



Strategic Nudging for Sustainable Tourism: A Game-Theoretic Model with Shapley Value Analysis

Yunus EROĞLU 

Dr. Öğr. Üyesi, Gaziantep Üniversitesi, Mühendislik Fakültesi/Endüstri Mühendisliği Bölümü, eroglu@gantep.edu.tr

Burhan DOĞAN 

Bağımsız Araştırmacı, burhandogan2@gmail.com

Hazal OVAYOLU 

Bağımsız Araştırmacı, ovayoluhazal@gmail.com

MAKALE BİLGİSİ

Geliş: 06.04.2026

Kabul: 30.09.2026

Anahtar Kelimeler:

Araştırma Makalesi

ÖZ

Bu çalışma, sürdürülebilir turizm bağlamında dürtme stratejilerinin turistlerin karar verme süreçlerini ve otel tercihlerini nasıl etkilediğini incelemektedir. Ayrıca turist özellikleri, tercih olasılıkları, otel seçim eğilimleri ve fiyat duyarlılığı gibi faktörlerin çevre dostu otel tercihlerindeki rolünü oyun teorisi çerçevesinde ele almaktadır. Çalışmada, literatürden yararlanılarak belirlenen modelleme varsayımlarıyla oluşturulan simülasyon tabanlı bir veri seti kullanılmaktadır. Veri seti; turist özellikleri (yaş, gelir ve eğitim düzeyi), sürdürülebilirlik farkındalığı, fiyat duyarlılığı, müdahalelere verilen tepkiler ve simüle edilen çevre dostu otel seçimlerini içermektedir. Model, turistler ile oteller arasındaki etkileşimi analiz etmek amacıyla oyun teorisini simülasyon teknikleriyle birleştirmektedir. Her bir dürtme stratejisinin toplam sistem faydasına katkısını ölçmek için Shapley değeri yöntemi kullanılmaktadır. Bulgular, indirim stratejisinin en yüksek Shapley değerine sahip olduğunu (296,51), bunu sosyal normların (225,06) ve bilgilendirmenin (219,34) izlediğini göstermektedir. Üç stratejinin birlikte uygulanması, en yüksek ortalama toplam sistem faydasını sağlamaktadır. Duyarlılık analizi, tepki olasılıklarının eşit olduğu ve bilgilendirme stratejisini destekleyen varsayımların kullanıldığı senaryolarda sıralamanın değiştiğini göstermektedir. Bu sonuçlar, seçilen simülasyon varsayımları altında müdahalelerin katkılarının karşılaştırılmasına olanak tanımaktadır. Stratejilerin gerçek koşullardaki ve zaman içindeki performanslarını değerlendirmek için daha fazla araştırmaya ihtiyaç duyulmaktadır.

ARTICLE INFO

Received: 06.04.2026

Accepted: 30.09.2026

Keywords: Sustainable tourism, nudge theory, game theory, Shapley value, eco-friendly hotels

Research Article

ABSTRACT

This study investigates how nudge strategies influence tourists' decision-making processes and hotel preferences within the context of sustainable tourism. The study also examines the role of factors such as tourist characteristics, preference probabilities, hotel selection trends, and price sensitivity in shaping eco-friendly hotel preferences within the framework of game-theoretic framework. This study uses a simulation-based dataset developed from modelling assumptions informed by the literature. The dataset includes tourist characteristics (age, income, and education), sustainability awareness, price sensitivity, responses to the interventions, and simulated eco-friendly hotel choices. The model integrates game theory with simulation techniques to analyze the interaction between tourists and hotels. The Shapley value method is used to measure the contribution of each nudge strategy to the overall system. The findings show that the discount

strategy has the largest Shapley value (296.51), followed by social norms (225.06) and information (219.34). The combination of all three strategies produces the highest mean total system utility. Sensitivity analysis shows that the ranking changes under equal response probabilities and information-favored assumptions. These results provide a comparison of intervention contributions under the selected simulation assumptions. Further research is needed to assess their performance in real settings and over time.

