

Household Solar Photovoltaic Adoption in Rural China: Feasibility, Affordability, and Institutional Dimensions of Energy Transitions

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Abstract

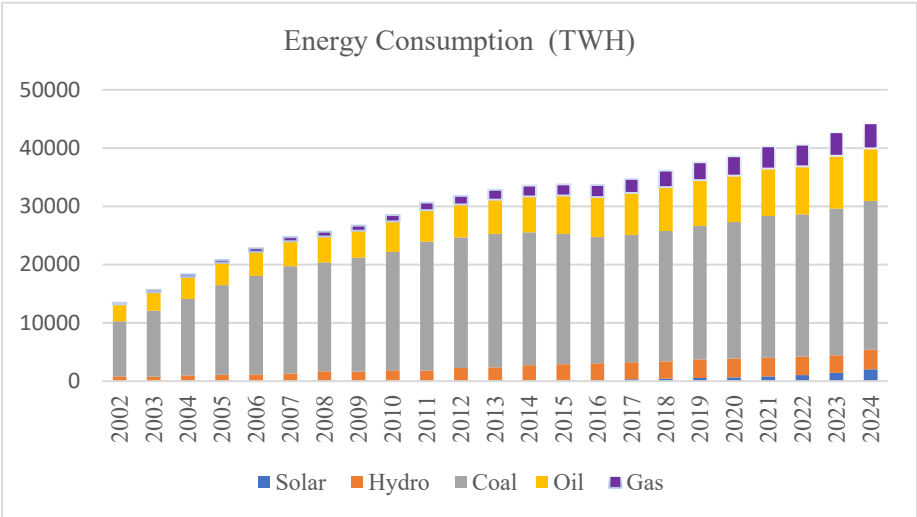
Despite China's rapid expansion of renewable energy, household solar photovoltaic (PV) adoption in rural areas remains uneven, reflecting a persistent gap between policy ambitions and household-level energy access. This study develops an integrated framework combining the Theory of Planned Behavior, Technology Acceptance Model, and Diffusion of Innovations to examine household adoption decisions, with particular emphasis on perceived affordability. Survey data from 568 rural households were analyzed using partial least squares structural equation modeling. The model explains a substantial proportion of variance in adoption intention ($R^2 = 0.895$). Perceived behavioral control shows the strongest association with adoption intention, followed by affordability, while social influence, perceived usefulness, and attitude are also significant; perceived ease of use is not. Indirect analysis highlights the roles of feasibility and financial clarity in shaping adoption decisions. The findings underscore the importance of accessibility, institutional support, and financial feasibility in enabling inclusive participation in decentralized energy systems and advancing sustainable development.

Keywords: Solar photovoltaic; Rural China; TPB; TAM; DOI; Perceived affordability; SDG 7; SDG 13

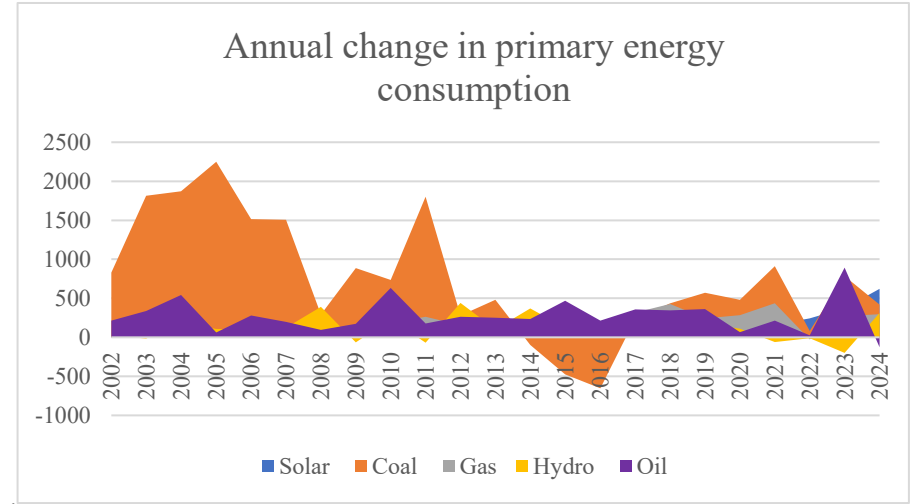
1. Introduction

Climate change remains a critical global challenge, largely driven by a continued reliance on fossil fuels, which account for the majority of global greenhouse gas emissions (Intergovernmental Panel on Climate, 2023). Rising temperatures, the increasing frequency of extreme weather events, and accelerating ecosystem degradation underscore the urgency of transitioning toward low-carbon energy systems (Intergovernmental Panel on Climate, 2023; Sovacool et al., 2021). Expanding access to affordable and clean energy is therefore central to sustainable development, particularly under Sustainable Development Goals 7 (Affordable and Clean Energy) and 13 (Climate Action) (Agency, I.E., 2023; Nations, 2015).

China occupies a central role in this global transition. Over the past two decades, it has emerged as the world's largest installer of renewable energy capacity, with solar photovoltaic (PV) systems forming a cornerstone of its national decarbonization strategy (Agency, I.R.E., 2023). As illustrated in Figure 1, China's total primary energy consumption has increased steadily from 2002 to 2024; while coal remains dominant, the share of renewables has gradually expanded. Figure 2 shows that the growth in fossil energy consumption has slowed as renewable energy gains momentum. Furthermore, Figure 3 highlights the rapid expansion of installed solar capacity, driven by robust policy support and declining technological costs. These trends reflect large-scale progress in renewable deployment alongside persistent structural challenges in the energy transition process.



Source: World Bank (2024)
 Figure 1. China's energy mix from 2002 to 2024



Source: World Bank (2024).
 Figure 2. Changes in China's primary energy consumption, 2002–2024.

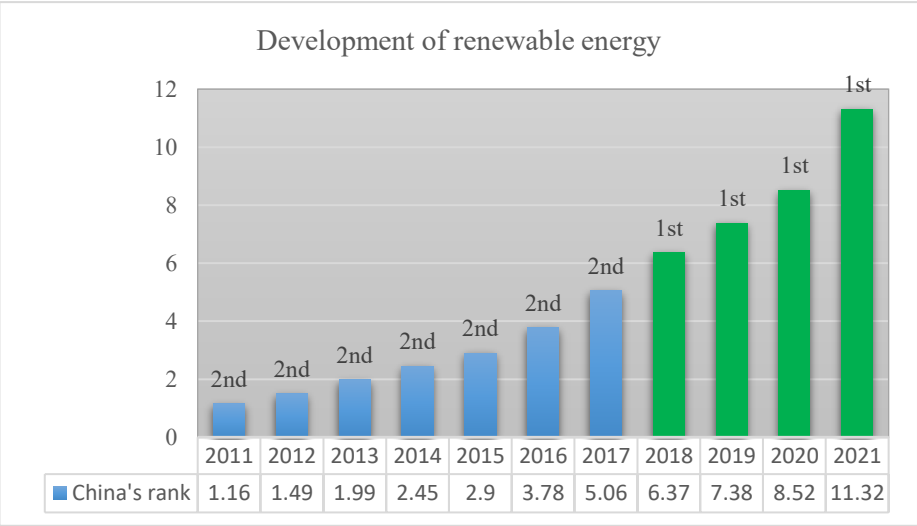


Figure 3. Renewable energy growth in China. For context, this data is from BP's Global Energy Statistics Report. One way to assess the strength of renewable energy sources is to examine China's share of global energy consumption.

In rural contexts, household rooftop solar PV systems are promoted not only for emission reduction but also for income diversification, energy access, and rural revitalization. Policy initiatives, including PV-based poverty alleviation programs, aim to enhance household income while supporting national climate goals (Liu et al., 2024; Yang et al., 2023). However, adoption outcomes remain uneven. While certain regions report high participation rates, many households remain hesitant or excluded, even where infrastructure and subsidies are available. This discrepancy between national expansion and localized uptake reflects a persistent "adoption gap" in rural China. Figure 4 conceptually illustrates how household rooftop solar PV reduces fossil-fuel CO₂ emissions, thereby linking micro-level adoption to broader climate mitigation outcomes.

