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Diffusion and Adoption Behavior of Environmentally Friendly Innovation: Sharing from Chinese Society

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Use of solar energy as one of environmentally friendly innovations has been adopted in rural Chinese society to save the environment and money. This study aimed to explore the processes and drivers of, and the barriers to, rural people's adoption of solar water heater (SWH), including to analyze and synthesize the diffusion and adoption of practical solar energy innovations. Based on the integration of diffusion of innovations theory, the theory of reasoned action, and the theory of acceptance model, the factors of SWH adoption were established. Binary logistics regression was used to analyze the factors influencing rural people's decision to adopt SWH. The key drivers were social influence, physical need and innovation attributes, respectively. To achieve widespread effective innovations from policy level to rural communities, a two-step flow of diffusion from the government to salespersons and then to rural communities, especially earlier adopters, to motivate rural people's behavioral intention to innovation adoption was strongly recommended. The practical implications for other agricultural rural communities are that the adoption processes and drivers to behavioral change need high collaboration and commitment by related ministries along with the private and academic sectors.

Keywords: adoption behavior, diffusion of innovation, environmentally friendly innovation, solar water heater

Solar energy is a clean and renewable energy that can reduce greenhouse gas (GHG) emissions and global warming to achieve a low-carbon economy (Yuan, Wang, Zuo, 2013). Solar water heaters (SWHs), as a kind of solar energy innovation, obtain free energy from the sun, which contributes to both household and global benefits. China is the world's leading manufacturer of solar heating technology, and SWHs are one of the most popular solar energy innovations (Yuan et al., 2011). China began utilization of SWHs in the 1970s (Han, Mol, & Lu, 2010) and has also been a forerunner in their usage in recent years as an environmentally friendly alternative (Bosselaar et al., 2004).

According to the previous literature on SWH diffusion and adoption in Chinese society, the main aspects to be investigated are: SWH acceptance (Yuan, Zuo, & Ma, 2011), application (Han et al., 2010; Zhu, Li, & Zhao, 2015), adoption intention (Li et al., 2013) and policy support (Chen, Xu, & Frey, 2016), review of related policies and evaluation of their effectiveness (Ma, Song, Smardon, & Chen, 2014; He, Zheng, Wu, Cui, & Qian, 2015), and the SWH industry and market (Bosselaar et al., 2004; Xin and Weiguo, 2011; Rungqing et al., 2012; Qiu, Ruth, & Ghosh, 2015), including integrated

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issues covering theory, application, marketing, and research (Wang, Yang, & Qiu, 2015). This study is based on the integrated innovation diffusion and adoption framework, namely the Diffusion of Innovation (DOI) (Rogers, 2003), Theory of Reasoned Action (TRA) (Fishbein, & Ajzen, 1975), and Technology Acceptance Model (TAM) (Davis, 1989), to explicate the empirical evidence in the context of Chinese rural society.

In the light of global climate change and SWH benefits as mentioned, it is crucial to thoroughly understand what the diffusion and adoption processes of SWHs, including related factors, are in the grassroots community. Accordingly, we particularly attempt to answer the following questions: What are rural people's perceptions regarding global warming, climate change, and changes in their surrounding environments? Who plays the major role in SWH diffusion and adoption? What are the processes and main drivers of, as well as the barriers to, SWH adoption to their daily lives? How should diffusion of solar energy innovations processes be carried out in practice? To answer these questions, the goal of this study is to investigate the processes and drivers of, as well as the barriers to, rural people's adoption of SWHs. These clarifications can contribute as the practical lessons-learned for collaborative local and central authorities and the business sector to support the provision of important information to rural people through awareness raising, the launch of further environmentally friendly innovations, and the promotion of economic growth policies regarding solar energy innovations for social benefits in the long run.

Literature Review

To gain insight into the processes and factors influencing SWH diffusion and adoption in the countryside, we have employed Diffusion of Innovation (DOI), Technology Acceptance Model (TAM) and Theory of Reasoned Action (TRA) to establish an integrated framework of SWH adoption in rural Chinese society.

DOI by Rogers (2003) mainly focuses on people's adoption decisions, and various factors affecting their decisions. Key constructs in the innovation decision process are the individual's socio economic characteristics, personality variables, communication behavior and the innovation's perceived attributes. Each person will evaluate the innovation based on five attributes: relative advantage, compatibility, complexity, trialability, and observability. To adopt an innovation, people can be grouped as five categories due to their high interest and responses to the innovation, respectively (Rogers, 2003): innovators, early adopters, early majority, late majority and laggards. People who are on the forefront of the innovation creation and adoption are called innovators. Early adopters are like opinions leaders being in the first groups to adopt the innovation and are considered to have more local social status than innovators. The early majority will adopt the innovation after having a chance to observe the early adopters, and adopt the innovation before the average individual. The late majority tends to take time to carefully evaluate the innovation before adoption, and will adopt the innovation after the average individual. Laggards are the last group to adopt the innovation. DOI was employed to

explore the public acceptance of SWH in Australia (Foster, 1993), and the adoption of SWH in New Zealand (Murphy and Donoghue, 2009).

TAM was developed by Davis (1989) in order to provide a basic understanding of the factors influencing customers' decisions to adopt new technology. Perceived usefulness and perceived ease of use are two main factors, and in turn influence one's attitude towards system usage. These two factors are also relevant with innovation attributes of DOI (relative advantage and complexity).

TRA developed by Fishbein, & Ajzen (1975), describes the two drivers of personal interests and social influence affecting an individual's behavioral intention to adopt or continue to use the innovation. The personal attitude toward adopting or continuing to use the innovation reflects the individual's evaluations of performing the behavior. Subjective norm as the social influence refers to the individual's perceptions of the social pressures to adopt or not adopt.

All three theories have their own contributions to this study. The key constructs of DOI cover both individual's internal and external factors to innovation adoption (Rogers, 2003). TAM is the well-known model related to technology acceptance and usage (Davis, 1989). TRA was considered as well researched intention model that has demonstrated successful in predicting and explaining behavior, which can fulfill DOI and TAM because of including the social influences on an individual adoption decision (Kaur & Kaur, 2010). Therefore, these theories provide the framework for the researchers to identify the drivers of SWH diffusion and adoption among the rural Chinese people responding the research objective.