1. INTRODUCTION

Tourism is one of the key contributing to the economic, social, and cultural development of countries due to its significant role (Robinson, Lück & Smith, 2020). Furthermore, growth in tourism has led to the overuse of natural sources, which causes serious sustainability issues such as carbon emissions and socio-cultural deterioration (World Commission on Environment and Development, 1987; Gössling, Hall, Peeters & Scott, 2010). The hotel industry is highlighted as being responsible for a significant portion of carbon emissions, which further increases environmental concerns (Lenzen, Sun, Faturay, Ting, Geschke & Malik, 2018). These issues have made sustainable tourism a necessity rather than a choice. As defined by the United Nations Environment Programme (UNEP) and the United Nations World Tourism Organization (UNWTO), sustainable tourism aims to strike a balance between environmental, economic, and social impacts while meeting the needs of both present and future generations (United Nations Environment Programme, 2005).

In terms of the organization's level, sustainability is also facilitated through operations including energy saving, waste management and resource saving. In addition to that, supporting local suppliers, using new environmental friendly technology would promote long-term sustainability within tourism. The two actions don't only improves the operational efficiency but also enhance sustainable performance of the organizations within the tourism business. Not only for operations, but individual's tourism behavior also play very important part for the sustainability in the tourism system. The demand of tourist towards environmental friendly accommodation and tourist's willingness to present green behavior has significantly influenced the entire sustainable system performance. Thus, understanding tourist's decision-making and managing the destination selection is one of the main challenge.

This research seeks to prompt tourists' environmental choices by means of behavioral nudges. Such nudges operate following the nudge theory of Thaler & Sunstein (2009) and aim to alter the choice architecture in which tourists make decisions, without removing their option to choose.

It is demonstrated by recent studies in tourism research that there is potential for 'nudge' strategies that are directed at changing individual consumption behavior towards a more sustainable pattern. Such strategies often rely on a package of interventions that include; provision of information, communicated social norms and incentives in order to steer individual behavior choices. Game-theoretic models are effective in examining the comparative performance of these strategies especially in an environment with repeated interactions (Farshbafiyān Hosseini, Heidari & Guerra, 2025). A description of how to account for the consequences of linked decisions by many different players, so that sustainability in tourism can be described, has been presented (Gössling et al., 2010). A characteristic of the system is the dynamics of the interdependence between organization and tourist which influence one another through the exchange that occurs between them (Fedeli, Tavares & Kumail, 2024). An examination from a game theory perspective is warranted.

Game theory can serve as an important tool to study strategic interactions in the tourism domain (Kopf & Hsu, 2021; Chen et al., 2021). Strategic interaction is crucial as it decides how decisions of multiple actors are interrelated, and subsequently affect each other and the entire system's performance. Thus, applying game theory models in the analysis of sustainable tourism gives much insight into behavior and decision-making. The Shapley value can be used as a very relevant tool to analyze individual contributions of various strategies in the system (Ciano & Ferrara, 2024; Li et al., 2024). The Shapley value in this work is used to analyze individual contribution of important steering strategies such as provision of information, social norm, and financial incentives. A comparison is performed among individual contributions of the important steering strategies and that helps to choose more sustainable solutions in the future.

The research adds value to the field of sustainable tourism through three key areas. Firstly it model tourists' interaction with businesses when it comes to the context of making a sustainable decision through a game theoretic approach. Secondly, it quantifies the contribution to overall steering success for information-based strategies, social norms and economic incentives by using the Shapley value approach. Lastly, it produces applicable comparative findings and policy-relevant implications for both researchers and practitioners.

2. LITERATURE REVIEW

The adoption of eco-friendly choices by tourists is a critical factor in achieving sustainable tourism. Recent tourism studies have shown a growing interest in “nudge” strategies that guide individuals toward eco-friendly choices without restricting their decision-making processes.

