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Must-Have or Nice-to-Have? Factors Influencing Chinese Travelers' Intention to Use E-Boarding Passes: Using Mixed Methods Approaches

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Article

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Abstract

Ranked as the world's second largest airport system, China attaches great importance to sustainable travel. Travelers' adoption of electronic boarding passes could promote green behavior and sustainability. Using mixed methods approaches, this study examines factors influencing Chinese travelers' attitudes and intentions to adopt electronic boarding passes (E-boarding passes), based on the technology acceptance model (TAM) and the theory of reasoned action (TRA). In Study 1, 317 online data responses are analyzed using partial least squares structural equation modeling (PLS-SEM) and necessary condition analysis (NCA) via SmartPLS 4.0 to identify sufficient and necessary conditions of proposed factors. In Study 2, semi-structured interviews are conducted to illuminate quantitative results. The findings indicate that emotional value and environmental concern are both sufficient and necessary conditions of travelers' attitudes towards E-boarding pass adoption. Although environmental concern emerges as a necessary condition (must-have factor), while a certain level is required to achieve the desired outcome (i.e., behavioral intention). The study illustrates the triangulation of advanced mixed-method approaches can advance theory testing, offering useful insights for the air travel industry and policymakers to understand Chinese travelers' technology adoption and sustainable behaviors.

Introduction

Ranked as the world's second-largest airport system, trailing only the US, China is set to become the world's largest by 2043 (International Trade Administration 2025; Liu et al. 2021; Zhang et al. 2020). As first half of 2026, China has about 60 airlines and 262 airports with 4,335 aircrafts, and the country has handled more than 380 million passenger trips, which is expected to reach 1 billion air passenger traffic by 2028 (Herrera, 2026; Liu et al. 2021; Xinhua, 2025). Tourism and air transportation are closely linked (Lim and Tkaczynski, 2017), and the rapid development of the Chinese airline industry has enabled individuals to travel to various destinations, connecting businesses and economies among cities (Chen et al. 2017).

While it is important to acknowledge the aviation industry's significant social and economic effects, there is growing public concern about commercial flights' negative environmental implications (Liu et al. 2021; Park 2019; Wang et al. 2020). The large volumes of traffic and goods airlines carried have resulted in significant carbon emissions (Chen et al. 2017). According to the Civil Aviation Administration of China (CAAC) in 2024, approximately 3,639 aircrafts from 45 airlines consumed about 0.287 kg of fuel per kilometer flown (International Trade Administration 2025; Liu et al. 2021).

Being the world's largest CO2 emitter, China places great importance on protecting the environment and has introduced carbon reduction schemes to decrease greenhouse emissions by 10% from the peak by 2035, striving to achieve carbon neutrality in 2060 (Ji and Xu 2025; Ma et al. 2021). This initiative aligns with the United Nation's 12th goal of SDG (i.e., responsible consumption and production). Therefore, it is imperative that policymakers and stakeholders in the airline industry devise effective

methods to promote green development in the aviation sector and mitigate the negative environmental impact of air travel (Liu et al. 2021).

A potential way to minimize the adverse environmental impact of the airline industry is to encourage the use of electronic boarding passes (E-boarding passes). The production of millions of paper boarding passes requires natural resources, energy, and emissions, whereas E-boarding passes could effectively reduce carbon emissions associated with production of paper boarding passes and promote sustainability (Wong and Sim 2025). Moreover, E-boarding passes could enhance the travelers' boarding experience and emotional well-being when environmental benefits are achieved, particularly by providing them with a sense of warmth for engaging in environmentally friendly consumption (Bouchard et al. 2008; Taneja 2016; Taufique 2022). Nevertheless, to the authors' best knowledge, it currently remains unclear whether travelers' environmental concerns and emotional evaluations can convert into their green behaviors. Previous studies have investigated consumers' behavioral intentions in various air transport settings, such as self-service technology adoption, airline e-ticket repurchase intention, airline service quality, intention to use low-cost carriers, and acceptance of biometric check-in kiosks (Lien et al. 2021; Liang and Shiau 2018; Lim and Tkaczynski 2017; Pan and Truong 2018; Wongyai et al. 2025). However, despite the enthusiasm shown by the airline industry to address environmental issues, limited empirical research has examined environmental concerns on travelers' adoption of technology, such as E-

boarding passes (Li et al. 2023).

This study is theoretically underpinned by the technology acceptance model (TAM) (Davis 1989) and the theory of reasoned action (TRA) (Ajzen and Fishbein 1980),

to examine travelers' attitudes and intentions toward using E-boarding passes through the lens of environmental knowledge and emotive evaluations. Both TAM and TRA have been previously adopted to understand consumer behaviors in diverse service contexts (Ruan et al. 2022; Suki and Suki 2017; Zhong et al. 2022). Additionally, this study distinguishes prior studies methodologically by employing advanced mixed method approaches to triangulate the research findings. The first phase of the study (Study 1) is quantitative through partial least squares structural equation modeling (PLS-SEM) and necessary condition analysis (NCA) to determine if the exogenous constructs are sufficient or necessary conditions for predicting consumers' behavioral intentions (Dul et al. 2016; Richeter et al. 2020). The second phase (Study 2) is a qualitative follow-up study that uses semi-structured interviews to reinforce and deepen the quantitative results of Study 1(Kurtaliqi et al. 2024). As such, this research provides fine-grained insights through a novel methodological approach.

The purpose of this research is to ascertain the interconnectedness between the antecedent constructs on travelers' attitudes and intentions to use E-boarding passes. Specifically, this study addresses the following questions:

RQ1. Do environmental concerns affect travelers' perceptions and intentions to use E-boarding passes?

RQ2. To what extent are variables from TAM and TRA associated with environmental concern and emotional value? Subsequently, how do these variables affect travelers' intentions to use E-boarding passes?

RQ3. What are the should-have and must-have factors that influence travelers' attitude and intention toward using E-boarding passes?

