GENDER DIFFERENCES IN ENERGY-SAVING BEHAVIOR

Wen-Hsiu Huang, Department of Public Finance, Ling Tung University, Taiwan, E-mail: michelle@teamail.ltu.edu.tw
Ming-Che Chao, Institute of Civil Engineering, National Chi Nan University, Taiwan,
Director, Department of Physical Medicine and Rehabilitation, Asia University Hospital, Taiwan,
Phone: +886-04-9291-2151, E-mail:dreame79.tw@yahoo.com.tw

Abstract

This study employs the simultaneous equation model to analyze gender differences in individuals' energy-saving behavior. In particular, we focus on energy-saving behavior in the aspects of transport and residence. The results show that the gender variable has significant effects on environmental knowledge, attitude, and behavior. Men tend to display higher levels of environmental knowledge relative to women. However, women exhibit a more positive attitude toward energy saving than men. For energy-saving behavior in transport and residence, we can draw the same conclusion that women are more willing to practice than men. This result highlights that a potential opportunity for energy saving may rest on incorporating gender education with environmental education. Therefore, gender equality in the responsibility for our sustainable environment would be an important issue that we need to pay attention to. It is worth noting that people make more efforts for energy-saving behavior in residence than in transport. This result implies that it is more challenging to change people's behavior patterns in transport than in residence. The policy makers should pay more attention to induce people's travel behavior toward energy conservation.

Keywords: Energy-saving behavior, Gender differences, Environmental attitude

1.Overview

To improve energy efficiency and energy saving, technological and economic tools have been the focus of attention around the world. There is growing concern that the exploring human behavior is critical for solving environmental problems (Kollmuss and Agyeman, 2002; Eisler et al., 2003). Many studies have explored the possible factors of environmental knowledge, attitudes and behavior in order to promote energy saving. Steg (2008) categorized the possible factors of energy-saving behavior into two groups: objective and subjective factors. The objective factors include socio-economic and demographic characteristics (Martinsson et al., 2011). Many studies have indicated that socio-economic and demographic characteristics, such as gender, age, marital status, education, and income, may influence energy-saving behavior (Flamm, 2009; Cayla, et al., 2011; Hori et al., 2013). The subjective factors contain personal norms and values, attitudes and beliefs, social norms and social integration, and political orientation and trust in governmental institutions.

Some researchers have noted that environmental knowledge, attitudes and behavior may differ between men and women. Numerous studies investigating the relationship between gender and environmental knowledge have found that men may be more likely to demonstrate higher levels of environmental knowledge than women (Hayes, 2001; Eisler et al., 2003; Vainio and Paloniemi, 2014). There exist gender differences in environmental knowledge, reflecting that men and women may differ in terms of accessibility to scientific and technological knowledge (Hayes, 2001). With respect to environmental attitudes, the empirical results of studies have revealed that females would hold more positive attitudes towards environmental quality and protection than males. And, women would express more concern with environmental issues relative to men (Zelezny et al., 2000; Diamantopoulos et al., 2003; Hunter et al., 2004; Franzen and Vogl, 2013; Sundstorm and McCright, 2013). Knox-Hayes et al. (2013) confirmed that women would tend to have better attitude toward energy security.

In addition, various studies have shown that gender exerts a significant influence on environmental behavior. Women tend to display stronger pro-environmental behavior than men (Zelezny et al., 2000; Eisler, et al., 2003; Hunter et al., 2004; Vicente-Molina, 2013; Lee et al., 2013). Women are more active than men in local environmental issues and more likely to participate in environmental movements (Mohai, 1992). Olli et al. (2001) indicated that, as all of the sociodemographic variables are considered, gender is the strongest predictor of environmental behavior. Vainio and Paloniemi (2014) also found that, in the Nordic countries, being female was positively associated with all types of proenvironmental behavior. Hunter et al. (2004) suggested that there are gender differences in “private” and “public” environmentally-oriented behaviors. In many nations, women would have more private-sphere environmentally-oriented behaviors than men. The private-sphere activities means more personal decisions regarding recycling, purchasing, and transportation. Besides, the findings of Lee et al. (2013)

showed that women are more likely to engage in energy-saving practices and are more willing to pay a higher price for energy-efficient light sources.

Although most studies have found that gender would play a substantial role in deternmining energy-saving behavior, some studies did not support the significant impact of gender on environmental knowledge, attitudes and behavior. Diamantopoulos et al. (2003) pointed out there is insufficient evidence that males are more knowledgeable about environmental issues than females. Tindall et al. (2003) suggested no substaintial connection between gender and behavior. Women may be more concerned about environmental issues, but they are entailed in both paid and domestic work that constrain the availability for activism. Clark et al. (2003) showed that the gender effect on green electricity partipation decision is not significant. The significance of gender effects is reduced when other variables are taken into account (Clark et al., 2003; Mobley et al., 2010).

