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Article

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International Journal of Energy Economics and Policy

Provided in Cooperation with:
International Journal of Energy Economics and Policy (IJEEP)

Reference: Dally, Dadang/Kurhayadi et. al. (2020). Personal carbon trading, carbon-knowledge management and their influence on environmental sustainability in Thailand. In: International Journal of Energy Economics and Policy 10 (6), S. 609 - 616. https://www.econjournals.com/index.php/ijeep/article/download/10617/5515. doi:10.32479/ijeep.10617.

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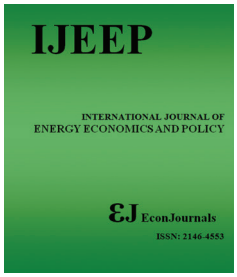

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2020, 10(6), 609-616.

Personal Carbon Trading, Carbon-Knowledge Management and their Influence on Environmental Sustainability in Thailand

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Received: 01 July 2020 **Accepted:** 16 September 2020 **DOI:** https://doi.org/10.32479/ijeep.10617

ABSTRACT

The relationship between personal carbon trading, carbon knowledge management and their impact on the environmental sustainability has got very little attention. Inspired from this gap in the literature, present research is exploring the relationship between carbon trading, carbon knowledge and their combine impact on sustainability of the natural environment in Thailand. A questionnaire is designed based on the various factors of both exogeneous and endogenous variables of the study. A sample of 251 respondents was collected for both measurement and structural equation models. Additionally, some descriptive measures are also calculated and presented which provide the fact that all items have been observed with moderate responses from the targeted respondents. It is found that there is a significant and positive influence of personal carbon trading on environmental sustainability. For the knowledge management, three dimensions like knowledge acquisition, knowledge dissemination, and knowledge responsiveness were also added in the structural model. Findings further explain that out of these three factors, there is a significant and positive influence of carbon knowledge acquisition and carbon knowledge responsiveness on environmental sustainability in Thailand. However, influence from carbon knowledge dissemination is insignificant on environmental sustainability. As per the practical implication, this study is found to be an initial effort to explore the relationship between the targeted variables, specifically in Thai economy. However, some limited context for this research is also observed like expanding the sample size and implication in other nearby regions too.

Keywords: Personal Carbon Trading, Carbon Knowledge Management, Environmental Sustainability
JEL Classification: Q19

1. INTRODUCTION: CARBON EMISSION AND CONTROLLED SCHEMES: A WORLD REVIEW

Currently, carbon discharge in the natural atmosphere effects natural climate which has produced extensive global concerns. In upstream production areas, the plans to deduct global carbon emission is depending too much on the real elevation of energy effectiveness and renewable energy consumption (Tan et al., 2019). The abatement consequence of energy effectiveness has offset due to rise in household energy depletion of rebound affect (Tan et al., 2019). The concept of personal carbon trading (PCT) is introduced by this effect. This strategy make to addition the "cap and trade" methods to diminish the carbon emission from distinct energy usage (Du et al., 2016; Stavins, 2008; Wittneben, 2009). From the government and scholars, PCT has got some serious concerns like emission trading scheme (ETS). As whole, the PCT structure has been divided into two categories: (1) voluntary PCT (2) mandatory PCT (Keown et al., 2016). Depending upon carbon emission and present permit invoices, the individuals could purchase and sell license for PCT. Contrarily, a fixed supply of payments does not require for the voluntary PCT (Li et al., 2019). It is believed that ecological modernization theories are associated with voluntary PCT that is related with the members from the society who are socially liable and ready to accept viable and green lifestyle.

Recently, climate change is one of the most insistent trails. The rate of greenhouse gases (GHG) emission from extreme use of fossil fuels is rising due to climate change, hence ever-rising in global warming (Liang et al., 2015; Syadullah, 2018). To reduce 60-65% CO_2 emissions per unit of GDP by 2030 compared with 2005, many states have regulated their own aims of GHG radiation deduction (Cui and Huang, 2018). In pervious few years, GHG emission has improved as faster than other economic sector due to the transport industry as it is the core basis of GHG emission (Cui et al., 2016; Pilli et al., 2016). To decarbonize the transport sector, struggles have been made, like easing the fuel substitution from petroleum-based fuels to low-emission electricity.