To align with the study's focus, specific objectives were followed: **1)** to examine how environmental concerns and emotional value influence individuals' attitudes and intentions to use E-boarding passes; **2)** to propose an integrated conceptual framework to explore the inter-relationships among the proposed variables of interest; **3)** to identify sufficient and necessary degree of determinants required for inducing travelers' attitudes and intention to use E-boarding passes via the joint analysis of PLS-SEM and NCA; **4)** conduct qualitative interviews to cross-validate and illuminate quantitative findings.

Literature review

Conceptual framework and research hypotheses

This study builds on TAM and TRA models to explain consumers' intention to use E-boarding passes (Ajzen and Fishbein 1980; Davis 1989). Under the TAM framework, perceived usefulness (PU) and perceived ease of use (PEU) are key predictors of attitude toward technology adoption, which subsequently influences behavioral intentions (Davis 1989). In this study, perceived usefulness refers to the degree to which travelers believe using E-boarding passes can enhance travel efficiency. Perceived ease of use captures the perceived effortlessness of the process (Davis 1989). Previous studies have confirmed that both perceived usefulness and perceived ease of use could significantly shape users' attitude and adoption intention toward digital technologies (Jeon et al. 2019; Yersüren and Özel 2024; Zhong et al. 2022).

The TRA has been regarded as a useful model for explaining the relationship between consumers' attitudes and behaviors in consumer service settings (Jang and Cho 2022; Ruan et al. 2022). Subjective norm and attitude, drawn from the TRA model, are incorporated in the proposed conceptual framework to capture travelers' volitional

behaviors. Subjective norm reflects perceived social pressure and referent groups that are important to influence one's behaviors and attitudes (Jang and Cho 2022). Attitude describes individuals' overall positive or negative evaluations of the behavior (Ajzen 1991; Davis 1989).

Furthermore, the proposed conceptual framework is extended by incorporating environmental concern and emotional value. Environmental concern often influences behavioral intention indirectly through cognitive and normative mechanisms, such as attitudes and subjective norms (Song et al. 2023; Wang et al. 2016), indicating environmental concern serves as a critical precursor variable within the proposed framework that promotes pro-environmental behaviors (Wang et al. 2025). Moreover, the integration of

emotional value into the research framework enables a more holistic understanding of travelers' responses along with the model's cognitive components, as emotional value can positively affect attitude and intention toward digital or sustainable services (Wang et al. 2016).

Subjective Norm

Prior studies have consistently shown that social influence from referent groups can positively shape individuals' behavioral intentions and attitudes (Liang and Shiau 2018). For instance, when passengers perceive that their significant others approve of using digital travel tools, they are more likely to develop favorable opinions and stronger intentions to engage in such behaviors (Jeon et al. 2019). In sustainability-related contexts, the subjective norm is also a major driver of pro-environmental behavior and attitudes. For instance, Liu et al. (2020) demonstrated that subjective norm significantly shaped consumers' green intention. Tonder et al. (2023) found that subjective norm can

serve as an antecedent of consumers' green attitudes. Moreover, recent studies further confirmed that subjective norms can serve as a key determinant of environmentally responsible and green behaviors (Park et al. 2024; Ruan et al. 2022). In the context of aviation sector, social influence positively affected passengers' intention to use mobile flight ticketing applications (Suki and Suki 2017). Accordingly, we proposed:

H1

Subjective norm positively affects travelers' attitudes toward using E-boarding passes.

H2

Subjective norm positively affects travelers' intention to use E-boarding passes.

Emotional value

Emotional value represents the positive affective responses that enhance users' evaluations beyond functional efficiency (Ravi et al. 2022). Han et al. (2021) found that emotional satisfaction significantly shapes travelers' attitudes and loyalty in airline services, suggesting that positive emotions play a crucial role in consumers' acceptance of service innovations. Additionally, Khan and Mohsin (2017) revealed that emotional value could strengthen consumers' willingness to engage in environmentally responsible behaviors. Furthermore, Kato (2021) argued that emotional value had a stronger impact than functional value on brand preference, highlighting its essential role in shaping consumer evaluations. This evidence implies that affective responses are critical in travelers' evaluation and adoption of self-service technologies (Lin and Hsieh 2006). Accordingly, we propose:

H3

Emotional value positively affects travelers' attitudes toward using E-boarding passes.

H4

Emotional value positively affects travelers' intention to use E-boarding passes.

Environmental concern

Environmental concern refers to the extent to which individuals are aware of environmental problems and are motivated to mitigate their impact on the natural environment (Lee et al. 2014). Studies have revealed that social and affective mechanisms underpin environmentally motivated behaviors. For instance, Xu et al. (2022) found that environmental concern significantly enhances subjective norms in green purchase contexts, indicating that ecological awareness can reinforce perceived social expectations toward sustainable practices. Similarly, Chen and Tung (2014) confirmed that environmental concern exerts a significant positive effect on subjective norms in the context of green hotel consumption, suggesting that individuals with stronger ecological awareness are more likely to perceive social pressure to act in environmentally responsible ways.

Prior studies also revealed that environmental concern influences consumers' attitudes toward environmentally sustainable behaviors and green purchase decisions (De canio et al. 2021; Kumar et al. 2022; Paul et al. 2016). In the air travel context, Öztürk and Özcan (2025) demonstrated that environmental concern positively affects passengers' willingness to participate in carbon offset programs, with attitude mediating this relationship. Similarly, Park et al. (2024) argued that environmental knowledge strengthens the link between environmental concern and pro-environmental intention among airline passengers. Additionally, Maduku (2024) also confirmed that environmental concern evokes strong positive emotions, fostering greater green consumption intentions. Therefore, the following hypotheses are proposed:

H5

Environmental concern positively affects the subjective norm.

H6

Environmental concern positively affects travelers' attitudes toward using E-boarding passes.

H7

Environmental concern positively affects travelers' intention to use E-boarding passes.

H8

Environmental concern positively affects travelers' emotional value.

