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EXPLORATION OF HUMAN BEHAVIOR OF WATER - SAVING UNDER CLIMATE CHANGE USING EXPANDED THEORY OF PLANNED BEHAVIOR MODEL

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Abstract

In response to the water shortage issue caused by climate change, an extending planned behavior model of environmental concern is applied to explain the household behavior related to water conservation in southern Taiwan. Based on the data from the 1678 valid samples using random sampling, an extending planned behavior model to which the variable of environmental concern is added besides the original variables in the theory of planned behavior (TPB) model. It was also verified to properly explain the household behavior related to water conservation for climate change mitigation. Furthermore, the exploratory factor analysis was successfully extracted into the three factors in environmental concern and the four factors in water conservation behavior. The results indicate that the extended TPB model including environmental concern can increase the explanatory power of the original one. Inaddition to the attitudes, perceived behavioral control and subjective norm, people's environmental concerns may reduce the impact on global warming and climate change. As a result, people's intentions to engage in water savings and carbon reduction behaviors can be expected to mitigate climate change problems.

Keywords

Mitigate climate change,Structural equation model,Sustainable water resources,Cross validity, Discriminant validity

1. Introduction

Faced with water resource constraints, many countries around the world have incessantly carried out research ways to tap new resources and economize on expense. To broaden sources, alternative sources of water, such as dams, recycled water, or desalination, may be sought. However, "increasing sources" often results in higher environmental ecological and economic costs, as well as more greenhouse gases (Hurlimann, 2007). Relatively, "Reducing expenditure" seems to be more in line with economic benefits and environmental issues. Decreasing expenditure means saving water.

Current studies on climate change and global warming crisis awareness have included excellent literatures (e.g.Dunlap, 1998; O'Connor, Bord, Yarnal, & Wiefek, 2002), but Brody, Grover, and Vedlitz (2012) pointed out in their research that many pro-environmental actions still attempt to limit people's attempt to sabotage the local environment in order to mitigate impacts brought about by climate change, which in turn directly affects the global climate change cycle (Brody et al.,2012).

Due to climate change factors, in 2015, many countries around the world, including Taiwan, have suffered the worst drought in recent decades. "Kaohsiung City" in southern Taiwan is the major city of industrial development. Due to the severe drought in 2015, the city government adopted the strategy of the "5-day water supply; 2-day water shutoff" (water supply is stopped for two days in a week of seven days). This seriously affected households and industrial units, totaling approximately 965,000 and accounting for about 2.559 million.

Various researcher collected relatively small samples with non-randomly selected populations (Han, Hsu, & Sheu, 2010; Kideghesho, Røskaft, & Kaltenborn, 2006; Kilic & Dervisoglu, 2013; Kim, Jeong, & Hwang, 2013; Kollmuss & Agyeman, 2002; Kortenkamp & Moore, 2006; Lam, 1999; Minton & Rose, 1997; Nooney, Woodrum, Hoban, & Clifford, 2003; Pradeep, 2012) could not approach the real problems. Hence, data randomly collected from significant samples was conducted in this research.

2. Theoretical Background

The theory of planned behavior (TPB) has been developed by Fishbein and Ajzen (1975) based on the theory of reasoned action (TRA). The theory of planned behavior (TPB) refers to people's behavioral intention (BI) determined by the attitude toward the behavior (ATB) and subjective norm (SN); the so-called ATB refers to an individual's evaluation of a particular behavior before taking action; SN refers to the social pressure detected by an individual before deciding whether or not to take action; PBC refers to a person's thoughts, the realization of how difficult or simple it is to implement an act.

The method for assessing environmental concern (EC) is derived from New Environmental Paradigm (NEP) established by Dunlap and Van Liere (1978). NEP represents worldview and protectionists' attitude and environmental concern. Studies have found that environmental concern directly leads to more water conservation behaviors (Gilg & Barr, 2006; Trumbo & O'Keefe, 2001; Willis, Stewart, Panuwatwanich, Williams, & Hollingsworth, 2011; Wolters, 2014). Wolters (2014) measured the Oregon using the NEP scale. Findings have shown that environmental attitude is associated with concern for water resource shortages and water-conservation behaviors.

