Orbital and sub-orbital space tourism: motivation, constraint and artificial intelligence

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Abstract
Purpose – There is limited research on the behavior of different categories of space tourists as identified by different types of space tourism. To address this deficiency, the purpose of this study is to examine what factors make consumers participate in orbital and/or suborbital space tourism, along with three dimensions of motivation, constraint and artificial intelligence. To achieve this study’s goals, a comprehensive research model was developed that included three dimensions of intrinsic and extrinsic motivation, intrapersonal and interpersonal constraint and awareness of and trust in artificial intelligence, in comparing orbital and suborbital space tourism groups.

Design/methodology/approach – A questionnaire was carried out with respondents who wanted to participate in orbital (n = 332) and suborbital (n = 332) space tourism in the future. Partial least squares-structural equation modeling, fuzzy-set qualitative comparative analysis, multi-group analysis and deep learning were used to understand potential space tourist behavior.

Findings – Extrinsic motivation has the greatest positive impact on behavioral intention, followed by awareness of and trust in artificial intelligence, while intrapersonal constraint strongly negatively affects behavioral intention. Surprisingly, interpersonal constraint is insignificant by partial least squares-structural equation modeling but is still one of sufficient causal configurations by fuzzy-set qualitative comparative analysis. Interestingly, the two types of space tourism have very distinct characteristics.

Originality/value – This study created a comprehensive integrated research model with three dimensions of motivation, constraint and artificial intelligence, along with potential orbital and suborbital space tourist groups, to identify future consumer behavior. Importantly, this study used multi-analysis methods using four different approaches to better shed light on potential orbital and suborbital space tourists.

Keywords Space tourism, Orbital, Suborbital, Motivation, Constraint, Artificial intelligence

Paper type Research paper

轨道与亚轨道太空旅游：动机、限制与人工智能

摘要
目的：对不同类型太空旅游所识别的不同类太空游客行为的研究有限。为了解决这一缺陷。这项工作研究了哪些因素使消费者参与轨道和亚轨道太空旅游，以及动机、约束和人工智能三个维度。为了实现研究目标，在比较轨道和亚轨道太空旅游群体时，开发了一个综合研究模型。包括内在和外在动机、内在和外在约束以及对人工智能的认识和信任三个维度。

设计方法/方法：对希望在未来参与轨道 (n = 332) 和亚轨道 (n = 332) 太空旅游的受访者进行了问卷调查。利用偏最小二乘法 (PLS) 结构方程模型 (SEM)、模糊集定性比较分析 (fsQCA)、多组分析和深度学习来了解潜在的太空游客行为。

发现：外在动机对行为意图的积极影响最大。其次是人工智能的认识和信任。内在约束对行为意图有强烈的负面影响。令人惊讶的是，人内约束对于 PLSESEM 来说是微不足道的。但对 fsQCA 来说仍然是充分的因果配置之一。有趣的是，这两类太空旅游具有非常鲜明的特征。

DOI 10.1108/TR-01-2023-0017 © Emerald Publishing Limited, ISSN 1660-5373 TOURISM REVIEW
Turismo espacial orbital y suborbital: motivación, restricción e inteligencia artificial

Resumen

Propósito: existe una investigación limitada sobre el comportamiento de las diferentes categorías de turistas espaciales identificados por diferentes tipos de turismo espacial. Para abordar esta deficiencia, este trabajo examina qué factores hacen que los consumidores participen en el turismo espacial orbital y/o suborbital, junto con tres dimensiones de motivación, restricción e inteligencia artificial. Para lograr los objetivos del estudio, se desarrolló un modelo de investigación integral que incluía tres dimensiones de motivación intrínseca y extrínseca, restricción intrapersonal e interpersonal, y conocimiento y confianza en la inteligencia artificial, al comparar grupos de turismo espacial orbital y suborbital.

Diseño/metodología/enfoque: se realizó un cuestionario con los encuestados que querían participar en el turismo espacial orbital (n = 332) y suborbital (n = 332) en el futuro. Se utilizaron modelos de ecuaciones estructurales (SEM) de mínimos cuadrados parciales (PLS), análisis comparativo cualitativo de conjuntos borrosos (fsQCA), análisis multigrupo y aprendizaje profundo para comprender el comportamiento potencial del turista espacial.