Perceived Usefulness and Perceived Ease of Use

Empirical studies have shown that perceived ease of use and perceived usefulness have positive influences on both attitude and behavioral intention (Jeon et al. 2019; Suki and Suki 2017; Zhong et al. 2022). Wongyai et al. (2025) revealed that passengers' perceived ease of use positively influences perceived usefulness. Furthermore, perceived ease of use indirectly affects intention by increasing perceived usefulness, as an intuitive and user-friendly system enhances the perception of usefulness (Lin and Hsieh 2006; Zhong et al. 2022). Accordingly, the following hypotheses are proposed:

H9

Perceived usefulness positively affects travelers' attitudes toward using E-boarding passes.

H10

Perceived usefulness positively affects travelers' intention to use E-boarding passes.

H11

Perceived ease of use positively affects perceived usefulness.

H12

Perceived ease of use positively affects travelers' attitude toward using E-boarding passes.

H13

Perceived ease of use positively affects travelers' intention to use E-boarding passes.

Attitude toward Using E-boarding Passes

Consumer attitude serves as a central determinant of behavioral intention in consumers' technology adoption (Davis 1989; Kumar et al. 2022). Prior studies in service contexts have confirmed that attitude significantly predicts behavioral intention toward technology adoption (Jeon et al. 2019; Suki and Suki 2017). Lien et al. (2021) further confirmed that attitude had a strong positive effect on behavioral intention in travelers' adoption of airport fast-travel services. Accordingly, the following hypothesis is proposed(Fig. 1):

H14

Travelers' attitude toward using E-boarding passes has a positive influence on their intention to use E-boarding passes.

[Insert Fig. 1 here]

Methodology

This study employed advanced mixed method processes consisting of quantitative and qualitative phases. The quantitative phase included analysis of PLS-SEM and NCA, as Study 1 examined the proposed research model. To address the limitations of a single database, Study 2 used interviews to provide detailed descriptions of the counterintuitive associations found in the qualitative results (Kurtaliqi et al. 2024; Richter et al. 2022). The qualitative phase was conducted after the quantitative phase to holistically explore the unexpected findings of the quantitative data (Kurtaliqi et al. 2024). The sequence was consistent with previous research (Lee et al. 2025; Pansiri 2006).

Study 1: Quantitative Phase

Sampling and data collection

In Study 1, self-administered online questionnaires were created through Credamo, a well-known Chinese survey platform. Before launching the full-scale data collection, a pre-test of 35 samples was conducted to ensure the accuracy of the measurement items.

The questionnaire was subsequently re-worded to improve the face and content validity of the model constructs. The survey link generated through Credamo was distributed to its data pool. Participants' personal identification remained anonymous, and their participation was voluntary. Upon completing the questionnaire, each respondent received 0.5 USD as compensation. From the initial 428 responses, 317 were retained for final analysis after removing incomplete responses and those failing attention checks. To calculate the minimum sample size, G*Power 3.1.9.4 software was used (Ringle et al. 2014), recommending a sample size of 146 as the minimum sample size to achieve 80% of statistical power. Hence, we deem the sample collected in this study adequate.

Measurement Scales

The measurement scales consist of 27 items, which were adopted and adapted from previous research (Table 2) from various studies to enhance the novelty of the research and minimize common method bias. All the scales were anchored on a seven-point Likert scale (1 = strongly disagree; 7 = strongly agree). Demographic and general questions were asked at the end of the questionnaire.

Analysis method

The quantitative phase employs a combination of partial least squares structural equation modeling (PLS-SEM) and necessary condition analysis (NCA) to jointly explore the causal relationship among proposed hypotheses and draw inferences. PLS-SEM focuses on sufficiency logic (should-have factors) to investigate causal relationships if the research objective is prediction-based (Dul, 2016; Rasoolimanesh and Ali 2018). On the other hand, NCA is an emerging method to identify the degree of

necessary conditions that need to be fulfilled to achieve the desired outcomes (Dul 2020; Dul 2022; Richter et

al. 2020). NCA has been increasingly applied in business and management research (Dul 2024); however, the investigation of necessity causality has been largely ignored in travel and tourism research (Dul 2022; Lee et al. 2023). Since necessary conditions are not always captured by variance-based models (Ritcher et al. 2020), results generated by PLS-SEM analysis alone may generate incomplete findings (Hauff et al. 2024). As such, the combination of these two methods emphasizes significant and non-significant determinants that are necessary conditions for creating a unique way of assessing causality (Hauff et al. 2004; Richter et al. 2020). The analyses in Study 1 follow procedures from Ritcher et al. (2020) and Sarstedt et al. (2024), using Smart PLS 4.0 software to identify both necessary and sufficient conditions.

Quantitative Results

Respondents' characteristics

The respondents' profile was displayed in Table 1. The respondents consisted of 110 male (34.7%) and 207 females (65.3%). Most of the respondents were at age between 18–30 (n

= 239, 25.4%) and only 5.4% of the respondents (n = 17) at the age range between 41–50. For education, most of the respondents had an undergraduate degree (n = 168, 53%) and about 35.3% of the respondents (n = 112) had a postgraduate degree. Regarding monthly income, 31.2% of the respondents (n = 99) had less than 2000rmb per month; 24.6% of the respondents (n = 78) had monthly income of 2000-5000rmb; 28.4% of the respondents' (n = 90) income were between 5001-10000rmb; only 15.8% of the respondents (n = 50) had monthly income larger than 10000rmb. The majority of respondents (n = 217, 68.45%) have used E-boarding passes.

[Insert Table 1 here]

PLS-SEM measurement model

This study assessed the measurement model by checking reliability and validity. The loading for each measurement item exceeded 0.7 (Hair et al., 2019). The Cronbach's alpha for all constructs ranged from 0.77 to 0.88; composite reliability (CR) values ranged from 0.85 to 0.92, demonstrating good internal consistency for the measurement items (Table 2). Average variance explained (AVE) ranged from 0.64 to 0.74, demonstrating good convergent validity (Hair et al. 2019). Discriminant validity was assessed using HTMT values (Table 3), which met the cut-off point 0.85 (Rasoolimanesh and Ali 2018). Thus, the discriminant validity issue was not present in this study.