The TPB model has been successfully applied a wide range of behaviors. However, this theoretical model has been criticized for ignoring ethical considerations (e.g., Manstead, 2000). Early studies indicate that as factors of actions and behaviors, personal moral obligations greatly improve intent predictions (Beck & Ajzen, 1991; Leonard, Cronan, & Kreie, 2004). Pro-environmental behaviors are behaviors that include personal moral and social responsibility elements. Hence, this study proposed a suitable water-conservation model, including the TPB extended model of environmental concern (EC). Its explanatory power should be higher than that of the original. The research findings shall be provided to researchers, consumers, business managers, and government policy planners to derive at effective water-conservation practices from different viewpoints, thereby better ensuring the sustainable use of water resources.

3. Methodology

3.1Questionnaire

This study focuses on a self-narrative questionnaire survey on the daily water usage of resident households from southern Taiwan under “mitigated climate change”. In January 2015, a questionnaire survey was conducted though simple random sampling, with the use of the numbers in the addresses. The questionnaires were sent via mail and were completed on condition of anonymity. The questionnaire was modified from the reports of different researcher. (Brody et al., 2012; Dervişoğlu & Kılıc, 2012; Dolnicar, Hurlimann, & Grun, 2012; Dunlap, Van Liere, Mertig, & Jones, 2000; Han et al., 2010; Kideghesho et al., 2006; Kim et al., 2013).The contents include: attitude toward the behavior (ATB) scale, such as “Saving water means reducing carbon emissions”, three items in total; subjective norm (SN) scale, such as “My neighbors and friends expect me to save water”, three items in total; perceived behavioral control (PBC) scale, such as ” My financial situation supports water saving”, four items in total. The environmental concern (EC) scale was revised from the 15 items in NEP; behavioral intentions (BI) scale, such as “I am willing to choose water-saving and power-saving household appliances in the next few months”, three items in total; water conservation behavior (WCB) scale, such as ”I recycle kitchen wash water for use elsewhere”, 19 items in total. Each item underwent the 7-point Likert scale. 1 represents “strongly disagree”; 7 represents “strongly agree”. The residents who accepted to be surveyed were given a special souvenir and some spending cash. In this survey, the social demographics include: gender, place of residence, age, education level, occupation, and income. 1678 valid questionnaire copies were obtained (accounting for the effective recovery rate of 68.76%). SPSS17.0 and AMOS17.0 were adopted for data analysis.

3.2 Structural Equation Model

Structural equation modeling (SEM) is typically applied to verify hypothetical or theoretical models. The primary principle of SEM involves combining path analysis and confirmatory factor analysis (CFA) to conduct accurate and comprehensive statistical analysis. SEM is also characterized as a data analysis with verifying empirical research using multiple variable techniques based on regression and path analysis. SEM can be simultaneously used to determine the relationship between multiple variable groups and examine the path relationships among variables for verification. Thus, SEM is an important technique of path modeling analysis (Bollen & Long, 1993).

SEM can also be employed to examine influential factors or the relationship among latent variables that cannot be measured directly, like behavior, subjective norms, perceived behavioral control, and behavioral intentions proposed in TPB . However, this problem can be solved by SEM (Jorgensen, Martin, Pearce, & Willis, 2013). As a result, SEM has been extensively applied in various fields, such as medicine, management, economics, sociology, psychology, education and environmental management. The advantages for SEM include the ability to simultaneously consider and process multiple dependent variables, and permission of measurement errors for both independent and dependent variables (Kline, 2015).

3.3Maximum likelihood estimation

Amos minimizes discrepancy functions (Browne, 1982;Browne, 1984) of the form in the formula (1). For maximum likelihood estimation (ML), CML and FML are obtained by taking f to be the formula (2).