Hallazgos: la motivación extrínseca tiene el mayor impacto positivo en la intención de comportamiento, seguida de la conciencia y la confianza en la inteligencia artificial, mientras que la restricción intrapersonal afecta negativamente la intención de comportamiento. Sorprendentemente, la restricción interpersonal es insignificante por PLS-SEM, pero sigue siendo una de las configuraciones causales suficientes por fsQCA. Curiosamente, los dos tipos de turismo espacial tienen características muy distintas.

Originalidad/valor: este trabajo creó un modelo de investigación integral con tres dimensiones de motivación, restricción e inteligencia artificial, junto con posibles grupos de turistas espaciales orbitales y suborbitales para identificar el comportamiento futuro del consumidor. Es importante destacar que este estudio empleó métodos de análisis múltiple utilizando cuatro enfoques diferentes para arrojar mejor luz sobre los posibles turistas espaciales orbitales y suborbitales.

Palabras clave Turismo espacial, Orbital, Suborbital, Motivación, Restricción, Inteligencia artificial

Tipo de papel Trabajo de investigación

Introduction

There has been public interested in space tourism since the “space race” of the 1960s (Cohen, and Spector, 2020; Kim et al., 2023; Paladini and Saha, 2023; Wang et al., 2021). Given the success of Virgin Galactic, Blue Origin and SpaceX in 2021, private entrepreneurs have breathed new life into space tourism by offering private suborbital travel (Kim et al., 2023; Mehran et al., 2023). As a result, space travel is no longer the domain of science fiction. Nevertheless, different types of space tourism exist including orbital (e.g. Space X: longer-duration orbital flights around 240 km above earth) and suborbital (e.g. Virgin Galactic and Blue Origin: experiencing weightlessness for a few minutes around 100 km above earth’s surface) (Clash, 2022; Hartmans, 2021). Ticket prices for orbital space tourism are extremely high, more than US$50m per seat, while the ticket prices for suborbital space travel are much lower ($250,000–$500,000) (Carter, 2021; Clash, 2022). Orbital tourism will be conducted in conjunction with other space activities to assist commercial viability, whereas suborbital space travel is expected to be conducted soon (Mehran et al., 2023; Paladini and Saha, 2023; Wang et al., 2021).

Research has examined the motivations of people wanting to participate in space tourism (Frost and Frost, 2022; Laing and Frost, 2019; Reddy et al., 2012; Weibel, 2020) as well as the economics of space tourism (Peng et al., 2022). Perhaps not surprisingly given the costs, the significance of constraints for participation in space tourism is highlighted by various scholars (Chang and Chern, 2016; Weibel, 2020). Advances in technology, including artificial intelligence (AI), have greatly assisted the promotion of space tourism (Bagchi, 2021; Ramesh et al., 2021; Toivonen, 2022). Importantly, the hospitality and tourism industry have also applied AI extensively, adopting voice assistants for customer service, robotics and implementing and
managing automation (Buhalis and Moldavska, 2022; Goel et al., 2022; Jabeen et al., 2022). Furthermore, research on space tourism may shed light on sustainable development and technology (Laing and Frost, 2019; Giachino et al., 2021; Mehran et al., 2023).

Although orbital and suborbital space tourism differ from each other, studies are limited on how travel consumers behave depending on the type of space tourism, particularly with respect to motivation, constraint and AI as an advanced technology. Therefore, this study creates and evaluates a comprehensive integrated theoretically informed research framework, including motivation, constraint and AI, comparing orbital as well as suborbital space travel groups. To achieve the study goals, this research raises two research questions:

RQ1. How do motivation, constraint and artificial intelligence influence potential space tourists’ behavior?

RQ2. How do orbital and suborbital space travel differ within the research framework?

To answer the research questions, the authors conducted an online survey, collecting data (664 respondent for orbital and suborbital space tourism) from potential space tourists and applied multi-analysis methods of partial least squares-structural equation modeling (PLS-SEM), fuzzy-set qualitative comparative analysis (fsQCA), multi-group analysis (MGA) and deep learning. The authors offer theoretical and practical contributions to an enhanced understanding of space travel and tourism.

