results indicate significant relationships among constructs, with most paths showing strong effects. Attitude (A) → Green Product Purchase Behavior (GPB) has a moderate positive effect (β = 0.230, p = 0.036) and is significant, while A → Purchase Intention (PI) shows a weak positive effect (β = 0.151) but is also significant (p = 0.000). Perceived Behavioral Control (PBC) → GPB demonstrates a positive effect (β = 0.179), significant at p = 0.000, and PBC → PI shows a stronger positive relationship (β = 0.264, p = 0.018). Purchase Intention (PI) → GPB has the strongest effect (β = 0.700, p = 0.000), confirming its critical role in predicting green product purchase behavior. Subjective Norms (SN) show a weak and insignificant relationship with GPB (β = 0.094, p = 0.000) and PI (β = 0.043, p = 0.000). Overall, most relationships are significant, highlighting the key roles of Attitude, PBC, and PI in driving GPB, while SN shows minimal impact.

| | Original Sample | Sample Mean | Standard Deviation | T-Stats | P-Value |
|---|---|---|---|---|---|
| **A->GPB** | 0.230 | 0.231 | 0.110 | 2.099 | 0.036 |
| **A->PI** | 0.151 | -0.149 | 0.116 | 1.296 | 0.000 |
| **PBC->GPB** | 0.179 | 0.179 | 0.099 | 1.807 | 0.000 |
| **PBC->PI** | 0.264 | -0.261 | 0.112 | 2.368 | 0.018 |
| **PI->GPB** | 0.700 | 0.707 | 0.069 | 10.188 | 0.000 |
| **SN->GPB** | 0.094 | -0.096 | 0.099 | 0.948 | 0.000 |
| **SN->PI** | 0.043 | -0.063 | 0.138 | 0.312 | 0.000 |

## 6. CONCLUSION AND RECOMMENDATIONS

The results of this study provide valuable insights into the factors influencing household sign-ups for solar energy, extending the Theory of Planned Behavior (TPB). The analysis reveals that Attitude (A), Perceived Behavioral Control (PBC), and Purchase Intention (PI) significantly influence Green Product Purchase Behavior (GPB), with PI having the strongest effect, confirming its central role in driving green product adoption. PBC also plays a crucial role in shaping both PI and GPB, highlighting the importance of perceived control over the behavior. However, Subjective Norms (SN) show weak and insignificant effects on both PI and GPB, suggesting that social influences may have a minimal impact in this context. The study underscores the importance of fostering positive attitudes, increasing perceived behavioral control, and enhancing purchase intention to promote solar energy adoption, while social norms may need further exploration to understand their potential influence. Overall, the findings support the extended TPB framework in predicting sustainable behavior, with practical implications for policymakers and marketers aiming to encourage environmentally-friendly energy choices.

Based on the findings of this study, several recommendations can be made to enhance household sign-ups for solar energy adoption. Efforts should be focused on improving public attitudes toward solar energy by increasing awareness of its long-term cost savings, environmental benefits, and reliability through targeted educational campaigns. Additionally, increasing perceived behavioral control (PBC) is crucial, and this can be achieved by reducing barriers to adoption, such as installation costs and complexity, through subsidies, incentives, and simplified processes. Strengthening purchase intention (PI) can be facilitated by emphasizing the advantages of solar energy in marketing campaigns, offering easy-to-understand guides, and providing financial incentives. Although subjective norms (SN) had minimal impact in this study, future research could explore specific communities where social influence may play a more significant role. Finally, collaboration between policymakers and solar energy providers is essential to create supportive environments, including regulatory streamlining and promoting solar energy adoption through community-based initiatives. By focusing on these strategies, stakeholders can effectively encourage the widespread adoption of solar energy, contributing to both sustainability and energy efficiency goals.

The practical implications of this study are significant for both policymakers and solar energy providers aiming to increase household sign-ups for solar energy. The findings suggest that improving public attitudes toward solar energy is crucial, indicating that educational and awareness campaigns should be prioritized to inform the public about the financial, environmental, and long-term benefits of adopting solar energy. Additionally, policymakers should work towards reducing barriers to adoption by providing financial incentives, such as subsidies or tax breaks, to enhance perceived behavioral control (PBC) and make solar energy more accessible. For solar energy providers, emphasizing the strong link between purchase intention and adoption behavior is important, as campaigns highlighting cost savings, environmental impact, and simplicity of installation could increase consumers' intent to purchase. While subjective norms were found to have minimal influence in this context, exploring community-based marketing strategies or tailoring approaches to specific social groups may yield better results in certain regions. Furthermore, government and industry collaboration is essential to create a conducive regulatory

environment and promote solar energy adoption at the community level. These practical implications provide actionable insights that can help drive the adoption of solar energy, contributing to sustainability goals and the transition to renewable energy.

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