$$C(\alpha(a)) = [N-\gamma]\left(\frac{\sum_{g=1}^{G} N^{(g)} f(\mu^{(g)}, \Sigma^{(g)}; \bar{x}^{(g)}, S^{(g)}) U_a - U_S}{N}\right) = [N-\gamma] F(\alpha(a)) \qquad (1)$$

$$f_{ML}\left(\mu^{(g)}, \Sigma^{(g)}; \bar{x}^{(g)}, S^{(g)}\right) = f_{KL}\left(\mu^{(g)}, \Sigma^{(g)}; \bar{x}^{(g)}, S^{(g)}\right) - f_{KL}\left(\bar{x}^{(g)}, \Sigma^{(g)}; \bar{x}^{(g)}, S^{(g)}\right)$$

$$= \log\left|\Sigma^{(g)}\right| + tr\left(S^{(g)} \Sigma^{(g)^{-1}}\right) - \log\left|S^{(g)}\right| - p^{(g)} + \left(\bar{x}^{(g)} - \mu^{(g)}\right)' \Sigma^{(g)^{-1}} \left(\bar{x}^{(g)} - \mu^{(g)}\right) \qquad (2)$$

q = the number of parameters

γ = the vector of parameters (of order q)

G= the number of groups

$N^{(g)}$ = the number of observations in group g

$N = \sum_{g=1}^{G} N^{(g)}$ = the total number of observations in all groupscombined

$p^{(g)}$ = the number of observed variables in group g

$d = p - q = df$ = the number of degrees of freedom for testing the mode

$x_{ir}^{(g)}$ = the r-th observation on the i-th variable in group g

$x_r^{(g)}$ = the r-th observation in group g

$S^{(g)}$ = the sample covariance matrix for group g

$\Sigma^{(g)}(\gamma)$ = the covariance matrix for group g, according to the model

$\mu^{(g)}(\gamma)$ = the mean vector for group g, according to the model

$\Sigma_0^{(g)}$ = the population covariance matrix for group g

$\mu_0^{(g)}$ = the population mean vector for group g

$s^{(g)} = vec(S^{(g)})$ = the $p^{*(g)}$ distinct elements of $S^{(g)}$ arranged in a single columnVector

$\sigma^{(g)}(\gamma) = \text{vec}(\Sigma^{(g)}(\gamma))$

$\gamma =$ the non-negative integer specified by the Chi Correct method. By default $\gamma = \text{G}$

$n = N - \gamma$

$\mathbf{a} =$ the vector of order p containing the sample moments for all groups.

$\alpha(\gamma) =$ the vector of order p containing the population moments for all groups according to the model.

$F(\alpha(\gamma), \mathbf{a}) =$ the function (of γ) that is minimized in fitting the model to the sample

$\hat{\gamma} =$ the value of γ that minimizes $F(\alpha(\gamma), \mathbf{a})$

$\hat{\Sigma}^{(g)} = \Sigma^{(g)}(\hat{\gamma})$

$\hat{\mu}^{(g)} = \mu^{(g)}(\hat{\gamma})$

$\hat{\alpha} = \alpha(\hat{\gamma})$

4. Results

4.1Demographics

Among the valid samples (N = 1678) in the survey, the numbers of men and women were similar (men 49.60%, women 50.40%); 65.36% people resided in urban areas, and 34.63% people resided in the countryside . In addition, 60.8% respondents were aged younger than 60 years, and 39.2% were aged 61 years and older. Moreover, 61.3% respondents had an education level below senior high school/vocational high school education; 38.7% respondents had university (college) education (or higher). Concerning respondent occupation, those in the service industry accounted for the majority, 30.76% people, followed by those in commerce, accounting for 22.03% people, and agriculture/forestry/fishery/husbandry, accounting for 16.94% people. The other occupation categories were faculty (6.81% people), laborers (5.08% people), civil servants (4.39%

people), medical/nursing personnel (4.14% people), students (4.08% people), soldiers (3.39% people), and homemakers (2.38% people). Finally, regarding respondent annual income, 63.06% respondents were under the category of below NT$720,000; moreover, 32.20% respondents were under the category of NT$720,001–1,800,000, and 4.74% were under the category of over NT$1,800,000 (NT$1 = US$0.33).

4.2 Exploratory Factor Analysis

In order to obtain stable parameter estimates and a simplified model, item parcels were employed to streamline the model analysis (Bandalos & Finney, 2001; Hau & Marsh, 2004). As for data processing, EC and WCB exploratory factor analysis (EFA) was first carried out. The test values of KMO and Barlett were 0.928 and 0.949 respectively, an indication of factor analysis appropriateness. The total variance of the three factors of EC obtained through principal component analysis and Varimax rotation was 76.94%; the total variance of the four factors of WCB was 73.6%.