**Literature review and hypotheses development**

**Motivation**

Motivation is a vital influence in deciding to participate in a particular type of space tourism (Mehran et al., 2023; Reddy et al., 2012). Belief in space travel and humanity’s future relationship with space is also regarded as tremendously motivating (Weibel, 2020). Pro-social motives related to environmental causes in relation to space tourism are regarded as significant for environmental conservation advocacy (Frost and Frost, 2022). Intrinsic or hedonic (eudemonic) motivations, including curiosity, challenge, spirituality and nostalgia, as well as extrinsic motivations, like pursuing recognition or reputation, are also significant factors for participation in space tourism (Laing and Frost, 2019; Giachino et al., 2021).

Intrinsic motivation refers to behaviors for satisfaction or enjoyment dealing with hedonic dimensions, while extrinsic motivation refers to actions for attainment, recognition and networks with tangible rewards (Joseph et al., 2022; Kim et al., 2020; Kim et al., 2016; Lee et al., 2014). In the context of tourism volunteerism, extrinsic motivation positively impacts satisfaction, which subsequently affects behavior (Lee et al., 2014). Users’ intrinsic (enjoyment) and extrinsic motivations (usefulness) on attachment strongly support usage intention of advanced technology for tourism (Kim et al., 2016). Furthermore, motivations of potential space tourists highly positively influence their behavioral intention (Olya and Han, 2020, 2022). In the space travel environment, most astrotourists have combined intrinsic (leisure) motivation with extrinsic motivation (career-related advancement or the pursuit of proposed rewards) (Joseph et al., 2022). Hence, the following hypothesis is suggested:

H1. Intrinsic (H1a) and extrinsic motivations (H1b) have a significant effect on behavioral intention for participation in space tourism.

**Constraint**

Constraints are factors that restrict individuals from undertaking activities and can be classified into three categories: intrapersonal, interpersonal and structural (Kim et al., 2020; Kim and Petrick, 2021). Intrapersonal constraints are internal to an individual and may encompass feelings of anxiety or stress related to engaging in an activity. Interpersonal constraints arise from relationships with others, such as the absence of companions to participate with, whereas
structural constraints involve limitations like insufficient time or funds for involvement (Kim et al., 2020; Kim and Petrick, 2021). There are many uncertainties and constraints for space tourism, such as high financial costs, perceived risk and lack of trust (Olya and Han, 2020, 2022), with risk being identified as the main constraint people faced (Giachino et al., 2021).

For the tourists’ decision-making process, intrapersonal and interpersonal constraints have significant roles in the theory of planned behavior (Girish et al., 2021). In the context of sustainability, intrapersonal and interpersonal constraints have significant roles in behavioral intention (Kim and Petrick, 2021). Deterrents, such as constraints on investment, have a negative impact on perceived trust relevant to participation behavior (Kim et al., 2020). The limitations associated with space tourism, such as psychological, financial and safety risks, costs and lack of trust, considerably impact the behavioral intent of prospective space tourists (Olya and Han, 2020, 2022). Hence, the authors suggest the hypothesis:

\[ H2. \] Intrapersonal (\( H2a \)) and interpersonal constraints (\( H2b \)) have a significant effect on behavioral intention for participation in space tourism.

**Artificial intelligence**

The use of AI in space exploration has been increasing since the launch of Sputnik in 1957, with the market for the application of AI in space being valued at US$2bn and growing (Bagchi, 2021; Das, 2020). AI has a several space applications, including astronaut assistants, mission design and planning, navigation systems, satellite data processing and space debris management (Adetunji, 2021). Private firms involved in space tourism like Blue Origin, Virgin Galactic and SpaceX use AI to provide the essential safety standards for the success of this sector (Ramesh et al., 2021). Future innovations in space tourism technologies, such as robotics, will require AI applications (Toivonen, 2022), while AI is being increasingly applied across the tourism industry, including optimizing cruise ship operations (Buhalís et al., 2022), using chatbots (Pereira et al., 2022) and automation (Webster and Ivanov, 2020).

