Influencing Factors and Countermeasures to Promote the Large-scale Development of Rural Solar Houses in China

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Abstract: The development and utilization of renewable energy, especially solar energy, is an important way to solve the problem that China's rural conventional power grids cannot cover remote rural areas. It is also an inevitable requirement of China's rural development strategy. This article explores the influencing factors of Chinese farmers' vigorous promotion of the use of solar houses, studies relationships among perceived value, farmer's attitude and willingness to convert traditional houses into solar houses. Using data collected by a questionnaire from 413 rural households in Chongqing, China, the results show that perceived value has a significant and positive effect on farmer's attitude and willingness to convert traditional houses into solar houses. Most importantly, the results of this research show that farmers' attitude partially mediates the effects of perceived value on willingness to convert. Finally, the study also proposes relevant suggestions for policymakers, marketing managers and further research.

1. Introduction

Among 1.38 billion people in China, approximately forty-two percent of the population reside in rural areas. Farmers' energy consumption has increased twofold or more in the last twenty years as their incomes have increased.

However, to our best knowledge, there have been no publications in open literature dealing with farmers' willingness to adopt clean energy for rural China. Due to the social structures, Chinese farmers usually "accept" government rules, regulations and policies without any implementations if there were no practical benefits. Thus, it is crucial to understand farmers' willingness in order to truly implement Paris Agreement at the beginning of 2020.

Existing literature has paid attention to research on the solar house market. Most of them take "solar house" and "comparison between solar house and traditional house" as the research object. The research angle focuses on the construction of solar house itself, and the research area focuses on the city. In recent years, scholars have also begun to pay attention to the construction of rural solar houses. For example, Nicholas Nixon Opiyo(2019) analyzed pacts of neighbourhood influence on social acceptance of small solar home systems in rural western Kenya[1]. Tahsina Khan et al.(2020) found in Sub-Saharan Africa that the current primary themes of research are technology, viability and user-centric.[2].
However, there are few studies on the rural solar housing market in China. Only the author studied conducted a survey based on the theory of planned behavior in Chongqing with 465 participants, 9 factors related to farmers' willingness (Li et al., 2013) [3]. The following characteristics are unique to Chinese farmers: (1) Each family lives in one house and does not have an extra lot for another new house; and (2) it is realistic and practical to convert traditional houses to solar houses.

The purpose of this study is to explore whether perceived value has a positive effect on farmer’s attitude; whether perceived value has a positive effect on farmer’s willingness to convert; whether farmer’s attitude has a positive effect on farmer’s willingness to convert; and whether farmer’s attitude has moderate effect between perceived value and willingness to convert. It is expected that the findings can serve as references for policy makers and marketing managers in their efforts to populate solar houses in rural areas and researchers for further conversion studies.

2. Research hypotheses and model construction

2.1. The Measurement of Perceived value
Farmers’ perceived value is their overall assessment of the utility of converting traditional houses to solar houses based on perceptions of what is received and what is given (Zeithaml, 1988) [4].

When farmers’ willingness to convert traditional houses to solar houses, particularly since solar houses belong to not only durable products but also smart houses, they would consider not only immediate situational factors, such as price and service, but also the longer-term implications of the ownership of the solar house products. Thus, future expectations of benefits and sacrifices, as well as current perceptions of benefits and sacrifices, need to be considered in any model of perceived value.

Multi-dimensional perceived value is proposed, but no unified classification basis is proposed, and there is no study on the perceived value of residential products (such as solar houses).

Sweeney and Soutar (2001) [5] classified perceived value of durables into 4 dimensions as quality value, emotional value, price value and social value. As solar houses belong to durables, in this study we classified perceived value of farmers’ converting into quality values, emotional value, price value and social value accordingly. Quality value (“functional value”) refers to the practical or technical benefits that farmers can obtain by using a solar house. Emotional value refers to mental or psychological needs of farmers and the utility they derive from the feelings or affective states that a solar house generates. Price value refers to how satisfactory a solar house is compared with cost, time, or effect spent in obtaining the solar house. Social value refers to the social utility (e.g., status, prestige) that consumption of the solar house’s product conveys.

2.2. Perceived value and farmers’ attitude toward converting
Farmers’ attitude toward converting was defined as “farmers’ positive or negative feelings (evaluative affect) about using solar houses” (Li et al., 2013) [3]. According to the literature (David Joon et al., 2011 [6]), perceived value is significantly and positively related to consumer’s consumption attitude. Based on the reviewed literature, the following hypothesis H₁ is offered:

H₁: An increase in perceived value (quality value, emotional value, price value, and social value) will increase farmers' attitude toward converting traditional houses to solar houses.