The gender difference in energy-saving behavior may be originated from many complex reasons. First, one of the possible reasons would be related to gender socialization and social roles (Hunter, et al. 2004; Sundstorm and McCright, 2013). Females play on the roles of caregivers and nurturers, and males take on roles as bread-winner. These patterns of gender socialization may lead to gender differences in environmental behavior. Second, the gender difference in perception and vulnerability would be another possible reason. Past studies demonstrated that women express greater concern over potential environmental risks (Davidson and Freudenburg, 1996). Knox-Hayes et al. (2013) attributed the gender gap to perceptions of climate vulnerability. Women would care more about energy security and climate change because they tend to be more vulnerable. Women express a stronger belief in negative outcomes driven by climate change (Bord and O'connor, 1997). Third, the different energy consumption patterns between men and women may contribute to gender differences in energy-saving behavior. Travel patterns among men and women are different, and energy use for travelling is higher for men than women (Carlsson- Kanyama and Linden, 1999). Raty and Carlesson-Kanyama (2010) indicated that leisure time activities have different energy intensities and differ between men and women. This result may also possibly contribute to gender differences in energy-saving behavior.

In this paper, we employ the three-stage least squares (3SLS) method and the world-wide data to analyze whether there exist gender differences in energy-saving behavior. In particularly, we focus on the energy-saving behavior in transport and residence. This study can identify the characteristics of high energy use and highlight the barriers to these actions. Then, we can explore how to improve individuals' efforts for energy saving.

2.Methods

2.1 The three-stage least squares (3SLS) method

Although many studies have contributed to analyze energy-saving behavior, there exist two problems in the literature. First, the literature has shown that energy-saving behavior would be associated with knowledge and attitudes. However, few studies considered both environmental knowledge and attitudes as the factors in the behavior models. To our knowledge, Flamm (2009) and Vicente-Molina et al. (2013) were the only two studies that incorporated environmental knowledge and attitudes in their models. Second, regarding to the relationship between environmental knowledge and attitudes, most studies took environmental knowledge as an explanatory variable and did not deal with the possible feedback effects between knowledge and attitudes. According to the modern analysis framework for environmental behavior, environmental knowledge and attitude should be treated as endogenous variables due to the interactive relationship between knowledge and attitude (Kollmuss and Agyeman, 2002). The empirical results may be biased if the models neglect the possibility of endogenity.

Therefore, we employ the three-stage least squares (3SLS) method to estimate a simultaneous equation model. The 3SLS method was introduced by Zellner and Theil (1962). This method can be used to estimate a system of structural equations, where some equations contain endogenous variables among the explanatory variables. According to the analytical framework suggested by Kollmuss and Agyeman (2002), we consider the possible interaction among environmental knowledge, attitude and behavior. The simultaneous equations can be represented as:

$$Behavior = \alpha_1 + \alpha_2 Knowledge + \alpha_3 Attitude + \alpha_4 X_1 + \varepsilon_1 \quad (1)$$

$$Attitude = \beta_1 + \beta_2 Knowledge + \beta_3 X_2 + \varepsilon_2 \quad (2)$$

$$Knowledge = \gamma_1 + \gamma_2 Attitude + \gamma_3 X_3 + \varepsilon_3 \quad (3)$$

Behavior means the variable of energy-saving behavior; *Attitude* is the variable of environmental attitude; *Knowledge* represents the variable of environmental knowledge. X_1, X_2, and X_3 are a vector of other exogenous variables. α, β, and γ represent the estimated parameters. ε_1, ε_2, and ε_3 are the error terms. If the simultaneous equations are estimated with ordinary least square method, the results my be biased due to the inherent correlation among the error terms and explanatory variables in the specified equations. Thus, the 3SLS method can be employed to sovle this problem. Moreover, the 3SLS is preferred over the two-stage least squares (2SLS), since the 3SLS can correct for both endogeneity problem and contemporaneous correlation of the error terms across equations (Adewuyi, 2017).

Before we proceed to estimate the model, the accurancy of the model specification should be verified. First, we perform the Hausman tests to examine the presence of regressor endogeneity (Hausman, 1978). We test for three hypotheses: whether the environmental knowledge and attitude variables are jointly exogenous in the eq. (1), whether the knowledge variable is exogenous in the eq. (2), and whether the attitude variable is exogenous in the eq. (3). When the hull hypotheses are rejected, the endogeneity of

regressors can be confirmed. Second, in order to be able to estimate the structural parameters, all the equations of the model need to be identified. Thus, order and rank conditions for identification are required. Only when the equations of the model satisfy the conditions of just-identified or over-identified, the model can be solved. In addition, if the model is over-identified, we need to test for the validity of the over-identifying conditions.