Meanwhile, the above stated kind of short carbonization methods will not be sufficient in transport sector, however, the change in one's action is closely essential. Recently, many countries are trying to attain some major features, like choosing the transportation styles with lower emission or guide the individuals to decrease long-distance travel (Fan et al., 2015). Presently, many scholars are concerned that is still a huge task of unstable conventional fuel vehicles (CFVs) to battery electric vehicles (BEVs). BEVs have no inner-combustion engine and usage power as generation sources, and finally have no carbon emissions. BEVs may have indirect carbon radiations, when the voltage power basis is reflected (Li et al., 2019). All these methods are primarily working to change the public attitude towards more carbon emission in the natural climate. Though, radiations of BEVs are smaller than that of CFVs, still coal is the powerful energy sources (Harrison, 2013). Meanwhile, the energy deduction power generated plants are larger than internal combustion engines in the country like China. So in transport sector, the development and upholding of BEVs is a way out by dealing these issues of energy deduction and ecological effluence. To discover proper plans to encourage such shift is value of studying as auto electrification develops an inevitable style.

In advanced economies, to reduce the greenhouse gas emission for which the main source is carbon dioxide is chief environmental issues. To lessen its GHG emissions by 80% until up to 2050, UK government is bound in legal terms (Wadud and Chintakayala, 2019). Although, growth has been made in several areas of economy by decreasing GHG radiations and fossil fuel imitative power usage, however, household energy consumption is a key challenge to address. In UK for travel purposes and domestic direct consumption of energy is liable for 57% of the carbon emission and almost one-third to one-half in EU countries (Wadud and Chintakayala, 2019). For domestic and travel purposes, all prevailing strategies have discussed energy usage and carbon emissions in a separate title. Instead of primarily focusing on carbon intensity, many of these strategies are not controlling the carbon emission from a household sector.

To inspire the users from shifting the cars, many plans are introduced and implemented in different countries. All of these plans are taking the concept of low energy consumption such like buses, cycling and walking for the sake of environmental safety. Simultaneously, there are plans to recover domestic energy efficiency and decrease carbon emission in household sector. For example, new build-housing efficiency standards are established in UK (Wadud and Chintakayala, 2019). At domestic level, there is lack of potential rule devices to report emission of carbon from carriage and household power. In present years, existing plans regarding the effectiveness of BEVs in China may have limited value (Wadud and Chintakayala, 2019). By the low growth of BEV distribution where it has dropped less of target, plans are mainly revealed. For instance, by the end of 2016, the BEVs stock considers almost 480,000 vehicles in China, which explained for <10% of the 2020 target. Obviously, to promote the distributions of BEVs is essential to find the more effective strategy measures. Personal carbon trading (PCT) is recently under concerned methods. The PCT policy is an emission trading policy where individuals are assigned specific extents of emission credits (Brohé, 2010). Under PCT, individuals are assigned with special emission credits. They are essential to submit these credits when acquiring electricity or fuel. Moreover, if he wants to acquire fuel or electricity in their credit allocations, there is also basis to obtain additional credits from others. Now, in many areas like Norfolk, Island, Australia, Guangdong province, China, Korea, and the United Kingdom, some alternations of PCT policy are also under observation of the government and related departments. Some studies have examined the features of PCT policy on affecting consumers to adopt BEVs. Meanwhile some researchers deliver new visions into intentions to adopt BEVs and help for purchaser of BEVs. This study aims to analyze the present trends in personal carbon trading, carbon knowledge management with their empirical relationship to environmental sustainability in Thailand.

2. LITERATURE REVIEW

Literature support is reasonably found while exploring the trends in personal carbon trading and various factors associated to it. In this context, climate change and global warming are widely examined. To improve the adverse impacts of global warming, a chain of carbon alleviation measures have been executed (Huang et al., 2017). Similarly, greenhouse gas (carbon emission) has negative effect on environment. To solve the problem of carbon emission, it is incredibly important to study main issue of carbon emission. In last few years, carbon emission has been increased due to transportation and economic growth etc. On other side, carbon emission is a major source of energy consumption and economic expansion. In different time periods, researchers have conducted their theoretical and empirical work in both developed and developing countries covering the horizon of carbon emission but with the community intention towards such issues. In this regard considerable work is presented by the following researchers (Egger, 2007; 2008; Eyre, 2017; Fawcett, 2017; Parag and Eyre, 2010; Paterson and Stripple, 2010; Seyfang, 2007). In different economies, the policy like personal carbon trading is helpful in escalation of risk linked with climatic and environmental trend. In their study, authors like Jiang et al. (2016) have examined the PCT schemes in China. The results of their study show that direct and strong drivers are linked with partition risk, perceived usefulness, and institutional technical environment are associated with PCT. However, the mediation effect of perceived usefulness is also impacting on personal willingness towards PCT. However, particularly, personal willingness of PCT has no effect from implementation cost.