Methodology

The Conceptual Framework

The conceptual framework of this study, elaborated and presented in Figure 1, is divided into external factors (independent variables) and internal factors (dependent variables). External drivers are those outside the individual and consisting of innovation attributes, salespersons, social influence, and government policy. Elements of innovation attributes are usefulness, ease of use, high quality, saving money, and environmental friendliness. Salespersons have the characteristics of credibility (expertise, trustworthiness) and offering sales services (before–during–after the selling). Social influence by friends or peer groups and neighborhoods, including government policy at both national and local levels, is included in the framework as affecting the individual attitude toward innovation. Internal factors are those inside each individual and comprise communication channels, namely cell phones, TV, social media, and face-to-face communication; physical need for cleanliness; and environmental awareness, assessed by the practices of not burning crop residues, using electricity saving machines, and taking one's own bags to buy things. A thorough understating of what drives and impedes SWH adoption can guide policy makers and society to achieve effective diffusion and adoption processes of solar energy innovations.

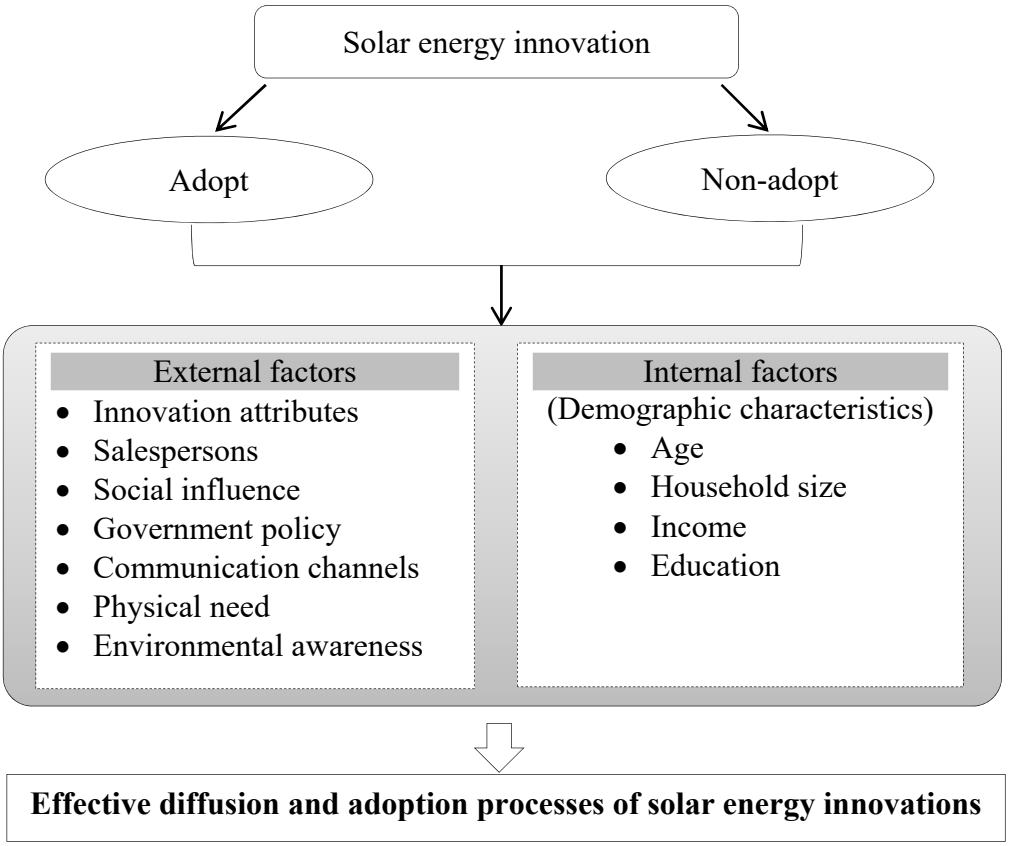

Figure 1. Conceptual framework.

Study Area and Samples Selection

The study area covered two villages in Qingdao city, Shandong province, P.R. China, and the total number of respondents was 184. Based on the willingness and readiness of the respondents to provide their information, 154 SWH adopters were overall households of installing SWH, while 30 SWH non-adopters were from the simple random sampling approach. The first village was Shagou West, which is relatively undeveloped and isolated, with 70 respondents. The other 114 respondents were from River South Xue Village, where both local and modern ways of living are practiced and more developed than Shagou West village. These two villages represent the suitable example for this study because of the detailed differences influencing the innovation diffusion and adoption in the rural area. Shagou West is the farthest from the town with economically backward residents, SWH diffusion in the village was mainly by the village's agent through interpersonal communication, and the SWH brands adoption were concentrated to the village business agent. River South Xue Village closes to the town, the spreading channels and brands are more diversified such as some acquaintance introduced SWH to the villagers or they went to the stores to buy SWH. The SWH diffusion was also affected by the government policy, which the low-rise residences were required to install SWH uniformly. Most residents in both areas are a farmer whose revenues were highly fluctuated and uncertain, but the numbers of SWHs user had been increased (Xianfeng, Xiang, Yan, Guosong, & Jianhua, 2009). SWHs in the study area were evacuated tube

collectors comprising three main elements: solar water collectors, a water storage tank, and an auxiliary heater.

Data Collection

Data were collected in April 2016 based on the triangulation method in order to ensure the trustworthiness of data collection (Denzin, 1970). In terms of methodological triangulation, this study employed both quantitative (questionnaire survey) and qualitative approaches (in-depth interviews and non-participatory observation).

The questionnaire was designed with the main purposes of exploring the SWH adoption processes of rural people, including knowledge and concerns about climate change and global warming. The details of the questionnaire were revised after pre-testing to ensure it was the most appropriate tool for collecting data from the rural people.

