Sustainable Attitudes and Future Visions for Energy Transitions: A Comparative Analysis of British and Chinese Undergraduates' Perspectives

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Conventional energy sources are neither secure nor sustainable, which is the motivation behind the energy transition to expand the availability of renewables or nuclear energy. Such reform should remove social barriers to understanding the sustainable attitudes and corresponding influences of the public, especially from the younger generation's perspective, as they will be the ethical consumers of the coming decades. The objectives of this study were to comprehend and compare British and Chinese undergraduates' sustainable attitudes, the future vision of the energy transition, and corresponding influences. 94 and 98 questionnaires from the Britain and Chinese participants were collected respectively, including psychosocial and socio-economic factors as independent variables, and behavioural intention as the dependent variable. Participants' sustainable attitudes were comprehended via quantifying their psychosocial variables including awareness of climate change and energy sources, and their behavioural intentions, i.e. willingness to pay a financial premium for renewables and nuclear power. The collected socio-economic information included grade, gender, nationality and economic dependence. The differences between sustainable attitudes were analysed through one-way analysis of variance, and correlations between the independent and dependent variables were examined via a linear regression test. The results showed that participants in both countries demonstrated high climate change awareness and limited energy-related knowledge base, but still exhibited a higher acceptance of renewables than nuclear power, with 'energy security beliefs' and 'energy sources familiarity' being vital influencing factors. This phenomenon underlines the significance of unbiased education, especially regarding nuclear power. In addition, Britain participants expressed a greater willingness to pay extra for both energy sources than the Chinese, although this was not statistically significant. The differences can be explained by the varied cultural and historical backgrounds, socio-economic levels, political situations and energy systems of the two countries. Comparative studies in other countries are still in demand to enhance the comprehension of their inhabitants' sustainable attitudes and to contribute to eliminating social barriers of the energy transition across the globe.

1. Introduction

At present, 74 % of energy demand is met via fossil-based electricity generation (Ul-Mulk and Reynaud, 2018), accompanied by non-negligible finite and detrimental effects. On the one hand, conventional energy sources are physically limited, and their replenishment rates cannot keep up with the surge in demand or meet long-term operations (Ul-Mulk and Reynaud, 2018). On the other hand, conventional energy sources are also insecure, leading to severe consequences. For example, accelerating the pace of global climate change (GCC) (Zhang, 2012); damaging the environment (Zhang et al., 2021) and ecosystems (Xiong et al., 2017), threatening public health and people's quality of life (Kotcher et al., 2019), affecting domestic and global economic development (Timilsina, 2015), and challenging the world configuration and stability (Zhong et al., 2017). Countries are therefore reforming their supply systems to establish a more sustainable and secure energy supply by vigorously exploring and exploiting more low-carbon and inexhaustible energy sources, e.g., renewable energy (RE) and nuclear energy (NE) (Vainio et al., 2019). Both energy sources have the potential to tackle the issues caused by fossil-based electricity generation and, therefore in line with the concept of sustainable development.

Energy transition reforms rely not only on qualified scientific, technological and professional expertise but also on the ability of residents to hold sustainable attitudes (Vainio et al., 2019). Therefore, researchers should conduct investigations through an interdisciplinary approach to assess the determinants of public attitudes. Skamp et al. (2019) demonstrated that an effective way to estimate people's sustainable attitudes and behavioural intentions is by understanding their sustainable consumption behaviour: investigating their willingness to pay more (WPM) for electricity generation when alternative resources (e.g., RE and NE) are available. It is reasonable to expect that environmentally positive consumers are more likely to pay a financial premium for carbon-free supplies, while those with different or even opposite attitudes (e.g., GCC sceptics and anti-nuclearists), will be more reluctant to do so (Maslin, 2014). In the United States of America (Roe et al., 2001), Japan (Nomura and Akai, 2004), South Korea (Yoo and Kwak, 2009), China (Zhang, 2012) and many other countries, studies have attempted to understand national WPM and the corresponding influences. Neverthelss, transnational study is still limited in this area, with Skamp et al. (2019) finding significant variations between students' WPM for RE and NE amongst 11 nations, and Ul-Mulk and Reynaud (2018) reporting several variations between French and Pakistanis. More studies are needed in other countries to fill this knowledge gap. This study selected the United Kingdom (UK) and China (CN) as the study sites, respectively representing socialist developing and capitalist developed country contexts,, with typical East-West cultural variations. It aims to investigate the profile, differences, and potential causes in sustainable attitudes and future visions of energy transitions from undergraduates' perspectives, as they will be the ethical consumers for the coming decades (Ho et al., 2019). The objectives are to quantify and compare the British and Chinese undergraduates' corresponding perceptions, dig the potential explanations of the similarities and differences, and investigate how social-psychological and social-economic variables influence their behavioural intentions. The findings can provide a scientific basis for the development of nationally appropriate energy-related regulatory frameworks and policies, and contribute to the elimination of social barriers to the energy transition.