To reduce carbon emission, the implementation of personal carbon trading and carbon tax are considered as main approaches (Fawcett and Parag, 2017; Huisingh et al., 2015). It is believed that adoption of PCT can change the motivation level of individuals for adopting the choice of electric vehicles. However, the effectiveness of PCT is superior than the overall carbon trading. In last few years, PCT is widely accepted in different regions. In this context, Li et al. (2018) has conducted their study in China to analyze the tendency in PCT. Their study shows that PCT can change the agreement of battery electric vehicles (BEVs).

3. TITLE OF VARIABLES

3.1. Personal Carbon Trading

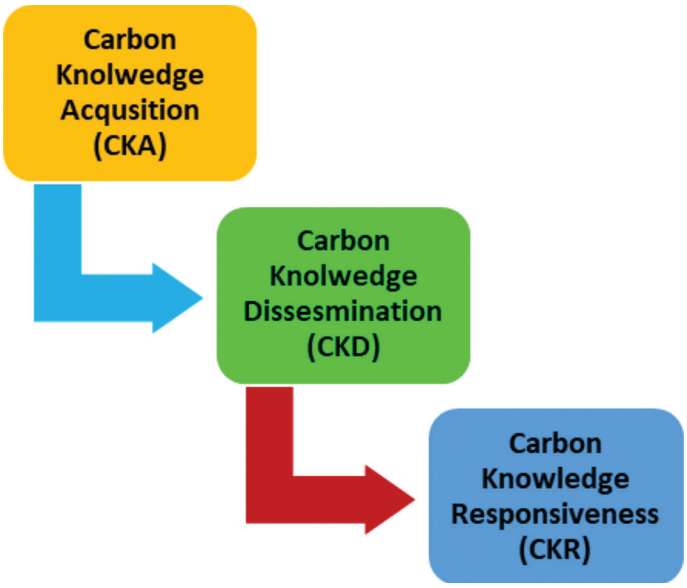
In its literature context, personal carbon trading (PCT) is found with another title of carbon rationing which is used to reduce the carbon emission in the natural climate. The fundamental assumption behind PCT is to insist the community members through some proposed carbon emission trading schemes where emission credits are allowed in terms of per capita. Additionally, it is known as a general term with the variety of cap-and-trade policies where rights and duties of the individuals are defined for the emission of carbon through household usage of energy. Meanwhile, cap-and-trade title of PCT covers the whole economy as per its scope and an independent committee establish a national carbon cap. Present study has adopted the similar meaning of PCT and considered overall eight items ranging from PCT1 to PCT8 as added in the questionnaire. All of these items are reasonably checking the individual's interest and their level of motivation towards PCT.

3.2. Carbon Knowledge Management

Although the concept of knowledge management is widely used in the literature, however, its implication in the field of environmental economy and natural environment and relevant fields is quite new. The concept of knowledge management refers to creating, sharing, processing, and finally providing some valuable response towards a set of knowledge within or outside the organization. A set of approaches have been explored and identified by the researchers to define the core idea of knowledge management. However, carbon knowledge management specify the individual's capability within their society to acquire, disseminate, and finally giving a significant response towards a carbon related awareness and level of social experiences etc. It means that carbon emission can significantly be reduced through working on the overall process of knowledge management in the community. Present study has considered the three interrelated steps of carbon knowledge management which can reasonably be understood in the Figure 1 below.

3.3. Environmental Sustainability

Environmental sustainability refers to the responsible interaction with the natural environment while the goal is to avoid from the degradation of the natural resources which can provide the quality of life. It is a common notion that environmental sustainability should be observed through utilization of available resources in a way that needs of future generation will not be disturbed. In different fields of life, sustainability exists. For example sustainable agriculture help to work for the betterment of the planet earth. Similarly, sustaniblity of the forest can work through regulations while meeting both the community and environmental needs.



