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Chinese Solar Photovoltaic Rooftop Adoption: The Impact of Culture, Environmental Beliefs, Norms and Barriers

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Abstract

With the rapid economic development and surging demand in energy, China has also observed severe environmental deterioration, which makes adopting clean energy especially solar photovoltaic (PV) rooftop systems critical. However, even with the largest production capacity, China's solar PV adoption at the distributed level is comparatively low. This research aimed at investigating how cultural factors, environmental beliefs, norms and barriers influence solar PV adoption decisions. After collecting data from 351 college students in China, we applied the backward variable selection procedure in logistic regression. Our data showed the following major findings: 1) price norm and action norm are significantly associated with individualism, long-time orientation, and masculinity; while environmental adaptation and professional assistant factor are only significantly associated with individualism and masculinity; 2) both environmental adaptation and professional assistance are significantly correlated to the price norm and action norm; 3) only long-time orientation and individualism are significantly positively related to the current solar PV panel adoption status.

Keywords: Solar PV Residential Rooftop Adoption, Culture, Environmental Belief, Norms, Barriers

1 Introduction

Coinciding with an era of rapid economic development, there has been an increasing demand in energy, especially electricity in China. The massive use of coal and natural gas as the major fuel resources to generate electricity, although met the strong demand for energy in the short run, created a series of environmental issues in the long run. As a result, large cities in China have begun facing bigger issues including pollution emissions, which have led to serious environmental consequences, namely damage to public health. After experiencing and observing day after day of smog, and intensive discussions of climate change and particulate matter (PM 2.5), Chinese people have started to reemphasize the importance of environmental protection. In fact, with European and American focus on advocating sustainability, terminology such as "sustainability", "low carbon" and "clean energy" have not only become frequently used terms and expressions, but have also led to a sustainable lifestyle, which has also started to grow in popularity across China, particularly among Generations Y and Z (Chen, 2014).

With the severe environmental deterioration, different from the traditional sources from power generation, renewable energy, such as solar and wind power, emits less pollutants and starts to get popular. Solar photovoltaic (PV) systems generating electricity through semiconductors and its ap- plication can be categorized into two types: centralized system or distributed system. Centralized solar applications are usually large-scale systems run by utility companies, while decentralized ap- plications are photovoltaic (PV) systems installed on the rooftops of residential buildings, business buildings, such as warehouses and shopping malls; and in other public areas, such as municipalities, schools and airports.

Starting as the major exporter, China seized the opportunity of exporting to European countries such as Germany who had initiated high-level feed-in tariffs and PV subsidy policies in 2004. Immediately China had leapfrogged to being the largest producer of PV systems. With more than 300 manufacturers directly involved in the PV system production, approximately 2,000 companies provide relevant products. More than 70GW PV solar cells and 18.66 GW production capacity of PV modules created a wave of overproduction in this country. Especially in 2012, the new 50%- 150% tax on the Chinese exported PV panel after the anti-dumping and anti-subsidy investigations from the European Commission and the U.S. led to the consequent shrinking international market (Wingfield, 2012). China has to rely on its own domestic market. The growth in China's installed PV capacity in just a few years has been truly astounding. China is expected to add up to 65 GW cumulative installed capacity in 2021, to reach 300 GW in cumulative installed capacity by the end of 2021 (Reuters 2021). The survival and growth of this industry cannot rely solely on government policy subsidies.

The unbalanced distribution of installed capacity in China with large-scale PV power plants are majorly located in the northwestern areas of China due to the local sufficient solar resources, such as long hours of sunshine and large spare landscape (Xia et al., 2007). Interestingly, they only have small distributed systems installed in the east areas of China. This distribution is also opposite to the unbalanced economic development in China. In eastern area of China, strong economic development leads to high demand for electricity while western part has limited development without strong demand for electricity. The transmission of energy from the western potentially generating lands to the eastern area becomes a challenge due to significant power loss in the process. With governmental policy, such as the Golden Sun Program, the Chinese government leaned towards encouraging self-generation and self-consumption of electricity in the eastern area (Bie and Lin, 2015). Therefore, by 2018, The accumulated installed capacity of distributed solar PV only ac- counts for 27.1% of China's total solar PV installation. Therefore, understanding what factors lead to the challenges of promoting distributed solar power in China became very critical.