2.2 Data

We use the data from the environmental modules of the International Social Survey Programme (ISSP) in 2010. The ISSP executed the third wave of the environmental modules between 2010 and 2012. This cross-sectional survey contains 34173 observations in 32 countries and includes questions about environmental behavior, attitude, knowledge, and concern (ISSP Research Group, 2012). In the model, we use individuals' energy-saving behavior in transport and residence as the dependent variable. In the questionnaire, two questions can be used to capture individuals' energy-saving behavior in transport and residence. One is "how often do you cut back on driving a car for environmental reasons?", and the other is "how often do you reduce the energy or fuel you use at home for environmental reasons?" Responses were coded as 1 = Never, 2 = Sometimes, 3 = Often, and 4 = Always.

The explanatory variables include objective and subjective factors. The objective factors consist of the characteristics of respondents, such as age, income, education, gender, marital status, and residential location. The age of respondents, measured by a continuous variable, is considered as a factor because the literature reveals that individuals' behavior may vary across different generations (Wang et al., 2011; Boardman, 2004). Martinsson et al. (2011) showed that the age of individuals was positively associated with energy-saving behavior. Hori et al. (2013) analyzed energy-saving behavior in some Asian cities. The results found that age had weak positive effects on energy-saving behavior for the full sample, but the age effects were not significant in most of Asian cities. Flamm (2009) evidenced that the age of respondents was negatively associated with energy saving in vehicle use. Gender is captured by a dummy variable, valued at 1 if the respondent is male and 0 if female. Due to different socialization and social roles, gender difference may exist in energy use and consumption behavior. Many studies indicated that females are more likely to have energy-saving attitude and behavior than males, while males may display higher levels of environmental knowledge (Zelezny et al., 2000; Hayes, 2001; Eisler et al., 2003; Hunter et al., 2004; Vicente-Molina et al., 2013). The education level, measured by years of schooling, is a continuous variable. The literature suggested that education would be an important channel to convey environmental knowledge, and pro-environmental behavior could be promoted through education (Casey and Scott, 2006; Tilbury, 2012). Marital status is a dummy variable, valued at 1 if the respondent is married and 0 if unmarried, separated, widowed, or divorced. Martinsson et al. (2011) showed that married people tend to have stronger energy-saving behavior than unmarried people. We also consider a

dummy variable to represent whether the respondent has at least one child. This variable is valued 1 if the respondent has at least one child and 0 if no child.

The income variable is an important factor to capture the economic ability of individuals. Some studies suggested that the income effects on energy-saving behavior would be positive, because people had better economic ability to invest in energy-efficient equipment (Sardianou, 2007; Wolters, 2014). But, some studies indicated that people would consume energy much more as the level of income rose (Tuan and Lefevre, 1996; Druckman and Jackson, 2008). In the dataset of the ISSP, the variables of household income in different countries are collected, but the monetary units of household income vary across countries. Franzen and Vogl (2013) suggested that the relative income variable can be calculated to make the income variable comparable across countries. Household income can be divided by the square root of the number of persons living in the household and then be z-transformed. In addition, some studies indicated that energy use patterns would differ between rural and urban areas, which was related to different lifestyles and income levels (Cai and Jiang, 2008; Dang et al., 2009). Thus, the variable of residential location is considered in our models. We also include the country variables so as to capture the culture, geography, and climate differences among these countries. The country variables are expressed by a dummy variable, valued at 1 if the household lives in a specific country and 0 if otherwise. The Taiwan dataset is taken as the reference category.

The subjective factors contain environmental knowledge, environmental attitude, risk consciousness, and environmental concern. Furthermore, we consider the variable of anti-science attitude in the environmental knowledge equation. And, in the environmental attitude equation, we take the variable of trust into account.

In the questionnaire, two questions can be used to capture environmental knowledge. One is "how much do you feel you know about the causes of these sorts of environmental problems?" , and the other is "how much do you feel you know about solutions to these sorts of environmental problems?" Optional items are coded as ordinal numbers from 1 to 5, where1 = know nothing at all and 5 = Know a great deal. The variable of environmental knowledge can be obtained by averaging the value of these two questions.

We consider the variables of willingness-to-pay to represent environmental attitude. Willingness-to-pay, which means individuals' willingness to pay at a higher price level for environmental protection, can be captured by three questions: "how willing would you be to pay much higher prices in order to protect the environment?, "how willing would you be to pay much higher taxes in order to protect the environment?", and "how willing would you be to accept cuts in your standard of living in order to protect the environment?". Responses are coded as 5 = Very willing, 4 = Fairly willing, 3= Neither willing nor unwilling, 2 = Fairly unwilling, and 1 = Very unwilling. The variable of environmental attitude can be measured by averaging the value of these three questions.