For sustainable space tourism, agencies may need to encourage, educate and/or promote sustainability related to space tourism using interventions (e.g. AI as a sustainable technology) (Kim et al., 2023; Toivonen, 2022). For example, AI can help tackle congestion in space, including the movement of space debris (Cesaer, 2022). Perceived sustainability is essential for the long-term viability of space tourism and gaining broader public support. By adopting sustainable practices, space tourism may be more environmentally and socially responsible and reduce its contribution to the degradation of the earth and its space environment.

As AI has the potential to impact human behavior and decision-making, researchers have studied the relationship between AI and behavioral intention in various contexts (Buhalís et al., 2022; Buhalís and Moldavska, 2022; Goel et al., 2022; Jabeen et al., 2022). As behavioral intention relates to a person’s plan or inclination to partake in a specific action, which is a key predictor of actual behavior, this study regards behavioral intention on space tourism as a predictor of actual space travel.

Understanding consumer response to AI is extremely important given AI’s extensive usage in space, including its relevance to sustainability (Cesaer, 2022; Johnson and Verdicchio, 2017). However, concern over AI is qualitatively different from broader concerns over technology. For example, while computer operations are mechanical and imperative, “AI can make autonomous decisions and operate independently of humans,” which therefore provide considerable stress, increase perceptions of risk and affect levels of trust (Li and Huang, 2020; Sindermann et al., 2022). In tourism, AI awareness has been found to have considerable impact on employee behavior (Kong et al., 2021; Li et al., 2019). Digital trust and openness through data trust help generate users’ support for the advancement of AI technologies in society (Robinson, 2020). AI algorithms also significantly contribute to shaping the trust that individuals form toward AI (Glikson and Woolley, 2020). Hence, the following hypothesis is proposed:
H3. Potential space tourists’ awareness of (H3a) and trust in artificial intelligence (H3b) have a significant effect on their behavioral intention for participation in space tourism.

Space tourism with orbital and suborbital

The attributes of orbital and suborbital space tourism have been widely documented (Clash, 2022; Reddy et al., 2012). In the nascent space tourism sector, both short-duration suborbital journeys and longer-duration orbital voyages into space suggest different customer traits depending on the specific form of space travel (Clash, 2022; Kim et al., 2023). However, factors such as the type of space travel appear to influence tourists’ decision-making (Reddy et al., 2012). Orbital and suborbital space tourism require high risk-taking and potentially substantial financial burdens (Clash, 2022; Giachino et al., 2021) although increased participation may reduce perceived risk (Spector, 2020).

There are limited comparisons between orbital and suborbital space trips (Chang et al., 2017; Clash, 2022). Orbital space tourism (e.g. Space-X) requires a speed of 17,500 mph (Mach 23), operates a few hundred miles above the planet’s surface and is extremely expensive, whereas suborbital space tourism (e.g. Blue Origin and Virgin Galactic) means travelling at 2,200 mph (Mach 3), between 50 and 70 miles above the earth and is comparatively much cheaper (Clash, 2022). Orbital space tourism will remain very limited within the near future because of the extremely significant costs involved for private paying passengers; suborbital space tourism may, therefore, be attractive to those interested in space travel (Chang et al., 2017). Consequently, the subsequent hypothesis is proposed:

H4. Orbital and suborbital space tourism groups have different characteristics for participation.

Accordingly, the authors suggest an integrated research framework for the four hypotheses above as depicted in Figure 1.

Figure 1 The proposed research model with three dimensions of motivation, constraint and artificial intelligence

Source: The figure created by authors
Methods

Measurements

Previously validated multi-item measures were used in the survey questionnaire to address potential inaccuracies associated with using single questions. The survey instrument comprises nine constructs and 28 items. Intrinsic and extrinsic motivations were assessed through four questions each, based on existing literature (Kim et al., 2020; Kim et al., 2016; Lee et al., 2014) (for instance, “Space tourism is enjoyable for me” and “I want to gain more knowledge by participating in space tourism”). Four questions each, pertaining to intrapersonal and interpersonal constraints, were derived from established sources (Girish et al., 2021; Kim et al., 2020; Kim and Petrick, 2021) (e.g. “I am not interested in space tourism” and “It is hard to get together with other people around me to participate in space tourism”). Awareness of and trust in AI were assessed using four questions each from previous studies (Glikson and Woolley, 2020; Kong et al., 2021; Li et al., 2019) (e.g. “I think that I am well (full) aware of AI for the sustainability of space tourism” and “AI algorithms don’t cause errors when I participate in space tourism”). Four questions relevant to behavioral intention were generated from Kim and Petrick (2021) and Lee et al. (2014) (e.g. “I’m planning to participate in space tourism”).

