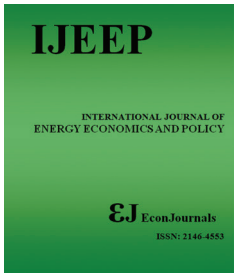

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Passengers' Willingness to Pay for Carbon Offsetting in Thailand's Aviation Sector: Evidence from Full-Service Airlines

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ABSTRACT

This study investigates passengers' willingness to pay for carbon offsetting within Thailand's aviation sector, with a focus on full-service airlines. Employing a quantitative methodology, a structured questionnaire was distributed to 400 passengers, and data were analyzed using Structural Equation Modeling (SEM). The results indicate that greater environmental knowledge and concern significantly increase the willingness to pay, with an average rate of 85.97%. Additionally, passengers who have a strong connection to nature and hold positive environmental attitudes are more likely to support carbon offset programs. Key recommendations include enhancing environmental awareness through targeted educational campaigns, providing transparent information about offset options, establishing effective communication channels, and collaborating with environmental organizations. By implementing these strategies, airlines can im-prove passenger engagement in sustainability initiatives, encourage responsible travel behaviors, and support the long-term sustainability of the aviation industry.

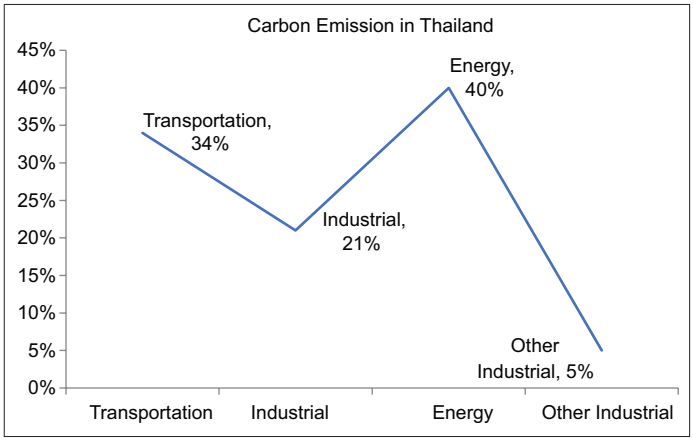
Keywords: Planning, Development strategies, Carbon credits offsetting, Passengers' willingness to pay, Sustainable air travel
JEL Classifications: Q5, R4, M2, M3, G29

1. INTRODUCTION

Sustainable air travel has become a major issue of importance. Due to the rising levels of greenhouse gases produced by human activities, particularly within the aviation sector (Liao et al., 2023; Kumari and Rhytheema, 2024). While air travel plays an essential role in providing safe and efficient transportation, it is also a significant contributor to carbon dioxide (CO_2) emissions, accounting for approximately 2% of global greenhouse gas emissions. The continued rise in these emissions is a key driver of climate change and global warming, leading to increasing global concern (Di Qi et al. (2022); Hassan et al., 2023; Nguyen et al., 2023; Kapoor, 2022) In response to The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) was first proposed by the United Nations' specialist agency, the International Civil Aviation Organization (ICAO). initiative. This program is designed to mitigate and offset CO_2 emissions from international flights while promoting sustainable practices within the industry. Simultaneously, airlines are making stronger commitments to environmental responsibility, integrating sustainability efforts that align with corporate social responsibility (CSR) principles (Schleich and Alsheimer, 2024; IATA, 2023).

According to Figure 1 the trend of carbon dioxide (CO_2) emissions in Thailand varies across different sectors. The energy sector is the largest contributor, accounting for 40% of total emissions, which aligns with the increasing CO_2 emissions from electricity generation due to rising energy demands. The transportation sector accounts for 34%, showing a slight reduction attributed to the growing adoption of electric vehicles. Meanwhile, the industrial sector contributes 21%, experiencing a significant decline in emissions due to reduced production capacity. The other

Figure 1: The proportion of CO_2 emissions in Thailand



industrial sector has the lowest emissions, making up only 5% of the total. To address the issue of greenhouse gas emissions, the Thai government has implemented an ambitious carbon policy, setting a goal to reduce greenhouse gas emissions by 30% by 2030 as part of a broader effort to achieve net-zero emissions by 2065 (World Bank, 2022).

Although this target remains lower than some neighboring countries, such as Cambodia, Indonesia, and Singapore (Sinha, 2023), Thailand is actively developing comprehensive strategies for climate adaptation and sustainable energy development. A key measure in these strategies is carbon pricing, which serves as a mechanism to incentivize emission reductions and facilitate the transition toward a low-carbon economy (Barker and Peters, 2023).

When formulating policies, decision-makers must carefully assess the advantages and disadvantages of implementing a carbon tax compared to an Emission Trading System (ETS) (Ahmad et al., 2024). Effective carbon pricing requires thorough consideration of the relevant sectors and the gradual removal of fossil fuel subsidies to establish a transparent and efficient market mechanism (Harrison, 2023). Revenue generated from carbon pricing should be strategically reinvested in various climate-related initiatives to mitigate potential economic and social impacts while fostering long-term sustainable development (Lee, 2022).

While making policy choices, policymakers must choose cautiously between maintaining a carbon tax or an Emission Trading System (ETS) (Alharbi and Brambley, 2019). A proper carbon pricing means adequately considering the interested sectors and the phasing out of fossil fuel subsidies to establish a clear and efficient market mechanism (van den Bergh et al., 2024). Revenue generated from carbon pricing must be invested wisely in various climate-related initiatives to minimize potential economic and social impacts while encouraging long-term sustainable development (Sonnenschein and Smedby, 2019).