As SWH salespersons were influential in SWH adoption of the rural people, in-depth interviews with the snowball technique and purposive sampling were performed to select these key informants. Then, two SWH salespersons were interviewed about their experiences and opinions regarding the diffusion of SWH, such as communication processes, drivers, and barriers influencing the adoption of the innovation among rural people. The key informants were asked to evaluate the importance of drivers and barriers identified by other previous studies. Additionally, the researchers allowed informants to give information, opinions, and suggestions on the issues without letting personal perceptions and bias judge the informants' responses.

Furthermore, Non-participatory observation was conducted so as to observe SWH adoption on household rooftops to determine the brands and their appearances, and check the numbers of SWH. In the meantime, observer triangulation was also concerned providing that six investigators could observe the same things and classify each SWH brand.

Data Analysis

Statistical analyses of the data were performed using SPSS (Version 20.0, USA). The values of the mean and standard deviation were used to represent SWH adoption and related factors in different areas. Binary logistic regression was chosen to investigate the rural people's decisions regarding SWH adoption based on a dichotomous choice (adopt or not adopt). Tolerance (TOL) and the variance inflation factor (VIF) were used as the two important indices for diagnosis of multicollinearity. A value of TOL smaller than 0.1 or a value of VIF greater than 10 indicates serious multicollinearity between the independent variables (Bai et al., 2010). Moreover, content analysis of all collected data was used to analyze, synthesize, and give further suggestions on effective communication techniques and significant factors regarding diffusion of SWH for practical adoption. The data analyses are also explained and illustrated in tables, charts, and diagrams.

Valuation of the variables: The rural people who install SWH, abbreviated as RPASWH, are the dependent variable in this analysis. The independent variables include innovation attributes, salespersons, social influence, and government policy as the external factors and communication channels, physical need, and environmental awareness as the internal factors. The proxies of these variables are listed in Part 2 of Table 1 and the descriptions of the independent variables are explained following the survey items in the questionnaire. The first set of variables, which focuses on innovation attributes, consists of usefulness, ease of use, high quality, saving money, and environmental friendliness. The second set of variables, which focuses on salespersons, covers the characteristics of credibility (expertise, trustworthiness) and sales services (before–during–after selling). The third set of variables examines how the social influence of friends and peer groups, neighborhoods, and household members can impact on SWH adoption. The fourth set of variables investigates the relationship between government policy and SWH adoption. The fifth set of variables emphasizes communication channels, including cell phones, TV, social media (WeChat, QQ), and face-to-face communication. The sixth set of variables emphasizes physical need in terms of cleanliness. The last set of variables, which focuses on environmental awareness, consists of the practices of not burning crop residues, using electricity saving machines, and taking one's own bags to buy things.

Control variables: Demographic characteristics comprising age, household size, income, and education are defined as the control variables (Table 1, Part 1). For the valuation, people are classified as young (< 35 years), middle age (35-60 years), and elderly (> 60 years). Household size is classified into small (one or two household members), medium (three or four household members), and large (more than four household members). Income is grouped into three levels: low (300-5,733 RMB/month), medium (5,734-11,167 RMB/month), and high (11,168-16,600 RMB/month). Education is grouped into five categories: primary school, junior high school, senior high school, college/bachelor's degree, and no education.

Table 1

Definition of Variables in the Model of Adoption among Rural People

Variables	Description	Expectations of variables on adoption
Part 1: Demographic characteristics (Dependent variables)		
Age	Continuous, age of a household head	Negative
Household size	Continuous, number of household members	Positive
Income	Continuous, total income of a household	Positive
Education	Continuous, number of years in school completed by a household head	Positive
Part 2: Independent variables		
External factors		
Innovation attributes	Dummy, 1 if SWH is usefulness, ease of use, high quality, saving money or environmentally friendly	Positive
Salespersons	Dummy, 1 if SWH salespersons is credible or provides sales services	Positive
Social influence	Dummy, 1 if SWH adoption is influenced by friends/peer groups or neighborhoods	Positive

Table 1 *(Continued)*

Variables	Description	Expectations of variables on adoption
Social influence	Dummy, 1 if SWH adoption is influenced by friends/peer groups or neighborhoods	Positive
Government policy	Dummy, 1 if there is the government policy to support SWH adoption	Positive
Internal factors		
Communication channels	Dummy, 1 if communication channels of cell phone, TV, social media or face-to-face is used by the rural people	Positive
Physical need	Dummy, 1 if the cleanliness is concerned by the rural people	Positive
Environmental awareness	Dummy, 1 if no burning crop residues, using electricity saving machine, or taking their own bags to buy things is practiced by the rural people	Positive

Empirical model used for the analysis: The regression capturing the relationships between RPASWH and the classified variables can be expressed by the equation below, where ε represents the error term and β_0 the constant.

$$RPASWH = \beta_0 + \beta_1 Age + \beta_2 HouseholdSize + \beta_3 Income + \beta_4 Education + \beta_5 Innovation + \beta_6 SalesPersons + \beta_7 SocialInfluence + \beta_8 GovernmentPolicy + \beta_9 CommunicationChannels + \beta_{10} PhysicalNeed + \beta_{11} EnvironmentalAwareness + \varepsilon$$

Results and Discussion

Part 1: Statistical Summary and SWH Adoption

This study divided the respondents into two main groups: those who had and those who had not used SWHs. Cell phone, TV, and face-to-face communication are the three most frequently used media and communication devices among both adopters and non-adopters. Comparing those using the Internet, the majority of SWH adopters (55.2%) and non-adopters (66.7%) used the Internet via cell phone, mainly to access to WeChat and QQ. Before making a decision to buy SWH, they mostly observed others households using it (65.8%), and the next largest group (23.7%) made the decision to buy it after watching TV. Meanwhile, only one third of the previous SWH adopters had recommended the benefits of SWH usage to others. 25% of the respondents mainly bought their SWHs in 2010 from salespersons at retail stores inside their villages or nearby. There were about 10 brands, which the local brands with medium price and high quality were adopted more frequently by the rural people. Before adopting SWHs, 50% of respondents had used dried wood for boiling hot water, followed by using public bathrooms (38.2%). The main reason for installing SWHs was for showering, followed by ease of use and convenience of purchase. Meanwhile, the main reasons for not installing an SWH were being able to shower with warm water at a relative's house and

continuing the previous practice of using dried wood for boiling hot water. Comparing the frequency of showering before and after SWH adoption, the respondents showered once a month before adoption, but this increased to once a week after adoption, during both summer and winter. After using SWHs, 42.3% of respondents had their SWHs repaired once, mainly by salespersons as part of the after-sales service, so they were able to continue using them. Only a few of them had already changed to a new SWH after using the previous one for almost ten years because of some parts of the previous SWH could be used in the new one with higher quality as informed and services provided by the salesperson. Overall, most of the respondents were quite satisfied with SWH usage, while none of them were quite or very dissatisfied.