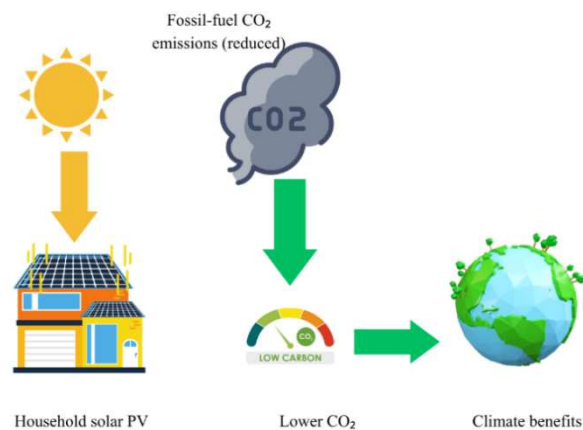


Figure 4. Conceptual illustration of how household rooftop solar PV reduces fossil-fuel CO₂ emissions and supports climate benefits

Source: Authors' construction

A growing body of research examines the behavioral, social, and economic factors influencing household solar PV adoption. In rural China, attitudes toward PV, perceived financial benefits, and perceived institutional support shape adoption intentions, particularly among lower-income households (Alam et al., 2014; Irfan et al., 2021; Wu et al., 2023). Social dynamics also influence decisions, as adoption is shaped by social learning, information transmission, peer interaction, and community-based diffusion processes, reflecting the collective nature of decision-making in rural settings (Liu et al., 2023; Noll et al., 2014; Wang et al., 2023). Evidence from other contexts likewise shows that localized peer effects and neighborhood visibility can accelerate residential solar uptake (Bollinger and Gillingham, 2012; Graziano and Gillingham, 2015). These patterns indicate that household energy transitions are embedded in both individual perceptions and community-level processes, with implications for inclusive and equitable access to clean energy.

From a theoretical perspective, these studies commonly draw on the Theory of Planned Behavior (Ajzen, 1991), the Technology Acceptance Model (Davis, 1989), and the Diffusion of Innovations (Rogers et al., 2003). TPB explains how attitudes, social influence, and perceived behavioral control shape intention and behavior (Ajzen, 1991, 2002). TAM emphasizes perceived usefulness and perceived ease of use as key determinants

of technology acceptance (Davis, 1989; Venkatesh and Davis, 2000). DOI provides a broader perspective on how innovations spread through social systems, highlighting factors such as relative advantage and observability (Rogers et al., 2003).

While widely applied, single-theory approaches often provide only partial explanations of household renewable energy adoption, as they tend to emphasize either behavioral, technological, or social dimensions in isolation. In rural contexts, adoption decisions are shaped by the interaction of these factors, alongside financial and institutional constraints (Curtius et al., 2018; Rai and Robinson, 2015). Importantly, economic considerations extend beyond direct cost barriers. Perceived affordability captures households' evaluation of financial feasibility relative to expected benefits, representing a dimension not fully reflected in constructs such as perceived usefulness or relative advantage (Afriyie et al., 2024; Liu et al., 2024; Owebor et al., 2025).

To address this limitation, this study develops an integrated TPB–TAM–DOI framework that distinguishes between perception-based factors (e.g., attitude, social influence, perceived usefulness) and feasibility-based factors (e.g., perceived behavioral control and perceived affordability). By explicitly conceptualizing affordability as a core economic construct, the framework provides a more precise explanation of how households evaluate both expected benefits and practical feasibility under real-world constraints.

The study therefore aims to: (1) assess the explanatory power of the integrated framework in capturing rural households' solar PV adoption intention; (2) examine the indirect roles of perceived behavioral control and perceived affordability as feasibility-related pathways; and (3) provide policy-relevant insights to support inclusive and sustainable rural energy transitions.

The rest of the paper is organized as follows. Section 2 reviews the theoretical background and formulates the research hypotheses. Section 3 describes the research methodology and data. Section 4 presents the empirical results. Section 5 discusses the theoretical and policy implications, and Section 6 concludes with limitations and suggestions for future research.

2. Literature Review

2.1. Theory of Planned Behavior

The Theory of Planned Behavior provides a widely used framework for understanding how individual perceptions are associated with behavioral intention. According to this theory, intention is shaped by three core components: attitude, social influence, and perceived behavioral control (Ajzen, 1991; Fishbein and Ajzen, 2010). In the context of renewable energy adoption, TPB has been extensively applied to explain how households evaluate and respond to low-carbon technologies such as solar photovoltaic systems. Empirical evidence consistently shows that favorable evaluations of solar PV, supportive social environments, and a stronger sense of perceived capability are associated with higher levels of adoption intention (Alam et al., 2014; Irfan et al., 2021; Wang et al., 2023)). This perspective is particularly relevant in rural China, where household decisions are not shaped solely by individual preferences but are embedded within broader socio-economic conditions, including income constraints, institutional arrangements, and dense community interactions.

2.1.1. Attitude

Within the Theory of Planned Behavior, attitude refers to the degree to which individuals evaluate a behavior positively or negatively (Ajzen, 1991). In the context of household solar PV adoption, it reflects households' perceptions of environmental value, reliability, and economic benefits, including long-term savings and energy security. Empirical evidence indicates that more favorable attitudes toward renewable energy are positively associated with adoption intention, particularly when solar PV is perceived as useful

and economically viable (Alam et al., 2014; Rai and Robinson, 2015). In rural China, this relationship highlights how positive evaluations support both environmental improvement and local economic resilience, contributing to the gradual normalization of solar PV within everyday energy practices.

H1: Attitude toward household solar PV is positively associated with rural households' adoption intention.

2.1.2. Social Influence

Social influence, derived from the Theory of Planned Behavior, refers to the extent to which individuals perceive that important others expect or support a behavior (Ajzen, 1991). In rural contexts, it reflects broader community dynamics such as peer interaction, shared experiences, and local leadership. Nearby installations, social networks, and trust in local actors often shape household decisions regarding solar PV. Empirical evidence shows that solar adoption tends to cluster within communities, indicating that visibility and social learning are associated with adoption intention (Curtius et al., 2018; De Groote and Verboven, 2019; Rai and Robinson, 2015). In rural China, where social ties are strong and information flows through informal channels, these dynamics are particularly relevant. As a result, solar PV adoption can be understood as a socially embedded process shaped by community norms and local interactions. Thus, we expect that stronger perceived social support for solar PV will lead to higher adoption decisions.

H2: Social influence is positively associated with rural households' adoption intention for household solar PV.

2.1.3. Perceived behavioral control

Perceived behavioral control refers to the extent to which individuals believe they have the resources, knowledge, and ability required to perform a behavior (Ajzen, 1991, 2002). In the context of solar PV adoption, this includes households' perceived ability to manage costs, access financial support, navigate installation procedures, and maintain the system. Empirical evidence indicates that higher perceived behavioral control is positively associated with adoption intention, particularly where access to information and institutional support is uneven (Afriyie et al., 2024; Alam et al., 2014; Wang et al., 2023). In rural China, this construct reflects both individual confidence and broader perceptions of feasibility under local constraints. Households are more likely to consider solar PV when they perceive the adoption process as manageable, highlighting perceived capability as an important condition for wider participation in sustainable energy transitions. In that regard, it is hypothesized that.

H3: Perceived behavioral control has a positive relationship with rural households' adoption intention for household solar PV.

2.2. Technology Acceptance Model

The Technology Acceptance Model provides a complementary perspective by focusing on how individuals evaluate technology-specific attributes before forming an intention to use it. The model emphasizes two core perceptions: perceived usefulness and perceived ease of use (Davis, 1989). Perceived usefulness captures the extent to which a technology is expected to improve outcomes, while perceived ease of use reflects the extent to which it is considered simple to understand and operate. Extensions of the model allow these perceptions to be directly associated with behavioral intention (Venkatesh and Davis, 2000; Venkatesh et al., 2012). In the context of renewable energy, TAM has been widely applied to examine how households assess the practical value and usability of technologies such as solar PV systems (Irfan et al., 2021; Masukujaman et al., 2021)

2.2.1. Perceived usefulness

Perceived usefulness reflects households' expectations that solar PV will provide tangible benefits, including reduced electricity costs, improved energy reliability, and potential financial returns. Empirical evidence indicates that when these benefits are clearly perceived, stronger adoption intention is observed (Curtius et al., 2018; Irfan et al., 2021; Liu et al., 2023). In rural China, perceived usefulness is closely linked to livelihood considerations, as households evaluate solar PV based on its contribution to income stability and energy security. When technology aligns with household needs, it becomes more attractive as an investment, underscoring the importance of linking technological benefits to local development priorities. As a result, the following is proposed.

H4: Perceived usefulness is positively related to rural households' adoption intention for household solar PV.

2.2.2. Perceived ease of use

Perceived ease of use refers to the extent to which a technology is considered easy to understand, operate, and manage (Davis, 1989). In rural settings, it depends on access to technical support, installer services, and community-based knowledge sharing. Empirical evidence indicates that ease of use is positively associated with renewable energy adoption, although it is often less influential than economic and social factors (Curtius et al., 2018; Schulte et al., 2022). In rural China, support programs and peer-based learning can reduce perceived complexity, allowing households to rely on external assistance. As a result, ease of use plays a supporting rather than central role in shaping adoption intention. Therefore, it is speculated that

H5: There is a significant positive relationship between perceived ease of use and intention to adopt solar PV.