Despite T-VERs currently accounting for only 7.61% of global carbon credit trading, the market demonstrates significant growth potential. In 2022, the issuance of car-bon credits in Thailand reached 1.19 million tons of CO_2 equivalent (tCO_2e), marking a 314.3% increase compared to the previous year, with a total market value of 128.50 mil-lion Baht, representing an impressive 1,222.7% growth. This rapid expansion reflects a rising interest in voluntary carbon offsetting and underscores the potential influence of passengers' environmental awareness on their willingness to participate in carbon cred-it programs (Thai Greenhouse Gas Management Organization, 2024). Previous studies indicate that passengers who are well-informed and concerned about environmental issues are somewhat more likely to participate in environmentally friendly travel and back carbon credit projects. Thus, designing efficient plans to promote passenger involvement in carbon offset programs and for a more sustainable aviation sector depends on an awareness of these behavioral drivers (Crosby et al., 2024).

Therefore, this study, titled " Passengers' Willingness to Pay for Carbon Offsetting in Thailand's Aviation Sector: Evidence from Full-Service Airlines" aims to explore passenger attitudes and readiness toward carbon offset initiatives. The findings are expected to provide valuable insights for airlines in designing effective policies and campaigns that promote environmental responsibility. Ultimately, this research seeks to raise environmental awareness among travelers in Thailand, encouraging greater participation in carbon offset programs and supporting the broader goal of sustainability in the aviation industry.

2. MATERIALS AND METHODS

2.1. Carbon Markets, Environmental Responsibility, and Passengers' Willingness to Pay for Carbon Offsets

Carbon credits represent measurable units of greenhouse gas (GHG) emission reductions or removals achieved through specific projects when compared to a busi-ness-as-usual scenario. These credits, certified under internationally recognized standards, serve as tradable instruments that enable entities emitting carbon to offset their emissions by purchasing credits from those who have successfully reduced or sequestered emissions. This mechanism provides essential incentives for various sectors to mitigate their carbon emissions (Diriba et al., 2023). However, a systematic review of 4,574 academic articles revealed that only 36 studies (approximately 0.79%) specifically examined consumers' willingness to pay (WTP) for carbon offsetting. This limited number of studies is consistent with other systematic reviews, where typically only about 1% of initial records are included in the final analysis (Abdeta, 2022). The scarcity of research in this area under-scores the need for further investigation, particularly in contexts like Thailand, where voluntary carbon markets are still in the early stages of development.

Geographically, the reviewed studies span 15 developing countries across three continents, with a significant proportion (47.22%) originating from Africa, followed by com-parable representations from Asia. Notably, eight studies were conducted in Ethiopia, five in Nigeria, and four each in Malaysia and Vietnam (Chien, 2023; Chechi and Cottam, 2021; De Arce and Mahía, 2023). In addition, several studies highlight the proactive role of airlines in offering carbon offset programs and the growing trend of voluntary contributions from environmentally conscious individuals worldwide (Goh and Matthew, 2021; Iqbal and Mozahid, 2022)

These findings underscore the global efforts to develop carbon credit markets to reduce greenhouse gas emissions. Specifically, under direction of the Thailand Greenhouse Gas Management Organization (TGO), Thailand has developed a voluntary carbon market, reflecting the country's commitment to promoting carbon off-setting mechanisms and sustainable development (Thanatrakolsri and Sirithian, 2024).

Carbon markets are generally divided into two main categories: compliance (mandatory) markets and voluntary markets. Compliance markets are established under legal frameworks that require entities to reduce greenhouse gas emissions, whereas voluntary markets are formed through collaborative initiatives where organizations and individuals engage in carbon credit trading without being legally mandated. In Thailand, voluntary carbon markets have been in operation since 2014, Serving as the central body certifying projects under the Thailand Voluntary Emission Reduction (T-VER) program is the Thailand Greenhouse Gas Management Organization (TGO) This framework aims to encourage broader participation in carbon offsetting and supports national efforts to mitigate climate change (Abadie et al., 2024)

Passengers' willingness to pay (WTP) for carbon credits represents a critical dimension of environmental responsibility, particularly in the context of sustainable aviation. Prior research has demonstrated that individuals who possess greater awareness of their car-bon footprint and its environmental consequences are more inclined to engage in carbon offsetting initiatives (Berger et al, 2022). The idea of a carbon footprint is the overall total green-house gas (GHG) emissions produced either directly or indirectly by an individual, product, or organization, expressed in terms of carbon dioxide equivalents (CO_2e). Importantly, studies highlight that passengers' WTP for carbon credits is not only influenced by their environmental awareness but also closely linked to their financial capacity and personal ethical considerations (Sustainable Aviation, 2020). These insights suggest that beyond mere economic calculation, passengers' decisions to purchase carbon credits often reflect deeper moral commitments to mitigating climate change. Thus, understanding the interplay between awareness, financial ability, and ethical motivation is essential for de-signing effective carbon offset programs that resonate with passenger values and contribute meaningfully to the aviation industry's decarbonization efforts.

Furthermore, biofuels derived from biomass have been identified as a promising sustainable alternative to fossil fuels, particularly within the aviation sector, offering significant potential for reducing greenhouse gas emissions (Ajzen, 1991; Schultz, 2020) Nevertheless, their widespread adoption remains constrained by challenges such as high production costs and competition for natural resources. Importantly, the aviation industry's carbon footprint extends beyond fuel consumption to include emissions associated with aircraft manufacturing, maintenance, airport operations, and the integration of technological innovations (Wang et al., 2020). Addressing these multidimensional sources of emissions is thus essential for developing comprehensive strategies toward sustainability in aviation.