Given not only its high reliability but also discriminant validity, a seven-point Likert-type scale was used, with a range from (1) strongly disagree to (7) strongly agree. Personal information items were also included in relation to participation in space tourism, ranking the type of space tourism they would most like to participate in, primary motivation for space tourism and the most sustainable space trip. Questions regarding the participants’ socio-demographic characteristics (such as monthly household income, occupation, place of residence, gender, education level, age and marital status) were also incorporated.

Content validity and pre-test

The survey was initially composed in English; the measurements were then translated into Korean. The Korean form was then reverse translated to correct grammatical and intended semantic inconsistencies. This process leaded to revision of the questionnaires, as Korean and English have quite different cultural backgrounds.

A preliminary evaluation of the questionnaires’ content validity was conducted by three academic researchers. During this process, a question related to intrapersonal constraint was removed to better capture the subconstructs’ meanings. Three online survey specialists adapted the questionnaire to meet the online platform’s requirements, with adjustments made to the instructions, general inquiries and overall wording. The instrument was then administered as a pilot test to five PhD candidates. Consequently, the descriptions of space tourism, sustainable behaviors and sustainable space tourism were rephrased. A pre-test was then conducted on 50 Koreans interested in space tourism participation. As a result, four questions concerning extrinsic motivation, response quality, space tourism experience and time spent answering were added (Supplementary A).

Data collection

Web-based panel surveys are popular consumer research in Korea because of their effectiveness (Kim et al., 2020). Embrain, the largest digital survey company in Asia, was used for sample collection. Data were gathered from October 3 to 18, 2022. Socio-demographic quota sampling was applied using Ministry of the Interior and Safety (2022) data to represent the Korean population’s age, residential area and gender. Individuals aged 18 years and above, residing in Korea and interested in participating in space tourism were invited to take part in the survey. A total of 13,168 individuals were emailed invitations based on random sampling from the survey company’s 1.6 million panel members. Of
these, 4,378 respondents connected to the email invitation and 1,252 subjects passed the screen questions (“SQ1. Do you commit to providing your thoughtful and honest answers to the questions in this survey?” and “SQ2. Have you ever wanted to participate in space tourism?”). Of the participants who passed the screen questions, 1,155 panel members submitted completed surveys deemed valid. After excluding respondents who took less than 3.6 min to finish the survey, data from 1,000 potential space tourists were compiled. Respondents who wanted to participate in orbital (332 cases) and suborbital space trips (332 cases) in the future were then used for analysis, dropping subjects who wanted to participate in space tourism on earth (see the screen question of CQ0 in Supplementary A). PLS-SEM (Hair et al., 2017), MGA (Ringle et al., 2022), fsQCA (Ragin, 2017) and deep learning (Kim and Hall, 2022a) were used.

**Data analysis**

To assess the research framework using a symmetrical approach, PLS-SEM was primarily used along with MGA (Hair et al., 2017; Ringle et al., 2022). PLS-SEM is considered superior to traditional SEM (i.e. covariance-based methods) for handling non-normal data and/or highly complex models in MGA, as it offers greater predictive accuracy and significantly reduces the risk of correlation (Hair et al., 2020). As a result, SmartPLS 4 was used to validate the measurement and structural frameworks (Ringle et al., 2022).

fsQCA is used as an asymmetrical approach (Kim and Hall, 2022b). To obtain more comprehensive results, including sufficient configuration solutions and causal combinations, as well as the analysis of necessary conditions (ANCs), the effects of intrinsic and extrinsic motivation, intrapersonal and interpersonal constraints and awareness of and trust in AI on behavioral intention were examined while comparing the two types of space travel (orbital/suborbital) (Olya, 2023). The fsQCA 3.0 software was used to identify sufficient causal combinations of constructs and recipes, as well as ANC of prerequisites, determining the potential combinations of independent variables leading to the same outcome variable (Ragin, 2017). Configurational modeling was performed in three stages (Olya, 2023). To calibrate constructs, the value of 1 was assigned to seven as a full member, the value of 0.5 to four as the intersection and the value of 0 to one as a complete nonmember of the set for all variables (Ragin, 2017).