2.3. Theoretical Integration: TPB, TAM, and DOI

This study integrates TPB, TAM, and selected DOI dimensions to provide a comprehensive explanation of rural household solar PV adoption. TPB highlights how attitude, social influence, and perceived behavioral control shape Willingness to adopt by capturing villagers' psychological readiness, normative expectations, and perceived capability in resource-constrained settings (Ajzen, 1991). TAM complements this perspective by emphasizing technology-related beliefs, perceived usefulness, and perceived ease of use, which influence expectations of performance benefits and operational simplicity (Davis, 1989). DOI theory offers a system-level perspective by examining how innovation attributes, including relative advantage, compatibility, complexity, and observability, influence adoption (Rogers et al., 2003). In this framework, complexity is reflected through PEOU, while perceived affordability represents the economic aspect of relative advantage. Observability operates indirectly through social influence as households learn from visible installations and peer experiences. Together, these theories combine behavioral, technological, and innovation-diffusion factors to deliver a more holistic explanation of solar PV adoption than any single model alone.

2.3.1. Perceived Affordability

Within this integrated framework, perceived affordability is treated as a central economic construct reflecting households' holistic evaluation of whether adopting solar PV is financially feasible, accessible, and worthwhile under their prevailing circumstances. Rather than capturing a single cost comparison, it encompasses three interrelated facets, perceived cost burden, perceived access to subsidies and financing, and perceived economic returns [6, 30]. While related to the Diffusion of Innovations concept of relative advantage, perceived affordability captures a more immediate, practical dimension of financial decision-making in rural contexts, extending beyond upfront costs to include financial risk, subsidy accessibility, and expected long-term savings [6, 23]. Households holding favorable attitudes toward solar PV are motivated to resolve dissonance between their positive evaluations and financial constraints, leading them to interpret

cost and subsidy information in ways that elevate affordability perceptions. Empirical evidence consistently links perceived financial feasibility to solar PV adoption, particularly among lower-income rural households [6, 8, 23, 30]. The following hypothesis is therefore proposed:

H6: Perceived affordability positively affects rural households’ adoption intention for household solar PV.

2.4. Bridging Theories: Towards an Integrated TPB–TAM–DOI Framework

Single-theory approaches such as TPB, TAM, or DOI often fail to capture the complexity of household solar PV adoption in rural contexts when applied in isolation. This study therefore adopts an integrated TPB–TAM–DOI framework (see Figure 5) in which TPB provides the core behavioral structure (attitude, social influence, perceived behavioral control), TAM contributes technology-specific perceptions (perceived usefulness and ease of use), and DOI offers a diffusion perspective by linking relative advantage, complexity, and observability to economic appeal, usability, and social visibility, respectively (Ajzen, 1991, 2002; Davis, 1989; Rogers et al., 2003). Building on prior evidence that integrated models outperform single-theory approaches in developing settings, the framework conceptualizes perceived affordability as a distinct economic perception. It highlights perceived affordability and perceived behavioral control as central feasibility-related pathways linking behavioral, social, and technological perceptions to household adoption decisions. Applied to rural China, the framework shows that adoption intention is most strongly associated with perceived behavioral control and affordability, while perceived ease of use plays a limited role, underscoring that rural household solar adoption is shaped more by economic practicality and actionable capability than by technological complexity (Irfan et al., 2021; Masukujjaman et al., 2021; Yang et al., 2023).

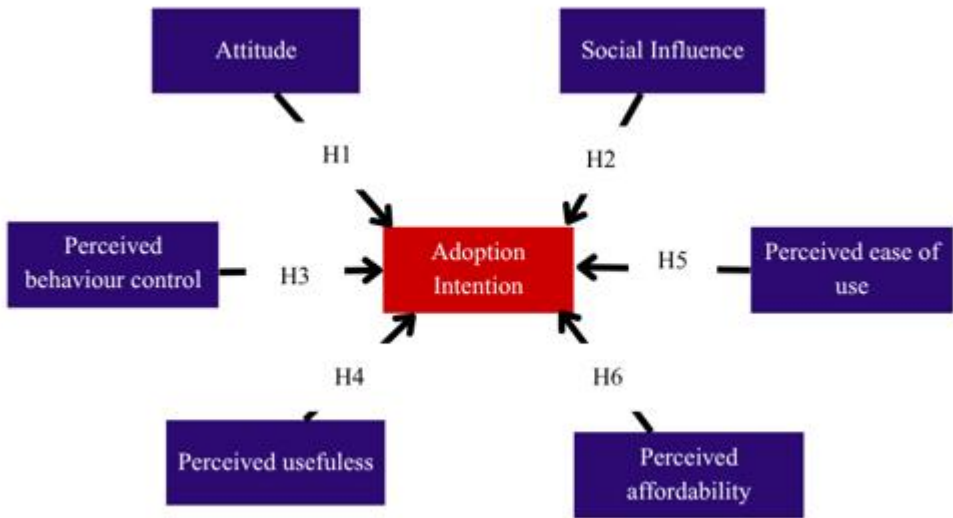


Figure 5. Integrated TPB–TAM–DOI model
Source: Authors' construction

2.5. Indirect Pathways Linking Perceptions and Adoption Intention

Perceived affordability and perceived behavioral control are key feasibility-related perceptions that shape how behavioral, social, and technological evaluations relate to household solar PV adoption intentions. From a diffusion perspective, perceived affordability reflects households’ assessments of economic trade-offs, including upfront costs, expected payback periods, and long-term benefits (Rogers et al., 2003), and prior research shows that such economic evaluations play a central role in linking attitudes and beliefs with intention formation (Preacher and Hayes, 2008; Zhao et al., 2010). Empirical evidence from residential

solar PV studies further indicates that perceived benefits and financial assessments are among the most consistently associated factors with adoption intention (Schulte et al., 2022; Wu et al., 2023). Perceived behavioral control complements this economic dimension by capturing households’ confidence in navigating information access, administrative procedures, installation, and ongoing operation, as emphasized in the Theory of Planned Behavior (Ajzen, 1991, 2002). In rural China, where informational, technical, and institutional constraints persist despite policy support, perceived affordability and perceived behavioral control constitute important indirect pathways through which attitudes, social influence, and technology-related perceptions are statistically linked to intentions to adopt household rooftop solar PV systems

3. Method

3.1. Research Design, Data Collection, and Analytical Strategy

This study examines household rooftop solar photovoltaic (PV) Willingness to adopt rather than realized installation behavior, reflecting households’ readiness and feasibility assessments under prevailing institutional and economic conditions in rural China. A cross-sectional survey design is employed to identify and prioritize the key behavioral, technological, and socio-demographic factors associated with adoption intention. To ensure measurement validity, cultural relevance, and analytical robustness, a multi-stage re-search process was implemented, as summarized in Figure 6.

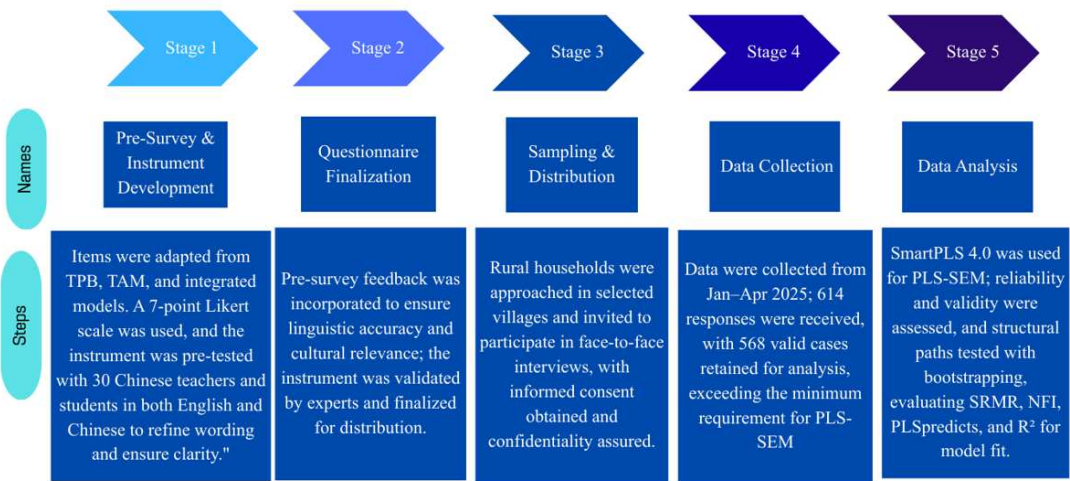
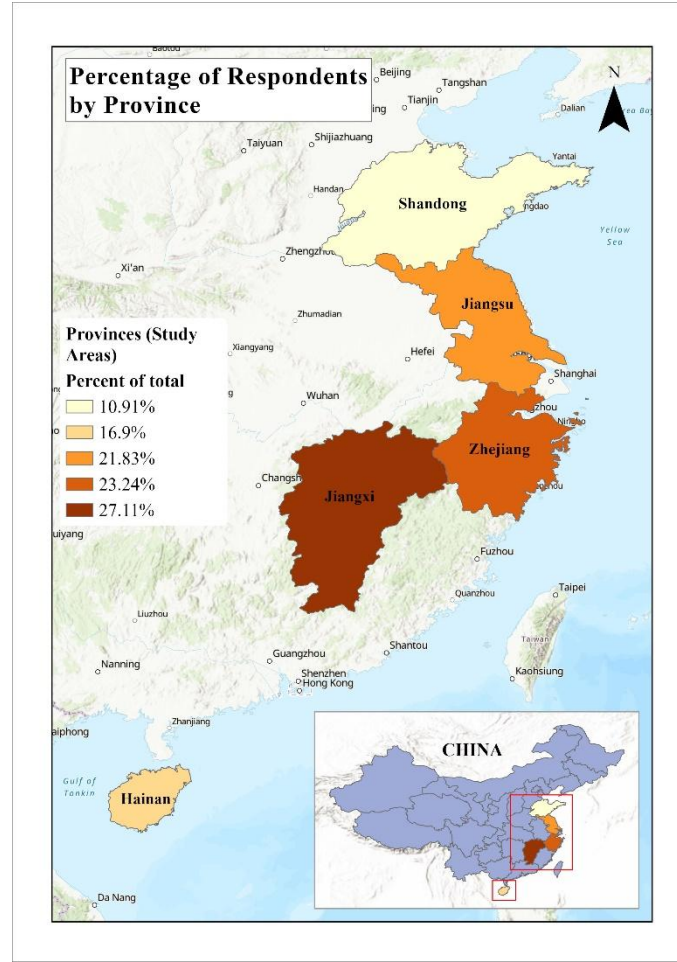