Recent research has demonstrated a positive correlation between passengers' environ-mental awareness and their willingness to pay for carbon credits, indicating that airlines perceived as environmentally responsible may cultivate stronger customer loyalty (Baumeister et al., 2022; European Commission, 2020). Given the significant contribution of aviation-related greenhouse gas emissions to climate change, public health concerns, and regulatory pressures, it is imperative for the industry to adopt effective mitigation strategies (Carbon Neutral, 2022). These strategies may include the adoption of sustainable aviation fuels such as biofuels, improvement of operational efficiencies, and the implementation of robust carbon offsetting initiatives (Liu et al., 2023; Albayati et al., 2023). The relationship between passengers' willingness to pay and airlines' environmental responsibility is a key factor in supporting sustainable development in the aviation industry, consistent with changing regulations and public expectations.

In conclusion, Thai passengers' willingness to pay for carbon offsetting reflects increasing recognition of aviation's environmental impact. Strengthened by the development of carbon credit markets, voluntary offset initiatives, and rising consumer awareness, this commitment offers a promising pathway to promote sustainable air travel and contribute to global climate change mitigation.

2.2. Theoretical Foundations and Conceptual Framework for Examining Passengers' Willingness to Pay for Carbon Offsets

The Theory of Planned Behavior (TPB), originally introduced by (Ajzen 1991; Liu et al., 2023) has been extensively applied in various domains (Nekmahmud et al., 2022; Loureiro et al., 2022). Yet certain limitations remain regarding its structural relationships. Empirical evidence generally supports TPB, suggesting that behavioral intentions are significantly shaped by attitudes toward the behavior, subjective norms, and perceived behavioral control. Together, these elements explain substantial variance in actual behavioral outcomes. Nevertheless, the interconnections among these constructs and the role of underlying beliefs, norms, and perceived controls are still subject to ongoing investigation

In the context of aviation, passengers' environmental awareness and behaviors are key determinants of their choices and actions that impact the environment. Passengers who recognize the environmental consequences of aviation are more likely to support eco-friendly services and adopt sustainable behaviors within the sector. These environmentally responsible behaviors include (Baxter, 2022): (1) Choosing airlines that utilize cleaner fuels and carbon-reducing technologies to minimize greenhouse gas emissions (Kumar and Rhytheema, 2024); (2) supporting the use of renewable energy, particularly airlines investing in biofuels (Alfaro and Chankov, 2022); (3) reducing waste through practices like recycling and minimizing single-use plastics during flights (Mumlu Karanfil and Karakuş, 2024); (4) advocating for technological innovations that enhance resource efficiency and lower emissions (Albayati et al., 2023); (5) participating in carbon credit and offset pro-grams to compensate for flight-related emissions (Fu et al., 2013); (6) promoting operational measures such as reducing aircraft weight

to improve fuel efficiency (Rouse et al., 2024); (7) engaging in conservation initiatives organized by airlines or partners (Despotović et al., 2021) and (8) supporting air-lines with effective energy management policies while offering feedback on improving environmental practices (Lu and Shon, 2012). Given that the aviation sector contributes approximately 2–3% of global CO_2 emissions, rising passenger volumes and increased flight frequencies raise concerns regarding environmental and climate impacts. Notably, carbon emissions in aviation are influenced by three key factors: (1) growing flight demand driven by increased air travel; (2) higher emissions from older, less efficient aircraft compared to newer models; and (3) passenger behaviors linked to low-cost carriers, which may incentivize frequent travel and elevate cumulative emissions, challenging the balance between affordability and sustainability (Choi, 2019; CAAT, 2024; Shaari et al., 2021). Based on these insights, this study adopts a conceptual framework consisting of seven latent variables to examine factors influencing passengers' willingness to pay for carbon credits. These include Environmental Knowledge (EK), Environmental Concern (EC), Connectedness to Nature (CN), Subjective Norms (SN), Perceived Behavioral Control (PBC), Attitude (ATT) (He et al., 2021), and Willingness to Pay for Carbon (WTP) (Shaari et al., 2021)., as illustrated in Figure 2.

From the Research Conceptual Framework, the following hypotheses can be articulated.

- H_1: Environmental knowledge has a statistically significant relationship with passengers' attitudes.
- H_2: Environmental knowledge has a statistically significant relationship with passengers' personal norms.
- H_3: Environmental knowledge has a statistically significant relationship with passengers' perceived behavioral control
- H_4: Environmental concern has a statistically significant relationship with passengers' attitudes H_4.
- H_5: Environmental concern has a statistically significant relationship with passengers' personal norms
- H_6: Environmental concern has a statistically significant relationship with passengers' perceived behavioral control.
- H_7: Connection to nature has a statistically significant relationship with passengers' at-titudes.
- H_8: Connection to nature has a statistically significant relationship with passengers' personal norms H_8.
- H_9: Connection to nature has a statistically significant relationship with passengers' perceived behavioral control.
- H_{10}: Passengers' attitudes have a statistically significant relationship with their will-ingness to pay for carbon credits.
- H_{11}: Passengers' personal norms have a statistically significant relationship with their willingness to pay for carbon credits.
- H_{12}: Perceived behavioral control has a statistically significant relationship with their willingness to pay for carbon credits.

3. METHODOLOGY

This study investigates the relationship between environmental awareness, passenger behavior, and willingness to pay (WTP) for carbon credits among airline passengers in Thailand. Employing a quantitative research approach, the research systematically examines these relationships over a 6-month period (01 January 2025-30 June 2025). The study was approved by the Mahasarakham University Ethics Committee (approval code: 086-106/2568) and conducted in accordance with the ethical principles outlined in the Belmont Report and Good Clinical Practice (GCP) standards for social and behavioral research.