2.3. Farmers’ attitude and willingness to converting
Farmer’s attitudes can influence these choices. The more they prefer to convert traditional houses to solar houses, the more they will choose to do that. It is also found by us that attitude toward converting had positive and significant impacts on farmers willingness to convert (Li et al., 2013) [3]. Thus, the following Hypothesis H₂ is proposed.

H₂: Farmers' attitude towards converting will positively affect farmers’ willingness to convert traditional houses to solar houses.
2.4. Perceived value and willingness to convert
Farmers' willingness to convert was defined as “the strength of the farmers’ intention to converting traditional houses into solar houses”. The Personal value reflects an individual's behavioral standard. The Perceived value and behavioral intention (willingness), the relationship between the many scholars has carried on the exploration, such as KisangRyu et al. (2008)[7] studies have shown that perceived value has a positive effect on behavioral intentions. Ching-fu Chen and Fu-Shian Chen(2010)[17] found that perceived value has a positive effect on behavioral intentions.

Based on the reviewed literature, the following hypothesis H3 is suggested:
H3: A increase in perceived value (quality value, emotional value, price value, and social value) will increase farmers' willingness to converting traditional houses to solar houses.

2.5. Mediating effect of farmers’ attitude
In addition to its direct influence on willingness to converting, farmer’s attitude may mediate the relationship between perceived value and willingness to converting.

Based on the mechanism of perceived value influencing the farmer's attitude and the mechanism of farmer's attitude to Betting, it is not difficult to reason that some aspects of perceived value can influence the counting through the farmer's attitude. For example, social value can change farmer's attitude and thus change to convert.

Therefore it is deducted that:
H4: Farmer’s attitude will have a mediating effect on the relationship between perceived value and willingness to convert traditional houses into solar houses.

3. Research methodology
3.1. Survey method and pre-test
We used a self-report questionnaire to empirically examine the proposed research model. The method is very commonly used in behavioral and management science research. The instruments of measurement in the questionnaire were developed on the basis of previous studies to enhance variability and reliability. Responses to the various variables related to the perceptions of the individual subjects were measured with Likert-type scale.

3.2. Measurement instrument
The measurement items of the questionnaire in the study were generated from in-depth interviews with farmers in local rural villages, and a relevant literature.

The measurement variables are a 5-point Likert scale (strongly disagree to strongly agree) was used in order to reduce extreme skewing of the statistical problems(Fornell et al., 1996)[9]. (1) Perceived value: there are 12 items covering 4 dimensions including quality value, emotional value, price value and social value; the reference is made on Gianfranco Walsh et al.(2014)[9] with few modifications. (2) Willingness to converting: there are 3 items converting 1 dimension including “Want to converting”, “First Choice”, and “Recommend”(DavoudNikbin et al.,2012[10]). (3) Farmer’s attitude to converting: there are 3 items converting 1 dimension. The three measurement items were adapted from Li et al.(2013)[3].

3.3. Statistical method
To empirically examine the proposed model, the Structural Equation Modeling (SEM) was used to validate the model and hypotheses.

3.4. Participants and data collection
The heads of households in Chongqing are surveyed, who are married and do not have any or reliable electrical power supplies to their homes. In rural China, the head of each household is usually the spokesman for the entire family.
Chongqing represents essential characteristics for Chinese solar house planning. Known as one of the four “ovens” in China, its annual solar energy radiation is 3,400-4,180 MJ/M², with the annual direct solar exposure time of 1000-1400 hours. It is one of the first areas to demonstrate new solar energy constructions in China.

To generate a representative sample, the respondents were selected from three different areas in Chongqing, by combining convenience sampling and judgment sampling methods. Five counties were selected, with two towns in each county and two random villages in each town. There were thirty households in each village. During March-May, 2021, 413 valid questionnaires were collected from 550 distributed. This relatively high response rate of 75.1% was achieved because the survey was carried out by face-to-face interviews, for example, let them all clear with the costs of different solar house construction methods for familiar with solar houses.

3.5. Descriptive analysis
Demographic characteristics of the participants are tabulated: gender, age, education level, family size, having any children in college, relatives in cities, and any family members being migrant workers in cities.

Most of the heads of the households are 54 or younger (80.14%) and have education levels at junior high schools or lower (80.84%). Some families have connections to cities: 32.93% with children in colleges, 37.53% with migrant workers and 17.19% with city relatives. Since three generations typically reside in one house, majority of the families (59.08%) have more than four members. The demographic characteristics are representative in rural areas. The standard deviation of the factor and variable is about 2, and the confidence level of the sample means 0.01, which is close to the actual situation, indicating that the sample estimate is valid.