Figure 6. Research method stages
Source: Authors' construction

In Stage 1, survey items were adapted from established TPB, TAM, and integrated behavioral models (Curtius et al., 2018; Masukujjaman et al., 2021; Schulte et al., 2022; Venkatesh et al., 2012) and measured on a 7-point Likert scale ranging from 1 = “strongly disagree” to 7 = “strongly agree”. All measurement items are presented in Appendix A. Before the primary survey, the instrument was pretested and refined through a two-step process. First, academic experts reviewed draft items, and a pilot study was conducted with 60 respondents in the study area to assess clarity, cultural relevance, and translation accuracy between English and Chinese. Stage 2 consolidated expert feedback and pilot results, resulting in minor wording adjustments but no changes to the underlying constructs. Stage 3 focused on data collection from rural households. Data were collected through face-to-face surveys across five provinces, Shandong, Jiangsu, Zhejiang, Jiangxi, and Hainan, chosen to capture variation in economic development, solar resource potential, and rural energy transition maturity. Shandong and Jiangsu represent leading rooftop PV provinces with strong infrastructure and subsidy support; Zhejiang reflects higher-income early-adopter contexts; Jiangxi captures affordability-driven adoption under PV poverty alleviation programs; and Hainan adds island-based geographic

and institutional diversity with high solar irradiance. Together, these provinces span coastal, inland, and island contexts, ensuring the sample reflects the heterogeneity of rural solar PV conditions across China. A multi-stage approach was used, with households selected through purposive and convenience sampling based on accessibility and relevance, which may limit statistical representativeness.

Trained enumerators administered the questionnaire to ensure consistency. Stage 4 yielded 614 completed questionnaires. After screening for inconsistent or patterned responses and incomplete cases, 46 questionnaires were excluded, leaving 568 valid responses for the PLS-SEM analysis. Finally, Stage 5: The analytical approach combines descriptive analysis and structural modeling. Preliminary data screening, descriptive statistics, and robustness checks based on ordinary least squares (OLS) regression were conducted using SPSS 26. Structural relationships among latent constructs were examined using partial least squares structural equation modeling (PLS-SEM) implemented in SmartPLS 4.0. PLS-SEM was selected for its suitability for predictive-oriented analysis, its robustness to non-normal data, and its ability to estimate complex models with multiple latent constructs (Hair et al., 2019). Following established guidelines, the analysis proceeded in two stages. First, the measurement model was assessed for internal consistency, convergent validity, discriminant validity, and collinearity using Cronbach's alpha, composite reliability, average variance extracted (AVE), and variance inflation factors (VIF). Second, the structural model was evaluated by examining path coefficients, explained variance (R^2), predictive relevance (Q^2), and global model fit indices, including SRMR and NFI. The statistical significance of the model estimates was assessed using a bootstrapping procedure with 5,000 resamples. Given the cross-sectional nature of the data, all estimated relationships are interpreted as statistical associations rather than causal effects. The integrated analytical framework allows for a comprehensive examination of how behavioral, technological, and economic perceptions jointly relate to household solar PV adoption intention in rural China.



Source: Survey data.

Figure 7. Spatial distribution of the survey sample across five Chinese provinces, with shading indicating each province's share of total respondents

3.2. Measurement model examination in PLS-SEM

Reliability and validity were assessed using Cronbach's alpha, Composite Reliability, and Average Variance Extracted, while multicollinearity was evaluated using Variance Inflation Factors. The analysis further examined structural paths and indirect effects to assess both direct and indirect relationships among the constructs. The formulas and statistical criteria used for each metric are shown below.

3.2.1. Cronbach's Alpha

Cronbach's alpha (α) assesses the internal consistency of a construct by comparing the variance of individual items to the variance of the total score. It is defined as:

$$\alpha = \frac{k}{k-1} \left(1 - \frac{\sum_{i=1}^k \text{Var}(Y_i)}{\text{Var}(\sum_{i=1}^k Y_i)} \right) \quad (1)$$

Where k is the number of items, $\text{Var}(Y_i)$ is the variance of item i , and $\text{Var}(\sum_{i=1}^k Y_i)$ represents the variance of the total composite. A Cronbach's Alpha value above 0.70 generally indicates acceptable reliability, while values above 0.80 are preferred in confirmatory studies (Hair et al., 2021).

3.2.2. Composite Reliability (CR)

Composite Reliability (CR) evaluates internal consistency while explicitly accounting for each item's standardized loading. For a reflective construct with k indicators, CR is calculated as:

$$CR = \frac{(\sum_{i=1}^k \lambda_i)^2}{(\sum_{i=1}^k \lambda_i)^2 + \sum_{i=1}^k \phi_i} \quad (2) \quad 304$$

Where λ_i denotes the standardized factor loading of item i and ϕ_i represents the corresponding error variance, defined as $\phi_i = 1 - \lambda_i^2$. CR values above 0.70 indicate satisfactory reliability, and values above 0.80 provide strong evidence of internal consistency (Fornell and Larcker, 1981; Hair et al., 2021).

3.2.3. Average Variance Extracted (AVE) 308

The Average Variance Extracted (AVE) assesses convergent validity by quantifying the average proportion of variance in the indicators that is accounted for by the latent construct. It is computed as: 309
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$$AVE = \frac{\sum_{i=1}^k \lambda_i^2}{\sum_{i=1}^k \lambda_i^2 + \sum_{i=1}^k \phi_i} \quad (3) \quad 311$$

Where λ_i and $\mu_i = 1 - \lambda_i^2$ are defined as above, an AVE value of 0.50 or higher indicates that the construct explains at least 50% of the variance in its indicators, thereby providing evidence of convergent validity (Fornell and Larcker, 1981; Hair et al., 2021). 312
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3.2.4. Variance Inflation Factor (VIF) 315

To ensure that multicollinearity does not bias path coefficient estimates, the Variance Inflation Factor (VIF) was computed for all latent constructs. VIF quantifies the extent to which the variance of an estimated regression coefficient increases due to multicollinearity among variables. The formula is expressed as: 316
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$$VIF_i = \frac{1}{1 - R_i^2} \quad (4) \quad 319$$

Where R_i^2 represents the coefficient of determination obtained by regressing the predictor i on all other predictors in the model, a higher R_i^2 implies stronger collinearity, leading to a larger VIF value. VIF values from both the SmartPLS model and the OLS robustness analysis remain within acceptable thresholds (below 5 and 10, respectively), indicating no severe multicollinearity. 320
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3.2.5. Structural Paths 324