Part 2: Perceptions of Global Warming and Climate Change and Environmental Awareness Behaviors

Most of the respondents of SWH adopters and non-adopters felt that the weather is getting warmer nowadays compared with their childhoods, while colder was not concerned at all. Agricultural plants, namely peanuts, wheat, corn, watermelon, and taro, had been hugely affected by the temperature changes according to both adopting and non-adopting respondents. Regarding changes in rainfall, all respondents in both groups perceived a decrease. According to both temperature and rainfall changes, 54% of the SWH adopters and 83% of non-adopters had not changed their cropping time because they did not have any information about what should be changed or adapted. Therefore, they felt more confidence in continuing to follow the traditional lunar calendar for planting rather than changing to new practices. Meanwhile, 27% of SWH adopters and 17% of non-adopters had planted crops earlier to avoid long water shortages. The majority of SWH adopters (85%) and non-adopters (83%) had heard about climate change before, mainly via TV. However, only 10% of SWH adopters and 17% of non-adopters could give the meaning of climate change as the weather was getting warmer, and gave examples of the ice melting and a lack of snow this year, while others remained unsure what climate change was.

Regarding environmental awareness behaviors, none of the respondents burned their crop residues on their fields; instead they left them in the field as soil fertilizer or removed them from the field as fuel for cooking or for other purposes. When buying home appliances, about half of both groups of respondents paid attention to the “China Energy Label”, but their understanding of the label’s meaning was neither clear nor correct. About one third of adopters took their own bags when buying things, while all respondents had noticed environmental pollution in their villages.

Part 3: Factors Influencing SWH Adoption: Empirical Evidence from Binary Logit Model

The average age and number years of education of respondents were 65.50 and 6 years, respectively. Their household average income was 5,433.33 RMB per month, and the average number of household members was three. A summary of the values of the independent variables is shown in Table 2.

Table 2

Statistical Summary of Independent Variables and Quantitative Control (N = 184)

Variable	*Mean*	*SD*
Age	65.50	22.70
Household size	3.00	2.11
Education	6.00	3.60
Innovation attributes	0.72	0.13
Salespersons	0.86	0.05
Social influence	0.91	0.21
Government policy	0.64	0.20
Communication channels	0.75	0.17
Physical need	0.96	0.08
Environmental awareness	0.83	0.32

The estimated TOL for independent variables was larger than 0.1, with a mean TOL level of 0.83 (0.77-0.89), while the VIF was less than 10, with a mean VIF level of 1.26 (1.13-1.38). These indicate that multicollinearity is not a serious problem in this model. The estimated coefficients and marginal effects of the binary logit model are listed in Table 3. The 1, 5, and 10% significance levels are tested to thoroughly examine the estimated coefficients of the parameters and the marginal effects in the binary logit model, where the high significance at the 1% level indicates the highest significance of the adoption variables. As the dependent variable is an ordinal measurement, an ordered logistic regression was performed. The results regarding the opportunity to adopt SWH are listed in Table 3.

Table 3

Ordered Logistic Regression Result with RPASWH as the Dependent Variable

	Coefficient estimates			Marginal effect			Odds
Variable	*Coef.*	SE	*P* level	*Coef.*	SE	*P* level	ratio
Age	-0.04*	0.01	0.06	-0.01*	0.00	0.06	0.78
Household size	0.51*	0.10	0.04	0.01*	0.01	0.03	1.056
Income	0.00**	0.00	0.00	0.00**	0.00	0.00	1.19
Education	0.04	0.02	0.11	0.00	0.00	0.11	0.76
Innovation attributes	0.54***	0.13	0.01	0.04***	0.02	0.00	1.18
Salespersons	0.09	0.03	0.31	0.01	0.00	0.23	0.94
Social influence	0.72***	0.24	0.00	0.08***	0.04	0.00	1.29
Government policy	0.067	0.01	0.58	0.00	0.00	0.36	0.83
Communication channels	0.65*	0.20	0.06	0.05*	0.02	0.05	1.21
Physical need	0.76***	0.22	0.01	0.06***	0.02	0.00	1.30
Environmental awareness	0.34	0.10	0.14	0.03	0.01	0.15	1.13
Constant	-5.01***	2.09	0.00	0.19***	0.08	0.00	
χ^2	29.77						
Pseudo R^2	0.12						

Note. Coef. = Coefficient of determination for logistic regression. χ^2 = Chi-Square. SE = Standard Error

Social influence, physical need, and innovation attributes are highly significant variables at the 1% level, leading to increases in the probability of SWH adoption of 8.4,

6.4, and 3.6%, respectively. The impact of social influence on SWH adoption is clearly demonstrated in this study, as the respondents had mostly observed others households using SWHs before making the decision to adopt. The impacts of social influence and physical need are also reported by Li, Li, & Wang (2013), who found that neighbors and friends have positive and significant impacts on Chinese farmers' willingness to convert traditional houses to solar houses in rural areas. Our results also support the findings of Foster (1993), who indicated that friends, neighbors, and social networks were crucial in communicating relevant information to promote public acceptance of SWH in Australia.