[Insert Tables 2 and 3 here]

Structural model assessment and hypotheses testing

The structural model of PLS-SEM was assessed by bootstrapping with 5,000 samples (Richter et al. 2020) to test the hypotheses. The R^2 values for attitude and intention to use E-boarding passes were 0.54 and 0.57, respectively, demonstrating a meaningful predictive power of the structural model (Chin 1998). The t-statistic value needs to be greater than 1.96 to indicate a significant hypothesized path (Hair et al. 2019). Three hypotheses were not supported (H1, H7, and H12), while rest of the hypotheses were supported (Table 4 and Fig. 2).

[Insert Table 4 and Fig. 2 here]

Necessary condition analysis (NCA)

The latent scores derived from SmartPLS 4 software were used for the NCA analysis (Hauff et al. 2024), with 10,000 permutations were utilized (Richter et al. 2020). Three iterations were carried out to test necessity associations among conditions and each endogenous construct (i.e., attitude and intention toward using E-boarding passes). Conditions are necessary factors if the effect size (d) is smaller than 0.1 or p-value is greater than 0.05 (Richter et al. 2020) (Table 5).

Moreover, the NCA analysis uses CE-FDH ceiling line, a non-decreasing stepwise linear line, to determine the effect sizes (Richter et al. 2020; Sarstedt et al. 2024). The bottleneck table (Table 6) was used to interpret the results of necessary factors by identifying critical values based on the outcome that are relevant to necessary conditions by percentage (Tiwari et al. 2023). According to the bottleneck table, to achieve 100% of the attitude toward using E-boarding passes, 3.47% of the cases do not satisfy (96.53% is required) the necessary level of emotional value and environmental concern; 1.57% and 10.73% of the cases do not satisfy the necessary level of subjective norm (98.43% is required) and perceived usefulness (89.26% is required); and notably, no case could satisfy the necessary level of perceived ease of use. For achieving 100% of the intention to use E-boarding passes, 5.66%, 5%, 5.38%, and 4.99% of the cases do not satisfy the necessary level of emotional value (94.34% is required), environmental concern (95% is required), perceived usefulness (94.62% is required), perceived ease of use (94% is required, and attitude toward using E-boarding passes (95.01% is required), respectively; and notably, no case could satisfy the necessary level subjective norm. About 6% of the cases do not meet the necessary level of perceived ease of use (94% is required). Figure 3

(a-b) presents the NCA scatter plots for all necessity relationships. Interpretations from the combined PLS-SEM and NCA analysis are summarized in Table A1.

[Insert Table 5, Table 6 and Fig. 3 here]

Study 2: Qualitative Phase Procedure of qualitative

Study 2 used in-depth, semi-structured interviews to further explore the main constructs of the research framework. A purposeful sampling was used to recruit interviewees who have used E-boarding passes from diverse backgrounds (e.g., age, occupation, travel frequencies). We conducted 14 interviews with each session lasting 15–20 minutes; however, four interviews were excluded from the final analysis due

to insufficient detail and failure to answer interview question prompts. Removing these data was necessary to eliminate data noise and preserve the internal validity of the study (Pullen Sansfaçon et al. 2024). Ten interviews were deemed sufficient in this study (Table 7), as interviews reached data saturation and no further information was generated (Perry 1998).

To ensure reliability and validity of the qualitative data, interviews were recorded to accurately capture responses. A consent form was provided before commencing interviews. All the interviews were asked same questions unless there was a need to follow up for clarification. Moreover, a friendly and comfortable environment was maintained for respondents, whose schedules were arranged at their convenience (Pansiri 2006).

Qualitative Results

Data was open coded via Nvivo 11 software to categorize interview quotes based on this research's main constructs. However, no specific themes were generated, as the

qualitative data in this study were mainly used to illuminate quantitative data by providing selected interview quotations through narrative analysis (Pansiri 2006).

[Insert Table 7 here]

Intention to use E-boarding passes

Overall, the qualitative findings revealed that travelers have high intentions of using E-boarding passes. Many interviewees expressed the willingness to use E-boarding passes, one respondent stated, "*I will definitely continue using an E-boarding pass on my next flight unless the destination airport explicitly does not accept mobile boarding passes"* (Male, 27 years old, corporate employee). Nevertheless, a few respondents highlighted the importance of keeping the option of both paper and paperless boarding passes. One respondent particularly indicated that "*I believe that completely eliminating paper boarding passes is highly inconsiderate. Passengers should be given the choice to use either electronic or paper boarding passes, based on their own preference"* (Female, 30 years old, teacher). Another respondent added *"I will continue using an e-boarding pass on my next flight, but I would still prefer to print a paper as the backup"* (Female, 58 years old, corporate employee).

Environmental concern

Respondents indicated that environmental concerns would not be a high priority. Rather, convenience played a prominent role in their intention. One respondent stated, "*I think environmental would count for 30% of the reason to use E-boarding passes*" (Male, 30 years old, corporate employee). Another interviewee described that *"Environmental concern played a secondary role. The most direct reason was convenience: I did not need to keep track of a piece of paper that could easily be lost or creased, and I could find the*

pass on my phone at any time" (Female, 34 years old, teacher). A respondent also indicated *"As a frequent business traveler, I use E-boarding passes because they save time and reduce the number of documents I need to manage. The environmental benefit is positive, but it is not the deciding factor"* (Male, 42 years old, corporate employee). These results corroborate the quantitative finding that environmental concern does not play a significant role in determining passengers' intentions. However, a high level of environmental concern is necessary for the intention to use E-boarding passes to manifest. **Emotional value**

Many interviewees reported that using E-boarding passes was efficient and relaxing. One respondent mentioned, *"It's very convenient. In the past, if you needed to bring a boarding pass, you had to print it out along with your passport or ID, which meant carrying a lot of items. But if you use an electronic boarding pass, all you need is your phone*" (Female, 30, teacher). The qualitative result further explains that emotional value is a necessary condition that enhances travelers' attitude and intention to use E-boarding passes.