1.1 Cultural Factors

According to Hofstede's Culture's Consequences (Hofstede, 1984), culture is a collection of loosely organized values, practices, goals and norms that distinguish humans from different groups or nations. Accordingly, cultural values can significantly affect people's thoughts, emotions and behaviors, attitudes, cognitive processes, and lifestyle (Chen, Chen, & Meindl, 1998). By systematically studying cultural differences, valuable insights can be gained about groups of people and/or nations. It is important to note here that such insights do not aim to essentialize groups of people; rather, they aim to gain a deeper understanding of how certain processes might unfold so that natural interactional flows in local contexts are not disrupted. For example, as demonstrated by Yeniyurt and Townsend's (Yeniyurt and Townsend, 2003) application of Hofstede's cultural dimensions, in order to understand how best to market a product that is new to a given group of individuals, entrepreneurs might want to observe hierarchical relationships, and history of new product introduction. In doing so, entrepreneurs would be more able to successfully launch their marketing scheme. Failure to recognize cultural differences may also cause managerial and le- gal problems for organizations that operate in different cultures (Franke & Nadler, 2008). Indeed market globalization has increased cross-border business activities, and the workforce globally has become diverse; thus it is important for multinational firms to understand cultural differences (Saad et al., 2015). Hofstede's (2010) dimensions approach culture at the national level, scoring a nation as a whole for each category: power distance(equal vs. unequal), individualism vs. collectivism, masculinity vs. femininity, uncertainty pursuit vs. avoidance, pragmatism, and indulgence. Figure 1 compares the index of each of these dimensions among China, Germany and the U.S. For de-tailed information on how these figures are calculated, see Hofstede's "Dimensionalizing Cultures: The Hofstede Model in Context" (2011).

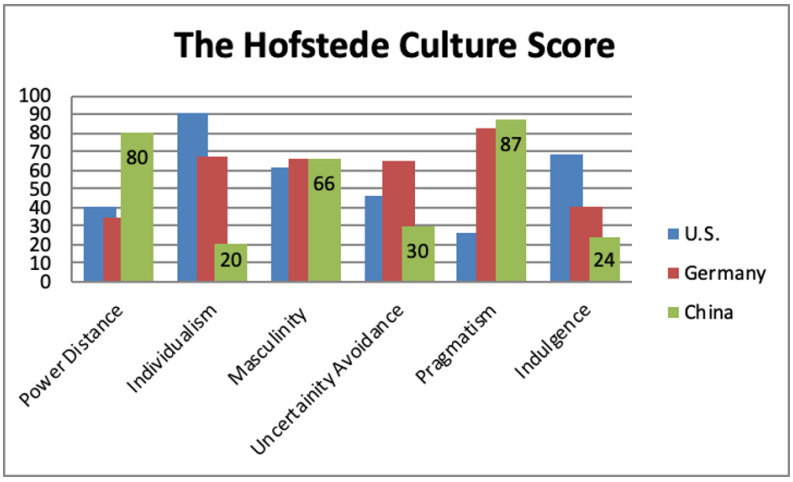

Figure 1: The Hofstede Culture Score

As Figure 1 indicates, China has a significantly higher score in power distance than Germany and the U.S. In terms of pragmatism, China and Germany have almost the same scores, which are higher than that of the U.S. Chinese scores in individualism, uncertainty avoidance and indulgence are lower than those of the U.S. and Germany. The three countries have very close scores in terms of masculinity. The next section explores these six dimensions further and considers how the scores influence decision-making in the solar adoption process.