SWH in this study represents a medium of health communication for hygiene promotion, leading to better quality of life, as it allows people to shower more often during both summer and winter. Our findings confirm those of Han et al. (2010) and Runqing, Peijun, & Zhongying (2012), who concluded that SWHs in China are mainly used to supply domestic hot water, particularly for baths in the house to improve public health conditions. The result is similar to that of Li et al. (2013), who revealed that the increased quality of life compared to traditional houses had a positive and significant impact on farmers' willingness to convert traditional houses to solar houses in rural areas. Accordingly, SWH is also compatible with respondents' values and needs, which supports SWH adoption in New Zealand according to Murphy & Donoghue (2009).

The sub-elements of innovation attributes consist of usefulness, ease of use, high quality, saving money, and environmental friendliness. The innovation attribute of ease of use (66%) gained the highest score as it was the biggest advantage of SWH utilization, followed by usefulness (16%), environmental friendliness (13%), and saving money (5%), respectively. Our findings are similar to those of Li et al. (2013), who indicated that SWHs can satisfy the daily hot water demands of residents reliably and at a reasonable price that competes favorably with the price of electric and gas water heaters. Our findings regarding saving money were in line with the results of Ma et al. (2014), who reported that SWH diffusion is the least expensive means of fulfilling China's renewable energy target compared with other renewable energies. It is also in good agreement with the findings of Qiu et al. (2015), who raised the good point of evacuated tube SWHs as lower prices compared with flat plate SWHs.

The factor of communication channels is positive and significant at the 10% level, leading to a 5.4% increase in SWH adoption. According to our study, cell phones, TV, and face-to-face interaction are the first three main communication channels, respectively, used among the SWH adopters. In the modern era of digital globalization, cell phones are also widespread in rural Chinese society, so it is more convenient for rural people to communicate and access more information including social media via cell phones. Meanwhile, TV is the only mass medium gaining popularity among Chinese rural society, and face-to-face communication is still important in their way of life. Regarding face-to-face communication as an informal channel, our result supports the finding of Foster (1993) that friends, neighbors, and social networks were crucial in communicating relevant information, the suggestion by McEacherna & Hanson (2008) that informal communication should be promoted, and the conclusion of Lei, Yang, & Jiayang (2014) that the most trusted channel through which consumers learned about the 13% subsidy providing to Chinese rural people for the purchase of home appliances, including SWHs, was their personal relationships.

Among the demographic factors, income and household size significantly increase the probability of SWH adoption by 0.00 and 1.1% at the 5% and 10% significance levels, respectively. Our result regarding income aligns with that of Sidiras & Koukios (2004), who revealed that available family income was one of the dominant factors influencing SWH diffusion. With regard to household size, having more family members makes SWH adoption more valuable because more members can benefit from utilizing the SWH. However, greater age has a negative relationship with SWH adoption, decreasing the probability of SWH adoption by 0.9%. This is because taking a shower is less important for older people than for younger people, so the older people tend toward a lower adoption rate. The result is also supported by McEacherna & Hanson (2008), who disclosed that older respondents take longer to move through the innovation-decision process than younger respondents. Furthermore, the positive relationship between demographic factors and SWH adoption confirms the direction of independent variables related to innovativeness, as summarized by Rogers (2003).

Meanwhile, environmental awareness, salespersons, government policy, and education have positive, although insignificant, effects, increasing the probability of SWH adoption by 2.8%, 0.5%, 0.3%, and 0.4%, respectively. This study found that only about one fourth of the respondents (23%) adopted SWH due to concerns about using environmentally friendly products. This supports the result of Han et al. (2010) concerning SWH production and consumption in China; they found that SWH utilization is another way in which people express concerns about protecting the environment but that adoption is mainly due to economic incentives and cultural appeal rather than environmental concerns. Nevertheless, the respondents' environmental awareness behaviors were the fundamental outstanding practices carried out to protect the environment.

Our study also confirms the important role of the salespersons, as most respondents bought SWHs from salespersons to whom they were close or who they knew very well. In the meantime, updated and understandable knowledge and information should be also obtained through research and disseminated to the public by both academic scholars and the central and local media. Basic knowledge regarding solar energy innovation and its benefits should be systematically embedded in the educational system based on students' level of education and ability to understand as well. The government policy of providing the 13% subsidy could promote a better quality of life for rural people. This study also found a positive effect of the policy on SWH adoption. However, not many respondents knew about this policy in detail, so it did not have much impact on their decision to adopt SWH, corresponding with the previous finding of Ma et al. (2014).

The estimated logit model from the maximum likelihood procedure can be represented as a function of rural people's decisions to adopt SWH:

$$RPASWH = -5.01 - 0.039(Age) + 0.51(HouseholdSize) + 0.00\,(Income) + 0.04(Education) + 0.54(Innovation) + 0.62(SalesPersons) + 0.72(SocialInfluence) + 0.06(GovernmentPolicy) + 0.65(CommunicationChannels) + 0.76(PhysicalNeed) + 0.34(EnvironmentalAwareness)$$

To predict the probability that rural people will decide to adopt SWH, substitution of the mean values of each independent variable of the adopters from Table 4 needed to

be calculated into the logit model and used the reduced form as the following equation. A general equation about the probability that rural people will make this decision could be constructed and expressed:

$$P = P[Y = 1] = \frac{e^{F(\text{RPASWH})}}{1 + e^{F(\text{RPASWH})}} = \frac{e^{F(0.643)}}{1 + e^{F(0.643)}} = \frac{1.903}{2.903} = 0.66$$

Based on the current characteristics and behavior of rural people in this study, it can be predicted that the probability that a rural person will decide to adopt SWH is 65.5%. This equation can be employed to preliminarily estimate the probability that a rural person will decide to adopt SWH by substituting the values for each area into the model.