Digital nudging has been examined by Ni, Wang, Chang & Li (2025). They suggest that a human-centered interface design, incorporating elements of information, engagement, and immersiveness, should be used to guide tourists toward eco-friendly, or sustainable, hotel choices. In another study, Nowak, Alnyme & Heldt (2024) examined “norm-based prompts and concluded that the frequency of these prompts does not negatively impact sustainable tourism practices; rather, they have a positive, encouraging effect. Their findings suggest that norm-based prompts can be effectively utilized to support sustainable tourist behavior and create a positive impact.

Souza-Neto, Marques, Mayer & Lohmann (2023) examine nudge strategies aimed at promoting eco-friendly practices and reducing environmental harm in sustainable tourism through a comprehensive literature review. Consequently, the study concluded that most nudge strategies attempt to influence behavior through subliminal messaging. However, conscious nudge strategies also yield positive outcomes. Furthermore, the study highlighted the lack of experimental research in this field and noted that there was insufficient information regarding the long-term effects of nudge strategies. In addition, a four-stage model comprising exploration, planning, testing, and validation is proposed to develop a legitimate nudge strategy in their work. In another study, Jayaraj and Chandrakala (2024) examined the innovative use of nudge strategies in sustainable tourism, highlighting the inclusive impact of public nudge units and successful case studies.

The impact of tourists’ views on climate change and destination social responsibility (DSR) on sustainability intentions has been empirically examined by Olya, Kim & Kim (2024) and Lee, Olya, Ahmad, Kim & Oh (2021). In their study, Olya et al. (2024) noted that concerns about climate change and destinations with a strong environmental awareness are of critical importance in this regard. Similarly, Lee et al. (2021) explain, using nudge theory, whether eco-friendly behaviors and incentives (such as DSR) that are implemented indirectly lead to the adoption of eco-friendly behavioral patterns. As a result of their study, they claimed that people in management positions took responsibility for directing visitors toward nature-friendly activities and that DSR plays a critical role in nature-friendly behaviors.

Another study examining eco-friendly applications of nudge strategies was conducted by Song, Wu and Zhang (2024). Their study concluded that nudge strategies positively influence travel choices with a low carbon footprint. Additionally, their findings indicate that perceptions of climate change lead people to prefer low-carbon travel options and are willing to pay a premium for them. However, whether nudge strategies lead to certain effects in the long term—and if so, how they do so—has been critically examined by Sharma, Saulais & Huang (2024). They examined whether short-term nudge strategies are sufficient to produce lasting behavioral changes in the long term. The application of the hybrid approach to a tourism setting has recently been put forward as a solution, the ‘nudge+’ approach developed by Yachin, Margaryan, Lexhagen & Ioannides (2025), which blends unconscious nudges with transformative experiences through their integration. This new technique seeks to evoke both instantaneous behavior and thoughtfulness, introducing a new way of thinking to the area of sustainable tourism (Yachin et al., 2025).

In addition to experiments testing the benefits of nudging, game theory is of great importance in order to represent the complex, multi-stakeholder interaction and the strategy selection in sustainable tourism.

Proper policies and incentives are significant in sustainable tourism, where sustainable and rational decision making is the desired state among stakeholders. Chica Serrano, Hernández & Perc (2023) Applied the study of incentive policies to induce the development of sustainable tourism by asymmetrical game theory. The authors modeled the interaction between tourists and the local stakeholder using an evolutionary game theory method in order to compare and analyze incentive policies in developing sustainable behavior. The study concluded that there are ways to make use of some types of incentives to improve the sustainability level through formal game theory models.

The communication between stakeholders is very important to achieving tourism sustainability. From game theory, Kopf and Hsu (2021) proposed two equilibrium points from Leopold’s Land Ethics (Leopold, 1989). Option A leads to short-term benefits, but to ecological loss; Option B has long-term and larger gains. Though option B is more economically reasonable than option A, it is hard to implement because there are uncertainties on estimating environmental cost and it is necessary to get co-operation from all the stakeholders. It is recommend that all the stakeholders can follow nature friendly behavior in a long term and reduce barriers by using Land Ethics.