Through factor extraction, it was found that EC1 indicates the responsibility-based consumer behaviors towards natural resources and products, EC2 is the relationship and outcome of concern for ecological balance, EC3 describes concern for the government’s policy implementation. WCB1 shows in order to mitigate climate change, individuals reduce water usage in daily life by various means, WCB2 shows that in order to mitigate climate change, individuals achieve water conservation by replacing water-saving equipment, WCB3 shows that in order to mitigate climate change, individuals’ recycle used water, WCB4 shows that in order to mitigate climate change, individuals examine pipes or equipment that might have leakage problems. The research model then underwent the structural equation modeling (SEM) test.

4.3 Reliability and Discriminant Validity

The estimates are calculated by latent variables (presented in big ellipse) and respective observed variables (presented in rectangle) using maximum likelihood procedure. In our model, $TPB_{Original}$ and $TPB_{expanded}$ included respectively five and six latent variables; and seventeen and twenty respective observed variables existed in $TPB_{Original}$ and $TPB_{expanded}$. Factor loadings between latent and observed variable represent should be greater than 0.5.

Cronbach's Alpha (α) used to measure the model exceeded 0.7, indicating good internal consistency. The Cronbach's Alpha values of respective structures in this research model all exceeded 0.826 (Table 1), thus indicating good internal consistency. Viewed from the estimated standardized coefficients, the Pearson's correlation coefficients of all the variables ranged from 0.124 to 0.615 (Table 1), mostly showing a moderate correlation and indicating no presence of collinearity (Bollen, 1989). Additionally, there were no irrelevant variables existing in the research model.

Table 1: *Reliability analyses and correlation matrix of studied constructs.*

	EC	SN	PBC	ATB	BI	WCB	α	Mean	SD
EC	1	0.124^{**}	0.520^{**}	0.354^{**}	0.446^{**}	0.615^{**}	0.885	4.993	1.022
SN	0.151	1	0.155^{**}	0.177^{**}	0.172^{**}	0.197^{**}	0.826	5.102	0.902
PBC	0.581	0.185	1	0.394^{**}	0.526^{**}	0.547^{**}	0.889	4.697	1.040
ATB	0.413	0.209	0.459	1	0.537^{**}	0.487^{**}	0.843	4.860	0.998
BI	0.504	0.21	0.602	0.645	1	0.589^{**}	0.855	4.955	1.068
WCB	0.68	0.168	0.608	0.48	0.672	1	0.914	4.893	0.979

Note: α is Cronbach's Alpha value. SD is standard deviation.The Pearson's correlation coefficientsare on the right upper. ** is significant at the 0.01 level (2-tailed).

In addition, both tools of confidence interval method and the bootstrap method were applied into completing the repeated estimations of 2,000 times to calculate the coefficients at 95% confidence interval. The results show that the bias-corrected percentile method, percentile method, and point estimate ±2 times the standard error (ϕ±2 ϭ), the 95% confidence interval between dimensions did not include the value of 1 (Table 2). This is a sign that this research model possesses discriminant validity (Torkzadeh, Koufteros, & Pflughoeft, 2003).