4. Results of hypothesis testing and discussion

4.1. Measurement model assessment
Using SPSS19.0 and Amos 17.0 to validate the measurement model, (1) Correlation analysis. Correlations were used to examine the presence of multicollinearity, which a correlation of greater than +0.70 and less than -0.70 indicated high correlation (Hair et al.,2003) [11]. The presence of singularity was also examined through the use of the Pearson correlation matrix. Singularity is the presence of a perfect correlation between independent and dependent variables. There is no evidence of multicollinearity or singularity within the data. It can also be seen that the four factors of perceived value, farmer’s attitude and willingness to convert are significantly positively correlated at the 1% confidence level. (2) Content validity is evaluated by pilot-testing the instrument. (3) Convergent validity is evaluated by examining Cronbach’s a, the Cronbach’s a of every subscales ranges from 0.924 to 0.947, which are above the acceptability value of 0.7 (Nunnally, 1978) [12].

4.2. Structural model assessment
For the Perceived value multi-dimensional variable, when calculating the measured value of the factor, according to the practice of Michael et al. (1999) [13], the mixed measurement method is adopted, that is, the measured value of each factor uses all the secondary indicators it contains The simple weighted average is measured. For example, the quality value factor in Perceived value is measured by the simple weighted average of the three indicators it contains. Structural Equation Modeling (SEM) was applied to estimate the Structural model.

(1) the external quality assessment of the overall model. The NFI of this research is 0.968 > 0.9; that is, the model fitness is excellent. The CFI is 0.976, signifying that the model fitness is very stable and it is an ideal theoretical model. Also, the IFI, GFI, AGFI > 0.9; RMSEA<0.08; CMIN/DF<5. The result complies with the recommended level (Chiou, 2011) [14]. Therefore, the fitness of the established linear structural model has reached a satisfactory level.
Figure 1 Result of the proposed structural equation model (M1)

(2) R-squares and the relevant path analysis.

The strength of associations among variables is examined by the squared multiple correlation coefficient ($R^2$). As seen from Fig.1, perceived value explains 33.7% of the variance of farmer’s attitude. Furthermore, these variables between perceived value and farmer’s attitude together explain 79.3% of the variance in willingness to convert.

The hypothesized relationships are tested using structural equation modeling through path analysis by using AMOS 17.0 (Fig.1), the relationships among variables according to the structural estimate of the suggested model are as follows.

First, there is a significant positive relationship between perceived value and farmer’s attitude toward converting traditional houses to solar houses. Hypothesis H1 was therefore supported ($\beta=0.581$, C.R.=11.701, $p<0.001$). Similar conclusions were reached in other studies (David Joon et al.,2011[6]).

Second, the relationship between farmer’s attitude and willingness to convert is positive and significant ($\beta=0.177$, C.R.=4.810, $p<0.001$), then hypothesis H2 was supported, which is consistent with results reported in other region literature (Li et al.,2013[3]).

Lastly, results show that there is a positive and significant relationship between perceived value and willingness to convert ($\beta=0.776$, C.R.=15.499, $p<0.001$) and did supported hypothesis H3, which is consistent with results reported in the literature (Lei-Yu Wu et al.,2014[15]).

Therefore, hypotheses H1, H2 and H3 are supported.

(3) The test of mediating effect of farmer’s attitude

According to the method suggested by Baron and Kenny(1986)[16], the two paths of Perceived value, factoring and farmer's attitude are removed on the basis of M1, and only the direct relationship between perceived value and quantitative is taken into account to obtain the model M2 (only a simplified model is given, and the fitting indices of the model are shown in Table 1. The chi-square difference between M1 and M2 ($\Delta \chi^2=60.698$) showed that M1 and M2 were significantly different. M2 illustrates that Farmer's attitude is not an intermediary variable of perceived value and converting. As can be seen in FIT Indices, M2 is not good at data fitting. Therefore, M2 is rejected in this paper. In other words, Farmer's attitude is an intermediary variable between perceived value and converting. Meanwhile, M1 and M2 can be seen that the first three criteria proposed by Baron and Kenny(1986)[16] are satisfied. As for the fourth criterion, when Farmer's attitude enters into the analysis of perceived value and quantitative relation, perceived value and quantitative are still significantly correlated ($\beta=0.776$, C.R.=15.499, $p<0.001$), but the relation is significantly reduced ($\beta$ decreases by 0.102; The value of C.R. changed by 2.428, $p<0.001$).
Therefore, this paper holds that Farmer's attitude plays an intermediary role in perceived value and betting relationship, and also plays a partial mediating role. (Farmer's attitude as perceived value → converting relationship.