The structural model specifies the direct relationships between constructs, measured by path coefficients (β values) estimated using partial least squares structural equation modeling (PLS-SEM) (Chin, 1998; Hair et al., 2019). The theoretical models can be summarized as follows: 325
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TPB model: 328

$$PI = \beta_1 ATT + \beta_2 PBC + \beta_3 SI \quad (5) \quad 329$$

TAM model: 330

$$PI = \beta_4 ATT + \beta_5 PU + \beta_6 PEOU \quad (6) \quad 331$$

Integrated model: 332

$$PI = \beta_7 ATT + \beta_8 SI + \beta_9 PBC + \beta_{10} PU + \beta_{11} PEOU + \beta_{12} PAFF + \varepsilon \quad (7) \quad 333$$

3.2.6. Indirect effects analysis 334

Indirect associations were assessed using the product-of-coefficients approach, which examines how independent variables are statistically linked to adoption intention through perceived affordability and perceived behavioral control, following established SEM procedures based on bootstrapped coefficient products (Preacher and Hayes, 2008; Zhao et al., 2010). Given the cross-sectional nature of the data, these indirect effects are interpreted as associational pathways rather than evidence of causal mechanisms. 335
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Two sets of indirect effects were calculated to evaluate the mediating roles of PAFF and PBC. The formulas are shown below: 340
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$$IE_{X(PAFF)} = \beta_{X \rightarrow PAFF} \times \beta_{PAFF \rightarrow PI} \quad (8) \quad 342$$

$$IE_{X(PBC)} = \beta_{X \rightarrow PBC} X \beta_{PBC \rightarrow PI} \quad (9)$$

Where $\beta_{X \rightarrow PAFF}$ and $\beta_{X \rightarrow PBC}$ denote the path coefficients from each independent variable to the mediators, and $\beta_{PAFF \rightarrow PI}$ and $\beta_{PBC \rightarrow PI}$ represent the paths from the mediators to household adoption intensification. The significance of indirect effects was assessed using bias-corrected bootstrapped confidence intervals at the 95% level, providing a robust test of the mediating roles specified in the integrated model.

4. Result and discussion

4.1. Demographic Statistics

Among the 568 respondents, gender was almost evenly split (50.7% male, 49.3% female). The largest age group was those aged 57 and above (29.0%), followed by those aged 37–46 (21.0%). Around one-third held a university degree (31.3%), while 24.8% had no formal schooling. Most households reported a monthly income of ¥6,001–7,500 (38.2%), and 30.1% reported a monthly income of more than ¥7,500. Geographically, respondents were drawn from five provinces, with the largest share from Jiangxi (27.11%), followed by Zhejiang (23.24%) and Jiangsu (21.83%). In terms of occupation, 34.7% were self-employed, 29.8% worked in private companies, and 26.6% were government workers. Full demographic details are shown in Table 1.

Table 1. Demographic statistics

Profiles		Frequency	%
Gender	Male	288	50.7
	Female	280	49.3
Age	18-24 years	89	15.7
	27-36 years	80	14.1
	37-46 years	119	21
	47-56 years	115	20.2
	>57 years	165	29
Education	No schooling	141	24.8
	Primary school	128	22.5
	College	121	21.3
	University degree(s)	178	31.3
Provinces	Shandong	69	10.91
	Hainan	96	16.9
	Zhejiang	132	23.24
	Jiangxi	154	27.11
	Jiangsu	124	21.83
Income	3000	29	5.1
	3000-4500	33	5.8
	4501-6000	118	20.8
	6001-7500	217	38.2
	>7500	171	30.1
Occupation	Unemployed	51	9.0
	Self-employed	197	34.7
	Private company worker	169	29.8
	Government worker	151	26.6
	Total	568	100

4.2. Analysis of measurement model

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The reliability and validity of the measurement model were confirmed using factor loadings (FL), Cronbach's alpha, composite reliability, and average variance extracted (Fornell and Larcker, 1981; Hair et al., 2019). During the assessment, a small number of indicators with loadings below the recommended threshold of 0.70 were removed to improve construct reliability and validity. As shown in Table 2, all retained factor loadings exceed the 0.70 threshold, indicating strong indicator reliability. Both Cronbach's alpha and composite reliability exceed the recommended value of 0.80, reflecting excellent internal consistency. Additionally, all AVEs exceed the 0.50 benchmark, supporting convergent validity (Nunnally and Bernstein, 1994). Moreover, variance inflation factor (VIF) scores remain below 5.0, confirming the absence of significant multicollinearity.

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Table 2. Validity and reliability construct

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Variables	Items	FL	a	CR	AVE	VIF
Attitude	ATT1	0.882	0.902	0.932	0.773	2.661
	ATT2	0.887				2.750
	ATT3	0.884				2.601
	ATT4	0.863				2.311
Perceived Ease of Use	PEOU1	0.784	0.849	0.892	0.623	1.744
	PEOU2	0.761				1.687
	PEOU3	0.795				1.834
	PEOU4	0.799				1.977
	PEOU5	0.807				1.936
Perceived Behavior Control	PBC1	0.875	0.901	0.913	0.770	2.507
	PBC2	0.878				2.604
	PBC3	0.890				2.736
	PBC4	0.868				2.358
Perceived Affordability	PAFF1	0.909	0.935	0.953	0.837	3.293
	PAFF2	0.923				3.857
	PAFF3	0.920				3.736
	PAFF4	0.907				3.361
Adoption Intention	AI1		0.917	0.941	0.800	2.673
	AI2	0.894				2.919
	AI3	0.906				3.225
	AI4	0.894				2.908
Perceived Usefulness	PU1	0.818	0.878	0.911	0.671	2.000
	PU2	0.813				1.960
	PU3	0.813				2.038

	PU4	0.814				1.979
	PU5	0.838				2.130
Social Influence						
	SI1	0.885	0.912	0.938	0.791	2.724
	SI2	0.887				2.752
	SI3	0.892				2.814
	SI4	0.894				2.889

Attitude = ATT, Social influence =SI, Perceived behavioral Control = PBC, Perceived usefulness = PU, Perceived ease of use =PEOU, Perceived affordability = PAFF.

Source: Authors' computation, SmartPLS 4 output

4.3. Rural Households Adoption Intention

As shown in Figure 8, the survey results indicate that most respondents agree or strongly agree with all four statements regarding the adoption of solar PV in rural China. Approximately 70–75% of participants stated that they would choose solar PV if they had to select a new energy source today, while roughly 65–70% plan to adopt renewable energy system in the near future. Similarly, around 60–65% are open to installing solar PV within the next few months, and nearly 75–80% intend to do so if financial and technical support are available. In contrast, less than 10% disagreed or strongly disagreed on all items. This high level of overall intention provides a solid foundation for the specific behavioral drivers identified in our model.

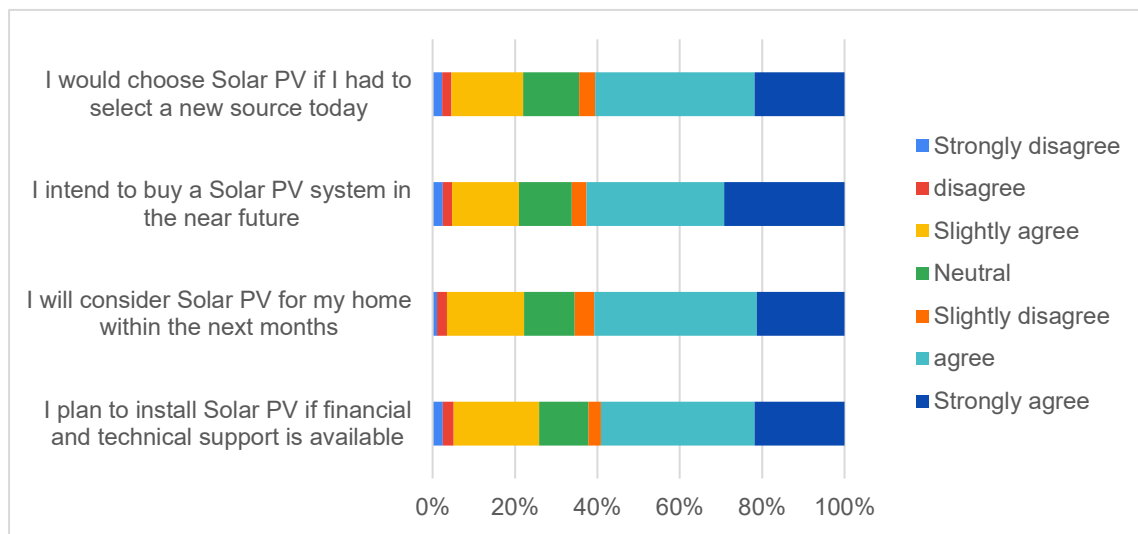


Figure 8. Rural households' Intentions to adopt solar PV (N=568)

Source: Survey data

4.4. Structural Models

The structural equation models demonstrated a strong fit. Table 3 shows that the SRMR values were well below the 0.08 threshold and the NFI values exceeded 0.80, confirming that the models fit the sample well. The integrative model performed the best, explaining 89.5% of the variance in adoption intention, followed by the TPB model at 87.3%, and the TAM model at 73.6%. The chi-square value decreased significantly from 1722.954 in the integrated model to 741.379 in the TAM model, and further to 683.601 in the TPB model. All models exhibit positive predictive relevance, as reflected by Q^2 values above zero, with the integrated model showing the highest Q^2 value (0.889). Consistent with this pattern, the integrated model also yields the lowest RMSE and MAE values, suggesting superior out-of-sample performance relative to the

alternative specifications. Within the integrated framework, perceived behavioral control, perceived affordability, social influence, and perceived usefulness are statistically significant at the 1% level in association with household adoption intention, while attitude remains significant at the 5% level; perceived ease of use does not show a significant association. In the TPB model, attitude, social influence, and perceived behavioral control are all significantly correlated to intention at the 1% level, whereas in the TAM model, perceived usefulness and attitude are significant, but perceived ease of use is not.