According to Chica et al. (2022) put forwards an evolutionary game theory approach for sustainable tourism and a clear definition for overtourism. By analyzing interaction social between tourist and stake holders (tourism business),

it study about sustainable behavior of them. It is found that the optimum equilibrium of the interaction system depends on economic benefits of stakeholder and cost for sustainable policy. Finally, the more mobilities the tourists, the less co-operations from stakeholders. There could be increasing polarized phenomena. It is also an important result of the first evolutionary game to explain the evolution of overtourism by interaction between tourist and stakeholder.

Another core concept is sustainable supply chains and operations which aim to preserve and maintain environmental values. Using evolutionary game theory and system dynamics, Lei et al. Analyzed how the relationships between stakeholders affect the evolution of policy changes in cultural heritage tourism. A strategy game with government, enterprises, tourists and local inhabitants was proposed in a simulation framework, and the impact of policies to changing stakeholder relationships was simulated. According to simulation results, after changes of policy, stakeholder strategies evolves to the forms of open conflict, hidden game, and dynamic equilibrium (Lei, Guo & Xu, 2025).

A multi-agent evolutionary game model was developed, aiming to analyze the steady state strategies of various stakeholders like local governments, enterprises and local residents (Sun, Liu, Fan & Qiao, 2021). Different from general sense, constraints are found to play a greater role than incentives in the strategic decision making process. With incentives and constraints used by local governments, the local inhabitants can be controlled and businesses are guided to participate in protection and development. However, the active management and development strategies will not be feasible, if the rewards of protective development go beyond the government's capacity.

The role of government subsidies in the supply chain for eco-tourism is discussed using Stackelberg game theory. The study concludes that these subsidies stimulate demand for eco-tourism and lead to outcomes that enhance environmental performance and social welfare. It also emphasizes the need for the government to avoid over-subsidizing, noting that when tourists have low environmental awareness, subsidies can increase business profits; therefore, the government must not go to extremes in its efforts to protect the natural environment. In the context of an eco-friendly tourism supply chain approach, this model reveals important findings regarding the government's action strategies (Zhang & Li, 2023).

A different Stackelberg model was examined by Mousavi, Hafezalkotob, Makui & Sayadi (2021) to analyze pricing policies in eco-friendly contexts and competitive hotel markets under government intervention. Their findings suggest that government intervention in the tourism sector can have a positive impact on hotel revenues and, by encouraging eco-friendly practices among hotels, help mitigate the negative environmental impacts of tourism. Furthermore, the article presents a new model for determining optimal hotel prices and government policies in a competitive market (Mousavi et al., 2021).

Previous studies in this field have highlighted the impact of nudge techniques on shaping individual behavior in sustainable tourism and the superiority of game theory in modeling interactions among stakeholders. However, research aimed at quantitatively measuring the relative contributions of different nudge applications within the system, particularly in the context of interactions between tourists and businesses, is limited. A simulation model based on strategic interactive game theory will be used to analyze information, social-norm, and discount strategies between tourists and hotels. Subsequently, the contribution of each nudge technique to overall system performance will be quantitatively calculated using the Shapley value, and a comparison will be made. The method contributes to the development of sustainable tourism policies from a strategic and scientific perspective by helping us understand under which conditions various nudge strategies are more effective and by elucidating the positive or negative interactions between strategies.

3. MATERIAL AND METHOD

3.1 Material

This study analyzes the nudge strategies that influence hotel choices in sustainable tourism from a game theory perspective. A simulation-based analysis was conducted using a dataset derived from literature-based assumptions. The dataset was constructed based on parameter ranges and behavioral assumptions reported in the literature, including Kahneman & Tversky (1979), Thaler & Sunstein (2009), and studies in sustainable tourism such as Lenzen et al. (2018) and UNEP (2025).