2. Methodology

This section describes the vital relevant contexts in the countries studied, the variables, data collection methods, and statistical tests. The corresponding research framework is shown in Figure 1.
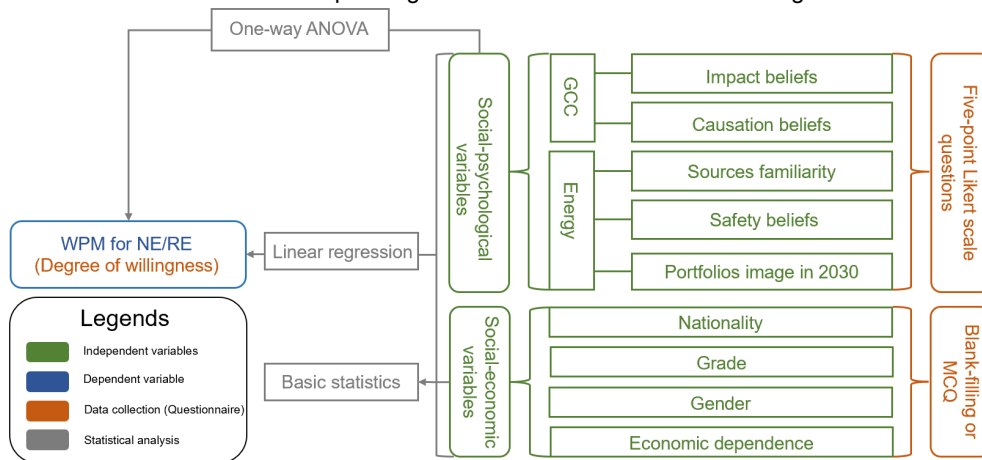

Figure 1: Study framework: variables, data collection, and statistical analysis

2.1 Study sites

Both China and the UK are seeking to address the 'trilemma': the 3 'A's, namely accessibility, availability and acceptability, and the 3 'E's, namely energy security, environmental growth and environmental protection (Keay, 2016). Firstly, both countries have been committed to seeking trade-offs of energy-environmental issues. London, the capital of the UK, was the first city in the World to experience haze, with the 'Great London Smog' (or 'Great Smog of 1952') having caused over 12,000 related fatalities due to nationwide fossil power generation (Polivka, 2018). Fine particulate matter ($PM_{2.5}$) pollution is also a big issue in China. It has led to targeted local (e.g., Beijing's Clean Air Action Plan 2013 - 2017) and national (e.g. Air Pollution Prevention and Control Action Plan) documents to limit the development of fossil industries (UNEP, 2019). Secondly, both countries are also facing energy supply issues. The UK's fossil energy sources are limited, unevenly distributed and declining, and energy demand is substantially dependent on imports (UK Energy in Brief, 2019). In China, as the 'factory of the World', its population and energy demand have grown at an alarming rate (at around 6.51 %/y) since China opened its markets in 1978 (Tang et al., 2015). Therefore, both countries have attempted to expand the provision of RE or NE in the energy portfolio.