4. METHODS AND HYPOTHESES

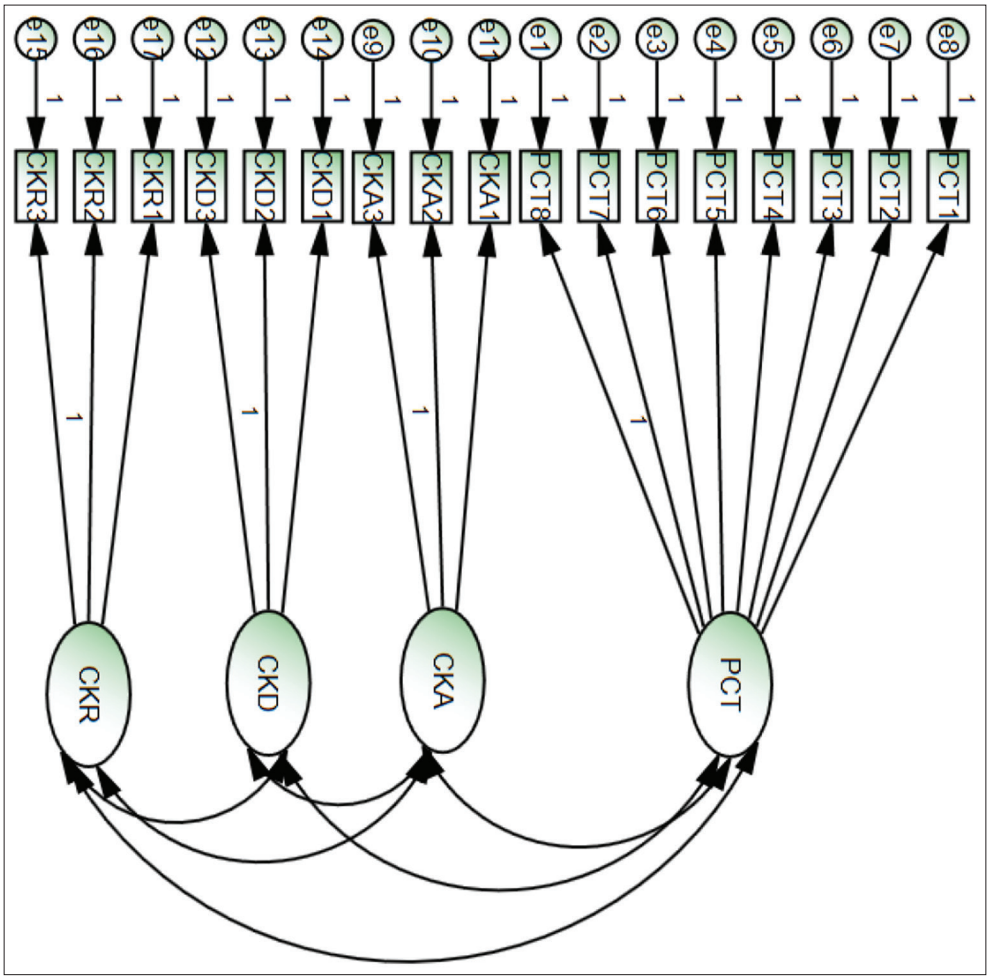
This study develops a questionnaire, considering the personal carbon trading with eight items (PCT1 to PCT8), carbon knowledge management with three sub latent indicators entitled as carbon knowledge acquisition (CKA), carbon knowledge dissemination (CKD), and carbon knowledge responsiveness (CKR) with all of these through further three items entitled as CKA1-CKA3, CKD1 to CKD3, and CKR1 to CKR3 respectively. similarly, for measuring the environmental sustainability four items are also added in the questionnaire entitled as ENS1 to ENS4. The questionnaire was developed with the following necessary information

A. Title of the questionnaire and research objective.
B. Key variables with their concept and dimensions
C. Demographic factors of the study
D. Thanking note to the respondents

After the development of questionnaire, researcher has observed the targeted respondents which are the community members from different local areas of Thailand. For the dataset with more reliable responses, 5 team members were jointly divided the obligation to collect the respondent view about PCT, carbon knowledge management, and environmental sustainability. Over the time duration of 8 eights, a sample of 369 questionnaires were collected. However, with the in depth investigation, it is found that out of total 100% collected copies, there were some questionnaire which are observed as not valid for the research, hence consequently dropped from the total considerable sample portion. For this purpose, total 118 copies were dropped from the sample and final number of 251 was found to be good enough for conducting the analyses. The overall structure of the analyses combine two approaches.