The dataset contains various characteristics of 1,000 tourists, and their tendencies to choose eco-friendly hotels have been determined based on individual and environmental variables. These consist of demographic characteristics (age, income level, education level), psychological and behavioral variables (sustainability awareness, price sensitivity, impulse responses), and decision variables. The demographic characteristics of

the dataset consist of various parameters, including age (normal distribution in the 18–65 age range; $\mu=35$, $\sigma=10$), education level (4 categories: High School (30%), College (40%), Master's Degree (20%), PhD (10%)), and income level (3 categories: Low (30%), Medium (50%), High (20%)).

In the psychological and behavioral variables section, sustainability awareness follows a normal distribution within the range [0.2, 0.6]. Sustainability awareness increases with higher education levels, price sensitivity (inversely proportional to income, scored on a 0–1 scale), and participants' responses to nudging techniques (individual responses to information, social norms, and discount strategies, scored as 0 or 1).

The literature informs the selection of information, discount, and social norm interventions. Their response probabilities are set at 0.45, 0.70, and 0.50, respectively, to define the baseline simulation scenario. These values represent assumed probabilities of binary intervention responses, rather than observed hotel-choice rates. Goldstein et al. (2008) examines towel reuse among hotel guests, while Benartzi et al. (2017) compares interventions across policy settings. These studies provide behavioural context rather than direct estimates for sustainable hotel choice. Intervention responses are generated through Bernoulli trials, and hotel choice is generated separately using Equation 2.

Table 1: Descriptive statistics of the dataset and key model variables

Parameter	Average	Std. Deviation	Min-Max	Median
Age	≈35.3	≈9.5	18-65	35
Awareness	≈0.50	≈0.14	0.20-0.85	0.50
Price Sensitivity	≈0.53	≈0.24	0.00-1.00	≈0.54
Info Nudge	≈0.44	±0.50	0-1	0
Discount Nudge	≈0.71	±0.46	0-1	1
Social Nudge	≈0.47	±0.50	0-1	0
Eco-Hotel Probability	≈0.62	±0.13	0.28-0.91	≈0.64
Eco-Hotel Choice	≈0.64	±0.48	0-1	1

Table 1 presents descriptive statistical data regarding the dataset used in this study. The average age of participants is 35.3, with values ranging from 18 to 65 years. The average awareness of eco-friendly practices (on a 0–1 scale) is 0.50. The price sensitivity value is 53%, indicating that while price is a factor consumers consider when making purchasing decisions. The discount nudge strategy has the highest rate at 71%, followed by social nudges at 47% and information-based nudges at 44%. This supports the strong impact of the discount nudge strategy, as observed in studies in the literature (Benartzi et al., 2017). Eco-friendly hotel preference has a high rate of 64%. Overall, the descriptive results are consistent with patterns reported in the literature.

3.2 Methods

3.2.1 Nudge Strategies

Nudge theory is a well-established concept in behavioral economics. This theory, refined by Thaler and Sunstein (2009), aims to help people make more accurate and clear decisions by restructuring choice architecture, taking into account the cognitive biases they exhibit when making any decision. In the implementation of nudge strategies, there are several critical points. These include principles such as liberty preservation, transparency, and an easy opt-out mechanism.

The "Principle of Liberty Preservation" implies that nudge strategies should not compromise individual freedom of choice. Within nudge strategies, nudging techniques should be suggestive or encouraging, not forceful or constraining. The second critical issue is "Clarity": nudging strategies should be simple, obvious and easy to access. Individuals need to be aware of the purposes of any nudging strategies that are being applied. If not, nudging strategies can be ethically dubious. Ethics is one of the crucial aspects concerning nudging strategies. The last critical issue is "Easy Opt-Out".

3.2.2 Game Theory

We proposed a simulation based system to study tourists' preferences over eco-friendly hotels under different nudges (information, discount, social norms). We assumed the interaction between tourists and hotels can be modeled as a two-player game between a tourist and a hotel. Then we estimated the contribution of different nudges in the system performance using Shapley value.