Risk consciousness can be measured by averaging the values of seven questions. Respondents are asked about whether they think that some environmental problems are dangerous. The environmental problems includes air pollution caused by cars and industry, pesticides and chemicals used in farming, pollution of rivers, lakes and streams, a rise in the world's temperature caused by climate change, modifying the genes of certain crops, and nuclear power stations. Optional items were coded as ordinal numbers from 1 to 5, where 1 = not dangerous at all for the environment and 5 = extremely dangerous for the environment. Environmental concern can be measured by the question that "how concerned are you about environmental issues?". Responses are coded as ordinal numbers from 1 to 5, where 1 = not at all concerned and 5 = very concerned.

The variable of anti-science attitude can represent the respondent's attitude and belief toward science. Anti-science attitude may block one's learning willingness and knowledge absorption. The variable of anti-science attitude can be captured by averaging the values of two questions. One is "we believe too often in science, and not enough in feelings and faith", and the other is "Overall, modern science does more harm than good". Responses are coded as ordinal numbers from 1 to 5, where 1 = disagree strongly and 5 = agree strongly. The variable of trust can be measured by averaging the values of two questions. One is "would you say that most people can be trusted, or that you can't be too careful in dealing with people?". Responses are coded as ordinal numbers from 1 to 5, where 1 = you can't be too careful and 5 = most people can be trust. The other question is "do you think that most people would try to take advantage of you if they got the chance, or would they try to be fair?". Responses are coded as ordinal numbers from 1 to 5, where 1 = most people would try to take advantage and 5 = most people would try to be fair.

Table 1 reports the descriptive statistics for dependent and explantory variables. In the world dataset, we found that the mean value of individuals' efforts for energy saving in transportation is 1.90, while the mean value of individuals' efforts for energy saving in residence is 2.35. These results imply that people would tend to have stronger energy-saving behavior in residence than in transportation. We observe the mean values of objective factors and the results show that, the mean value of age is 47.79 and average years of schooling are 11.20. About 53.5% of respondents are female, 54.2% are married, and 58.1% live in rural areas. As for the subjective factors, the results show that the mean values of risk consciousness, and environmental concern are higher relative to environmental knowledge and environmental attitude.

Table 1 Descriptive statistics for dependent and explantory variables

Variables	Mean	Standard deviation	Variables	N	%
Dependent variables			**Explantory variables**		
Energy-saving behavior in transport	1.90	0.88	**Dummy/Categorical**		
Energy-saving behavior in residence	2.35	0.98	Gender		
Explantory variables			Male	15879	46.5
Continuous/Numeric variables			Female	18294	53.5
Age	47.79	17.06	Marital status		
Income (Z-transformed)	-0.05	1.06	Married	18520	54.2
Education	11.20	4.99	Other	15653	45.8
Environmental knowledge	2.88	1.00	Child		
Environmental attitude	2.62	1.08	With child	11346	33.2
Risk consciousness	3.76	0.71	Without child	22827	66.8
Environmental concern	3.60	1.15	Residential location		
Anti-science	2.89	0.88	Urban	14331	41.9
Trust	2.88	1.09	Rural	19842	58.1
			Country		
			Argentina	868	2.5
			Austria	736	2.2
			Belgium	1025	3.0
			Bulgaria	729	2.1
			Canada	702	2.1
			Chile	976	2.9
			Taiwan*	1921	5.6
			Croatia	665	1.9
			Czech Republic	882	2.6
			Denmark	1218	3.6
			Finland	819	2.4
			France	1601	4.7
			Germany	1186	3.5
			Israel	731	2.1
			Japan	1180	3.5
			South Korea	1379	4.0
			Latvia	527	1.5
			Lithuania	741	2.2
			Mexico	657	1.9
			New Zealand	1026	3.0
			Norway	1225	3.6
			Philippines	1180	3.5
			Russia	1256	3.7
			Slovak Republic	962	2.8
			Slovenia	495	1.4
			South Africa	2201	6.4
			Spain	1874	5.5
			Sweden	1000	2.9
			Switzerland	890	2.6
			Turkey	1471	4.3
			United Kingdom	795	2.3
			United Stated	1255	3.7
Total observations	34173				

Notes: 1. *Na* means that the variable is not available in the dataset.
2. * is used as the reference category.

3.Results

In this study, we analyze gender differences in energy-saving behavior. Particularly, we focus on individuals' energy-saving behavior in transport and residence. The model 1 captures energy-saving behavior in transport, which refers to individuals' efforts for cutting back on driving a car for environmental reasons. The model 2 captures energy-saving behavior in residence, which refers to

individuals' efforts to reduce the energy or fuel at home for environmental reasons. Before we perform the model estimation, the model specification should be confirmed. Since the possible interaction among environmental knowledge, attitude and behavior should be considered, we use the Hausman tests to examine the presence of regressor endogeneity. In other words, we need to clarify the possible feedback effects among these three variables (Hausman, 1978). The results show that, at the 5% significance level, environmental knowledge and attitude variables are enogenous to energy-saving behavior. And, environmental knowledge and attitude variables are endogenous to each other. These results help us to specify the model correctly and confirm the adequency of the simultaneous equation model. In addition, we examine the identification conditions, and all of the equations satisfy the conditions of just-identified.