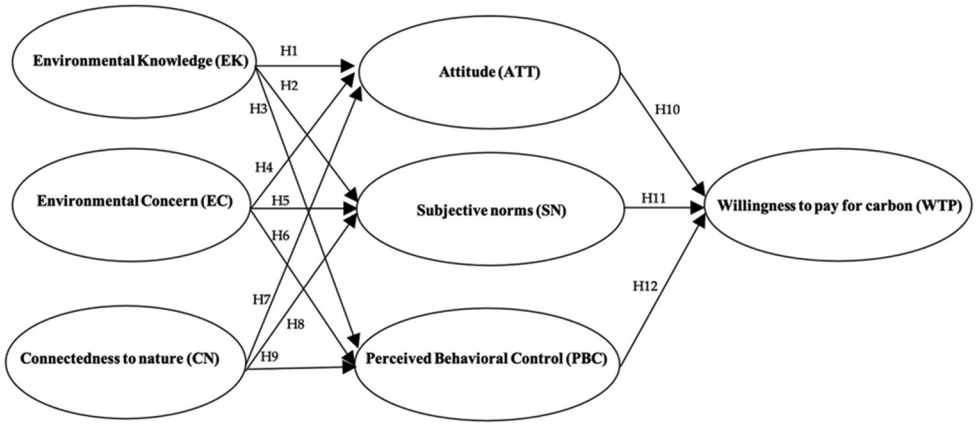
3.1. Population and Sampling

The target population for this study comprises tourists who have traveled with full-service airlines in Thailand, specifically Thai Airways and Bangkok Airways. To focus on relevant carbon offsetting behaviors, purposive sampling was utilized to identify tourists who are likely to consider purchasing carbon credits. Additionally, a stratified sampling approach was implemented to segment respondents into distinct subgroups based on characteristics pertinent to the research objectives, thus enhancing the overall representativeness of the sample.

According to the sample size determination formula proposed by Krejcie and Morgan (1970), a sample of 400 respondents was determined to be optimal, ensuring a 95% confidence level and a 5% margin of error. This sample size exceeds the minimum requirement of 384 participants, thereby bolstering the study's reliability.

Tourists were specifically recruited from Thai Airways and

Figure 2: Research conceptual framework



Bangkok Airways, both of which are full-service airlines known for their financial stability and willingness to invest in carbon offset initiatives. Passengers traveling with full-service airlines generally exhibit higher purchasing power and a stronger inclination towards sustainable practices compared to travelers of low-cost carriers. Furthermore, these airline customers tend to prioritize service quality and corporate social responsibility (CSR), making them more inclined to partake in environmental initiatives. Both airlines also maintain robust sustainability policies and are actively engaged in efforts to reduce greenhouse gas (GHG) emissions. This careful selection of respondents is aligned with the study's aim to investigate willingness to pay (WTP) for carbon offsetting within Thailand's aviation sector.

3.2. Research Instrument

The research instrument used in this study is a structured questionnaire consisting of 66 items divided into five sections. Section 1 collects general demographic information, comprising 8 items. Section 2 assesses environmental awareness through 21 questions related to environmental knowledge, concern, and connection to nature. Section 3 evaluates passenger behavior with 29 items focusing on personal norms, social responsibility, and attitudes. Section 4 measures willingness to pay for carbon credits using 8 questions, while Section 5 gathers additional suggestions from respondents through one item. The questionnaire employs a 6-point Likert scale (GQ-6) (McCullough et al., 2002), ranging from "Strongly disagree" (1.00–1.49) to "Strongly agree" (5.50–6.00), allowing for detailed insights into respondent attitudes.

To ensure content validity, the questionnaire was developed through a comprehensive literature review and expert consultations. The Index of Item Objective Congruency (IOC) was employed to assess alignment with research objectives. The instrument was further refined to ensure reliability and validity in capturing the study constructs.

3.3. Data Collection and Analysis

Data collection was conducted online through Facebook and LINE groups, utilizing Google Forms for efficient and accessible distribution. The survey was open for 10 days and successfully achieved a 100% response rate, yielding 400 fully completed questionnaires.

The collected data were analyzed using statistical software through a multi-step procedure. First, descriptive statistics were employed to summarize demographic characteristics and key study variables. Following this, inferential statistics were used to investigate the relationships among environmental awareness, passenger behavior, and willingness to pay (WTP) for carbon credits. To validate the measurement model, Confirmatory Factor Analysis (CFA) was applied to examine the relationships between latent constructs and their observed indicators, ensuring robust construct validity. Subsequently, Structural Equation Modeling (SEM) was conducted to assess the hypothesized relationships among variables and to evaluate overall model fit (Hair et al., 2010).

In addition, reliability testing was performed using Cronbach's Alpha, with a criterion threshold set at ≥0.70 (Nunnally, 1978) to ensure internal consistency. Both convergent and discriminant validity were evaluated through Average Variance Extracted (AVE) and the Fornell-Larcker criterion (Fornell and Larcker, 1978) to confirm the validity of the measurement model. Furthermore, Bootstrapping techniques were employed to estimate confidence intervals for parameter estimates and to support hypothesis testing and model adequacy assessments. Significance levels were analyzed to determine the strength and direction of the relationships among the studied variables (Hair et al., 2017).

4. RESULTS

The analysis of a sample of 400 passengers from full-service airlines in Thailand, comprising Thai Airways and Bangkok Airways, revealed essential insights regarding demographic characteristics, environmental awareness, and willingness to pay (WTP) for carbon offsetting. Among the respondents, 62.7% (n = 251) were female, and 37.3% (n = 149) were male. The majority were aged 20–29 years (68.5%, n = 274). Regarding marital status, 70% (n = 280) reported being single, and 67.5% (n = 270) were employed in the private sector. In terms of income, 23.8% (n = 95) reported earning between 20,001 and 30,000 Baht per month.