Table 3. Model fit Indices

Items	Benchmark Figure	Current research Model	TPB	TAM
SRMR	< 0.08	0.039	0.037	0.048
NFI	> 0.80	0.894	0.922	0.901
Chi-square		1722.954	683.601	741.379
R2		0.895	0.873	0.729
Q2		0.889	0.870	0.731
RMSE		0.335	0.363	0.521
MAE		0.236	0.255	0.345

Source: Authors' computation, SmartPLS 4 output

Table 4 compares the three models, which are significantly different from one another. The TAM model has the lowest predictive ability. The most effective model was the integrated one, which showed the best fit and the highest predictive values (SRMR, Q2, RMSE, MAE, and R²). Perceived behavioral control emerges as the most strongly associated construct with household adoption intention, followed by perceived affordability. A summary of these paths is presented in Table 5.

Table 4. Path factors of TPB, TAM, and the integrative model

Paths	TPB		TAM		INTEGRATED	
	B	p-value	B	P-value	B	P-value
ATT->AI	0.214***	0.000	0.564***	0.000	0.101**	0.020
SI->AI	0.223 ***	0.000			0.162**	0.005
PBC->AI	0.545***	0.000			0.387***	0.000
PU->AI			0.270***	0.000	0.116**	0.006
PEOU->AI			0.067	0.303	0.010	0.833
PAFF->AI					0.249***	0.000
R2	0.873		0.729		0.895	
SRMR	0.037		0.048		0.039	

Attitude = ATT, Social Influence SI, Perceived Behavioral Control = PBC, Perceived usefulness = PU, Perceived ease of use =PEOU, Perceived affordability = PAFF.

Source: Authors' computation, SmartPLS 4 output

Table 5. Results of hypotheses

	H	B	t	p-value	Confidence Interval	
					2.50%	97.50%
H1	ATT->AI	0.101*	2.333	0.020	0.018	0.188
H2	SI->AI	0.162**	2.822	0.005	0.054	0.278
H3	PBC->AI	0.387***	6.717	0.000	0.271	0.498

H4	PU->AI	0.116**	2.773	0.006	0.037	0.202
H5	PEOU->AI	0.010	0.211	0.833	-0.079	0.188
H6	PAFF->AI	0.249***	5.707	0.000	0.166	0.335

Attitude = ATT, Social influence SI, Perceived behavioral control = PBC, Perceived usefulness = PU, Perceived ease of use = PEOU, Perceived affordability = PAFF.

Source: Authors' computation, SmartPLS 4 output

4.5. Hypotheses outcomes

Based on the results, most of the developed hypotheses were confirmed. Attitude, social influence, and perceived behavioral control show statistically significant positive associations with rural household adoption intention, supporting hypotheses H1, H2, and H3. Perceived usefulness and perceived affordability are also significantly associated with rural households' household adoption intention, confirming hypotheses H4 and H6. However, perceived ease of use was not significantly associated with adoption intention, thereby rejecting hypothesis H5. A summary of the hypothesis-testing results is presented in Table 5, and the structural relationships are illustrated in Figure 9.

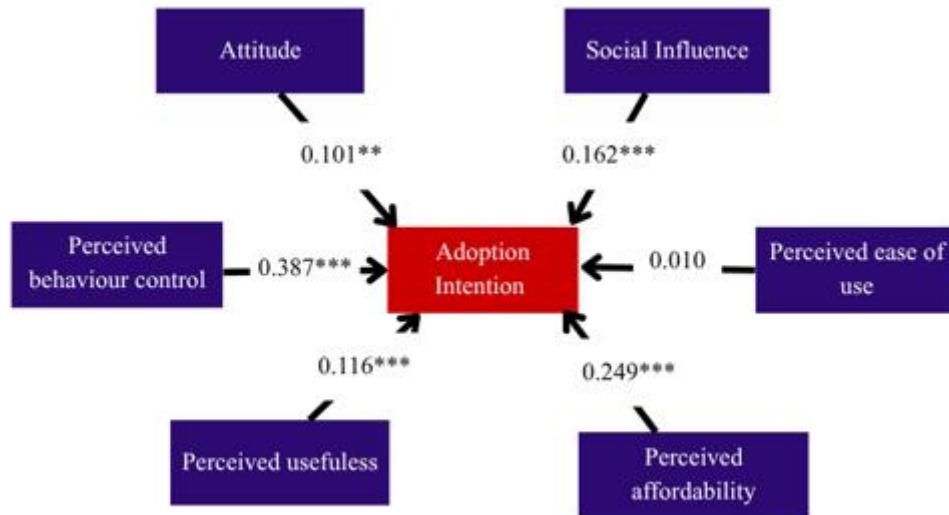


Figure 9. Graphical illustration of the hypotheses

Source: Authors' computation, SmartPLS 4 output

4.6. Indirect effect

4.6.1. Indirect effect through PAFF

The indirect effect analysis was conducted to examine indirect associations between perceived affordability and household adoption intention. As reported in Table 6, perceived affordability exhibits significant indirect associations with attitude, perceived behavioral control, and social influence, linking them to household adoption intention. In contrast, no significant indirect associations are observed for perceived usefulness or perceived ease of use.

Table 6. Indirect effect through PAFF

Item	B	T	p-values	Confidence Intervals	
				2.50%	97.50%

ATT -> PAFF -> AI	0.051**	3.182	0.001	0.023	0.086
PEOU -> PAFF -> AI	-0.017	1.101	0.271	-0.05	0.011
PBC -> PAFF -> AI	0.134***	4.344	0.000	0.079	0.199
PU -> PAFF -> AI	0.014	1.088	0.276	-0.012	0.039
SI -> PAFF -> AI	0.041**	2.934	0.003	0.015	0.069

Attitude = ATT, Social influence SI, Perceived behavioral Control = PBC, Perceived usefulness = PU, Perceived ease of use = PEOU, Perceived Affordability = PAFF.

4.6.2. Indirect effect through PBC

Table 7 reports the results of the indirect effect analysis through perceived behavioral control. The results show that perceived behavioral control exhibits significant indirect associations linking attitude, perceived affordability, perceived usefulness, and social influence with household adoption intention. In contrast, no significant indirect association is observed between perceived ease of use and household adoption intention through perceived behavioral control.

Table 7. Indirect effect through PBC

Item	B	T	p-value	Confidence Intervals	
				2.50%	97.50%
ATT->PBC->AI	0.051*	2.213	0.027	0.012	0.103
PEOU->PBC->AI	-0.031	1.599	0.110	-0.074	0.004
PAFF->PBC->AI	0.119***	4.978	0.000	0.077	0.171
PU->PBC->AI	0.051**	2.741	0.006	0.017	0.089
SI->PBC->AI	0.192***	4.742	0.000	0.117	0.276

Attitude = ATT, Social influence SI, Perceived behavioral Control = PBC, Perceived usefulness = PU, Perceived ease of use = PEOU, Perceived Affordability = PAFF.

Source: Authors' computation, SmartPLS 4 output

4.7. Importance Performance map

The importance–performance map analysis (Figure 10) indicates that perceived behavioral control has the highest importance for household solar PV household adoption intention, underscoring its central role in shaping adoption decisions. Social influence also demonstrates meaningful importance, reflecting the continued relevance of community norms and peer influence in rural settings. Perceived usefulness, perceived affordability and attitude occupy a mid-range position, suggesting that expected system benefits and financial considerations remain important but secondary to perceived feasibility. In contrast, perceived ease of use shows relatively low importance, indicating that usability concerns are less influential in explaining household adoption intention in the studied context.