3.1 The effects of explanatory variables

We employ the 3SLS method to estimate the simultaneous equation models. Table 2 shows the estimation results of the simultaneous equation models. We describe the effects of the objective and subjective factors on energy-saving behavior in the following sections.

First, we observe the effects of the objective factors. The age variable has significantly positive effects on energy-saving behavior in transport and residence, while the age effects on environmental knowledge are significantly negative. The younger generations may exhibit better environmental knowledge but have a lower level of efforts for reducing energy use than the older generations. The seniority effect on energy-saving behavior is positive, because older generations are more frugal due to economic experiences and more likely to reduce energy use (Wang et al., 2011).

The effects of the income variable on energy-saving behavior are significantly negative, while the income effects on environmental knowledge and attitude are significantly positive. High-income people may have a higher level of environmental knowledge and attitude than low-income people. However, people would tend to pursue a better material life standard and consume more energy when their economic ability increases. Thus, there exists a gap between environmental attitude and behavior. High-income people would have a lower level of effort for energy saving than low-income people. The coefficients for the education variable are significan and positive in the equations of energy-saving behavior, environmental knowledge and attitude. This result is meaningful for policymaking because it indicates that education plays an important role in the improvement of energy-saving behavior. Since education is effective in reducing energy use in transportat and residence, the importance of pro-environmental behavior should be reinforced through education in the hope that educated individuals can develop good energy consumption habits and show concern for environmental sustainability.

The effects of the gender variable are significantly positive on energy-saving behavior and environmental attitude but negative on environmental knowledge. The results indicate that the male may have a higher level of environmental knowledge than the female, but the female tend to have more pro-environmental attitude and behavior than the male. The gender differences in energy-saving behavior can

be evidenced in our study. Our results are consistent with the findings of other studies that women are more likely to engage in energy-saving practices than men (Hunter et al., 2004; Vicente-Molina et al., 2013; Lee et al., 2013).

Table 2 Estimation results of the simultaneous equation models

Variables	Model 1			Model 2		
	Behavior	Knowledge	Attitude	Behavior	Knowledge	Attitude
Objective factors						
Age	0.0039**	-0.0024**	0.0003	0.0034**	-0.0038**	-0.0002
Income (Z-transformed)	-0.3888**	0.0263**	0.0554**	-0.0137*	0.0247**	0.0423**
Education	0.0098**	0.0166**	0.0082**	0.0113**	0.0167**	0.0047**
Gender (Male)	-0.0143*	0.2079**	-0.0297*	-0.0284*	0.2058**	-0.0560**
Marital status (Married)	-0.0054	0.0505**	-0.0240	0.0215	0.0655**	-0.0164
With child (Yes)	-0.0829**	0.0473**	0.0655**	-0.0309*	0.0531**	0.0656**
Residential location (Urban)	0.0805**	0.0199*	0.0204	0.0519**	0.0292**	-0.0083
Country (Base= Taiwan)						
Argentina	-0.4178**	-	-	0.1033	-	-
Austria	-0.0416	-	-	-0.0145	-	-
Belgium	0.0338	-	-	0.4073**	-	-
Bulgaria	-0.7824**	-	-	-0.8816**	-	-
Canada	0.0979	-	-	0.1724**	-	-
Chile	-0.0811	-	-	-0.3221**	-	-
Croatia	-0.5953**	-	-	-0.3966**	-	-
Czech Republic	-0.2567**	-	-	-0.0039	-	-
Denmark	-0.0597	-	-	0.2178**	-	-
Finland	-0.2792**	-	-	0.1342**	-	-
France	-0.0178	-	-	0.2628**	-	-
Germany	0.1491**	-	-	0.1630**	-	-
Israel	-0.6796**	-	-	-0.8047**	-	-
Japan	-0.0229	-	-	0.1491**	-	-
South Korea	0.1107*	-	-	0.1933**	-	-
Latvia	-0.7839**	-	-	-0.8463**	-	-
Lithuania	-0.7737**	-	-	-0.1981**	-	-
Mexico	0.0613	-	-	-0.0434	-	-
New Zealand	-0.3595**	-	-	-0.1748**	-	-
Norway	-0.2822**	-	-	-0.0304	-	-
Philippines	-0.0653	-	-	-0.1573*	-	-
Russia	-0.5419**	-	-	-0.5010**	-	-
Slovak Republic	-0.0870	-	-	0.0188	-	-
Slovenia	-0.4846***	-	-	-0.0128	-	-
South Africa	-0.6316**	-	-	-0.4887**	-	-
Spain	-0.3974**	-	-	-0.0438	-	-
Sweden	-0.2096**	-	-	0.0127	-	-
Switzerland	0.3473**	-	-	0.2045**	-	-
Turkey	-0.0890**	-	-	-0.1377**	-	-
United Kingdom	-0.1630**	-	-	0.0620	-	-
United Stated	-0.1695**	-	-	-0.0923**	-	-
Subjective factors						
Environmental knowledge	0.3888**	-	0.2779*	0.3814**	-	0.5271**
Environmental attitude	0.2033*	0.3421**	-	0.2366*	0.4697**	-
Risk consciousness	0.1488**	0.0156*	0.1663**	0.1691**	0.0185**	0.1094**
Environmental concern	0.1451**	0.1373**	0.1703**	0.1754**	0.1286**	0.1062**
Anti-Science	-	-0.0815**	-	-	-0.0672**	-
Trust	-	-	0.1460**	-	-	0.1245**
Constant	1.3139**	1.6055**	0.1145*	1.3072**	1.3204	-0.0711
R-square	0.25	0.29	0.22	0.34	0.25	0.24