Table 2: *Estimated correlation coefficient of 95% confidence intervals.*

Parameter			**PointEstimate**	**ϕ±2 ϭ**		**Bias-corrected**		**percentile method**	
				Lower	***Upper***	***Lower***	***Upper***	***Lower***	***Upper***
SN	<-->	PBC	0.182	0.115	0.247	0.119	0.246	0.115	0.243
ATB	<-->	SN	0.209	0.135	0.283	0.137	0.282	0.137	0.28
ATB	<-->	PBC	0.456	0.392	0.52	0.392	0.515	0.393	0.515
SN	<-->	EC	0.146	0.073	0.217	0.075	0.214	0.074	0.213
PBC	<-->	EC	0.581	0.526	0.634	0.525	0.633	0.524	0.633
ATB	<-->	EC	0.406	0.335	0.475	0.334	0.476	0.332	0.475
ATB	<-->	BI	0.633	0.578	0.686	0.579	0.685	0.578	0.684
ATB	<-->	WCB	0.554	0.489	0.617	0.487	0.613	0.483	0.612
SN	<-->	BI	0.202	0.125	0.277	0.128	0.281	0.128	0.278
SN	<-->	WCB	0.225	0.153	0.297	0.153	0.296	0.152	0.295
BI	<-->	PBC	0.601	0.547	0.655	0.545	0.652	0.545	0.652
PBC	<-->	WCB	0.607	0.552	0.66	0.555	0.659	0.551	0.658
BI	<-->	EC	0.503	0.436	0.568	0.437	0.567	0.436	0.565
WCB	<-->	EC	0.679	0.632	0.724	0.63	0.721	0.63	0.721
BI	<-->	WCB	0.66	0.601	0.717	0.599	0.711	0.6	0.712

4.4 Cross Validity

Cross-validity is a statistical method commonly applied to measure invariance for cross-sample and cross-scenario effectiveness. The population was randomly divided into two groups (N1 = 807 and N2 = 871), and cross-validity testing was performed to verify the measurement variance of the model. The results show that whole ΔTLI, defined as no difference between the nested structure in this study, were less than 0.05 (Table 3); thus, the study model possesses practical measurement invariance(Byrne, 2013). It proves that model developed in this research exhibits stability owing to the complication with the criteria for cross-validity.

Table 3:*Model fits of the cross-validation*

Model	χ^2	**df**	**Δdf**	$\Delta\chi^2$	**P**	**ΔCFI**	**ΔTLI**	**RMSEA**
Unconstrained	718.849	314	-	-	0	-	-	0.028
Measurement weights	732.484	328	14	13.635	0.477	0	-0.001	0.027
Structural weights	748.95	335	7	16.466	0.021	-0.001	0	0.027
Structural covariances	762.403	345	10	13.453	0.199	0	0	0.027
Structural residuals	766.842	347	2	4.439	0.109	0	0	0.027
Measurement residuals	819.844	367	20	53.002	0	-0.002	0	0.027

4.5 Model Test

Based on the measurement of model analysis, the factor loading (i.e. Standardized Regression Weights) exceeded 0.7 (minimum: 0.81); the average variance extracted (AVE) exceeded 0.5 (minimum: 0.59), indicating the research model possesses convergent validity(Fornell & Larcker, 1981; Hair, Anderson, Tatham, & Black, 2009). The Structural equation modeling (SEM) analysis is often used in testing the fitness of hypothetical models. The analysis consists of two stages (Anderson &Gerbing, 1988; Gerbing& Anderson, 1987): (1) to test and measure the model; (2) to test the hypothetical relationship between the tested structures.

Chi-square statistics is adopted to evaluate the model fitness. The purpose of the data is to evaluate the fitness between the hypothetical model and observed indicators. When the chi-square value is insignificant, it shows the model and observation data have reached fitness. Since the chi-square statistical volume is subject to the effect sample size and model complexity, it should not be the only measurement indicator (DeJoy, Della, Vandenberg, & Wilson, 2010). Other than the chi-square statistical volume, current studies also recognize six suitable indicators: root mean square error of approximation (RMSEA) less than 0.08, adjusted goodness-of-fit index (AGFI) greater than 0.9, comparative fit index (CFI) greater than 0.9, Tucker-Lewis index (TLI) greater than 0.9, parsimonious normed fit index (PNFI) greater than 0.5, and parsimonious goodness-of-fit index (PGFI) greater than 0.5. With the original TPB structural model (χ^2 = 455.885, df = 111, χ^2/df = 4.107, p = 0 < 0.05, RMSEA=0.043, AGFI=0.958, GFI=0.97, CFI=0.98, TLI=0.975, PNFI=0.795, PGFI=0.703) and extended TPB structural model (χ^2 = 539.407, df = 157, χ^2/df = 3.436, p = 0 < 0.05, RMSEA=0.038, AGFI=0.959, GFI=0.97, CFI=0.982, TLI=0.978, PNFI=0.805, PGFI=0.725) and in terms of indicator values, other than the chi-square value that reached significance, the other assessment indicators are all in conformity with the recommended values (Fig. 1 A& Fig. 1 B). It is an indication that the extended TPB model proposed in this study possesses good fitness. The original TPB model variables have 52% explanatory power towards WCB (Fig. 1 A). In the extended TPB model, all the variables have 62% explanatory power towards WCB (Fig. 1 B),it shows it is more appropriate to use all the variables in the TPB model to explain the effect on WCB.