A. Analysis of Measurement Model.
B. Analysis of structural model.

Figure 1: Structural model/path input diagram for CFA



The process of analysis of measurement model covers some model fit and reliability test which can reasonably provide the answer whether the research can go for the structural model and empirical association between the variables. For analyzing the measurement model, present study has conducted confirmatory factor analysis or CFA with some additional model fit indices. With the evidence from model fit indices, reserachers than move towards analysis of structural model which is widely known as SEM. The overall hypotheses of the study are as follows

H_1	PCT is positively and significantly determining the environmental sustainability in Thailand
H_2	CKA is positively and significantly determining the environmental sustainability in Thailand
H_3	CKD is positively and significantly determining the environmental sustainability in Thailand
H_4	CKR is positively and significantly determining the environmental sustainability in Thailand

5. RESULTS

5.1. Descriptive Results

This research has divided into findings into descriptive and structural model. The reason for the division of both of these findings is that it explains the data trends and stated observations in the form of dispersion and the mean score under descriptive values (Table 1). Whereas structural model provides some of those findings which can help to accept or reject the research hypotheses of the study. Starting the discussion with descriptive score, overall seven items were added in the survey questionnaire for personal carbon trading; PCT1 to PCT8 where all of these items have provided a moderate score as presented through Mean title. However, PCT2 and PCT8 show lowest mean score in all the items of the study. for carbon knowledge acquisition (CK1 to CK3), carbon knowledge dissemination (CKD1 to CKD3), and carbon knowledge responsiveness (CKR1 to CKR3), all items are observed with the mean value of above 3 but below 3.50, showing again a moderating trends as experienced through respondent's argument on the questionnaire. Similarly, all these items for the carbon knowledge management providing a reasonable value in terms of standard deviation from the average score. In the last, environmental sustainability items (ENS1- ENS4) also show out a moderate trend for the mean and standard deviation. In general, all of these items are measured on the Likert scale, and for this reason, minimum observation is 1 and maximum is 5.

5.2. Structural Model Results

For presenting the structural model, initially some model fit indices are calculated to justify the presence of each and every item in the model for which confirmatory factor analyses play a major role. A lot of literature support is found to be good enough

Table 1: Descriptive results

Items	PCT1	PCT2	PCT3	PCT4	PCT5	PCT6	PCT7	PCT8
obs	251	251	251	251	251	251	251	251
Mean	3.143	2.785	3.183	3.04	3.127	2.94	2.92	2.793
Std. dev.	0.994	0.93	1.145	0.95	0.959	1.177	1.044	1.034
Min	1	1	1	1	1	1	1	1
Max	5	5	5	4	5	5	5	5
Items	**CKA1**	**CKA2**	**CKA3**	**CKD1**	**CKD2**	**CKD3**	**CKR1**	**CKR2**
Obs	251	251	251	251	251	251	251	251
Mean	3.239	3.315	3.486	3.45	3.446	3.51	3.594	3.57
Std. dev.	0.829	0.732	1.24	1.259	1.274	1.224	1.234	1.45
Min	2	2	1	1	1	1	1	1
Max	5	5	5	5	5	5	5	5
Items	**CKR3**	**ENS1**	**ENS2**	**ENS3**	**ENS4**	**AGE**	**QUALI**	**WEXP**
Obs	251	251	251	251	251	251	251	251
Mean	3.697	3.637	3.39	3.363	3.271			
Std. dev.	1.393	1.445	1.245	1.293	1.264			
Min	1	1	1	1	1	1	1	1
Max	5	5	5	5	5	5	5	5

to state that model fitness can be better reflected through CFA and related findings. Table 2 provides the score for the factor loading as generated through AMOS-24 version, for each of the items of exogeneous variables like personal carbon trading, carbon knowledge acquisition, knowledge dissemination, and knowledge responsiveness accordingly. Findings through CFA show that PCT factors have their factor loading of above 0.50 where lowest is observe for PCT3 is 0.515 and highest is presented by PCT5 which is 0.886. It means that all of these factors are providing a good score to present the reliability of the model. Meanwhile, the factor loading for the other items covering the title of carbon knowledge acquisition, dissemination and responsiveness are also in reasonable and acceptable range, hence Individual Item Reliability is not questionable for the exogeneous constructs of this research. Figures 1 and 2 presents the overall structure of the CFA model of the study, known as input path diagram under AMOS-24, where all variables like PCT, CKA, CKD and CKR are correlated to each other. In addition, error terms entitles as e1 to e17 are also presented under the similar figure to control the effect of other factors which are affecting the model from outside.