Importantly, all respondents (100%) indicated a willingness to offset carbon emissions for domestic round-trip flights within 2,000 km. Regarding specific preferences, 85.5% (n = 342) expressed willingness to purchase carbon credits for domestic routes, and 94.5% (n = 378) were willing to engage in carbon offsetting for international round-trip flights within Asia (distances under 6,000 km).

Furthermore, the data indicated a high level of connectedness to nature, with many respondents emphasizing nature's significance for their well-being and mental tranquility. Overall, environmental awareness among passengers was consistently high across various dimensions, including knowledge of climate change, carbon reduction projects, aviation-related environmental impacts, conservation efforts, and governmental policies for greenhouse gas (GHG) mitigation. Notably, participants expressed strong concern about climate change and its consequences. The measurement model's fit statistics are presented in Table 1 summarizing the model evaluation.

Table 1 presents the final measurement model's fit statistics. The model seems to fit the data rather satisfactorily, according the results. Particularly below the advised thresholds of 0.07 and 0.08, respectively, are the RMSEA value of 0.061 and SRMR value of

Table 1: Summarizes the fit statistics of the measurement model

Final measurement model	df	RMSEA[a]	SRMR[b]	CFI[c]	TLI[d]
	2.496	0.061	0.046	0.918	0.913
The target of the criterion	3	<0.07	<0.08	>0.90	>0.90

Root mean square error approximation is [a]RMSEA; standardized root mean squared is [b]SRMR; comparative fit index is [c]CFI; Tucker Lewis Index is [d]TLI

0.486. Additionally, the CFI and TLI values are 0.918 and 0.913, both exceeding the acceptable benchmark of 0.90. The degrees of freedom (df) are reported as 2.496, which indicates appropriate model complexity. Thus, based on these indices, the measurement model meets the required fit criteria and can be considered appropriate for further structural model analysis.

Emphasizing the assessment of reliability, convergent validity, and discriminant validity of the fundamental constructs, the evaluation of the measurement model was done depending on the established guidelines advised by Hair et al. (2017). The measurement model was investigated under a thorough validation process to guarantee the suitability of the used constructs in the research. Reviewed were the questionnaire items used to identify each construct, as Table 2 shows all factor loads exceeded the 0.70 threshold value. demonstrating satisfactory item reliability. Furthermore, to verify internal consistency, both composite reliability (CR) and Cronbach's alpha coefficients were computed. The results indicated that all values were above the recommended cut-off point of 0.70, confirming that the scales employed exhibit strong internal consistency and reliability suitable for further analysis (Hui et al., 2024).

By means of the average variance extracted (AVE), convergent validity of the constructions was assessed; all values exceeded the suggested threshold of 0.50, so verifying enough convergent validity for the measurement objects. Moreover, variance inflation factor (VIF) values were investigated to guarantee the absence of multicollinearity among the predictor variables, following the advise given by Hair et al. (2010), which suggests VIF values not higher than 5.00. Table 2 shows that the VIF values, much below the critical limit, ranged from 1.141 to 1.580. These findings support the stability of the relationships among the constructions under investigation since they show that multicollinearity was not a concern in the structural equation model used in this study (Nunnally, 1978).

Table 3 results of the discriminant validity analysis, assessed with the Fornell–Larcker criterion. Following accepted standards, discriminant validity was verified when the square root of the average variance extracted (AVE) (Geng et al., 2023) for every construct exceeded the highest correlation coefficients with other constructions in the model Fornell and Larcker, (1981). The results show that every construct satisfied this criterion, so indicating a suitable degree of discriminant validity for the measuring model. Particularly as shown in Table 3 each square root of the AVE for every construct exceeded its corresponding correlation with another, ranging from 0.795 to 0.902. Attitude (ATT), for example, proved unique from other measured variables since its AVE square root value of 0.845 exceeded its correlations with all other constructs. Comparatively, Willingness to Pay for Carbon (WTP) displayed an AVE square root of 0.795, which likewise exceeded its inter-construct correlations. These results taken together support the discriminant validity of the used constructions in this study.

As presented in Table 4 the results of hypothesis testing for the twelve proposed relationships indicate that nine hypotheses were statistically supported, while three were rejected. Specifically, hypotheses H_8, H_9, and H_{11} were not supported by the data. Hypothesis H_8, which proposed a significant relationship between connectedness to nature (CN) and subjective norms (SN), was rejected ($t = 1.014$, $P = 0.311$). Similarly, H_9, suggesting a link between connectedness to nature (CN) and perceived behavioral control (PBC), was also rejected ($t = 0.714$, $P = 0.475$). Moreover, H_{11}, which posited that subjective norms (SN) would significantly predict willingness to pay (WTP) for carbon credits, was not supported ($t = 0.023$, $P = 0.981$). These findings suggest that despite the presumed influence of personal connection to nature and social expectations, these variables did not show significant effects on perceived control or payment willingness in the current context.

Conversely, the findings revealed strong support for several key hypotheses. Environmental knowledge (EK) significantly