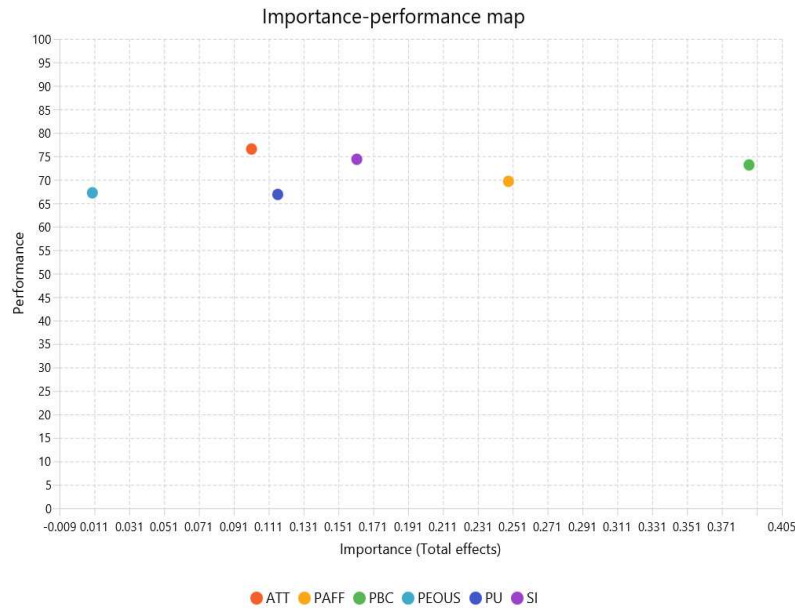


Figure 10. Importance Performance map
Source: Authors' computation, SmartPLS 4 output

4.8. Robustness Analysis

4.8.1. Hierarchical OLS Regression

Table 9 reports the results of the hierarchical OLS regression analysis. The Socio-demographic factors explain little variation in adoption intention (Model 1), with income showing a positive association. Adding TPB and TAM variables substantially improves explanatory power, with perceived behavioral control and perceived affordability emerging as the strongest correlates in the full model followed by attitude, social influence, and perceived usefulness. Perceived ease of use remains non-significant across all specifications.

Table 9. Hierarchical OLS Regression Results

Variables	Model 1 (Controls)	Model 2 (TPB)	Model 3 (TAM)	Model 4 (Full model)
(Constant)	3.880***	-0.425	-0.462	-0.335
Gender	-0.007	0.064	-0.042	0.033
Age	0.068	0.053***	-0.019	0.032
Education	-0.066	-0.007	-0.019	-0.009
Income Level	0.456	-0.030	0.025	-0.060
Occupation	-0.059	0.018	0.019	0.036
ATT	-	0.220***	0.613***	0.130***
SN	-	0.221***	-	0.163***
PBC	-	0.609***	-	0.431***
PU	-	-	0.470***	0.152***
PEOU	-	-	0.040	0.001
PC	-	-	-	0.217***
RS	0.154	0.878	0.737	0.898
Adjust Rs	0.146	0.877	0.733	0.896

Source: Authors' computation, OLS regression output

4.8.2. Consistency between SmartPLS and OLS

Results from the PLS-SEM and OLS analyses are highly consistent across all key constructs (see Table 10), indicating strong robustness of the empirical findings. Perceived behavioral control and perceived affordability exhibit the largest and most stable associations with adoption intention in both estimation approaches, while attitude, social influence, and perceived usefulness show moderate but significant relationships, and perceived ease of use remains insignificant.

Table 10. Consistency between SmartPLS and OLS

Variables	SmartPLS	OLS	Consistency
PBC	Strong, sig.	Strong, sig.	Yes
PC	Strong, sig.	Strong, sig.	Yes
ATT	Strong, sig.	Strong, sig.	Yes
SN	Strong, sig.	Strong, sig.	Yes
PU	Small-moderate, sig.	Small-moderate, sig.	Yes
PEOU	Not sig.	Not sig.	Yes

Source: Authors' computation

4.9. Institutional and Post-Installation Perceptions

Figure 11 shows that 75% of rural households report difficulties or uncertainty with grid connection, while only 25% perceive the process as straightforward, indicating a gap between policy support and local implementation. Figure 12 further reveals that 64% of respondents lack clarity regarding long-term maintenance costs, compared with 36% who report having clear information. Together, these findings highlight persistent institutional and informational barriers that reduce household confidence in managing solar PV systems. This supports the strong role of perceived behavioral control and affordability identified in the model and aligns with prior research emphasizing institutional support and system accessibility in energy adoption (Rai and Robinson, 2015; Sovacool et al., 2021), as well as broader challenges in achieving inclusive access under SDG 7.

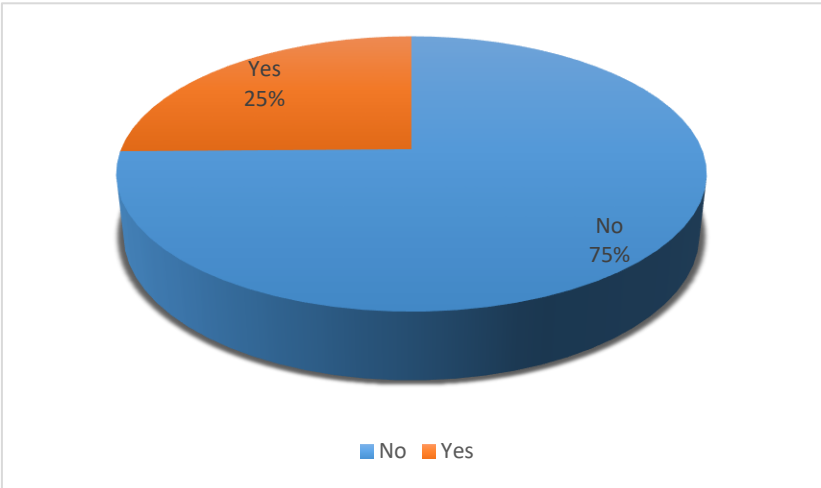


Figure 11. Ease of grid connection
Source: Survey data

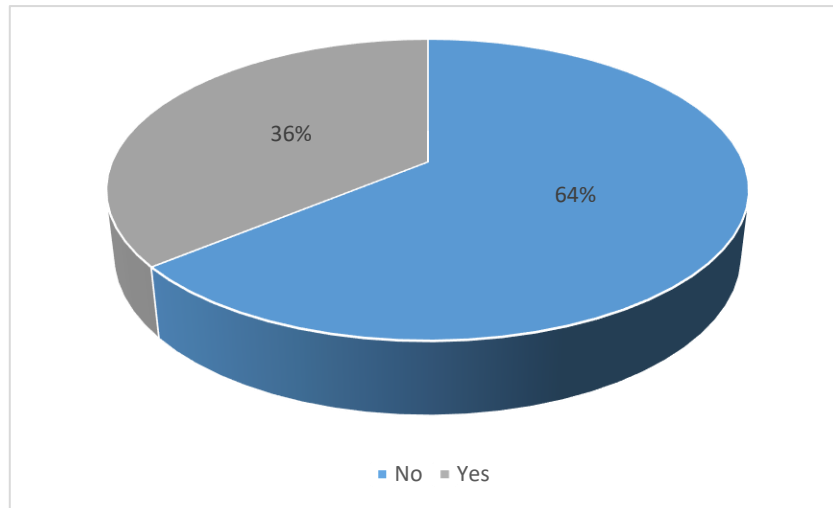


Figure 12. Clarity of maintenance costs

Source: Survey data

5. Discussion, Implications, and Limitations

5.1. Discussion

This study contributes to the literature on household renewable energy adoption by developing and empirically validating an integrated TPB–TAM–DOI framework to examine rooftop solar PV adoption in rural China. By jointly considering behavioral, technological, and economic dimensions, the analysis provides a more comprehensive account than single-theory approaches and clarifies the relative importance of different perception domains. The findings highlight a distinction between benefit-based and feasibility-based evaluations in shaping household adoption decisions. In particular, perceived behavioral control shows the strongest association with adoption intention, followed by perceived affordability, while attitudes, social influence, and perceived usefulness play supporting roles. This pattern suggests that household participation in decentralized energy systems is more closely associated with financial feasibility and practical capacity than with usability considerations in resource-constrained settings. The model explains a substantial proportion of variance ($R^2 = 0.895$), reflecting the combined contribution of multiple dimensions, with results interpreted as associational relationships within the study context. These findings underscore that progress toward Sustainable Development Goal 7 (Affordable and Clean Energy) and Sustainable Development Goal 13 (Climate Action) is linked not only to the availability of technology but also to improvements in financial accessibility and households' capacity to engage in low-carbon energy transitions

Firstly, the positive association between attitude and household adoption intention indicates that households are more likely to consider solar PV when they perceive it as beneficial and economically worthwhile. This aligns with the Theory of Planned Behavior (Ajzen, 1991) and prior studies linking favorable evaluations to the formation of adoption intentions (Irfan et al., 2021; Marius et al., 2013; Wang et al., 2023). However, its relatively smaller magnitude suggests that positive perceptions alone may not translate into adoption without corresponding feasibility conditions.