In our system, the game is played between two players, tourists T and hotels H. Tourists can choose between eco-friendly hotels E and non-eco-friendly hotels N. Hotels can decide to implement sustainability policy S or not C. We can analyze this game as a dilemma of two players where the society optimal point is (E,S) but the Nash equilibrium point is (N,C).

Each tourist's preference is modeled as a Bernoulli random variable (Eq.1), where $Y_i \in \{0,1\}$ indicates the choice outcome. The probability $p_i \in [0,1]$ represents the likelihood of choosing an eco-friendly hotel. The probability p_i is defined as a function of sustainability awareness and responses to the three nudge strategies as in Eq. 2.

$$Y_i \sim \text{Bernoulli}(p_i) \quad (1)$$

$$p_i = \min(0.2 + 0.4A_i + 0.08I_i + 0.18D_i + 0.08S_i, 1) \quad (2)$$

where;

A_i : Sustainability awareness (0 - 1)

I_i : Response to the information nudge (0 - 1)

D_i : Response to the discount nudge (0 - 1)

S_i : Response to the social norm nudge (0 - 1)

The coefficients define the baseline scenario, informed by the behavioral mechanisms discussed in the literature (Benartzi et al., 2017; Cialdini, Reno & Kallgren, 1990). Alternative response probabilities and preference coefficients are examined in the sensitivity analysis.

The dataset was created based on the characteristics of 1,000 tourists. The age range in the dataset is between 18 and 65, with a mean of 35 and a standard deviation of 10. Income levels are categorized as low (30%), medium (50%), and high (20%). Educational level is divided into four categories: high school, college, master's, and doctoral degrees; additionally, sustainability awareness increases in direct proportion to educational level. Price sensitivity and income, however, have an inverse relationship. Responses to nudging techniques were determined according to the Bernoulli distribution. The probability parameters were set at 0.45 for informational nudges, 0.70 for discount nudges, and 0.50 for social norm nudges. Eco-friendly hotel choice was generated using Bernoulli trials based on the calculated p_i values.

The game-theoretic analysis is formulated as a repeated game. In the repeated game model, a discount factor $\delta \in (0,1)$ was used to ensure that players take their future payoffs into account. This formulation enables the analysis of the likelihood of the emergence of cooperation-based strategies such as Tit-for-Tat.

The game is assumed to repeat infinitely, as in Eq. 3, and future earnings are discounted to the present using a discount factor $\delta \in (0,1)$.

$$U_i = \sum_{t=0}^{\infty} \delta^t u_i(s_t) \quad (3)$$

U_i : Total discounted payoff of player i

t : Time period

δ : Discount factor ($0 < \delta < 1$)

$u_i(s_t)$: Instantaneous payoff of player i at time t

s_t : Strategy profile at time t

3.2.3 Utility Function

The strategic interaction between tourists and hotels has been modeled within a game theory framework, and the utility functions of each stakeholder are defined in Eq. 4. The variable values were determined based on trends reported in the literature [35 - 37] through scaling to ensure the simulation had adequate sensitivity. The utility function is defined in a piecewise form depending on whether the tourist chooses an eco-friendly option ($E_i = 1$) or not ($E_i = 0$)

$$u_T^{(i)} = \begin{cases} \alpha_A A_i - \alpha_P P_i + \alpha_N (I_i + D_i + S_i), & E_i = 1 \\ \gamma, & E_i = 0 \end{cases} \quad (4)$$

A_i : Level of sustainability awareness among tourists,

P_i : Price sensitivity

I_i, D_i, S_i : Information, discount, and social norm nudges, respectively

$\alpha_A = 5.0$: Awareness coefficient (high impact)

$\alpha_P = 2.0$: Price sensitivity coefficient (negative effect)

$\alpha_N = 1.0$: Equal contribution of nudges to utility

$\gamma = 5.0$: Base utility level when a non-eco-friendly option is chosen

The simulation uses $\gamma = 5.0$ as the fixed utility for a tourist who chooses a non-eco-friendly hotel.