In addition, Table 3 shows the model fit measurement as observed through AMOS-24 along with CFA results. It is found that all model fits are finally accepted because either they are near the threshold or cross the cut points as explained in the existing body of literature.

Figure 3 provides a good graphical presentation for the structural model of the study, covering the impact of three latent constructs which are exogeneous in nature like PCT, CKA, CKD, and CKR on ENS as measured through four items earlier. It is observed that all of these variables are latent in nature and showing a reflective and 1st order construct where no additional variables or construct are further added in the model. In the end, error terms are added with the titles of e1 to e22 where the last one is specifically showing its influence on ENS.

The discussion about the factor loadings have provided some enough evidence to states that all of items under this model are reasonably reflecting the reliability of each item. Under this discussion, the direct impact of PCT, CKA, CKD and CKR is measured on ENS under full sample consideration. Moving towards

Table 2: CFA results

Items	Direct	Main construct title	Factor loadings estimates
PCT8	<---	PCT	0.731
PCT7	<---	PCT	0.822
PCT6	<---	PCT	0.799
PCT5	<---	PCT	0.886
PCT4	<---	PCT	0.863
PCT3	<---	PCT	0.515
PCT2	<---	PCT	0.815
PCT1	<---	PCT	0.869
CKA3	<---	CKA	0.796
CKA2	<---	CKA	0.702
CKA1	<---	CKA	0.820
CKD3	<---	CKD	0.880
CKD2	<---	CKD	0.825
CKD1	<---	CKD	0.871
CKR3	<---	CKR	0.894
CKR2	<---	CKR	0.880
CKR1	<---	CKR	0.680

Table 3: Model fits for CFA

Model fit titles	Value received	Final decision
Chi-square	472.394	
Probability value	0.000	
GFI	0.870	
AGFI	0.867	All are Accepted
TLI	0.851	
CFI	0.896	
PCFI	0.785	
RMSEA	0.049	

Table 4: Standardized regression weights

DV	Direction	IVs	Estimate	S.E.	C.R.	P	Sig. level
ENS	<---	PCT	0.021	0.005	4.20	0.000	***
ENS	<---	CKA	0.095	0.026	3.65	0.000	***
ENS	<---	CKD	-0.036	1.292	-0.120	0.905	
ENS	<---	CKR	0.955	0.062	15.40	0.000	***

Table 4 which shows the standardized regression weights for each of the exogenous variables on ENS. The impact of PCT on ENS is 0.021 reflects the direct and positive impact, found to be statistically significant as CR is 4.20 above the threshold level of