Subjective norm

Interviews revealed that subjective norm could influence attitudes somewhat, but intentions toward e-boarding passes are not entirely predicated on it. One respondent said, "*My friends, relatives or colleagues won't change my mind. Only the method or approach, and whether it's convenient, can alter my perspective* (Female, 30 years old, teacher). Another respondent recognized that subjective norm could change their attitude and stated: "*On my last flight, I saw that most passengers scanned their phones directly, while only a small number used paper boarding passes. This made me feel that e-boarding*

passes had become normal practice, but it did not directly change my choice at that moment because I had already decided to use my phone before going to the airport. It mainly confirmed that my approach was consistent with current travel habits" (Female, 34 years old, teacher). Another indicated similarly, "*When I see many younger passengers using their phones, I feel that it is the current trend and that I should learn how to use it. However, it would not make me immediately give up my paper boarding pass"* (Female, 58 years old, corporate employee). The qualitative results corroborate with NCA in Study 1 that no minimum level of subjective norm is needed, as it is not a necessary condition for travelers' attitude toward using E-boarding passes.

Perceived ease of use

While several interviewees indicated that E-boarding process remains smooth, occasional glitches and minor issues could occur. For example, one respondent mentioned, "*Most of the time it is very smooth, but I become anxious when the battery is low or the network connection is poor. I have experienced a QR-code screenshot that was too dark, the photo album rotating automatically, and the airline webpage failing to reload.*" (Female, 23 years old, student). Another participant stated, *"I have encountered airline-app crashes, company phone security that prevent screenshots, and airport scanners that have difficulty reading a damaged screen*" (Male, 42 years old, corporate employee). These qualitative findings confirm the insignificant relationship between perceived ease of use and attitude. An increase in perceived ease of

use does not necessarily lead to a positive change in travelers' attitudes toward using E-boarding passes.

Perceived usefulness

Interviews revealed that most respondents think E-boarding passes is useful, which strengthens their willingness to use it. For example, one respondent indicated, "*I think the advantage of an electronic boarding pass is that you don't have to worry about losing it. Since you always have your phone with you, you can use it anytime. You no longer need to carry a separate paper pass in your pocket like in the past"* (Male, 43 years old, government employee). Another respondent echoed "*Overall, I think the electronic version is more useful. Frequent travelers can retrieve it more quickly and do not need to keep multiple pieces of paper"* (Male, 27 years old, corporate employee). However, usefulness is also predicated on individual's familiarity of smartphone. For example, one participant stated "*It is useful, but I do not think it is better than paper in every situation. It is more useful for people who are familiar with smartphones, while a paper boarding pass remains more intuitive for me"* (Female, 58 years old, corporate employee). The results confirm the NCA findings that a high degree of usefulness is required for an individual to express intention.

Discussion

This study uses mixed methods to examine factors that influence Chinese travelers' intention to use E-boarding passes. The combined PLS-SEM and NCA analyses distinguish between factors that increase behavioral outcomes and those that are required for their occurrence. Environmental concern shows a positive effect on attitude, and NCA identifies it as both a sufficient and a necessary condition for forming favorable evaluations. However, environmental concern emerges as necessary, but not sufficient condition for intention. This pattern aligns with previous green consumption research,

which suggests that environmental concern is an important contributor to consumers' pro-environmental attitudes and usually guides behavioral responses indirectly (De Canio et al. 2021; Paul et al. 2016). The interview results further validated that environmental concern plays an indirect role in influencing consumers' adoption process. This pattern is consistent with prior research that environmental concern often shapes behavior indirectly through attitudes or internalized norms rather than through direct behavioral intention (Dong et al. 2024).

In line with the assumptions of TAM and TRA, perceived usefulness and attitude are strong predictors of intention, emphasizing the central role of value-based beliefs and evaluations in technology adoption (Chi 2018). These positive findings underscore the complementary roles of cognitive, affective, and environmental factors in passengers' evaluations of E-boarding passes. Perceived usefulness emerges as a significant predictor of both attitude and intention, consistent with its central role in digital adoption. Emotional value positively influences both attitude and intention, aligning with NCA results indicating it as a necessary condition for both. These results suggest that a minimal level of emotional benefit is

necessary to elevate consumers' evaluations, reinforcing the critical role of affective responses in shaping sustainable consumption intentions (Han et al. 2017).

Surprisingly, inconsistent with Liang and Shiau (2018), subjective norm does not significantly influence behavioral intention statistically. However, this aligns with previous research showing that social pressure plays a limited role in digital and technological applications (Suki and Suki 2017; Jain et al. 2022). Moreover, the results of qualitative interviews further corroborate that the adoption of E-boarding passes is a

personal choice and preference, affirming the sense of collectivism may be fading among Asian consumers (Wongyai et al. 2025). Thus, we extrapolated that Chinese travelers tend to rely more on their own evaluations than on referent opinions.

Furthermore, antithetical to the research hypothesis, this study found that perceived ease of use is neither significantly shaped attitude nor a necessary condition on attitude. A plausible explanation is that Chinese travelers may already view E-boarding systems as inherently straightforward as other mobile applications. This also aligns with interview results that the experience of using E-boarding passes is generally deemed as smooth. Therefore, ease of use is less influential in shaping travelers' evaluations and behaviors, and travelers' decision-making relies more heavily on perceived usefulness and the emotional benefits associated with digital boarding rather than the system's effortlessness.

Theoretical Implications

This study offers several theoretical contributions. Firstly, this study extends the technology adoption literature by providing a holistic research framework to enhance the understanding of travelers' attitudes and behavioral intention toward the adoption of E-boarding passes. Limited studies have conducted in similar fashion in the context of travel technologies (Wong and Sim 2025). Secondly, this study illustrates that exclusively using a standard multivariate technique may not engender a complete result. This study shows NCA can uncover critical bottleneck conditions by identifying which variables are required for outcomes to reach meaningful levels (Lee et al. 2023). For instance, this study illustrates that environmental concern is deemed as an important factor to form travelers' attitudes; however, unless environmental concern reaches a certain threshold

level, it is the utility rather than the evaluation of environmental concern that ultimately forms travelers' intention to use E-boarding passes. Furthermore, this study makes a clear distinction from prior studies employing necessity analysis. Unlike the necessary analysis in Qualitative Comparative Analysis (QCA) that defines necessity only in kind (X is necessary for Y), NCA can identify more necessary conditions both in kind and degree (X is necessary for level Y) than QCA (Dul 2022; Dul 2024). This study provides evidence for future research that necessity in-degree is different from necessity in-kind (Dul 2022; Rasoolimanesh 2026). Lastly, this study cross-validated quantitative results by using qualitative data, which adds ecological validity to address the limitation of using single data. Other than through the lens

of PLS-SEM and NCA, this study further proffers fine-grained evidence through qualitative interviews to enrich the results obtained through quantitative study (Kurtaliqi et al. 2024; Pansiri 2006).