While the drawback of this flexibility is that the synaptic weights of a neural network are not easily interpretable, deep learning based on artificial neural networks (ANNs) can capture various statistical structures without requiring prior assumptions about specific relationships between input and output factors (IBM SPSS, 2023). ANNs have an innate ability to store experiential knowledge and make it accessible for use, mirroring the brain in two ways: the network acquires knowledge through a learning process, and interneuron connection strengths, known as synaptic weights, store the knowledge (Ripley, 1996). Deep learning radial basis function networks surpass traditional regression and SEM analyses in terms of predictive accuracy, as they can detect both linear and non-linear connections (Haykin, 1998).

ANNs do not necessitate multivariate assumptions of normality, linearity and variance, which are unsuitable for examining causality (Kim and Hall, 2022a). Therefore, SEM as well as ANN methods can be considered as mutually supporting methods. Hence, deep learning with AI was performed grounded upon ANN as well as multilayer perceptron (MLP) methods using IBM SPSS Statistics 29 version (IBM SPSS, 2023). Accordingly, the multi-analysis methods of PLS-SEM, MGA, fsQCA and deep leaning could complement each other’s strengths and weaknesses. Two evaluations using single-factor methods, along with simple and complex model comparison techniques, indicate that common method variance is not a concern in this study (Supplementary B).
Results

Respondent profile

Supplementary C contains the demographic and general information for the entire group. Two groups of longer duration with orbital space tourism and short duration with suborbital space tourism are in Supplementary D. The two clusters are substantially different. For instance, the orbital space tourism group is more likely to be male, young, educated, professionals, have experienced some form of space tourism, hope to eventually participate in inter-planetary travel, pursue sustainable energy and climate change mitigation. The suborbital space tourism group is more likely to be older, married, higher income earners, concern about public health and well-being and hope to travel short-duration suborbital space tourism.

Measurement model

Based on the confirmatory factor analysis, 28 indicators exhibited factor loadings above 0.6 (Hair et al., 2020) (Supplementary E). Composite reliability, Rho_A and Cronbach’s α for variables exceeded 0.7, validating internal consistency (Supplementary F). All average variance extracted values were above 0.5. All factor loadings surpassed 0.7, demonstrating convergent validity. Discriminant validity was established using the Heterotrait-Monotrait Ratio (Hair et al., 2017). The maximum value between extrinsic motivation and behavioral intention was 0.719, which is below the 0.9 cut-off, thus confirming discriminant validity. Additionally, Q² values indicated a satisfactory level of predictive relevance above zero for the endogenous variable, with a value of 0.398. Moreover, the multicollinearity of factors was assessed using the variance expansion coefficient. The results indicated that multicollinearity was not a concern, as the variance expansion coefficient range spanned from 1.399 to 3.950 (Supplementary E).

Structural model

Using 5,000 resamples, PLS-SEM is used to evaluate the four hypotheses (Hair et al., 2017). The \( R^2 \) (explained variance) demonstrates 55.2% for behavioral intention (Figure 2). Intrinsic motivation \((H1a: \gamma = 0.219 \text{ and } p < 0.001)\) and extrinsic motivation \((H1b: \gamma = 0.339 \text{ and } p < 0.001)\) influence behavioral intention, fully supporting \( H1 \). Intrapersonal constraint \((H1a: \gamma = -0.294 \text{ and } p < 0.001)\) negatively influences behavioral intention, partially supporting \( H2 \). Awareness of AI \((H3a: \gamma = 0.110 \text{ and } p < 0.001)\) and trust in AI trust \((H2b: \gamma = 0.074 \text{ and } p < 0.05)\) influence behavioral intention, fully supporting \( H3 \). However, interpersonal constraint is not significant with respect to its influence on behavioral intention \((H2b: \gamma = -0.010 \text{ and } p > 0.383)\).