Figure 2: Output for CFA

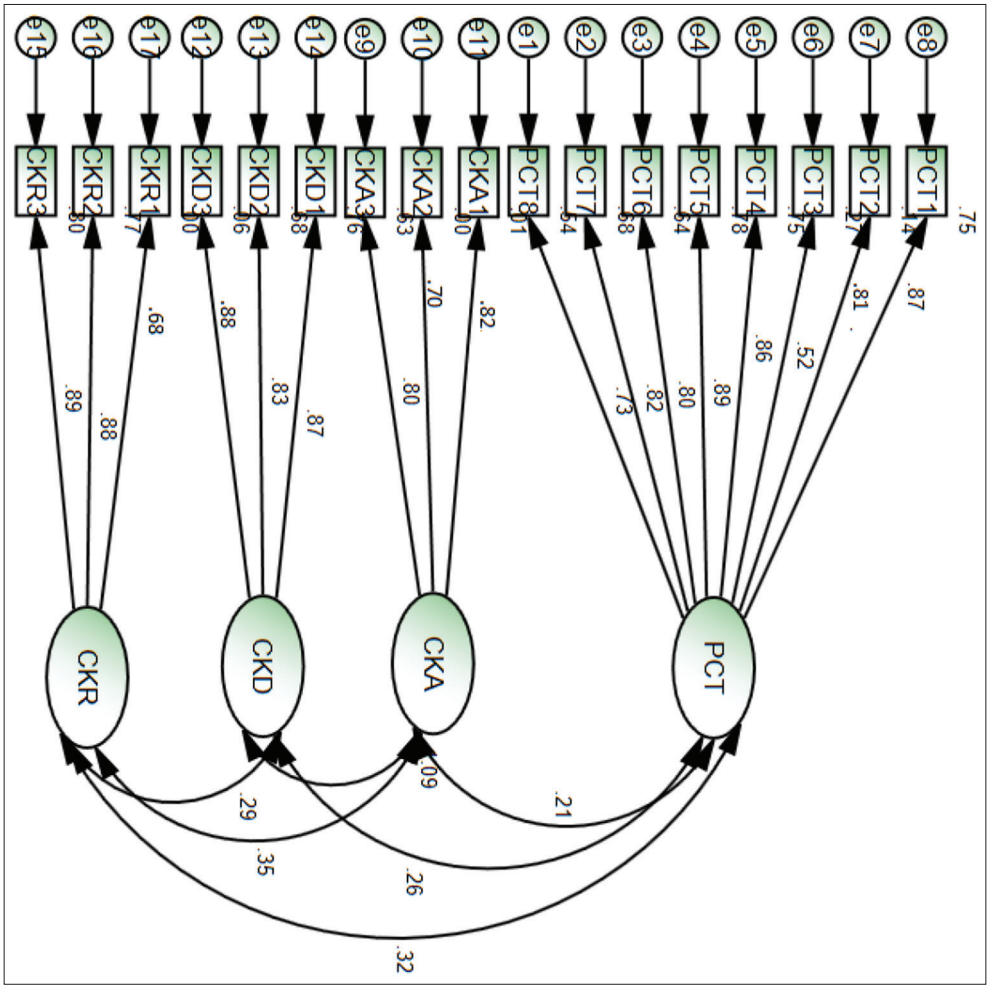
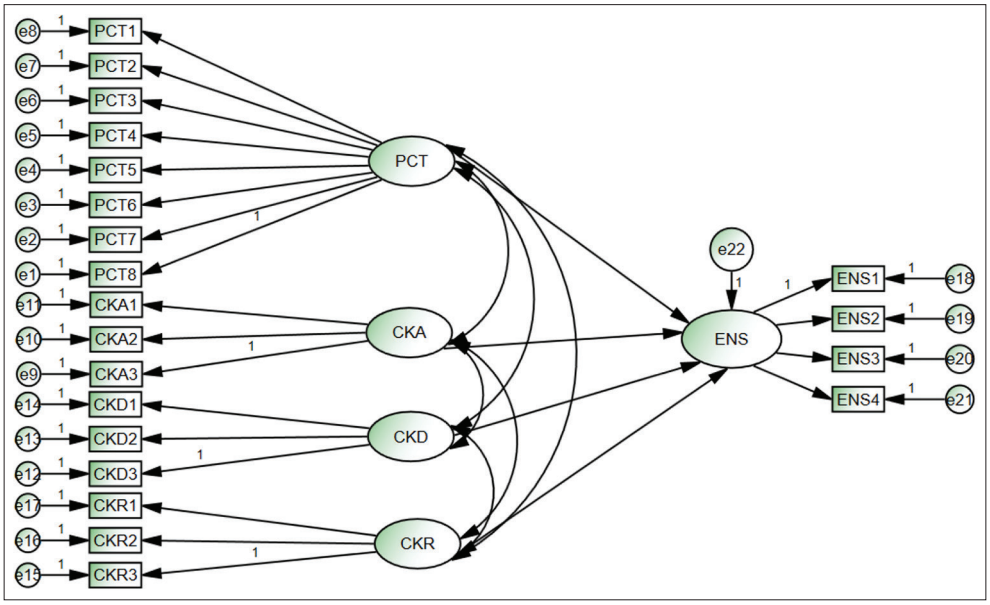


Figure 3: Structural equation model for exogenous and endogenous variables



1.96. It means that on average the overall impact of PCT and related schemes on ENS is very good as it is causing a positive influence on environmental sustainability. This effect is highly significant at $p < 1\%$, hence the first research hypotheses is supported, showing the statement that PCT is positively and significantly determining the environmental sustainability in Thailand.