Practical Implications

This study offers practical insights for policymakers and airline industry to promote the adoption of E-boarding passes. Given the sheer volume of passengers and frequent use of air transportation in China, managers should devise effective strategies to facilitate travelers' adoption of E-boarding passes by emphasizing not only the convenience of digital boarding service, but also the increasing degree of awareness that potential environmental impact can bring to the aviation sector. Airlines should prioritize promotional strategies that simultaneously elicit positive emotions and strengthen travelers' environmental awareness. For example, integrating emotionally resonant sustainability cues, highlighting the environmental benefits of paper reduction, or providing gentle, non-moralizing feedback on environmental impact could enhance both

emotional value and environmental concern, thereby reinforcing attitudes and encouraging the use of E-boarding passes.

However, there is a caveat when promoting E-Boarding passes. Practitioners should be cautious to not overly emphasize environmental implications of using E-boarding passes, as utility should be prioritized. The belief of benefit stemming from perceived usefulness remains a dominant driver of travelers' adoption (Yersüren and Özel 2024). While highlighting environmental implications of switching to E-boarding passes, airlines should streamline the digital boarding process by reducing procedural uncertainty, such as minimizing waiting times, enhancing system reliability and convenience. Furthermore, providing clear guidance and system stability during the boarding process could alleviate travelers' concerns regarding device failure or operational uncertainty (Figure A1).

Moreover, while promoting E-boarding passes, airlines should avoid heavily relying on social influence tactics. Instead, we should emphasize individual, user-centered benefits. The airline industry needs to use tailored communication strategies that highlight convenience, autonomy, and positive environmental impact to promote travelers' adoption of E-boarding passes. Lastly, airlines should not phase out the paper version completely. Eliminating paper boarding passes completely could be inconsiderate, as certain travelers may not be familiar with smart technologies. Hence, paper boarding pass option should remain.

Limitations and Future Studies

This study needs to acknowledge several limitations. First, the sample collected in this study is skewed toward females, and the participants were primarily between 18 to 30 years old. As such, the generalizability of the sample may be limited to the data pool of

Credamo. Moreover, this study is based on Chinese travelers. Hence, the generalizability of this research may not apply to consumers of different nationalities. Future studies may consider conducting similar

research in more culturally diverse settings and recruiting participants from diversified channels with more balanced demographics. Secondly, this study only examined direct effects that influence consumers' attitude and behavioral intention toward E-boarding passes; however, variables such as environmental concern and emotional value may play potential moderating or indirect roles among proposed variable of interests. Future studies can explore the moderating role or indirect effect of variables to yield unique insights. Furthermore, study 1 and 2 are both based on cross-sectional data, which could inhibit the development process. Future studies could employ longitudinal designs to capture changes in travelers' attitudes over time. Lastly, this study used intervention design (qualitative analysis after quantitative one) without generating any themes (Kurtaliqi et al. 2024), which may not fully disclose unanticipated insights from interviews. As such, future studies can consider adopting explorative sequential design with thematic analysis before building suitable research framework.

Data Availability Statement

The shared materials include datasets, the survey questionnaire, and interview transcripts. These materials can be accessed via the supplementary files.

Declarations

Author Contribution

Dimin Wang conceived and designed the study, collected and analyzed the data, and drafted the manuscript. Xianmei Wu participated in data collection and revised the manuscript.

Data Availability

The data supporting the findings of this study is available upon reasonable request.

Tables

Tables 1-7 are available in the Supplementary Files section.