1.2 Power Distance

Considering the fact that all individuals in society are not always equal, power distance reflects the attitude of the culture towards these inequalities in the nation. Specifically, it defines the extent to which the less powerful members of institutions and organizations within a country expect and accept unequal power distribution. China has a higher rank as 80 in this dimension, much higher than the U.S. (40) and Germany (35), which indicates the polarized subordinate-superior relationship is so common that individuals are highly influenced by formal authority. The difference in the power distance index will have mixed impacts on the progress of promoting a solar PV system among Chinese residents. On one hand, this higher power distance makes the breakdown of the centralized energy system difficult. According to Yoon (Yoon, 2009), customers from high power distance index (PDI) countries are less open to new ideas and products. Chinese people have already gotten used to the energy system run by the larger state-owned generation companies; they have become used to the formal authorities and fear any failure to do with innovation, such as a new generation distributed system. Therefore, promoting a distributed solar power system will take much effort and time. On the other hand, this higher power distance index also leads the central government and local government to be the major enablers for this process because people usually follow the guidance of the authorities. In addition, due to the Internet and the social network, those quiet but significant changes in this cultural dimension are noted. People in China are able to access more information through different information channels such as the Internet, and in doing so, explore ways in which to question formal authority. The downward trend of PDI is imminent, especially likely with increased rates of higher education and greater mobility worldwide.

1.3 Individualist-Collectivist

In Hofstede's second dimension, individualist vs. collectivist, individualism addresses how much interdependence a society has with its members (Hofstede, 1984). Individualistic cultures are self- oriented with personal responsibility and achievement; people in individualist societies do not rely on any groups, so they would take full responsibility of caring for themselves and their direct family. People with collectivist cultures, on the other hand, are more group-oriented; they prefer to act in the interests of the group so that they are loyal to the groups that can look after them as exchange; thus, group goals and norms outweigh personal goals and attributes in guiding behavior (Triandis et al., 1988).

China is a prototypical collectivist country with a low score of 20 (Figure 1). Rooted in the historical, political and religious foundations of Confucianism, Buddhism and Taoism, Chinese people value Families, friends and groups over the self; self-effacement is preferred to self-promotion in a group; and there are strong sensitivities to in-group and out-group boundaries. The recent paper published by Ang, Fredriksson, and Sharma (Ang et al., 2020) discussed individualism influences the adoption of clean energy. There are several mixed implications of this cultural perspective on the adoption of a distributed solar power system.

Firstly, people in China rely on the current business model of centralized electricity generation so much that they would have concerns on emerging distributed systems through which individual families would generate electricity on their own. They would not only question the operations of the system, but also be anxious about the stability of the system. Those concerns and doubts would make them hesitant in adopting this new idea, thus making the progress of promoting distributed solar energy longer than in other countries. Secondly, due to this collectivist culture, China has shown a strong response to the Trade War by industry consolidation to get together to better utilize resources and quickly respond to the change of the external environment. The quick consolidation would benefit a few large companies and the stabilization of the whole solar industry, but it would do so at the cost of a large number of middle or small-scale companies. As mentioned by Ayre (2015), the 10 largest PV manufacturers in this country would supply 70-80% of domestic demand. Thirdly, since social interaction is strong among people in a collectivist culture, people would be greatly influenced by the other members of the community. Because of this cultural feature, further promoting the distributed solar power system through the community has great potential. Consistent with the feature of the Chinese housing structure, most residents live close to each other and own rooftops together. If they can form some consensus to invest in rooftops together and share the benefit together, China would become the largest solar PV domestic market in a very short period of time.

1.4 Masculinity vs. Femininity

The masculinity/femininity dimension of culture refers to the extent to which a society stresses achievement or nurture. The masculinity aspect reflects how strongly society emphasizes traditional masculinity values, such as competitiveness, achievement, ambition, and success, while the femininity aspect reflects the value of nurturing, helping others, and quality of life. According to Hofstede (Hofstede, 1984), masculinity refers to a society in which social genders are distinct; men should be assertive, tough and focused on material success; women should be modest, more caring of others, and place more value on the quality of life. In a masculine culture, the standard of success would be defined by the winner or the best in the field; this culture would be reflected from the beginning of school education and extend to organizational behaviors. In contrast, in a feminine culture, success would be defined by the level of enjoyability of life, in which it would not be important to stand out as extraordinary. With a score of 66, China is considered a masculine society, which means that people work hard and economic growth is a high priority. Germany and the U.S. have a score of 66 and 62, respectively. Therefore, these three cultures share, in terms of masculinity, similar values. This observation holds three implications for the future of the solar industry in China.