Table 2: Measurement model results

Constructs	Measurement label	Loading	t-value
Environmental Knowledge (EK)	EK1. I have knowledge about climate change issues.	0.867	46.081
VIF=1.309; CR=0.942; α=0.944;	EK2. I have knowledge of projects or activities that contribute to carbon reduction.	0.870	40.281
AVE=0.742	EK3. I understand the environmental impacts of air travel.	0.837	33.441
Environmental Concern (EC)	EC1. I am very concerned about the impacts of climate change on the world.	714	17.789
VIF=1.291; CR=0.967;	EC2. I believe that reducing greenhouse gas emissions is important for the future of humanity.	0.780	23.642
α=0.962; AVE=0.772	EC3. I am concerned about the environmental impacts of aviation.	0.772	22.896
Connectedness to nature (CN)	CN1. I am very concerned about the impacts of climate change on the world.	0.724	17.622
VIF=1.141; CR=0.940; α=0.943;	CN2. I believe that reducing greenhouse gas emissions is important for the future of humanity	0.945	86.753
AVE=0.810	CN3. I am concerned about the environmental impacts of aviation.	0.927	61.257
Subjective norms (SN)	SN1. The people around me support carbon offsetting.	0.867	33.441
VIF=1.580; CR=0.920;	SN2. My family and friends often talk about carbon offsetting.	0.892	43.729
α=0.910; AVE=0.739	SN3. I feel that people in my community recognize the importance of carbon offsetting.	0.764	25.156
Perceived Behavior Control (PBC)	PBC1. I feel that I can easily offset carbon.	0.852	28.621
VIF=1.292; CR=0.972;	PBC2. I believe there are convenient methods for carbon offsetting.	0.783	23.953
α=0.967; AVE=0.792	PBC3. I have sufficient financial means to carry out carbon offsetting.	890	37.744
Attitude (ATT)	ATT1. I have a positive attitude towards carbon offsetting.	0.854	49.386
VIF=1.426; CR=0.955;	ATT2. I believe that carbon offsetting will help reduce environmental issues.	0.838	30.858
α=0.956; AVE=0.714	ATT3. I think that carbon offsetting is a valuable choice.	0.863	47.600
Willing to pay for	WTP1. I am willing to spend extra money to support environmental projects.	0.754	20.817
Carbon (WTP); CR=0.927;	WTP2. If there is an option to purchase an airline ticket that includes carbon.	0.763	23.943
α=0.929; AVE=0.632	WTP3. I feel that paying for carbon credits is an important action for the environment	0.761	21.000

CR: Composite reliability, α: Cronbach's alpha values, AVE: Average variance extracted

Table 3: Discriminant validity using the Fornell–Larcker criterion

Construct	Mean	S.D.	ATT	CN	EC	EK	PBC	SN	WTP
Attitude (ATT)	4.2773	1.07176	0.845						
Connectedness to nature (CN)	4.5325	1.13656	0.344	0.902					
Environmental Concern (EC)	4.3150	1.11862	0.562	0.288	0.879				
Environmental Knowledge (EK)	4.1618	1.11302	0.424	0.309	0.448	0.862			
Perceived Behavior Control (PBC)	4.1733	1.15508	0.352	0.164	0.354	0.287	0.890		
Subjective norms (SN)	4.0140	1.14756	0.533	0.195	0.416	0.330	0.458	0.860	
Willing to pay for Carbon (WTP)	4.4414	0.97765	0.518	0.128	0.195	0.096	0.081	0.245	0.795

The values of the square root of AVE are presented through the italicised diagonal elements. the other elements present the mutual correlations among the constructs. The highlighted diagonal values indicate the square roots of AVE. Discriminant validity is supported when each √AVE exceeds the correlations between the corresponding construct and other constructs (Fornell Larcker, 1981).

Table 4: Path analyses (direct effects)

Direct Effect	Path	t-value	P-values	Results
H_1	EK→ATT	4.042**	0.001	Accepted
H_2	EK→SN	3.096**	0.002	Accepted
H_3	EK→PBC	2.503**	0.012	Accepted
H_4	EK→ATT	8.544***	0.000	Accepted
H_5	EK→SN	5.857***	0.000	Accepted
H_6	EK→PBC	4.708**	0.000	Accepted
H_7	CN→ATT	3.584***	0.000	Accepted
H_8	CN→SN	1.014(n.s.)	0.311	Rejected
H_9	CN→PBC	0.714(n.s.)	0.475	Rejected
H_{10}	ATT→WTP	12.784***	0.000	Accepted
H_{11}	SN→WTP	0.023(n.s.)	0.981	Rejected
H_{12}	PBC→WTP	2.416	0.016	Accepted

***P<0.01; **P<0.05; n.s.P>0.05

influenced passengers' attitudes (ATT) (H_1, t = 4.042, P = 0.001), as well as subjective norms (SN) (H_2, t = 3.096, P = 0.002), and perceived behavioral control (PBC) (H_3, t = 2.503, P = 0.012), confirming the role of knowledge in shaping environmental engagement. Environmental concern (EC) also exhibited significant effects on attitudes (H_4, t = 8.544, P = 0.000), subjective norms (H_5, t = 5.857, P = 0.000), and perceived behavioral control (H_6, t = 4.708, P = 0.000), emphasizing the broader role of concern for environmental issues in shaping pro-environmental behaviors.

Additionally, connectedness to nature (CN) showed a significant effect on attitude (ATT) (H_7, t = 3.584, P = 0.000), though its impact on subjective norms and behavioral control was not confirmed. Importantly, attitude (ATT) significantly predicted willingness to pay for carbon credits (H_{10}, t = 12.784, P = 0.000), underscoring the critical role of attitudinal alignment in fostering consumer behavior toward environmental actions. Perceived behavioral control (PBC) also demonstrated a significant positive effect on willingness to pay (H_{12}, t = 2.416, P = 0.016), further highlighting the role of self-efficacy and perceived ability in such financial commitments.

These results reinforce the theoretical understanding that environmental knowledge and concern are vital in shaping passengers' pro-environmental attitudes and behaviors. Although social norms (SN) did not directly predict willingness to pay for carbon credits, attitudes and perceived control emerged as crucial determinants of passengers' intentions to financially support carbon offset programs.

Qualitative responses further supported these quantitative outcomes, illustrating passengers' growing recognition of environmental issues and the importance of participating in carbon offset initiatives. Respondents emphasized that they were willing to incur additional expenses for flights that include carbon offset options and expressed a preference for airlines that actively engage in environmental sustainability. This reflects a growing expectation among passengers that airlines should assume a proactive role in mitigating the environmental impact of air travel.