2.2 Exploratory variables and data collection

A self-reported questionnaire method was conducted to comprehend participants' perceptions, distributed via WeChat (an generic soical media) for the Chinese and paper forms for the British (at the University of Liverpool) during June and July in 2019. Their sustainable attitudes were examined via their WPM for RE/NE (the dependent variable), including five levels ranging from '1 = not at all willing' to '5 = extremely willing'. The independent variables included five social-psychological variables: GCC-impact belief (Vainio et al., 2019), GCC-causation belief (Tang et al., 2015), energy sources familiarity (Onencan and Walle, 2018), energy safety belief (Zhang and Wu, 2012), and energy portfolios image in 2030 (Vainio et al., 2019), which were collected via five-point Likert scale questions (ranging from '1=strongly disagree' to '5=strongly agree' with a threshold of '3=neutral') (Ul-Mulk and Reynaud, 2018); and four social-economic variables: nationality (Ul-Mulk and Reynaud, 2018), grade (Çelikler, 2016), gender (Abrahamse and Steg (2009), and economic dependence (Hess and Jepsen, 2009), which were collected through multiple choice questions (Vaino et al., 2019). The native language of each country was used to ensure response rates, and any incomplete or unfaithful answers were annulled (Vainio et al., 2019). A total of 94 out of 132 responses from Chinese participants and 98 out of 116 responses from UK participants were eventually condiered valid.

2.3 Statistical analysis of the variables

The socio-economic distribution of participants in each country was analysed through basic statistics. A one-way analysis of variance (ANOVA) was conducted on the variance of the participants' social-psychological variables and WPM through Minitab. Linear regression was conducted through Statistical Package for Social Sciences (SPSS) to test the association between the independent and dependent variables.

3. Results

This section provides the socio-economic distribution of participants in each country, demonstrates the statistical differences between their social-psychological variables and WPM, and the statistical correlations between the independent and dependent variables.

3.1 Social-economic distribution

Table 1 shown below domenstrates that in both countries, participants were generally gender balanced, and second-year students make up the majority (around 40 %), with first-year and third-year students accounting for around 30 % each. Whilst, the proportion of UK participants (79.59 %) who are financially independent is even ten times greater than the Chinese (7.45 %), as a considerably different social-economic variable in this study.

Table 1: Participants' social economic distribution in the UK and China

Nationality	Gender	N (%)	Grade	N (%)	Economic dependence	N (%)
Britain	Male	53 (54.08 %)	Year 1	29 (29.95 %)	Independent	78 (79.59 %)
	Female	45 (45.92 %)	Year 2	38 (38.78 %)	Dependent	20 (20.41 %)
	N	98	Year 3	31 (31.63 %)		
Chinese	Male	42 (44.68 %)	Year 1	26 (27.66 %)	Independent	7 (7.45 %)
	Female	52 (55.32 %)	Year 2	38 (40.43 %)	Dependent	87 (92.55 %)
	N	94	Year 3	30 (31.91 %)		

3.2 Sustainable attitudes – similarities and variations

Table 2 presents the social-psychological variables for the British and Chinese and the statistical differences of their WPM regarding NE and RE. Out of the 14 factors, only four did not demonstrate statistically significant differences. Both UK and Chinese participants exhibited strong 'GCC impact beliefs' (M>4, F = 0.16, P = 0.70), and the former more regarded it as an anthropogenic process (P<0.01). All participants showed a relatively low level of energy familiarity. Only the UK participants had a mean value greater than the threshold regarding RE (M_{UK} = 3.34, M_{CN} = 2.99, P<0.01), but the Chinese participants were more likely to consider themselves familiar with NE (M_{CN} = 2.71, M_{UK} = 2.35, P<0.01) and fossil fuels (M_{CN} = 2.94, M_{UK} = 2.25, P<0.01). They perceived fossil fuels (M_{CN} = 2.73, M_{UK} = 1.93, P<0.001) and NE (M_{CN} = 2.35, M_{UK} = 2.71, P<0.05) to be unsafe, believing that which supply would be reduced by 2030, and the UK participants showed a stronger attitude (P<0.001). In comparison, there were high expectations of domestic RE supply by 2030 in both countries (M_{CN} = 4.09, M_{UK} = 4.17, P = 0.48). Eventually, all participants were more willing to pay a financial premium for RE (M_{CN} = 3.86, M_{UK} = 4.06, P = 0.13) rather than NE (M_{CN} = 2.52, M_{UK} = 2.56, P = 0.80), and the UK participants exhibited higher WPM for both energy sources, although there was no statistical difference.