Notes: 1. *, and ** represent 5% and 1% significance levels, respectively.

2. Model 1 captures energy-saving behavior in transport, which refers to efforts for cutting back on driving a car for environmental reasons. Model 2 captures energy-saving behavior in residence, which refers to efforts to reduce the energy or fuel at home for environmental reasons.

The effects of the variable of marital status on energy-saving behavior and environmental attitude are not significant. But, the variable of marital status has significantly positive effects on environmental knowledge. The results mean that married people tend to have a higher level of environmental knowledge than unmarried people. Besides, we find that those people who have children tend to have better environmental knowledge and pro-environmental attitude, but they would have a lower level of efforts for energy saving than those who do not have any child. This result may be attributed to the effects of household size, which indicates that the energy demand would rise as the members of households increase. The variable of residential location has significantly positive effects on envieonmental knowledge and energy-saving behavior. Urban residents have better environmental knowledge and more intention to save energy than rural residents, which is related to civilization and modern development in urban areas. With the well-developed infrastructure and public transportation, urban people are more likely to access the public service and live in a high-tech environment. Thus, they would have more opportunities to live in a pro-environmental lifestyle.

As for the effects of subjective factors, our results show that environmental knowledge, environmental attitude, risk consciousness, and environmental concern would have significant and positive effects on energy-saving behavior in transport and residence. As expected, environmetal knowledge is positively related to environmetal attitude. Therefore, these results reveal a potential opportunity to promot individuals' energy-saving behavior by improving their environmental knowledge and raising public awareness about the environmental issues.

The variables of risk consciousness and environmental concern have significantly positive effects on environmental knowledge and attitude. If people are more risk-conscious and concerned about the damage to our environment, they would tend to have more pro-environmental attitude and better environmental knowledge. In addition, the variable of anti-science has significantly negative effects on environmental knowledge, indicating that people who have more stronger anti-science attitude may have a lowler level of environmental knowledge. Besides, the effects of the trust variable on environmental attitude are significantly positive. The results show that people who express a higher level of trust in others would tend to have more pro-environmental attitude.

3.2 The gender effects on energy-saving behavior, environmental knowledge and attitude

From the previous results, we find that there exist gender differences in environmental knowledge and attitude. Men have more environmental knowledge than women, but women exhibit a more pro-environmental attitude than men. Moreover, the gender variable has significantly negative effects on energy-saving behavior in transport and residence, suggesting that women tend to make more efforts for energy saving in transport and residence than men. These findings are consistent with the results of previous studies. The literature showed that men tend to display higher levels of environmental knowledge relative to women (Hayes, 2001; Eisler et al., 2003). But, women exhibit a more positive

attitude and behavior toward environment than men (Zelezny et al., 2000; Eisler et al., 2003; Franzen and Vogl, 2013; Knox-Hayes et al., 2013).

Furthermore, we additionally incorporate the interaction terms in the models to investigate the relationship between the gender variable and other variables. Due to the limited space, Table 4 mainly reports the estimation results of the interaction terms. The results show that, for the both models, the coefficients for the interaction term $gender \times income$ are significantly negative in the environmental attitude equations, while the coefficients for the interaction term $gender \times education$ are significantly positive in the environmental knowledge equations. Thus, high-income males would tend to have negative environmental attitude, and high-education males may tend to have better environmental knowledge than others. Besides, the effect of the interaction term $gender \times marital\ status$ on energy-saving behavior in residence is significant. Married males would be more likely to reduce energy use in residenc, because their altruistic behavior and responsibility for the environmental protection would be aroused due to the marital relationship. Therefore, our previous results show that environmental knowledge and attitude may be improved as the levels of education and income increase. However, for men, the higher income level would not result in more pro-environmental attitude, and the gap between environmental knowledge and attitude is still an obvious problem. It is worth noting that the effect of the interaction term $gender \times marital\ status$is only significant in residence but not significant in transport. The possible reasons are that people may be more willing to cut down energy use in residence than in transport, and people may not change their transportation habits easily.