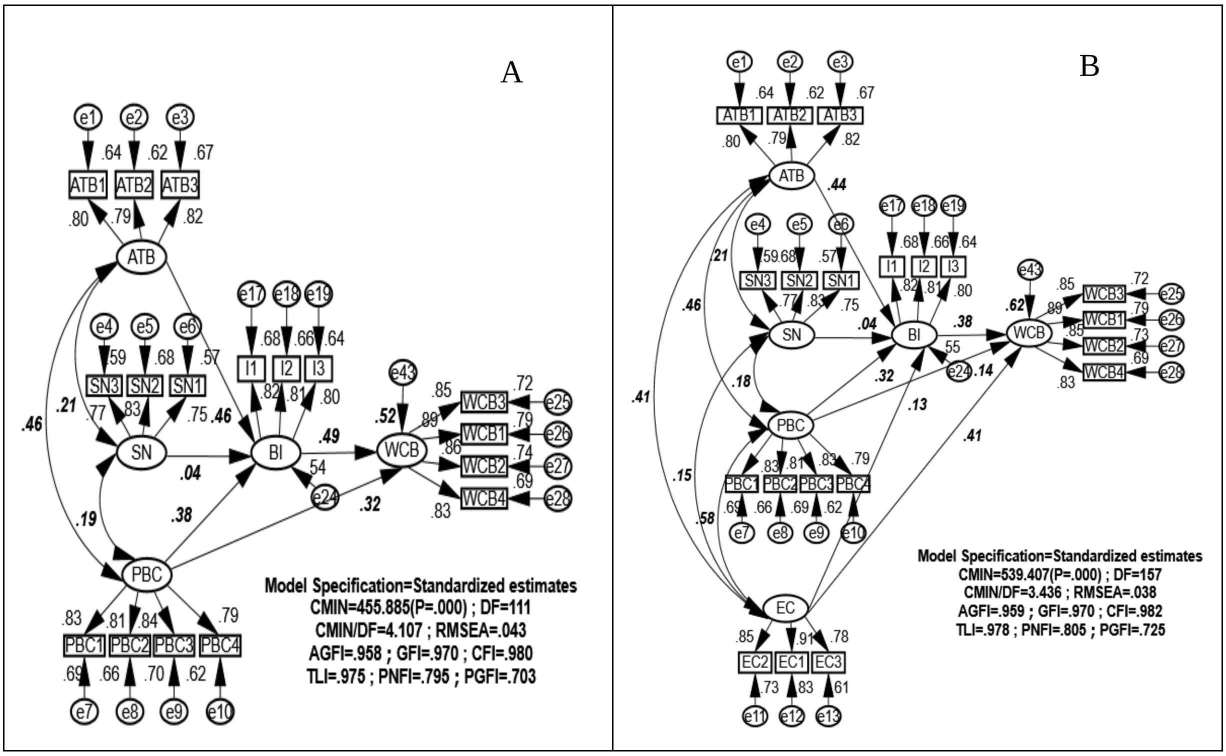

Figure 1: (A)*$TPB_{Original}$* (B)*$TPB_{expanded}$ modelin water-saving behavior for mitigation climate change*

5.Conclusions

Some major findings are summarized as follows:

- Three environmental concern factors were successfully extracted from NEP scale by exploratory factor analysis, including:EC1 (responsibility-based consumer behaviors towards natural resources and products), EC2 (the relationship and outcome of concern for ecological balance), and EC3(concern for the government's policy implementation).
- People to conserve water behavior patterns could be described by original TPB mode as well as expanded TPB mode in mitigating climate change.
- The explanatory power of original TPB model was incrementally increased about 10% (from 52% to 62%) while environmental concern was added into NEP scale.
- Subjective norm (SN) in both original and extended TPB model is insignificant effect to behavioral intention (BI).

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