Firstly, from the internal competition point of view, China's solar PV industry has been through a tough period due to strong international competition, especially after the anti-dumping and anti-subsidy investigations in the last ten years. The fall of Suntech Power, a PV company that was the number one in the market that went bankrupt in 2011 is a particularly stinging example of this difficult period. As mentioned above, a masculine society values financial success; it is no surprise, then, that a growing lack of confidence in the PV industry led to financial institutes withdrawing existing loans or rejecting new funding requests connected to the solar industry. The whole situation made it more difficult for many small and middle size enterprises to survive.

Secondly, from the perspective of competition, Chinese manufacturers are not afraid of competition worldwide. Although China is famous for its focus on harmonious relations, it would choose to fight back in the fiercely competitive solar PV arena instigated by anti-dumping and anti-subsidy investigations. In order to avoid the high tax tariffs, for example, Chinese manufacturers established their manufacturing facilities in South Korea or other Asian countries. Further, while the trade war caused solar PV manufacturing facility closures in China, most Chinese manufacturers thrived to success beyond mere survival, as evidenced by its top 10 solar PV manufacturers worldwide. Indeed, these points reflect a culture of masculinity.

Thirdly, and quite notably, China has begun undergoing a trend from masculinity to femininity. Feminine cultures place a higher value on quality of life. Chinese people have also started to care about quality of life more, especially about clean energy and other sustainability issues. With this trend in culture, distributed solar PV systems would become popular in China.

1.5 Uncertainty Avoidance

The uncertainty dimension measures how much risk a society can take and how much ambiguity can cause anxiety. This index shows the level of threat felt by the members of a culture when they meet ambiguous or unknown situations and how they create beliefs and institutions that try to avoid these (Hofstede, 1984). Hofstede found that there exist significant differences among nations in terms of the way that they deal with uncertainty: Western cultures focus on managing or reducing uncertainty (Lind and Van den Bos, 2002), whereas Eastern cultures might tolerate, accommodate or even embrace uncertainty (Mor et al., 2013). China received 30 in this dimension, which is a low score. Therefore, most of the time, the Chinese are not comfortable with ambiguity and sometimes avoid risk.
Uncertainty is critical to entrepreneurship (Folta, 2007). The way an entrepreneur deals with uncertainty can significantly affect the success of his or her entrepreneurship, for example, whether the entrepreneur could exploit and seize the opportunity through the uncertainty (Alvarez et al., 2013). In the solar PV industry, we noticed that Germany and the U.S. spend more money and efforts on R&D to improve the efficiency of PV panels, while most Chinese companies focus more on manufacturing. Without risk-taking and innovation, the technology development would be slow. On the other hand, this cultural practice exists in contract behavior. Since the investment on PV panels is huge, leasing with a 20-year contract is very normal in western countries. However, in China, most of these contracts are very ambiguous, so residents are hesitant to sign these contracts. According to this risk-avoidance culture, formal and standard contracts with explicit rights and obligations are very necessary and useful to convince consumers to participate in the solar PV market.

1.6 Pragmatism - Long Term Orientation

This dimension indicates how every society connects with its own past, the present and future (Hofstede, 1998). With a score of 87, China has a very pragmatic culture, which means that Chinese people find definitions of truth or falsity to depend on the situation, context, and time. They have the strong capability to adapt traditions according to new conditions. The high score also reflects the long term-orientation in society. According to Liu, Sun & Kaloustian (Liu et al.,2015), the investment of solar power panels usually takes a longer time period to expect returns, 8-10 years on average. Therefore the long term orientation will be hypothesised to have some influence in the adoption of this technology.

1.7 Indulgence

This dimension is defined as the extent to which people try to control their desires and impulses, based on the way they were raised. Cultures can be categorized as indulgent or restrained. In the indulgent culture, people have relatively weak control of their desires and impulses based on how they were raised. In contrast to this, the culture with a strong control has “restraint”. China has 24 in this dimension, which means that it is a restrained society with a strong tendency toward cynicism and pessimism. People perceive that indulging is somewhat wrong and do not value leisure that much; therefore they strictly comply with social norms.