Part 4: SWH Diffusion and Adoption: Empirical Analysis of Processes and Key Players

SWHs have been introduced to the rural people in the study area by a few salespersons since around 2006. Salespersons provided sales services, including sales presentation, selling and installation, repairs and sales consultations, and reinstallation of new SWHs. Due to their long-term experience in selling home appliances including SWHs in the study area and providing information on SWHs to rural people as well as they fact that they stayed in the same village as the respondents, the salespersons were trusted by the rural people, which accelerated SWH adoption. There were also a few villagers who played the role of opinion leaders in SWH adoption, as their names were mentioned by the respondents, and talking to the opinion leaders could persuade the respondents to adopt SWHs. Moreover, most of the respondents had observed SWHs on their neighbors' rooftops and had talked to the neighbors and friends/peer groups about the costs, benefits, limitations, and installation processes of SWHs. Neighbors and friends/peer groups are crucial players influencing SWH adoption.

In order to gain a better understanding of the rural people's characteristics regarding SWH adoption, adopters are analyzed and classified into five categories based on the adopter categorization model (Figure 2), employing the mean ($\bar{X}$) and standard deviation (SD) of the starting year of SWH adoption.

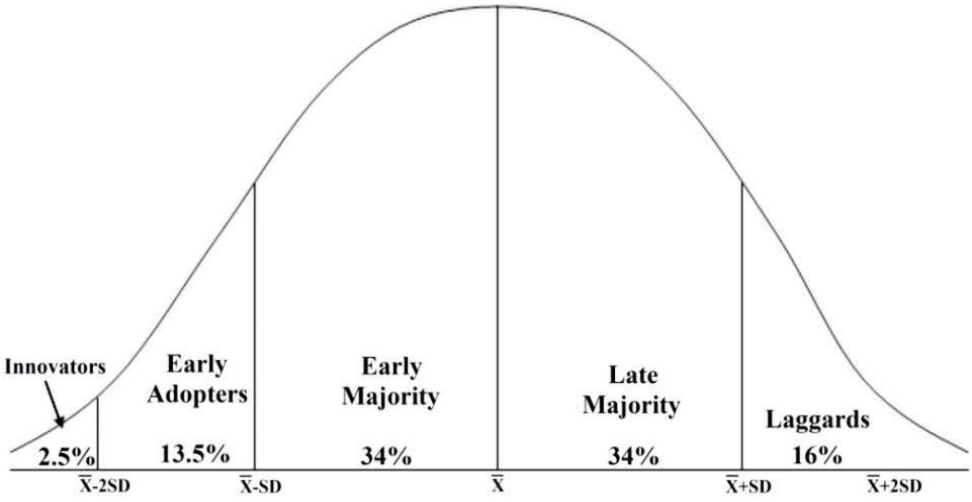

Figure 2. Adopter categorization (Rogers, 2003).

In the calculation based on the frequency distribution of the adopters, the mean year of adoption was 2006 and the standard deviation was 5. The first group comprises the people with the highest innovativeness, who adopted the innovation in 1998-2000. This group is called innovators and is in the area to the left of the mean time of adoption minus two standard deviations ($\bar{X}$ - 2SD). Early adopters who adopted SWH during 2001-2005 are the next group, which lies in the area between $\bar{X}$ - 2SD and the mean minus one standard deviation ($\bar{X}$ - SD). The early majority, whose SWH adoption took place in 2006, is next, covering the area between the mean time of adoption ($\bar{X}$) and the mean minus one standard deviation ($\bar{X}$ - SD). Then, the group represented by the area between the mean time of adoption and the mean plus one standard deviation ($\bar{X}$+SD) is the late majority, who adopted SWH during 2007-2011. The last group is the laggards, who adopted SWH during the period 2012-2014, and lies in the area of the mean plus one standard deviation ($\bar{X}$ + SD) and the mean plus two standard deviations ($\bar{X}$ + 2SD).

The results of the SWH adopter categorization showed that almost half of the respondents were the late majority with regard to SWH adoption; they took time to carefully evaluate the innovation before adopting it (Figure 3 and Table 4). The results presented the outstanding difference from adopter categorization in DOI (Rogers, 2003) that the late majority gained the highest number among all types of adopters, implying the influence of the government policy of providing a 13% subsidy, which was trialed at the end of 2007 and finally promulgated in 2009, led to an increase in SWH adoption. The results also reflect the crucial role of salespersons as middlemen who introduce the innovation to promote a better quality of life. The rural people might be unconcerned about the innovation without the product presentation made by the salespersons, because an SWH is not one of the basic needs for living (food, clothes, housing, and medicine), so it is not required for survival. Understanding the adopter categories of SWH adoption can provide baseline information for policy makers to help them design policies that are aligned with the characteristics of each group of adopters.

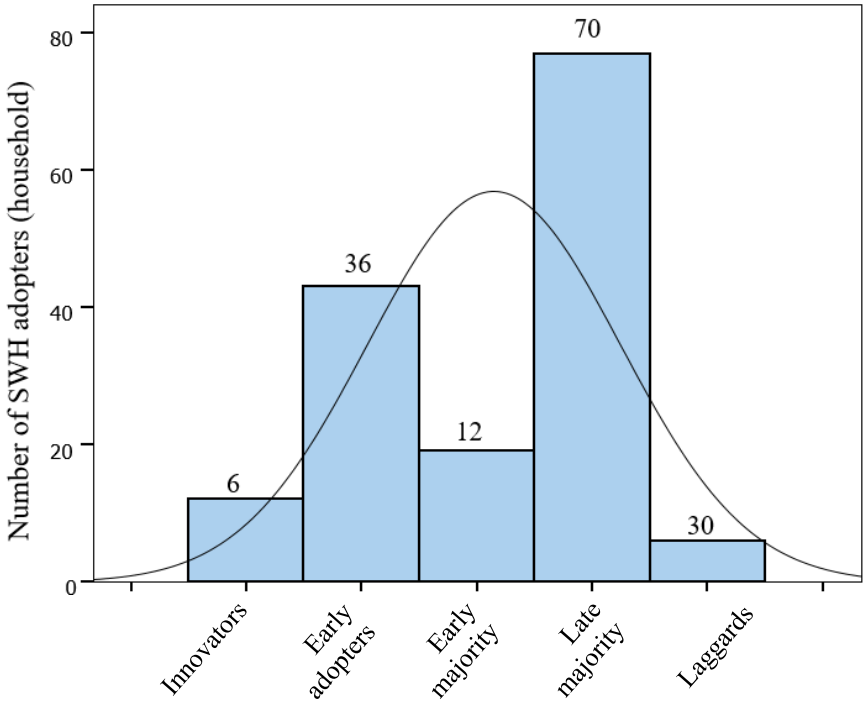

Figure 3. SWH adopter categorization.