Figure 4: Demographic factors of the study

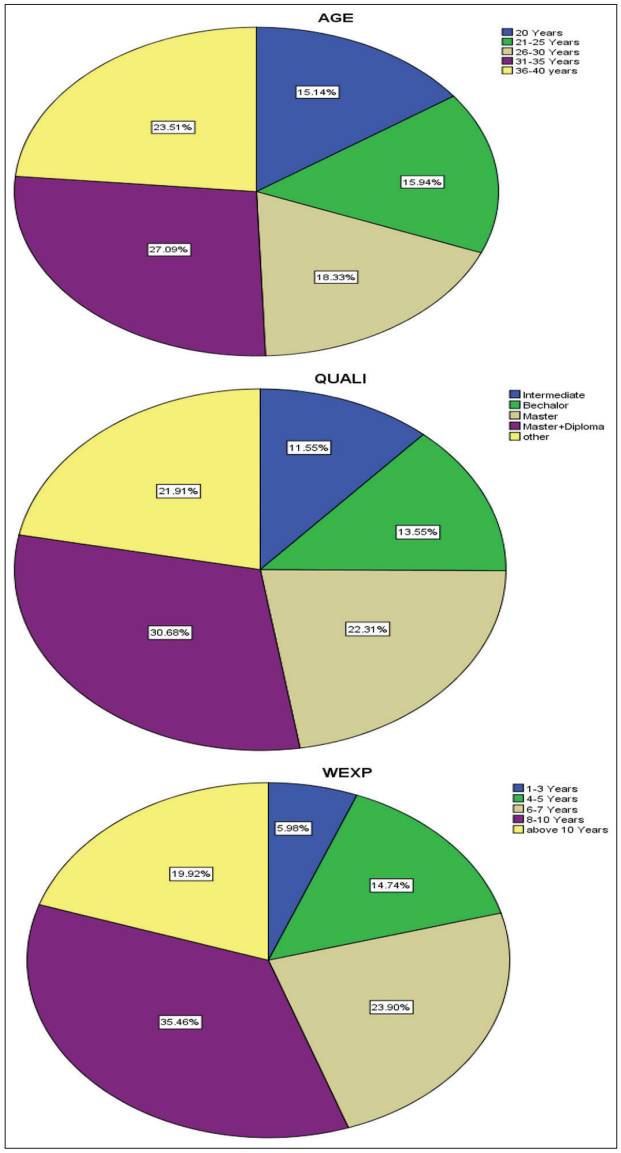


Table 5: Final remarks for the research hypotheses

Hypotheses title	Statement	Final remarks	Accepted criteria
H_1	PCT is positively and significantly determining the environmental sustainability in Thailand	Supported	T-value and P-value
H_2	CKA is positively and significantly determining the environmental sustainability in Thailand	Supported	T-value and P-value
H_3	CKD is positively and significantly determining the environmental sustainability in Thailand	Not supported	T-value and P-value
H_4	CKR is positively and significantly determining the environmental sustainability in Thailand	Supported	T-value and P-value

Demographic factors of study are presented in Figure 4. In addition, the details of hypothesis are reported in the Table 5.

6. CONCLUSION

This research intended to examine the impact of scheme like personal carbon trading and carbon knowledge management on environmental sustainability in Thailand economy. The reason to investigate this relationship is that Thai economy is facing some serious issues with changing climate and natural environment which needs to be addressed on serious grounds. To address the issue of climate change and sustainability in the natural environment, schemes like personal carbon trading can be a significant role player among other tactics as adopted by the government in the similar region. At the same time, carbon knowledge management is also observed a new topic in the field of controlling the carbon emission. This study has adopted a good method to explore the public opinion about the personal carbon trading and carbon knowledge management with their influence on environmental sustainability through questionnaire survey with a sample of 252 respondents. descriptive results providing the fact that all items have their moderate level of mean score with a reasonable score of standard deviation too. After descriptive statistics, reliability analyses through CFA was conducted, showing the individual item significance in the overall measurement model of the research. CFA shows a minimum score of above 0.50 whereas highest value for the factor loading is observed above 0.80, defending the supposition that all items are statistically fit to consider their role in structural equation model. The output through SEM shows that personal carbon trading on average has its positive and highly significant impact on Mean value of ENS respectively. It is stated that higher the public awareness about PCT, more positive impact on environmental sustainability is found. Furthermore, carbon knowledge management as observed through knowledge acquisition is observed as direct and positive determinant of ENS, whereas carbon knowledge disseminations is found to be insignificant while impacting the ENS. Lastly, carbon knowledge responsiveness is observed as among the positive indicator of ENS as found through SEM under AMOS-24.

As per the current findings through SEM, this study is suggested to the policy-makers for environmental sustainability and climate change who are searching for some new strategies. For this reason, the influence of PCT and knowledge management of carbon are found some new determinants of green environment is a new evidence with the support from empirical results. However, this study is examined with some limitations. For example, although a sample of 252 is a reasonable for the research, yet expanding the future sample size can provide better results. In addition, questionnaire survey has some limitations, comparatively to interview survey which is not examined in this research. Therefore, future studies may explore the respondent trends for PCT and carbon knowledge management with its impact on environmental sustainability.

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