1.8 Environmental Factors

Environmental factors could be some major reasons leading to the lower PV rooftop system adop- tion. The environmental factors include environmental beliefs, norms and barriers. Stern et al.(1999) developed the value-belief-norm theory and they suggested that those holding strong pro- environmental beliefs were generally observed to be highly possible in engaging in pro-environmental actions such as consumer behaviors (Pickett-Baker and Ozaki, 2008). This paper adopted the the- ory from Gadenne, Shama, Kerr and Smith (Gadenne et al., 2011). Particularly, this paper focuses on people’s belief in environmental limits and environmental adaptation; Environmental norms are generally believed to be positively related to pro-environmental consumer behavior. Environmental norms include price norms factor and action norms factor. Environmental barriers include all the barriers which lead to the difficulties in the process of undertaking pro-environmental consumer behavior; Generally, believe that professional assistance factors, a cost factor and a regulation factor are the potential obstacles to adopt solar PV distributed systems.

This paper sheds light on the environmental influences involved in adopting the solar power system at a distributed level. Such considerations may allow for more strategic interactions with households and homeowners in discussions of solar PV systems installation.

2. Literature Review

To get an overview of the history, status quo and projection of the PV industry in China, interested readers might want to refer to Zhao, Zhang, Hubbard and Yao (Zhao et al., 2013) and Sun, Zhi, Wang, Yao and Su (Zhi et al., 2014) for detailed information. Sun et al. (Sun et al., 2014) re- viewed the history of China's solar PV industry and summarized the current status of China's PV development. Correspondingly, the suggestions here advocate expansion in the domestic market and international markets, establishment of a market access mechanism, an integrated innovative financial system, and a grid-connected power generation system.

The existing literatures relevant to the impact of social factors on solar PV adoption can be categorized into the following three major research streams: 1) policy analysis (Carley, 2009, Li et al., 2007), 2) economic analysis, and 3) social and cultural impact. In the social strand of power research, Labay and Kinnear (Labay and Kinnear, 1981) used a multivariate technique to analyze the factors affecting solar photovoltaic (PV) adoption. Kaplan (1999) explained that technical knowledge, motivation, experiences and familiarity are four critical influences of interest in PV. Under the framework of diffusion of innovation, Faiers and Neame (Faiers and Neame, 2006) compared a group of 'early adopters' and 'early majority' regarding the attitudes towards domestic solar power systems. For the building of integrated solar energy adoption, Li, Zhang, Li, Zhou, Li, and Li (Li et al., 2007) argued that policy-oriented markets, subsidies, and social interaction/acceptance are the three factors influencing the solar industry's development. Schelly (Schelly, 2010) applied a logistic regression model to test the relationship between residential solar thermal adoption at the county level and three indices: socioeconomic index, environmental concern index and environmental index. The paper concluded that counties with higher education levels, less unemployment, and higher levels of disposable or investment income indicated higher interest in adopting solar thermal technology. More recently, Chen (Chen, 2014) investigated a frame- work between value, life-style, personality and environmental behavior intentions related to solar power system adoption. He concluded that environmental value has a significant positive effect on ecological lifestyle and solar PV system installation intention. Karakaya and Sriwannawit (2015) provided a summary of barriers from the following four dimensions: sociotechnical, management, economic, and policy.

There is very limited research discussing how culture factors intervene with solar PV adoption. But based on Steers et al. (Steers et al., 2008)'s work, culture influences could influence new technology adoption. The recent paper published by Ang, Fredriksson, and Sharma (Ang et al., 2020) discussed individualism influences the adoption of clean energy. Alipour, Salim, Stewart and Sahin (Alipour et al., 2021) gave a thorough review on the factors influencing solar residential PV adoption. Culture was not listed.