3.2.4 Hotel utility function

The hotel's utility function depends on the selected sustainability strategy (Eq. 5). Total number of tourists choosing an eco-friendly hotel (n_E) and the investment cost (β_2) are taken into account if the hotel implements sustainability measures (S):

$$u_H(S) = \beta_1 n_E - \beta_2 \quad (5)$$

The traditional strategy (C) uses the standard revenue derived from the total number of tourists (N) (Eq. 6)

$$u_H(C) = \beta_0 N \quad (6)$$

$n_E = \sum_{i=1}^N E_i$: Number of tourists choosing an eco-friendly hotel,

$\beta_1 = 2.0$: Revenue per eco-customer,

$\beta_2 = 200.0$: Fixed cost of sustainability,

$\beta_0 = 1.2$: Revenue per traditional customer.

These parameter values suggest that while sustainability strategies involve additional costs, they can attract eco-conscious tourists and potentially increase long-term profitability.

3.2.5 Total utility function

The total system utility under the sustainable hotel strategy is the sum of the individual utilities of all tourists and the hotel's utility. The hotel's utility is added only once, as shown in Equation 7.

$$U_{tot}(S) = \sum_{i=1}^N u_T^{(i)} + u_H(S) \quad (7)$$

The total number of tourists (N) and the fixed utility (γ), combined with the hotel's utility, yields the total utility in the conventional strategy, as shown in Eq. 8. The formulas make it possible to measure the socially optimal capacity of different combinations of strategies.

$$U_{tot}(C) = N\gamma + u_H(C) \quad (8)$$

3.2.6 Coalition Value Function

The set of strategies used in this study is defined as $N = (\text{Info}, \text{Discount}, \text{Social})$. Each element represents the nudge strategies used to shape tourists' behavior. A coalition of the form $S \subseteq N$ represents a scenario in which certain nudge strategies within a subset are considered active, while the remaining strategies are inactive (represented by a binary value of 0). The coalition value is as specified in Eq. 9:

$$v(S) = E[U_{tot}(S) \mid S \text{ is active}] \quad (9)$$

$U_{tot}(S)$: Total system utility representing the combined welfare of tourists and hotels

$E[\cdot]$: Expected value estimated via Monte Carlo simulation (see Eq. 10).

$$v(S) = \frac{1}{R} \sum_{r=1}^R U_{tot}^{(r)}(S) \quad (10)$$

where R denotes the number of simulation runs.

Each coalition value was estimated using 1,000 simulation replications with the same synthetic population of 1,000 tourists. Tourist characteristics and nudge responses were held fixed, while eco-friendly hotel choices were drawn again in each replication. For each coalition, we report the mean total utility, sample standard deviation, standard error, and a 95% confidence interval based on the Student t distribution with 999 degrees of freedom in Table 2. The standard error equals the sample standard deviation divided by the square root of the number of replications. The intervals measure simulation uncertainty conditional on the fixed synthetic population and model parameters.

Table 2 Simulation uncertainty for coalition utilities

All coalitions use 1,000 replications. SD denotes sample standard deviation; SE denotes standard error.

<i>Coalition</i>	Mean	SD	SE	95% confidence interval
<i>None</i>	4219.13	26.89	0.85	4217.46 to 4220.80
<i>Information</i>	4383.47	22.95	0.73	4382.05 to 4384.90
<i>Discount</i>	4433.93	18.92	0.60	4432.75 to 4435.10
<i>Social norm</i>	4385.10	21.81	0.69	4383.74 to 4386.45
<i>Information + Discount</i>	4675.54	16.79	0.53	4674.50 to 4676.58
<i>Information + Social norm</i>	4581.47	19.86	0.63	4580.24 to 4582.70
<i>Discount + Social norm</i>	4685.36	17.13	0.54	4684.30 to 4686.43
<i>All three strategies</i>	4960.04	17.67	0.56	4958.94 to 4961.13