Table 4 Estimation results of the simultaneous equation models: the interaction terms

Variables	Model 3			Model 4		
	Behavior	Knowledge	Attitude	Behavior	Knowledge	Attitude
Gender × Income	0.0082	0.0074	-0.0323**	-0.0036	0.0082	-0.0290**
Gender × Education	0.0012	0.0064**	0.0032	-0.0029	0.0041*	-0.0003
Gender × Marital status (Married)	0.0514	0.0394	0.0444	0.0542*	0.0232	0.0155
Gender × With child	0.0126	0.0444	-0.0069	0.0282	0.0075	0.0162

Notes: 1.*, and ** represent 5% and 1% significance levels, respectively.
2.The model 3 and model 4 captures energy-saving behavior in transport and residence, respectively.

3.3 A cross-national comparison of gender differences

We make use of the national-level data separately. We use the independent-sample T test to analyze whether there are gender differences in energy-saving behavior, environmental knowledge, and environmental attitude among each country. Table 5 reports the results of the independent-sample T test. Our results show that, at the 10% significance level, energy-saving behavior in transport exhibits significant gender differences in 16 of the 32 nations, while energy-saving behavior in residence shows significant gender differences in 15 of the 32 nations. We further observe the value of individuals' effort for energy saving. Women would be more likely to save energy use than men, except for South Africa. In addition, environmental knowledge displays significant gender differences in 24 of the 32 nations,

while environmental attitude exhibits significant gender differences in 13 of the 32 nations. For the full sample, we find that gender differences exist in energy-saving behavior, environmental knowledge, and environmental attitude. These results indicate that gender exerts a significant influence on environmental knowledge, attitudes, and behavior. Furthermore, our findings confirm that men tend to display higher levels of environmental knowledge, but women have more positive energy-saving behavior and attitude than men in all of these countries.