There are a handful of papers regarding the influence of environmental beliefs and attitudes on green products or environmental behaviors. The environmental factor part of this research adopted the measurements from Gadenne et al. (Gadenne et al., 2011). We focused on general environmental beliefs discussed by Pickett-Baker and Ozaki (Pickett-Baker and Ozaki, 2008), environmental norms Ozaki (Ozaki, 2011), and environmental barriers Neimeyer (2010) based on their framework. Belonging in the three factors are other sub-factors namely environmental limits and environmental adoption factors for general environmental beliefs; price norm and action norm factors for environmental norms; and professional assistance, cost, and regulation factors for environmental barriers. In order to get a sense of environmental behaviors of our respondents' concerning energy saving and solar PV adoption, we designed our survey with predominant items or questions targeting the aforementioned sub-factors relating to each of the three major environ- mental behavior factors. All of the items were analyzed on a 5-point Likert-type scale, where 1 is strongly disagreed and 5 is strongly agreed.

3. Method

This survey was administered in China in 2016. Although the data we collected is from college students on campus in Beijing and Shanghai, they can represent college students originally from different parts of China because most students were from their hometowns and came to Beijing and Shanghai to study. After a brief explanation of the purpose of the research, the questionnaire was filled. A total of 351 questionnaires were distributed and completed from college students. Getting response from students who are convenience samples received lots of critiques, however, the group could represent the attitude and tredence of millennium.

The questionnaire included four sections relating to the status of the plan of adopting solar PV systems, their environmental attitude and demographic information. The survey for college students was using t English since most of the college students have more than 10-year-study in English and have a fair understanding in English. Since most Chinese college students had years of English education and they all had a good understanding of English in writing, the questionnaire was designed and distributed in English. However, during the distribution process, if they asked for help with understanding some wording, our researchers offered very basic help.

4. Statistical Analysis and Result

4.1 Demographic Characteristics of Respondents

The following respondents' demographic characteristics (table 1) shows 40.6% of 351 responded students were under 20 years old, and 59.4% of them were between 20 - 30. It is reasonable to assume that the majority of respondents were not fully employed nor with high salaries. The number of female and male respondents were roughly the same. It has also been seen that the proportions of the respondents' highest education level in each of the four categories were approximately equal. In relation to major, the largest group of students were from the Engineering field (56.7%), the second largest population was from Business field (16.9%), which corresponds to the most popular majors in China according to the recent Chinese college graduates' employment annual report (2015 - 2020). The remaining 26.4% of students are from Humanity, Science, and other fields. According to the 2016 China Statistical Yearbook, six regions are categorized in China including Beijing and Shanghai; they are North China (Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia), Northeast China (Liaoning, Jilin, Heilongjiang), East China (Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong), Southwest China (Chongqing, Sichuan, Guizhou, Yunnan, Tibet), Northwest China (Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang), and South Central China (Henan, Hubei, Hunan, Guangdong, Guangxi, Hainan, Hongkong, Macau). The birthplace data in the table shows that 80.9% of the respondents were from the more developed region, East China, North China, and South Central China, including the megacities such as Beijing and shanghai. The rest 19.1% of students were from the less developed region, Northeast China, Northwest China, and Southwest China.

Table 1: Respondents' demographic characteristics

Characteristic	Range	Percentage (%)
Age	Under 20 years	40.6
	20 - 30 years	59.4
Gender	Female	52.2
	Male	47.8
Education	High school	26.1
	Some college	29.1
	Bachelor degree	21.4
	Graduate degree	23.4
Major	Business	16.9
	Engineering	56.7
	Humanity	10
	Science	12.2
	Other	4.2
Birth Place	East China	30.9
	North China	28.9
	Northeast China	6.3
	Northwest China	6.5
	South Central China	21.1
	Southwest China	6.3

4.2 Factor Description and Selection

The questionnaire consisted of varieties of items designed to detect whether they significantly affect the solar PV panel adoption status. Given that the PV panel adoption status is a binary dependent variable, we followed the backward variable selection procedure in logistic regression (Bursac et al., 2008) to reduce the number of items. The selection results are listed as follows.

Corresponding to the culture, five factors are selected,

4.2.1 A power distance factor is the item for an ideal job, "be consulted by your boss in decisions involving your work".