Table 2: Statistical differences in psychosocial variables and WPM between the UK and Chinese participants

Variables	Concepts	Mean value (M)		F-value	P-value (Sig.)
GCC-impact belief		M_{CN} 4.22	M_{UK} 4.17	0.16	0.7
GCC-causation belief	Artificial	M_{CN} 4.13	M_{UK} 4.42	6.86	**
	Natural	M_{CN} 3.31	M_{UK} 2.73	18.86	***
Energy sources familiarity	Fossil fuels	M_{CN} 2.94	M_{UK} 2.25	20.97	***
	NE	M_{CN} 2.71	M_{UK} 2.35	6.8	**
	RE	M_{CN} 2.99	M_{UK} 3.34	7.39	**
Energy safety belief	Fossil fuels	M_{CN} 2.73	M_{UK} 1.93	39.73	***
	NE	M_{CN} 2.35	M_{UK} 2.71	6.63	*
	RE	M_{CN} 3.89	M_{UK} 4.22	6.84	**
Energy portfolios image in 2030	Fossil fuels	M_{CN} 2.18	M_{UK} 1.58	30.95	***
	NE	M_{CN} 3.46	M_{UK} 2.62	39.64	***
	RE	M_{CN} 4.09	M_{UK} 4.17	0.51	0.48
WPM	NE	M_{CN} 2.52	M_{UK} 2.56	0.07	0.8
	RE	M_{CN} 3.86	M_{UK} 4.06	2.34	0.13

*Note: *** $P<0.001$, ** $0.001< = P<0.01$, *$0.01<=P<0.05$ (Cotton et al., 2016)*

3.3 Regression testing of the influencing factors

Psychosocial variables were the main determinants of participants' behavioural intentions (WPM), with all five items being statistically correlated to certain degrees. Both the UK and Chinese participants' beliefs regarding GCC-impacts were positively and strongly associated with their WPM for RE ($P<0.01$), and those who perceived NE and RE to be more secure showed higher corresponding WPM for both energy sources ($P<0.01$). There were two distinctive findings in China: the more the participants believed that GCC is a natural process, the less they were willing to pay a financial premium for RE ($P<0.1$); the energy source's familiarity with fossil fuels ($P<0.01$) and NE ($P<0.05$) was positively associated with their WPM. The British's imaginations of domestic fossil fuels (negative effects, $p<0.05$) and RE (positive effects, $P<0.01$) provisions in 2030 were strongly correlated with their WPM for RE, while the imagination regarding NE exhibited positive relationships with which corresponding WPM in both countries ($P_{UK}<0.01$, $P_{CN}<0.05$).

The three social-economic factors exhibited little influence on participants' WPM. Only Chinese participants showed little evidence that female ($P<0.1$) and senior ($P<0.1$) students had more WPM for RE, and no correlation was found for these other variables.

Table 3: The associations between the dependent and independent variables, linear regression with standard coefficients (β) and standard errors (S.E.).

Variables		British				Chinese			
WPM for		NE		RE		NE		RE	
		β	S.E.	β	S.E.	β	S.E.	β	S.E.
GCC-impact belief		-.11	.13	.64***	.08	.03	.12	.40***	.10
GCC-causation belief	Artificially	.03	.19	.19	.14	-.12	.11	.10	.10
	Naturally	-.04	.13	-.11	.09	.01	.11	-.18	.11
Energy sources familiarity	Fossil fuels	-.01	.11	.16	.08	.24	.10	.27***	.09
	NE	-.01	.13	-.01	.10	.23***	.10	-.13	.10
	RE	.01	.14	.01	-.01	.25	.11	-.14	.11
Energy safety belief	Fossil fuels	-.02	.20	-.09	.15	.24	.10	-.04	.10
	NE	.69***	.10	-.10	.10	.26***	.10	.01	.10
	RE	.08	.13	.67***	.07	.03	.14	.53***	.12
Energy portfolios image in 2030	Fossil fuels	-.01	.15	-.31**	.11	.01	.12	.06	.10
	NE	.45***	.11	-.05	.09	.22**	.11	-.06	-.10
	RE	-.04	.12	.67***	.07	-.11	.13	.13	.12
Gender		-.01	.23	.04	.18	-.15	.20	.18*	.19
Grade		.56	.32	-.03	.11	.10	.13	.18*	.13
Economic dependence		-.27	.29	-.01	.22	-.06	.31	.00	.37