Table 4

Categorization of SWH Adopters

Adopter category	Year	Number of households	Percentage of households
Innovators	1998-2000	6	3.90
Early adopters	2001-2005	36	23.38
Early majority	2006	12	7.79
Late majority	2007-2011	70	44.45
Laggards	2012-2014	30	19.48
Total		154	100.00

Part 5: From SWH to Practical Diffusion and Adoption of Solar Energy Innovations

Based on our study, the most influential drivers for SWH adoption are, in order: social influence, physical need, innovation attributes, income, communication channels, household size, environmental awareness, salespersons, government policy, and education (Table 3). In order to achieve practical diffusion and adoption of solar energy innovations in a rural society, these adoption drivers should be promoted, while the technological barriers should be managed. Related stakeholders comprising policy makers, the business sector, media organizations, and the education and research sector should collaborate to plan and promote these elements in accordance with their respective social contexts as per the following recommendations (Figure 4).

1) Social influence as one of the proposed factor in TRA (Fishbein, & Ajzen, 1975) can be promoted by opinion leaders and rural people who have already adopted SWHs, who are also the early adopters as categorized by Rogers (2003). Early adopters, who are more integrated into the local social system than innovators and asked by a person before adopting a new idea, can be the change agents or connectors to provide the information and persuade those who have not decided to adopt SWHs or who are unsure about whether or not to adopt them. Better understanding of the benefits and usage of SWHs enables all rural people to obtain the right information and knowledge to allow them to make decisions regarding adoption.

2) Physical need can be promoted by the development of innovations with lower cost and high quality, including policy incentives, which more recommendations are mentioned in the following drivers of Income and household size and government policy.

3) To promote the perceived innovation attributes as a person evaluate the innovation based on five attributes proposing in DOI (Rogers, 2003), the communication guidelines regarding renewable energy initiatives developed by Silk, Hurley, Pace1, Maloney, & Lapinski (2014) can be applied to solar energy innovations. In terms of relative advantage, it is important to emphasize the clear benefits of the innovations in terms of economics, employment, self-sufficiency, and the environmental advantages of using innovations. The compatibility of stakeholder resources with the adoption of solar energy innovations needs to be investigated, and targeting and tailoring of messages should be considered as well. Scientific research results and information on the innovations provided in understandable terms need to be translated to reduce the complexity of the innovations. The facilitation of opportunities to demonstrate and test

the actual innovations or to use small-scale innovations or pilot studies of nearby households or communities is necessary for rural people to gain insight and understanding regarding the innovations before adoption. Moreover, observing others adopt the innovations, especially if they are opinion leaders, might help develop perceived norms and self-efficacy, leading to the adoption of innovations (Rogers, 2003).

4) Income and household size: In order to spread the innovations to rural people, the product price is important, particularly for non-essential products. If the innovations are too expensive, there is a higher possibility that people will not adopt them. Large households seem to gain more worthwhile benefits compared to smaller households with regard to adopting innovative technologies. Therefore, the promotion of products through policy incentives from the national government is the most crucial factor for motivating users from rural areas to buy the products. In the meantime, the policy can also motivate the business sector and entrepreneurs to produce and sell the products. This kind of policy can be trusted by both groups as the government is a credible and powerful sector in society.

5) Communication channels: According to our study, cell phones, TV, and face-to-face interaction were the first three main communication channels used among the adopted SWHs respondents, including social media which were accessed via cell phone. This study also highly recommends that policy makers use these social media networks to disseminate related policy information to the wider public. In the meantime, media organizations at both national and local levels should broadcast news and special issues regarding the discovery of solar energy initiatives by researchers, experts, and/or local wisdom, which will promote a better quality of life for people. Integrated media should be employed based on each social context in which rural people have the most exposure to the media. Cell phones together with social media discovered in this study has expanded from mass and interpersonal communication focused in DOI (Rogers, 2003) due to the effect of communication technology development raising role of the media in the society.

6) Environmental awareness: Nowadays, the general public is more aware of the impacts of global warming and climate change, so products should be also developed with an environmentally friendly basis. At the same time, the government should promote low-carbon technology products via market instruments such as taxation. For example, low-carbon technologies should be taxed at a lower level than those without an environmentally friendly basis. Although the energy efficiency label exists, most of the rural people were confused by it and had misunderstood which number represented the best energy saving level. More importantly, environmentally friendly products should be supported by the government to achieve a lower cost of production, and information regarding this should be more clearly disseminated to the general public, particularly people in rural areas. If this energy efficiency policy is implemented, environmentally friendly innovations can be more widely adopted among rural people for global benefits as well.

7) Salespersons, as another key player, should enhance their knowledge of innovations, information on related government policies, and knowledge of customers'

needs and characteristics, including the skills of transferring the information to the people to expand knowledge of the innovation. The knowledge consists of: (1) the awareness knowledge, (2) how-to-knowledge, and (3) principles-knowledge, which enable the people to determine "what the innovation is and how and why it works" (Rogers, 2003). Additionally, salespersons with the knowledge can increase perceived innovation attributes of the rural people as one of the decision process to adoption (Rogers, 2003) regarding the innovation's relative advantage (Davis, 1989), compatibility and ease of use Davis, 1989). In the meantime, provision of independent advice before buying to people and product trialability should be promoted to increase observability leading to more possibility of adoption. In addition, the business sector should collaborate with research organizations to perform research on solar energy innovations and development as well as trying to produce new products at lower prices and to maintain high quality to support the utilization of environmentally friendly products.