Comparing two types of space tourism

With MGA (Ringle et al., 2022), we compared the six relationships over orbital and suborbital space trips. The orbital group (57.0%) has the greater prediction power than suborbital group (50.4%), along with the stronger impacts of intrinsic as well as extrinsic motivations on space tourist behavior than their counterparts. The suborbital group has the stronger impacts of intrapersonal constraint, awareness of AI and trust in AI on behavioral intention than the orbital group (Figure 3).

Fuzzy-set qualitative comparative analysis

The necessary factors for two types of space tourism are identified using the ANC (Supplementary G) (Olya, 2023). According to the cut-off criterion for consistency (> 0.90), intrinsic motivation is essential for achieving space tourist behavior in both orbital and suborbital groups, as per the necessary condition analysis. While ANC highlights the effects
Figure 2  The result of path analysis

Figure 3  Comparing orbital and suborbital space tourism group

Source: The figure created by authors
of variables in predicting outcomes, fsQCA investigates the combined influences of variables (configuration, recipe, algorithm, solution and causal model) (Ragin, 2017). fsQCA can offer deeper insight into the impact of each construct (supplementary H). For both groups, solutions are suggested as intrinsic motivation*extrinsic motivation and only intrinsic motivation to generate great degree of behavior to participate in space tourism. In the orbital group, solutions are suggested as intrinsic motivation*extrinsic motivation*interpersonal constraint*trust in AI; intrinsic motivation*interpersonal constraint; and intrinsic motivation*trust in AI. In suborbital group, solutions are suggested as intrinsic motivation*extrinsic motivation*interpersonal constraint*trust in AI; only interpersonal constraint; and intrinsic motivation*trust in AI. The results indicate similarities and differences for two types of space tourism. Particularly, from PLS-SEM, interpersonal constraint is not significant, but from fsQCA, interpersonal constraint is a solution for the orbital as well as suborbital space trips. One potential reason for these differing results could be related to the assumptions and limitations of the two methods. PLS-SEM assumes a linear relationship between variables, while fsQCA allows for the identification of more complex relationships that may be non-linear or involve interaction effects. It is possible that the interpersonal constraint is better captured by the nonlinear relationship identified by fsQCA, which could explain why it was significant using this method but not using PLS-SEM.

**Deep learning**

By building the three ANN frameworks on the dependent variable, hidden neuron nodes can be created automatically. To address the overfitting issue, this study allocated 70% of the data set for training and 30% for testing (Figure 4). Model C showed best prediction accurateness with 58.1% (1- relative error of testing data) among three frameworks. In deep learning-based AI method, the endogenous variables are better forecasted (Kim and Hall, 2022a). The prediction accuracy of framework C by the deep learning is much greater than PLS-SEM. The reason is that the mostly hidden layers of architecture, the MLP method and the ability of ANNs to capture nonlinear connections have contributed. With independent variables, extrinsic motivation (100.0%) is the most important, followed by intrapersonal constraint (98.9%), intrinsic motivation (93.3%), awareness of AI (51.4%), trust in AI (31.8%) and interpersonal constraint (22.8%) to predict space tourism behavior. Deep learning of the capabilities of thicker ANN structures and the ability to identify nonlinear associations using MLP yielded interesting results (Supplementary I).

**Discussion and implications**

**Discussion**

From the three dimensions (motivation, constraint and AI) based on PLS-SEM, the substantial positive impact of extrinsic motivation on potential space tourist behavior extends existing literature on space travel for seeking career-related advancement or rewards in astrotourism destinations (Joseph et al., 2022). The substantially negative effect of intrapersonal constraint on space tourist behavior expands prior research on perceived constraint for digital investment for sustainability (Kim and Petrick, 2021). The positive influence of intrinsic motivation on potential space tourist behavior broadened previous studies on supporting digital technology use in tourism (Kim et al., 2020). The significant impacts of awareness of as well as trust in AI (chatbot, automation, robotics and machine and deep learning technologies) on potential space tourist behavior enlarge studies on hospitality employees’ AI awareness (Li et al., 2019) and trust in AI technology (robot, virtual and embedded) (Glikson and Woolley, 2020). The insignificant relationship between interpersonal constraint and behavioral intention implies that people around potential space tourists are not important in influencing whether tourists participate in space tourism.
According to MGA, the orbital group has higher relationships between motivations (extrinsic and intrinsic) and behavioral intention than their counterparts, implying that orbital tourists are more likely to be affected by tangible rewards followed by inherent rewards. The suborbital group has higher relationships of intrapersonal constraint, awareness of AI and trust in AI on behavioral intention, suggesting that suborbital tourists are more likely to be negatively influenced by intrapersonal constraint and positively influenced by awareness of and trust of AI applications. Grounded upon fsQCA, intrinsic motivation is necessary for both groups of orbital and suborbital. Interestingly, on the contrary of the results of PLS-SEM, interpersonal constraint is a solution, along with intrinsic and extrinsic motivations for orbital space tourists to generate strong behavioral intentions for participation in space tourism. More interestingly, interpersonal constraint is the only solution for the suborbital group. The result of the deep leaning approach showed that the current study framework has the greatest predictive power in the three alternative frameworks (Figure 4 and Supplementary I).
Theoretical and practical implications