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Figures

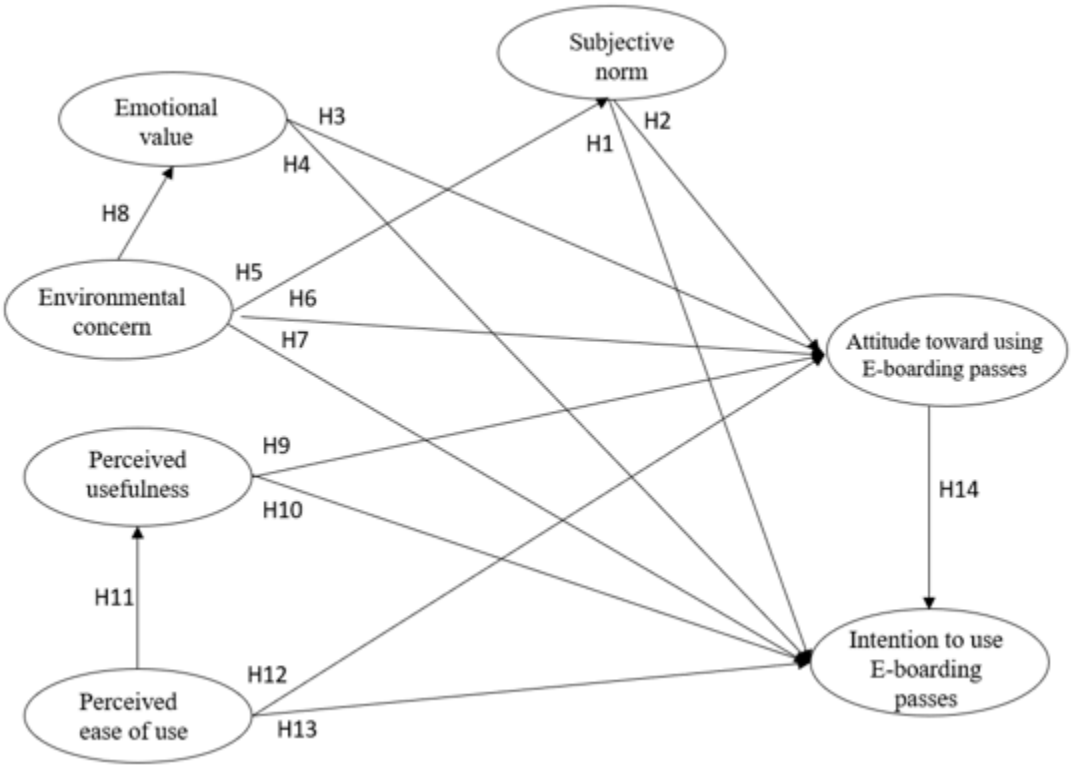


Figure 1

Figure 1. Conceptual model

Source: Authors own work

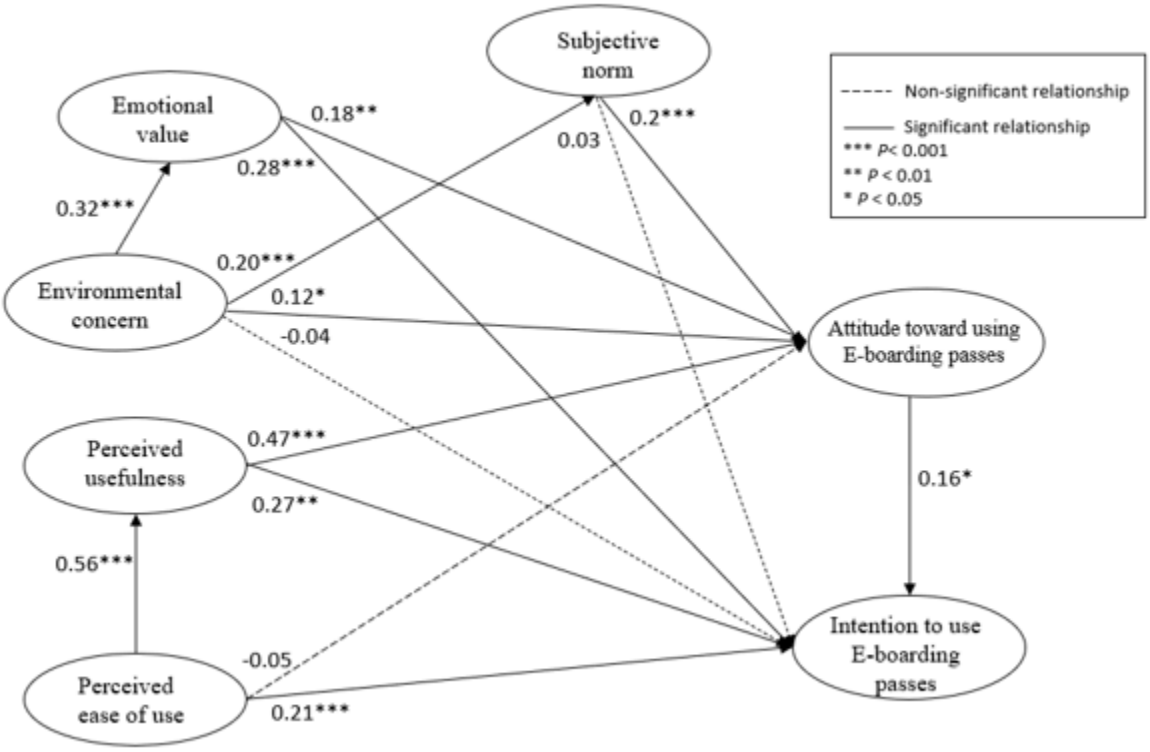


Figure 2

Figure 2. Results of the PLS-SEM

Source: Authors own work

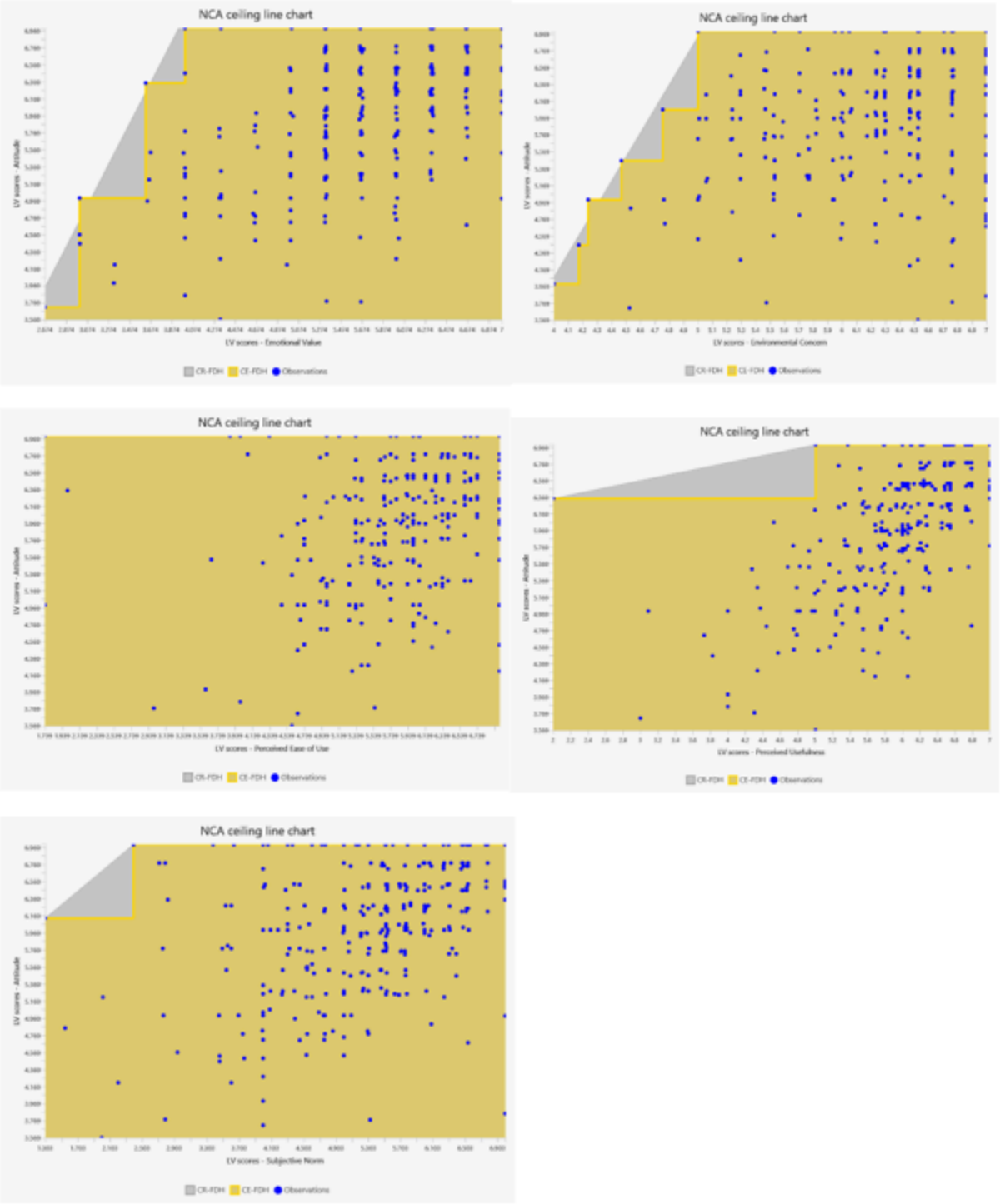


Figure 3

Figure 3a. NCA Scatter Plots- Attitude as the outcome