Table 5 The results of the independent-sample T test

Country	Energy-saving behavior in transport	Energy-saving behavior in residence	Environmental knowledge	Environmental attitude	Country	Energy-saving behavior in transport	Energy-saving behavior in residence	Environmental knowledge	Environmental attitude
	Mean M/Mean F (t value)	Mean M/Mean F (t value)	Mean M/Mean F (t value)	Mean M/Mean F (t value)		Mean M/Mean F (t value)	Mean M/Mean F (t value)	Mean M/Mean F (t value)	Mean M/Mean F (t value)
Argentina	1.83/1.87 (-0.40)	2.59/2.67 (-1.09)	2.86/2.60 (3.44***)	2.37/2.25 (1.65*)	Lithuania	1.38/1.50 (-1.84)	2.09/2.36 (-3.06***)	2.61/2.49 (1.62)	2.02/2.09 (-0.99)
Austria	2.09/2.21 (-1.60)	2.38/2.48 (-1.50)	3.12/3.05 (1.27)	2.67/2.71 (-0.61)	Mexico	2.12/2.22 (-1.18)	2.56/2.42 (1.60)	2.83/2.82 (0.15)	2.81/2.62 (1.94*)
Belgium	2.03/2.11 (-1.53)	2.80/2.76 (0.81)	3.05/2.73 (5.72***)	2.60/2.68 (-1.12)	New Zealand	1.70/1.90 (-4.00***)	2.17/2.39 (-3.71***)	3.24/2.94 (5.36***)	2.67/2.82 (-2.41***)
Bulgaria	1.40/1.60 (-2.50**)	1.64/1.65 (-0.16)	2.78/2.52 (3.31***)	2.08/1.94 (1.74*)	Norway	1.80/2.01 (-4.26***)	2.24/2.48 (-5.14***)	3.53/3.20 (6.27***)	2.67/2.94 (-4.84***)
Canada	2.04/2.21 (-2.52**)	2.60/2.82 (-3.23***)	3.31/3.09 (3.19***)	2.84/2.88 (-0.50)	Philippines	2.21/2.22 (-0.10)	2.35/2.36 (-0.01)	3.14/3.10 (0.62)	2.56/2.55 (0.12)
Chile	1.83/1.87 (-0.36)	2.04/2.14 (-1.44)	2..68/2.45 (3.26***)	2.78/2.73 (0.69)	Russia	1.59/1.69 (-1.24)	1.94/2.07 (-2.03**)	2.70/2.47 (3.73***)	2.23/2.11 (2.04**)
Croatia	1.74/1.82 (-1.06)	2.03/2.17 (-2.08**)	2.98/3.04 (-0.81)	2.08/2.09 (-0.04)	Slovak Republic	1.80/1.98 (-2.74***)	2.35/2.39 (-0.65)	2.74/2.53 (3.43***)	2.39/2.38 (0.21)
Czech Republic	1.73/1.93 (-2.84***)	2.23/2.40 (-2.76***)	2.83/2.64 (3.22***)	2.15/2.23 (-1.19)	Slovenia	1.83/1.89 (-0.77)	2.58/2.57 (0.24)	3.32/3.22 (1.36)	2.61/2.63 (-0.28)
Denmark	1.76/1.92 (-3.23***)	2.50/2.54 (-0.72)	3.20/2.89 (6.28***)	3.01/3.13 (2.18**)	South Africa	1.51/1.50 (0.34)	1.94/1.81 (2.88***)	2.78/2.58 (4.09***)	2.38/2.26 (2.36**)
Finland	1.77/2.05 (-4.47***)	2.43/2.64 (-3.51***)	3.39/3.12 (-4.28***)	2.58/2.77 (-2.88***)	Spain	1.65/1.62 (0.72)	2.35/2.43 (-1.47)	2.80/2.52 (6.40***)	2.67/2.55 (2.40**)
France	2.14/2.23 (-2.20**)	2.73/2.77 (-0.85)	3.13/2.93 (3.90***)	2.63/2.54 (1.52)	Sweden	1.73/1.96 (-4.39***)	2.29/2.43 (-2.50**)	3.19/2.93 (4.59***)	2.74/2.85 (-1.72*)
Germany	2.20/2.27 (-1.48)	2.57/2.61 (-0.68)	3.18/2.86 (5.94***)	2.92/2.75 (3.02***)	Switzerland	2.22/2.37 (-2.41**)	2.56/2.65 (-1.67*)	3.26/2.96 (5.54***)	3.31/3.27 (0.74)
Israel	1.43/1.57 (-2.21**)	1.68/1.72 (-0.50)	3.07/2.96 (1.27)	2.84/2.73 (1.55)	Taiwan	1.93/2.11 (-4.16***)	2.34/2.50 (-4.02***)	3.10/2.77 (7.47**)	2.99/2.97 (0.64)
Japan	1.97/1.95 (0.37)	2.46/2.60 (-3.02***)	2.74/2.51 (4.34***)	2.68/2.67 (0.12)	Turkey	1.97/2.16 (-3.17***)	2.28/2.33 (-1.02)	2.97/2.80 (2.94***)	2.50/2.43 (1.29)
South Korea	1.89/1.94 (-1.01)	2.36/2.68 (-6.02***)	2.87/2.64 (4.74***)	3.27/3.04 (4.22***)	United Kingdom	1.84/1.99 (-2.29**)	2.26/2.34 (-1.06)	3.06/2.77 (4.35***)	2.53/2.42 (1.41)
Latvia	1.61/1.67 (-0.54)	1.65/1.67 (-0.23)	2.84/2.82 (0.21)	1.87/1.81 (0.77)	United Stated	1.72/1.83 (-2.15**)	2.21/2.37 (-2.97***)	2.93/2.58 (6.62***)	2.79/2.85 (-1.06)
Full Sample	1.86/1.95 (-8.82***)	2.32/2.37 (-5.26***)	3.01/2.76 (23.50***)	2.65/2.59 (5.20***)					

Notes: 1. "Mean M" indicates the mean value of energy-saving behavior in the male sample; "Mean F" indicates the mean value of energy-saving behavior in the female sample.

2. *, **, and *** represent 10%, 5% and 1% significance levels, respectively.

4.Conclusions

This study employs the simultaneous equation model to analyze gender differences in individuals' energy-saving behavior. In particular, we focus on energy-saving behavior in the aspects of transport and residence. The results show that the gender variable indeed has significant effects on environmental knowledge, attitude, and behavior. Men tend to display higher levels of environmental knowledge relative to women. However, women exhibit a more positive attitude and behavior toward energy saving than men.

For energy-saving behavior in transport and residence, we can draw the same conclusion that women are more willing to practice than men. This result highlights that a potential opportunity for energy saving may rest on incorporating gender education with environmental education. Therefore, gender equality in the responsibility for our sustainable environment would be an important issue that we need to pay attention to. It is worth noting that people make more efforts for energy-saving behavior in residence than in transport. This result implies that it is more challenging to change people's behavior patterns in transport than in residence. The policy makers should pay more attention to induce people's travel behavior toward energy conservation.

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