4.2.2 An indulgence factor is the item for private life, "moderation: having few desires".

4.2.3 A long-time orientation factor is also the item for private life, "doing a service to a friend".

4.2.4 A masculinity factor (with a Cronbach's alpha of 0.7579) comprising the following items for an ideal job: "get recognition for good performance", "have pleasant people to work with", "live in a desirable area", and "have chances for promotion".

4.2.5 An individualism factor (with a Cronbach's alpha of 0.6974) comprising the following items: "If a coworker gets a prize, I would feel proud", and "It is important to maintain harmony with my group".

Five factors were selected from the categories of general environmental belief, environmental norms, and environmental barriers.

1. An environmental adaptation factor measures general environmental belief (with a Cronbach's alpha of 0.6736) comprising the following items, "Plants and animal exist primarily to be used by human", "Humankind was destined to rule over the rest of nature", and "Hu- mans have the right to modify the natural environment to suit their needs".

2. A price norm factor measures environmental norms (with a Cronbach's alpha of 0.6505) comprising the following items, "I would be prepared to pay higher prices overall in order to protect the environment", "I will be prepared to spend $5 more per week for everyday items in order to protect the environment", and "I would be prepared to reduce my standard of living in order to protect the environment".

3. An action norm factor also measures environmental norms (with a Cronbach's alpha of 0.8432) comprising the following items, "As an individual I must do what I can to prevent climate change", "Business and industry should be responsible and help prevent climate change by reducing their emission", and "I would purchase a green product with a payback period of less than 10 years".

4. A professional assistant factor measures environmental barriers (with a Cronbach's alpha of 0.5888) comprising the two items: "I need professional or additional assistance before using/installing green products" and "I need other people to assist in my decision to purchase green products".

4.3 Hypotheses Testing

The prior studies and the selected factors suggest the following hypotheses:

H1: The culture factors are associated with the environmental norms, beliefs and barriers. H2: The environmental beliefs are associated with the environmental norms.
H3: The environmental barriers are associated with the environmental norms.
H4: The culture factors significantly affect the status of solar PV panel adaptation.
H5: The environmental norms, beliefs and barriers significantly affect the solar PV panel adaptation status.

To test Hypothesis 1, given that there are 5 culture factors and 4 factors regarding environmental norms, beliefs and barriers. Multivariate Analysis of Variance analysis (MANOVA) is appropriate (Gadenne et al., 2011). The results are provided in Table 2, and show that the price norm and action norm were significantly associated with the individualism, long-time orientation, and masculinity; while the environmental adaptation and professional assistant factor were only significantly associated with the individualism and masculinity. The power distance and indulgence were not significant to the environmental beliefs, norms

Table 2: MANOVA: dependent variable - environmental beliefs, norms, and barriers

Dependent Variable	Independent Variable	F value	p-value
Corrected model	Power distance	1.6	0.179
	Indulgence	0.5	0.755
	Long-term orientation	5.3	0.000***
	Masculinity	13.5	0.000***
	Individualism	47.8	0.000***
Environmental adaptation	Power distance	0.144	0.705
	Indulgence	1.009	0.316
	Long-time orientation	2.354	0.126
	Masculinity	7.550	0.006**
	Individualism	45.688	0.000***
Price norm	Power distance	1.337	0.248
	Indulgence	0.559	0.455
	Long-time orientation	7.177	0.008**
	Masculinity	9.019	0.003***
	Individualism	75.685	0.000***
Action norm	Power distance	0.474	0.492
	Indulgence	0.444	0.506
	Long-time orientation	14.162	0.000***
	Masculinity	49.088	0.000***
	Individualism	173.526	0.000***
Professional assistance	Power distance	2.093	0.149
	Indulgence	0.771	0.381
	Long-time orientation	1.753	0.186
	Masculinity	16.130	0.000***
	Individualism	18.411	0.000***

The MANOVA is also applied to test Hypothesis 2 and Hypothesis 3, the environmental norms are considered as the dependent variables, and the general environmental belief and environmental barrier are the independent variables. The analysis results are given in Table3. From the table, both the environmental adaptation and professional assistance are significantly correlated to the price norm and action norm, which strongly support Hypothesis 2 and 3.