Second, perceived behavioral control is the most influential construct in both the TPB and the integrated models. In the rural Chinese context, PBC reflects households' perceived ability to navigate the full adoption process, including information acquisition, administrative procedures, installation coordination, and ongoing operation and maintenance. Rather than capturing technical competence alone, PBC appears to reflect

institutional and procedural feasibility, echoing findings from previous studies showing that adoption depends strongly on whether households feel capable of managing the process under uncertainty (Ajzen, 2002; Irfan et al., 2021).

Furthermore, perceived affordability represents a distinct but complementary dimension of feasibility. It captures households' assessments of whether upfront costs, financing arrangements, and expected savings make solar PV economically worthwhile. The results indicate that affordability remains a strong correlate of adoption intention even after accounting for behavioral and technological perceptions, underscoring that economic evaluations extend beyond income levels to include cost transparency, perceived risk, and return expectations. This is consistent with evidence that financial feasibility is a key determinant of adoption (Afriyie et al., 2024; Gerarden et al., 2017; Sovacool et al., 2021).

Moreover, social influence shows a stable positive association with adoption intention, reflecting the continued importance of community norms and peer influence in rural China. Households often rely on neighbors, relatives, or trusted local figures when evaluating unfamiliar technologies, particularly in environments characterized by limited formal information channels. This finding aligns with recent studies highlighting the role of village-level social dynamics in shaping renewable energy decisions (Yang et al., 2023).

In addition, perceived usefulness remains positively associated with adoption intention, indicating that households recognize benefits such as cost savings and energy reliability. This is consistent with the Technology Acceptance Model (Davis, 1989) and extended technology adoption research (Curtius et al., 2018; Venkatesh et al., 2012). In contrast, perceived ease of use is not significant; this finding refines the applicability of the Technology Acceptance Model by suggesting that the importance of perceived ease of use may diminish in service-supported and institutionally mediated contexts. While earlier studies often report a positive relationship between ease of use and adoption, more recent evidence indicates that its influence can be weak or non-significant when technologies are externally managed or when economic and institutional factors dominate decision-making (Curtius et al., 2018; Rai and Robinson, 2015; Venkatesh et al., 2012).

Finally, the analysis of indirect effects further enriches the interpretation by highlighting explanatory pathways among perceptions. Perceived affordability and perceived behavioral control exhibit significant indirect associations that link attitudes, social influence, and perceived usefulness to adoption intention. These results should be interpreted as associational rather than causal, given the cross-sectional design. Nonetheless, they suggest that positive evaluations and social norms are more likely to translate into adoption intentions when households perceive both financial feasibility and procedural capability. This interpretation is consistent with behavioral research emphasizing the role of control- and cost-related perceptions as key channels through which broader beliefs shape the formation of intentions (Preacher and Hayes, 2008; Schulte et al., 2022).

Overall, promoting household solar PV adoption in rural China requires coordinated policies that combine financial support, institutional simplification, local engagement, and reliable system performance. The findings indicate that institutional and post-installation uncertainties, particularly grid connection, potential curtailment, and maintenance responsibilities, remain key concerns that may constrain sustained participation in decentralized energy systems. Addressing both perception-based and structural barriers can strengthen household engagement. These efforts contribute to Sustainable Development Goals 7 (Affordable and Clean Energy) and 13 (Climate Action), while supporting rural development by improving income stability, energy security, and local resilience.

5.2. Implications

The findings highlight that rooftop solar PV adoption in rural China is shaped by institutional conditions, including grid integration constraints, administrative procedures, and unclear responsibilities for system operation and maintenance. Despite subsidies reducing upfront costs, uncertainty regarding grid connection, potential curtailment, and long-term maintenance may weaken perceived feasibility. These results suggest that policy efforts should extend beyond financial incentives to address procedural complexity, institutional clarity, and households' confidence in managing system performance. Such measures are essential for strengthening inclusive access to decentralized energy systems and advancing Sustainable Development Goal 7 (Affordable and Clean Energy) in rural contexts.

First, the significant association between attitude and adoption intention suggests that communication strategies should emphasize tangible and experience-based benefits rather than abstract climate narratives. Information campaigns that highlight reliable electricity supply, long-term cost savings, and improved household energy security are likely to strengthen favorable evaluations of solar PV, particularly when conveyed through trusted local channels such as village meetings, cooperatives, and demonstration households.

Second, the strong relationship of perceived behavioral control indicates that policy effectiveness depends not only on incentive availability but also on households' confidence in their ability to navigate the adoption process. Measures aimed at simplifying grid-connection procedures, clarifying administrative responsibilities, and strengthening coordination between installers and local grid operators can directly enhance households' perceived feasibility of adoption. Establishing accessible local support mechanisms, such as designated service contacts or village-level technical assistance, may further reduce procedural uncertainty.

Third, perceived affordability emerges as a key economic consideration, underscoring that financial feasibility extends beyond upfront costs to include uncertainty about maintenance, repair responsibilities, and long-term returns. Policies that improve cost transparency, such as standardized maintenance agreements, clear warranty arrangements, and predictable subsidy disbursement, can reduce perceived financial risk and enhance households' confidence in solar PV as a viable investment.

Importantly, the significant role of perceived usefulness highlights that households' adoption intentions are also shaped by their assessment of practical benefits. Policies that improve the reliability and performance of distributed solar systems, ensure stable grid integration, and demonstrate consistent economic returns can strengthen perceived usefulness and reinforce incentives for adoption. Public dissemination of verified performance outcomes from existing installations may further enhance households' expectations regarding the functional value of solar PV.

Again, the positive influence of social networks suggests that adoption strategies should leverage existing community structures. Encouraging peer learning through demonstration projects, supporting collective village-level installations, and involving respected local figures can amplify social influence and normalize solar PV adoption as a shared community practice.

Finally, the consistently weak association between perceived ease of use implies that basic usability is no longer a primary constraint in the studied context. Ensuring minimum usability standards remains important, particularly for vulnerable households. However, policy efforts may yield greater impact by prioritizing procedural feasibility, economic clarity, and demonstrable system usefulness rather than incremental improvements in interface simplicity.

Promoting household solar PV adoption in rural China requires coordinated policy approaches that combine financial support, institutional simplification, and local engagement. Addressing both structural and perception-based barriers can strengthen household participation in decentralized energy systems.

Such efforts support Sustainable Development Goal 7 (Affordable and Clean Energy) and Sustainable Development Goal 13 (Climate Action), while contributing to rural income stability, energy security, and local resilience

5.3. Limitation

This study recognizes several limitations that open important avenues for future research. First, the cross-sectional design, although it identifies significant associations, cannot establish definitive causality regarding how psychological factors influence the adoption of Solar PV over time. Conducting longitudinal studies that track actual behavior would improve causal understanding and clarify the intention-behavior gap. Second, focusing on specific rural regions may limit the generalizability of the findings across China's diverse socio-economic landscape, underscoring the need for future studies with stratified sampling to enhance external validity. Lastly, relying on self-reported data, despite the use of statistical controls, introduces the risk of common method bias. Therefore, future research should include objective measures, such as adoption records or energy-usage data, to complement the perceptual measures used in this study.

6. Conclusion

This study develops and empirically tests an integrated TPB–TAM–DOI framework to examine household rooftop solar PV adoption intentions in rural China, explicitly incorporating perceived affordability as a key economic perception. The findings show that perceived behavioral control exerts the strongest association with adoption intention, followed closely by perceived affordability, while social influence, perceived usefulness, and attitude remain significant but comparatively weaker, and perceived ease of use shows no significant effect, suggesting that households prioritize financial feasibility and procedural control over technical simplicity. The model's high explanatory power ($R^2 = 0.895$) confirms the value of integrating behavioral, technological, and economic perspectives to capture household energy decision-making in resource-constrained rural settings, demonstrating that favorable attitudes alone are insufficient without accompanying perceptions of affordability and feasibility. These findings offer practical guidance for designing subsidy structures and financing mechanisms that directly address households' financial and procedural concerns, while advancing progress toward affordable and clean energy (SDG 7) and climate action (SDG 13). Despite methodological and geographical limitations, this study provides a robust foundation for future research on household renewable energy adoption and the continued refinement of integrated behavioral frameworks.

Ethics Approval

The study was approved by the Research Ethics Committee of Nanjing University of Information Science and Technology (NUIST) on 17 May 2025. All research procedures were conducted in accordance with the Declaration of Helsinki and applicable national and institutional ethical guidelines and regulations.

Informed Consent

Informed consent was obtained from all participants prior to their participation in the study.

Data Availability Statement: The dataset, variable coding scheme, SmartPLS output, and survey instrument supporting this study's findings are provided as supplementary files with this submission and are available upon reasonable request.

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