*Note: *** $P<0.01$, ** $0.01< = P<0.05$, *$0.05<= P<0.1$ (Smith et al., 2017)*

4. Discussions

4.1 Sustainable attitudes and corresponding influences

Participants in both countries shared concerns about GCC could be explained by its seriousness, global nature and widespread publicity, which has attracted widespread worldwide attention (Smith et al., 2017). The variations in sustainable attitudes can be explained by the educational, historical and socio-economic differences between nations (Ul-Mulk and Reynaud, 2018). Alike the results of this study, Skamp et al. (2019) and Driver et al. (2010) also revealed that fewer students endorsed the willingness to pay extra for NE compared to RE. The underlying reasons could be the safety issues such as proliferation, waste contamination, catastrophic severe radioactive release events (Skamp et al., 2019), and the extensive marketing of RE (Driver et al., 2010). The knowledge base of the respondents in this study was limited because they all tended to 'disagree' that they were familiar with RE and NE, and their judgement of 'future image' and 'WPM' could therefore be based on a societal level rather than personal (Driver et al., 2010). Similarly, Nakibolu and Tekin (2006) pointed out that many Turkish students believe that NE is unsafe because they have heard about the harmful effects of radioactive substances while lacking further scientific understanding, e.g., the probability of occurrence. In this study, Chinese participants who are knowledgeable about NE have exhibited higher corresponding WPM. This phenomenon aligns with the 'belief bias' proposed by Wu and Tsai (2011) that previous negative perceptions about NE may bias public attitudes, highlighting the significance of objective education. Besides, UK participants exhibited higher WPM for both RE and NE, although there was no statistical difference. This might be due to the materialistic values of developing countries like China, which are already being fulfilled in the UK as a developed country. The latter may be more willing to imagine that the energy transition is more sustainable and secure, accepting carbon-free energy and paying a premium (Ul-Mulk and Reynaud, 2018). Further studies could enlarge the sample size, implement random sampling, and uniform the sampling approaches to understand the variation better.

4.2 Influencing factors of behavioural intentions

Overall, psychosocial variables were the main determinants of participants' behavioural intentions, with all five items being statistically correlated to certain degrees. The varied impacts of psychosocial variables on WPM can be explained by varied social structures and values between the two countries. Unlike the UK, the Chinese may view the energy transition more as a national than individual responsibility (Smith et al., 2017). Social-economic variables exhibited less impact in this study, especially for the British participants, as none of the three tested factors has affected their WPM for both alternative energy sources. Only age and gender had a limited effect on Chinese participants' WPM regarding RE. Such a finding is consistent with Vainio et al. (2019). However, unlike Abrahamse and Steg (2009), those who reported socio-economic variables were more likely to influence individuals' pro-environmental attitudes. Besides, the UK has a high Human Development Index (HDI) and which socio-economic barriers therefore may not be as significant as those in developing countries (Vainio et al., 2019). Future studies are recommended to detect more exploratory variables considering the publics' attitudes and behavioural intentions could be influenced by other factors, either psychosocial or social-economic, e.g., participants' undergraduate courses and the number of children in their families (Vainio et al., 2019).

5. Conclusion

Overall, this study revealed that undergraduates in both countries were generally aware of the impact of GCC (M>4), while participants in the UK were more likely to perceive it as artificially-induced (P<0.01). Several significant variations were found in psychosocial perceptions about energy, which can be explained by the discrepancies in historical, cultural, educational, political and energy status. Although both nations show a higher acceptance of RE than NE, participants' corresponding knowledge base is rather limited, especially regarding NE (M<3). This highlights the significance of unbiased understanding and suggests that more corresponding education is needed to promote further energy transition, especially regarding NE. Besides, psychosocial variables were the main influences on participants' behavioural intentions, showing a more or less robust association (P<0.01), while socio-economic variables had only a limited effect in terms of age and gender of Chinese participants (P<0.1). This study fills a knowledge gap in understanding the sustainable attitudes and future visions of energy transition of undergraduates in the UK and China, and further enhances the recognition of the differential role of influencing factors across countries. It is also recommended that future research could include additional study sites and expanded sample sizes to more comprehensively examine the variations and influences between Western developed capitalist countries and Eastern developing socialist countries.

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