Therefore, hypotheses $H_4$ is supported, which verifies MaCarthy and Shrum (1994)\(^ {17}\) value-attitude-behavior theory.

Perceived value can directly influence farmer’s willingness to converting traditional houses to solar houses. At the same time, it can also influence farmer’s willingness to convert by changing farmer’s attitude.

Organizations can change farmer’s attitude to convert by enhancing farmer’s perceived value, including quality value, emotional value, price value and social value. Because attitude is the habitual tendency of farmers to react to solar house products or services in a way they like or don't like through learning and strengthening, it is the basis for forming farmers' choices and shows their overall evaluation of a certain solar house product. Therefore, Organizations (solar house developers) can conduct marketing activities to influence and change farmers' attitude towards converting traditional houses into solar houses and finally promote their conversion behavior.

Hence, effective perceived value change farmer's attitude to converting, enhancing the overall evaluation of solar houses, To get more hopeful of betting to converting traditional houses to solar houses. It is important for Organizations (solar house developers) to support farmers to improve their attitude toward converting and to achieve higher factors to convert.

### Table 1

| Fit Indices | CMIN/DF | $\Delta x^2$ | NFI | CFI | IFI | GFI | AGFI | RMSEA |
|-------------|---------|--------------|-----|-----|-----|-----|------|------|
| M1          | 3.583   | 0            | 0.968 | 0.976 | 0.977 | 0.939 | 0.901 | 0.079 |
| M2          | 6.630   | 60.698***    | 0.970 | 0.974 | 0.974 | 0.944 | 0.879 | 0.117 |

Fitness requirement $1 < \text{CMIN/DF} < 5$, $> 0.9$, $< 1$, the bigger, the better $< 0.08$.

*P<0.001.

### 5. Conclusion

This study developed a novel conceptual framework for understanding the mediating effect of farmer’s attitude on the relationship between perceived value and willingness to convert traditional houses into solar houses.

In summary, the study shows that perceived value has a significant and positive effect on farmers’ attitude and willingness to convert traditional houses to solar houses. Most importantly, the study also shows that farmer’s attitude partially mediates the effects of perceived value on willingness to converting. That is, farmer’s attitude can not only lead to achieve higher willingness to converting, but also has a mediate effect between perceived value and willingness to converting.

### 6. Implications and limitations

The present research offers academic as well as practical implications. First, it makes scholarly contributions by providing new insights into the theoretical relationships among perceived value, farmer’s attitude, willingness to convert. The findings of this study constitute a significant addition to the literature and may serve as a foundation for future research about converting traditional houses to solar houses. On the other hand, the study provides practical implications for government policy makers and marketing managers. First, the mediating role of farmer’s attitude in the relationships between perceived value and willingness to converting suggests that solar houses can be promoted in rural areas by first heightening the perceived value, thereby increase their attitude toward converting that then will function to boost converting of willingness. First, the mediating role of farmer's attitude in the relationships between perceived value and converting assuring that solar houses can promote by First heightening the perceived value in rural areas.

Furthermore, government and solar house developers must keep in mind the willingness to converting is directly affected by perceived value including quality value, emotional value, price value.
and social value. It implies that they should make efforts to increase farmers’ value perceptions if they are to improve the popularization of solar houses in rural areas.

The government can provide subsidies for the proper construction of solar houses, or relevant bank institutions can provide loans for the construction of solar houses, and solar energy products provided by solar house developers are worthwhile, and after-sales service is guaranteed. Let farmers feel that the conversion of traditional houses into solar houses has real value, whether it is quality, emotional, price, social value. At the same time, the government and solar house developers can first find some pilot projects in rural areas, and vigorously promote the benefits of solar houses through the pilots, such as solar houses are green houses, energy saving and environmental protection, etc., and promote farmers’ positive attitudes towards solar houses, thereby increasing their willingness to switch.

Despite the potential contributions mentioned earlier, this research is subject to a few limitations. (1) Firstly, farmer’s perceived risk and motivation are often primary factors in farmer’s decision making in this market. Thus, in order to have greater reliability and external validity, it is important that future research should consider farmers’ perceived risks and motivations. (2) Another limitation of this study stems from data collection in a single country. Therefore, results may be skewed due to culturally accepted values. For example, Chinese farmers may prefer value to risk in converting traditional houses to solar houses, whereas other countries farmers may prefer risk to value in converting traditional houses to solar houses. The generalizability of the findings may be limited. Therefore, it is necessary to retest the results with subjects from different countries.

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