In conclusion, the results of this study suggest that while personal connection to nature and social influence may not directly drive willingness to pay for carbon credits, environmental knowledge, concern, and positive attitudes are critical factors. Hence, airlines and policymakers should prioritize educational and communication strategies that enhance public understanding of carbon offsetting benefits and empower passengers to participate effectively. Furthermore, aligning environmental initiatives with passengers' values and expectations may improve participation rates and foster long-term commitment to sustainable travel practices

5. DISCUSSION

The results of this study indicate that Environmental Knowledge (EK) has a significant positive influence on Attitude (ATT), Subjective Norms (SN), and Perceived Behavioral Control (PBC) (H_1, H_2, H_3: P < 0.05), as shown in Table 4 These findings align with previous studies (Saxena and Zhao, 2021), demonstrating that individuals with greater environmental awareness are more likely to support carbon offset initiatives. Moreover, as demonstrated in Table 2 the AVE value of EK is 0.742, and all item loadings range from 0.837 to 0.870, confirming the robustness of the construct's measurement.

Similarly, Environmental Concern (EC) significantly influences ATT, SN, and PBC (H_4, H_5, H_6: P < 0.001), supporting prior research (Rotaris et al., 2020; de Mello, 2024) that individuals concerned about environmental issues are more inclined to engage in carbon offsetting. According to Table 2 the AVE of EC is 0.772, and its item loadings range from 0.714 to 0.780, indicating high internal consistency and validity of the construct.

Interestingly, Connectedness to Nature (CN) significantly influences only ATT (H_7: P < 0.001) but not SN and PBC (H_8, H_9: P > 0.05), as presented in Table 4 This contrasts with previous findings (Fischer and Wiegand, 2020), which have suggested broader effects of CN. However, Table 3 reveals that although CN has the highest mean (4.5325), its correlations with SN and

PBC are relatively low (0.195 and 0.164, respectively), potentially explaining these non-significant paths.

Furthermore, Attitude (ATT) shows a strong positive effect on Willingness to Pay for Carbon Offsets (WTP) (H_{10}: $P < 0.001$) according to Table 4 supported by Table 2 where ATT demonstrates an AVE of 0.714 and high factor loadings (0.838-0.863), confirming its predictive power. This is consistent with prior research (Tsai and Yang, 2022), highlighting the role of positive attitudes in shaping pro-environmental behavior.

In contrast, Subjective Norms (SN) do not significantly affect WTP (H_{11}: $P = 0.981$), as indicated in Table 4 suggesting that social pressure alone may not be sufficient to motivate passengers' willingness to pay for carbon offsets. This observation is reinforced by Table 3 where the correlation between SN and WTP is only 0.245, a relatively weak relationship (Harrison, 2023; European Commission, 2020). Regarding Perceived Behavioral Control (PBC), a significant positive influence on WTP was identified (H_{12}: $P = 0.016$), as seen in Table 4 with an AVE of 0.792 and acceptable factor loadings (0.783-0.890) per Table 2. This suggests that individuals who believe in their capacity to engage in carbon offsetting are more likely to financially contribute to such initiatives (Carbon Neutral, 2022). Additionally, as illustrated in Table 1 the measurement model shows a good model fit (RMSEA = 0.061, SRMR = 0.046, CFI = 0.918, TLI = 0.913), which supports the reliability and validity of the path analysis presented in this study.

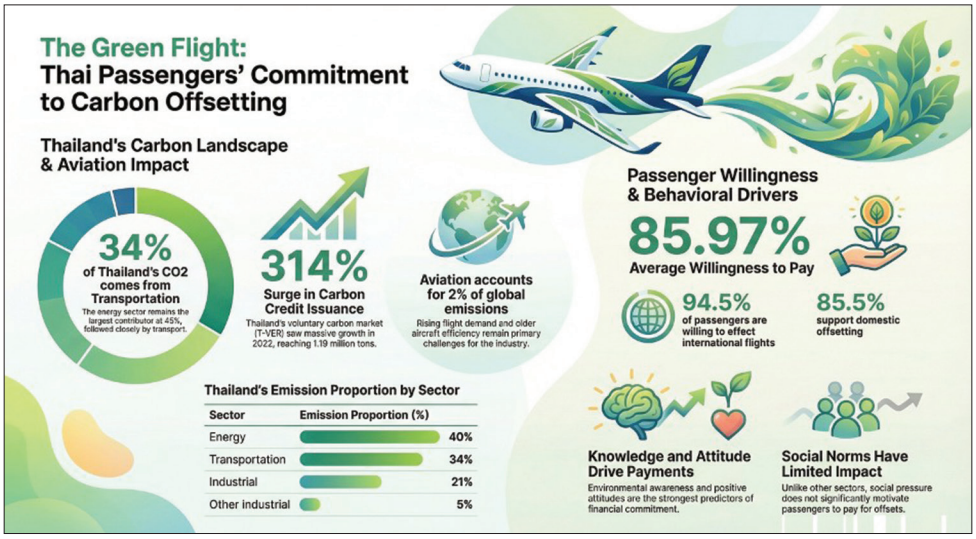
In summary, the findings supported by Tables 1-4 highlight the pivotal roles of environmental knowledge, environmental concern, and attitude toward carbon offsetting in shaping passengers' willingness to pay for carbon credits. These insights emphasize the need for airlines to proactively promote environmental education and cultivate positive attitudes toward carbon offsetting. Clear and accessible information, alongside practical resources, should be provided to encourage participation in carbon offset programs. Consequently, these measures could enhance environmental responsibility and sustainable practices within the aviation industry.