8) Government policy: An effective incentive policy initiated by the government based on the assessment of previous policies and research assessing the needs of the public should be promoted, and ensuring of people's correct understanding and benefits to obtain. Moreover, the policy should be designed and implemented with regard to the characteristics of the majority of people and geographical standpoint, and this should be done at the right time and in the right space for each society.

9) Education: Knowledge about SWH was correlated with positive beliefs about its effects on global warming, climate change, and environmental awareness. In the light of the extended innovation diffusion and adoption models, the investigation of how to promote more practical environmental awareness and knowledge of solar energy can enlighten future research dedicated to promoting the adoption of solar energy and policy support. Specifically, widespread use of the research results on promoting knowledge on solar energy and innovations through mass and local media and in the educational system should be part of well-organized interventions to motivate the adoption of technology by individuals. Moreover, local authorities should provide practical knowledge along with demonstrations to rural farmers regarding agricultural adaptation to enable a better understanding and transfer of new knowledge and technologies to reduce the impacts of climate change. Besides, in some rural areas, non-governmental organizations (NGOs) also play an important role in supporting local adaptation to climate change by working directly with the farmers, so both local government and NGOs should cooperate in supporting farmers to build their adaptive capacity.

The main barriers to SWH adoption revealed in this study are technical ones caused by the processes of SWH installation in order to make it operate. According to further explanations by a few respondents, to complete the SWH installation, each household needs to have a specific well-equipped room to keep the water pipe from being frozen during the winter season, so existing households without an appropriate construction to serve the SWH installation face difficulties in adopting the innovation. Furthermore, SWHs cannot operate well when there are many cloudy days without sunshine.

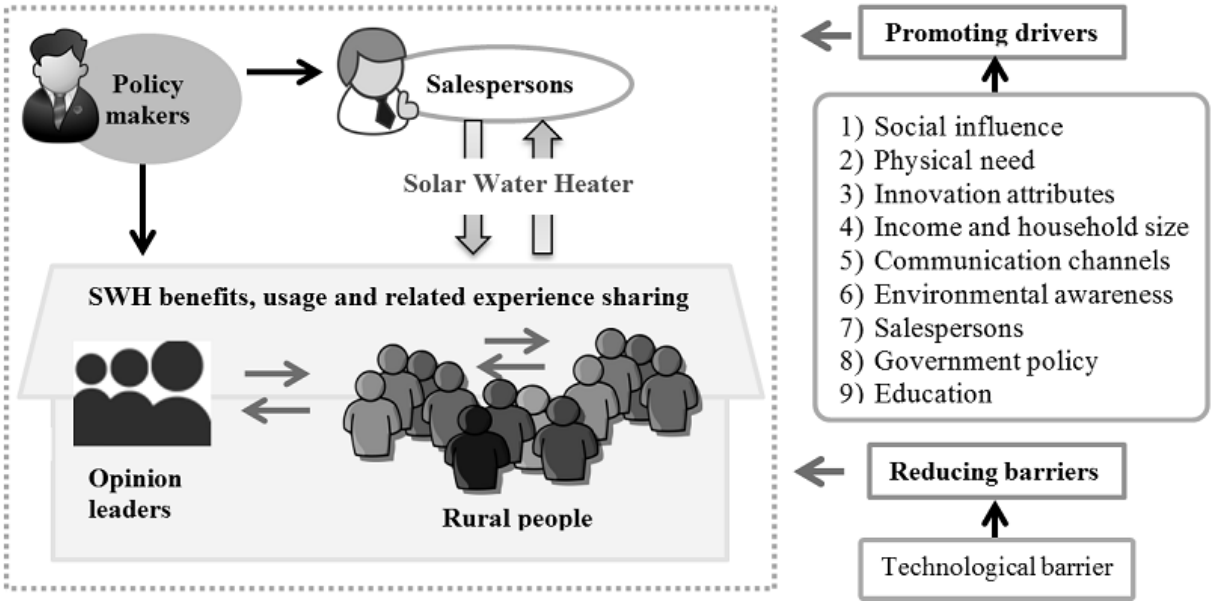

Figure 4. Practical diffusion and adoption of solar energy innovations.

Moreover, practical diffusion and adoption of solar energy innovations is also relevant with opinion leaders and rural people (Figure 4). Opinion leaders played the key role of influential persons affecting the rural people decision to adopt SWH. The rural people mentioned about the opinion leaders as the persons they talked to and could persuade them to install SWH. Rural people were the majority group of people who will adopt or not to adopt SWH. When they observed other households install SWH, talked to the opinion leaders, and gained the information from the sales persons, the majority of them trended to install SWH.

Conclusion and Implication

This study investigated the behavioral perspectives of both SWH diffusion and adoption in rural Chinese society to inspire and share with other societies. The crucial driver increasing the probability of SWH adoption was social influence, followed by physical need and innovation characteristics, respectively. Salespersons and opinion leaders, including neighbors and friends/peer groups, are the key players influencing SWH adoption behavior. In order to achieve practical diffusion and adoption of solar energy innovations in a rural society, these adoption drivers should be promoted, while the technological barriers should be managed. Importantly, the development of solar energy innovations in the future should have an environmentally friendly basis that is appropriate for the needs and characteristics of rural people. Effective diffusion of the innovations should be a two-step flow from the government to salespersons and then to rural communities, particularly earlier adopters.

The findings of this study could contribute to prediction and planning for diffusion of innovations in other rural communities, including guiding future research development and applications regarding low-carbon initiatives for social change. The practical implication can be applied among other agricultural rural communities where the

appropriate solar energy innovation diffusion to reduce farmers' production cost in the long run should be seriously emphasized. The policy initiatives regarding the spread of innovations and related information should also be supported by the government to motivate rural people's behavioral intention to adopt the innovation. Related ministries regarding energy, agriculture and technology should initiate and implement the incentive policy, collaborated with private and academic sectors to invent the environmentally friendly innovation by considering the drivers of rural people's behavioral change as brightened up in this study. The key findings from rural Chinese experience have potential implications for other developing countries at comparable levels of social contexts and solar energy efficiency.

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Ethics Approval and Conflict of Interest Statement

The authors declare ethics approval and no conflict of interest.

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