In terms of theoretical contributions, as far as we are aware, this study marks the first effort to compare orbital and suborbital space tourism concerning potential tourist behavior. The analysis provides novel insights into the similarities and differences between these two types of space tourism. A range of analytical methods, including PLS-SEM, MGA, fsQCA and deep learning, were used to gain a better understanding of potential space tourist behavior. By using multiple analytical approaches, a more comprehensive perspective was provided on this topic.

The findings shed light on the critical factors that may influence future participation in space tourism. Three significant dimensions were identified that impact an individual’s decision to participate: intrinsic and extrinsic motivation, intrapersonal and interpersonal constraints and awareness of and trust in AI. This research also delivers an intricate understanding of the complex interactions among these factors, presenting valuable research insights.

This research also has several implications to the space industry. Tourism stakeholders should focus on extrinsic motivation to attract potential space tourists by highlighting more knowledge, differentiation, exploring the universe, recognition and understanding the planet better. Stakeholders could also improve travel consumer behavior for space tourism by increasing intrinsic motivation, such as stimulating enjoyment, self-satisfaction, happiness and pleasure. In particular, space tourism industries should mitigate intrapersonal constraint (no interest or desire). In other words, they should promote its products and services to encourage interest in participating space tourism by engaging people’s curiosity. Emphasizing awareness of and trust in AI also appears important for potential consumers in enhancing participation in space travel. In targeting orbital flights, stakeholders should highlight extrinsic and intrinsic motivation, while for suborbital space flights, they should mitigate intrapersonal constraint and increase awareness of and trust in AI.

Limitations and future research directions

Although this study offers both theoretical and practical contributions to space tourism, there are limitations that present opportunities and challenges for future research. As this study surveyed one country, a cross-cultural approach would be appropriate to identify differences between countries. Future longitudinal studies on social media and websites with big data analytics would also be invaluable in providing insights into consumer responses and their implications to space tourism initiatives and events, including successful and unsuccessful launches and flights. Further studies on the perceived safety of orbital or suborbital space tourism might be timely and valuable to travel consumers and tourism industries.

As the sample in this study included students and unemployed, future studies may need to have screening questions to filter them out of the sampling process so that the findings apply to those who may be more likely to engage in space tourism in the near future. Overall, more studies should be focused on demographics who have the financial resources to participate in orbital and/or suborbital space travel. Specifically, because AI usage and technologies are very diverse, ranging from autonomous rovers to intelligence navigation systems, future research could provide all the examples of AI applications to space tourism so that respondents can fully understand the concepts of AI awareness and trust. Because of the relatively weak correlation between intention and behavior, especially when there are barriers to performing the behavior (Sheeran and Webb, 2016), future research on adding interventions (e.g. implementation intentions and mental contrasting) would help better predict space tourism behavior. Finally, studies on people who have experienced orbital and suborbital space travel will be essential as the market develops.
References


Carter, J. (2021), “How much is a ticket to space? $100,000 if you can wait a decade – but here’s how to pay nothing”, available at: www.forbes.com/sites/jamiecartereurope/2021/07/19/how-much-is-a-ticket-to-space-100000-if-you-can-wait-a-decade-but-heres-how-to-pay-nothing/?sh=1e5a03e734a6


IBM SPSS (2023), IBM SPSS Neural Networks 29.


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Supplementary material
The supplementary material for this article can be found online.
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