Table 3: MANOVA: dependent variable - environmental norms

Dependent Variable	Independent Variable	F value	p-value
Corrected model	Environmental adaptation	37.025	0.000***
	Professional assistance	40.712	0.000***
Price norm	Environmental adaptation	31.763	0.000***
	Professional assistance	44.714	0.000***
Action norm	Environmental adaptation	72.359	0.000***
	Professional assistance	75.376	0.000***

To examine which factors may significantly affect the current solar PV panel adaptation status, a logistic regression analysis is appropriate since the adaptation status is a binary variable. The logistic regression model is based on the coefficients provided in Table 4,

$$\text{Logit}\hat{p} = -4.430 - 0.250\text{PowerDistance} - 0.274\text{Indulgence} + 0.350\text{LongtimeOrentation} + 0.441\text{Individualism} + 0.185\text{Masculinity} + 0.034\text{EnvironmentalAdaption} + 0.331\text{PriceNorm} - 0.107\text{ActionNormFactor} + 0.036\text{Professional Assistance}$$

where is the probability that the respondents have the solar PV panel on their houses.

Table 4: Logistic regression coefficients table

Factor	Coefficient	Std. Error	z value	p-value	Odds ratio
Intercept	-4.430	1.543	-2.871	0.004	–
Power distance	-0.250	0.170	-1.473	0.141	0.779
Indulgence	-0.274	0.171	-1.594	0.111	0.760
Long-time orientation	0.350	0.205	1.705	0.088*	1.419
Individualism	0.441	0.237	1.862	0.063*	1.554
Masculinity	0.185	0.248	0.746	0.455	1.203
Environmental adaptation	0.034	0.165	0.205	0.837	1.035
Price norm	0.331	0.265	1.253	0.210	1.392
Action norm	-0.107	0.266	-0.401	0.689	0.899
Professional assistance	0.036	0.190	0.186	0.852	1.037

With a 0.10 significance level, only long-time orientation and individualism are significantly positively related to the current solar PV panel adoption status. Therefore, the students who considered the long-time orientation more with a score increase by 1 point, are 1.419 times higher to adopt the solar PV panels. And the students who strongly agree with individualism more with a score increase by 1 point, are 1.554 times greater to adopt the solar PV panels

5 Conclusion, Implications and Future Study

Our data indicates the following major findings: 1) price norm and action norm are significantly associated with individualism, long-time orientation, and masculinity; while environmental adaptation and professional assistant factor are only significantly associated with individualism and masculinity; 2) both environmental adaptation and professional assistance are significantly correlated to the price norm and action norm; 3) only long-time orientation and individualism are significantly positively related to the current solar PV panel adoption status. The implication of the findings are significant. Similarly like the other new production adoption, solar PV adoption also is associated with long-time orientation. The two implications here are 1) from a marketing perspective, the solar industry could highlight the long-term benefits of solar PV residential rooftop systems to get custom buy-in. 2) From a technology perspective, the new product development team and R&D should continue to work on improving the solar panel pay-back time so that consumers will be confident about their investment decisions. The typical pay-back period for solar panels is still 7-8 years, which sounds long for most investors. In terms of the culture trait of individualism, our results are consistent with Ang, Fredriksson, and Sharma (Ang et al., 2020)'s work. Their data supported that the adoption probability's increase if an individual has individualistic values. This paper has similar findings.

This paper shows since we collected data majorly from college students, convenience samples might influence the accuracy level of the conclusion. Therefore, this points to the future research direction to include household data from the household head. Meanwhile, the current analysis is based on the current installation. We also collected the intention for PV rooftop installation in the next five and ten years, which can be analyzed in future research. We are also interested in collecting data from different countries in future research, which can provide a more solid comparison since with current single population the variation might not be that significant In the survey, we did ask a few questions for each variable. However, validity is an issue. Then we only adopt one question for most variables. More exploration could be done with this perspective.

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