6. POLICY RECOMMENDATIONS FOR BOTH THE PUBLIC AND PRIVATE SECTORS

Based on the findings, this study recommends that airlines focus on several key strategies to develop effective planning and development approaches for carbon credit charging with passengers. First, airlines should prioritize enhancing passengers' environmental knowledge and fostering positive attitudes toward carbon offsetting, as these factors significantly influence their willingness to pay for carbon credits. Targeted educational campaigns utilizing online platforms, in-flight information, and collaborative projects with environmental organizations can improve passengers' understanding of climate change and the environmental impacts of air travel, thereby promoting responsible behaviors. Additionally, since perceived behavioral control was found to strongly affect willingness to pay, airlines should develop simple, transparent, and accessible carbon offset programs. Providing clear instructions and transparent information about how carbon credits are used can increase passenger confidence and participation. Offering multiple options tailored to different passenger preferences can further facilitate engagement across diverse groups. Although subjective norms showed limited direct influence, building a culture of environmental responsibility remains valuable; airlines can promote community initiatives and long-term environmental commitments to gradually shape favorable social norms associated with carbon offsetting.

Furthermore, incorporating incentives such as discounts, loyalty points, or recognition like eco-traveler badges for those opting into offset programs can motivate more passengers to participate. To ensure successful implementation, airlines should establish comprehensive communication channels to educate passengers about the importance, benefits, and procedures related to carbon offsetting, thus building trust and encouraging active involvement. Integrating carbon credit charges into flexible pricing models, especially in international flights, with options for voluntary or mandatory participation along with incentives, will promote

Figure 3: Passenger carbon offset participation cycle



acceptance and mainstream adoption. Lastly, airlines should collaborate with reputable environmental organizations to support credible carbon offset projects and conduct pilot programs to assess passenger willingness, allowing for data-driven adjustments and refinement of policies. By adopting these integrated strategies, airlines can play a vital role in global climate change mitigation efforts while aligning with the increasing environmental consciousness of modern travelers.

7. CONCLUSION

This study identified crucial factors influencing passengers' willingness to pay (WTP) for carbon offsetting within Thailand's aviation sector. The findings reveal that environmental knowledge, environmental concern, connectedness to nature, attitude toward carbon offsetting, and perceived behavioral control (PBC) significantly affect passengers' willingness to participate in carbon credit initiatives. Passengers who possess greater environmental knowledge and concern, as well as those who feel connected to nature, tend to exhibit more positive attitudes toward carbon offsetting and demonstrate a higher willingness to engage in such initiatives. Notably, passengers' willingness to pay for carbon offsetting was found to be remarkably high, with an average of 85.97%, including 85.5% for domestic flights and 94.5% for international flights, which reflects strong support for carbon reduction initiatives among airline passengers in Thailand.

From the twelve tested hypotheses, nine were accepted, while three were rejected. Specifically, environmental knowledge was found to have a significant influence on attitude, subjective norms, and perceived behavioral control, while environmental concern also significantly affected attitude, subjective norms, and perceived behavioral control. Furthermore, connectedness to nature significantly influenced passengers' attitudes toward carbon offsetting. However, contrary to expectations, connectedness to nature did not significantly influence subjective norms or perceived behavioral control. The study also demonstrated that passengers' attitudes toward carbon offsetting had a strong and significant relationship with their willingness to pay for carbon credits, and perceived behavioral control likewise exhibited a significant influence on willingness to pay. In contrast, subjective norms were not found to significantly affect passengers' willingness to pay for carbon offsets, suggesting that social pressures or expectations do not yet play a decisive role in motivating passengers to participate in carbon offset programs.

The results of this study are summarized in Figure 3, which illustrates the circular process underlying passengers' willingness to pay for carbon credits. The process begins with passengers making payments to airlines for carbon offsetting. Airlines then collect and allocate these funds to certified carbon offset projects, such as forestry initiatives in Thailand. Subsequently, passengers receive carbon offset certificates, which help reinforce positive attitudes toward environmental responsibility and encourage continued participation in carbon offsetting schemes.

This cyclical mechanism reflects a consistent pattern of passenger behavior in carbon credit offsetting and highlights the pivotal role of environmental awareness and user-friendly mechanisms in sustaining participation in sustainability initiatives. The findings suggest that simple, transparent processes and clear communication of environmental benefits can strengthen passenger engagement and support broader sustainability goals within the aviation sector.

Therefore, airlines are encouraged to develop targeted campaigns and partnerships with environmental organizations to build trust and awareness among passengers. By focusing on enhancing environmental knowledge and offering incentives for participation, airlines can effectively promote carbon offsetting programs, contributing to broader sustainability goals within the aviation industry.

Although this study provides valuable insights into passengers' willingness to pay for carbon offsetting, several limitations warrant consideration. First, the study focused exclusively on passengers within Thailand's aviation sector, which may limit the generalizability of the findings to other contexts or countries. Future research should explore similar models in different geographical or cultural contexts to validate and extend these findings. Second, this study employed a quantitative method using structured questionnaires, which may not fully capture the depth of passengers' motivations and perceptions. Future studies could incorporate qualitative approaches, such as in-depth interviews or focus groups, to gain richer insights into the underlying factors influencing carbon offsetting behaviors. Finally, further research could examine longitudinal changes in passengers' attitudes and willingness to pay following the implementation of carbon offset initiatives by airlines, thereby offering a dynamic understanding of how environmental behaviors evolve over time

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9. INSTITUTIONAL REVIEW BOARD STATEMENT

Review Board Statement: The document is a Certificate of Approval from Mahasarakham University Ethics Committee for Research Involving Human Subjects. The certificate is valid from February 17, 2025, to February 16, 2026.

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