Source: Authors own work

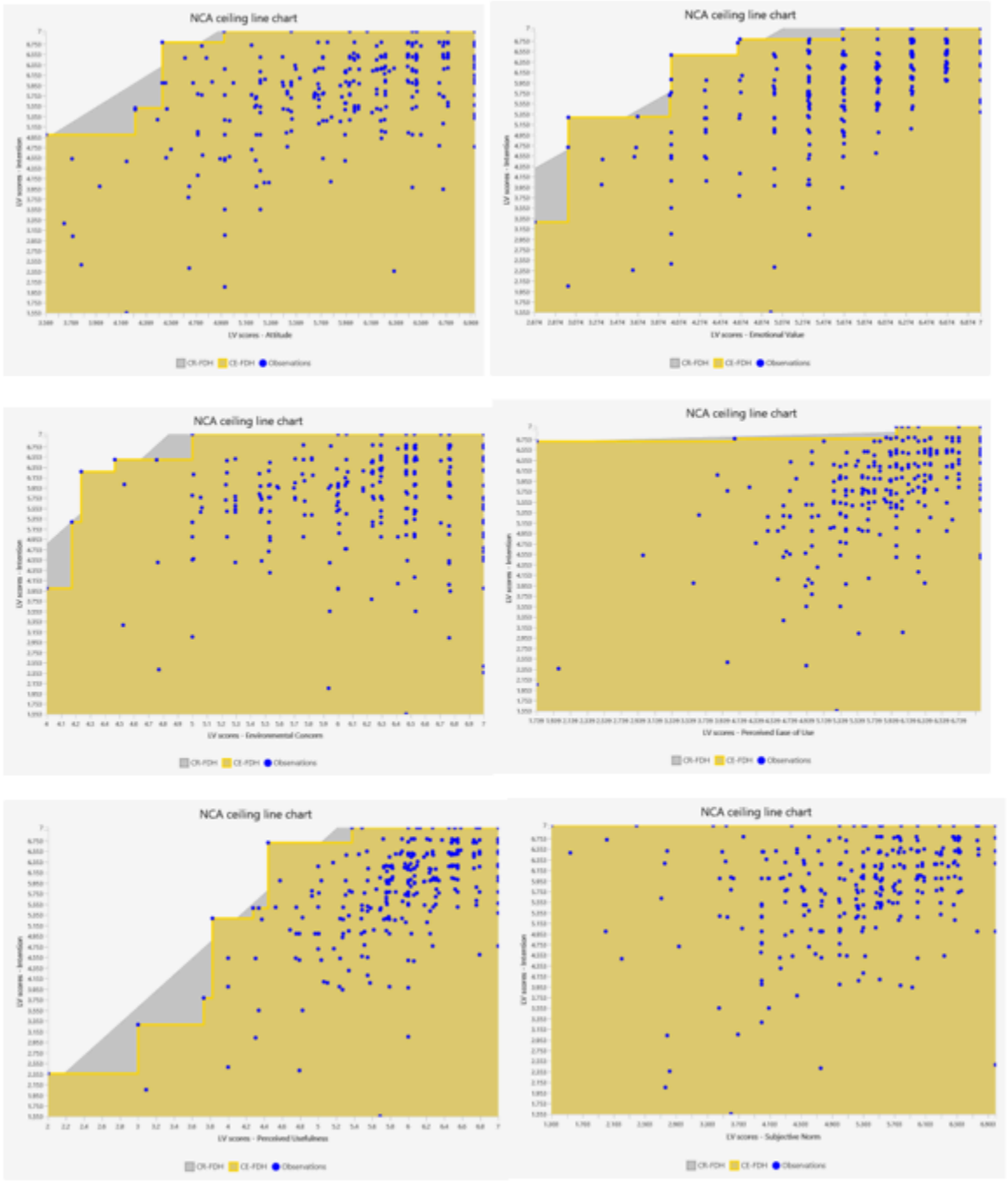


Figure 4

Figure 3b. NCA Scatter Plots- Intention as the outcome

Source: Authors own work

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Tables.docx
- Appendix.docx
- InterviewQuestionEnglish.docx
- SurveyQuestionniaireEnglish.docx
- InterviewTranscript.docx
- InterviewDataCoding.nvp