3.2.7 Shapley Value

The marginal contributions of nudge strategies to overall system utility are calculated using the Shapley value method, as shown in Eq. (11). It measures the average marginal contribution of each strategy across all possible coalitions and allocates the increase in total system utility relative to the coalition without nudges.

$$\phi_j(v) = \sum_{S \subseteq N \setminus \{j\}} \frac{|S|!(|N| - |S| - 1)!}{|N|!} (v(S \cup j) - v(S)) \quad (11)$$

ϕ_j : Shapley value of strategy j ,

N : The set of all strategies,

v : Coalition value function.

In this modeling framework, the use of the Shapley value enables a quantitative assessment of the marginal contributions that different nudging strategies make to overall system benefits. It provides a structured basis for evaluating the strategic interactions between tourists and hotels in the context of sustainability.

A sensitivity analysis was conducted using 15 scenarios, including the baseline. Each scenario used all eight coalitions and 1,000 simulation replications per coalition. The low-effect scenario multiplied the three response probabilities by 0.8 and the preference coefficients by 0.5. The high-effect scenario multiplied them by 1.2 and 1.5, respectively. Equal-probability scenarios used 0.55 for all interventions, while equal-coefficient scenarios used 0.12. Price sensitivity was multiplied by 0.75 or 1.25 and restricted to the range [0, 1]. Awareness was decreased or increased by 0.10 and restricted to [0, 1]. Investment costs were set to 100 or 400 utility units, compared with 200 at baseline. Population sizes were 500 or 2,000, compared with 1,000 at baseline. The information-favored scenario used response probabilities of 0.70, 0.45, and 0.50 and preference coefficients of 0.18, 0.08, and 0.08 for information, discount, and social norms, respectively. All other parameters were held at their baseline values. These settings represent exploratory assumptions rather than empirically established ranges.

Table 3 Shapley values under alternative scenarios

I = Information, D = Discount, S = Social norm. Ranking refers to numerical estimates within each scenario.

<i>Scenario</i>	I	D	S	Ranking
<i>Baseline</i>	219.34	296.51	225.06	D > S > I
<i>Low intervention effects</i>	155.21	234.59	158.22	D > S > I
<i>High intervention effects</i>	307.84	399.95	356.68	D > S > I
<i>Equal response probabilities</i>	263.37	263.53	282.03	S > D > I
<i>Equal preference coefficients</i>	216.51	313.15	219.65	D > S > I
<i>Equal probabilities and coefficients</i>	259.88	274.58	279.85	S > D > I
<i>Low price sensitivity</i>	228.54	330.01	235.03	D > S > I
<i>High price sensitivity</i>	211.18	267.36	216.30	D > S > I
<i>Low awareness</i>	184.19	204.88	186.97	D > S > I
<i>High awareness</i>	254.85	388.07	262.92	D > S > I
<i>Low investment cost</i>	219.34	296.51	225.06	D > S > I
<i>High investment cost</i>	219.34	296.51	225.06	D > S > I
<i>Small population</i>	110.65	150.92	118.75	D > S > I
<i>Large population</i>	446.26	589.89	483.60	D > S > I
<i>Information-favoured scenario</i>	290.87	204.24	225.55	I > S > D

Tourist characteristics and nudge responses were fixed within each scenario; hotel choices were redrawn across replications. Response-probability scenarios regenerated the nudge-response indicators using the revised probabilities and the same seed. Population-size scenarios generated a new synthetic sample of the specified size using seed 42. Shapley values were recalculated from each scenario's coalition means. The original baseline estimates were reproduced before the sensitivity analysis was performed.

4. Results and Discussion

Focusing on the effects of information, social norms, and discounting strategies on tourists' preferences for eco-friendly hotels, this section presents the results of a simulation-based game theory analysis.

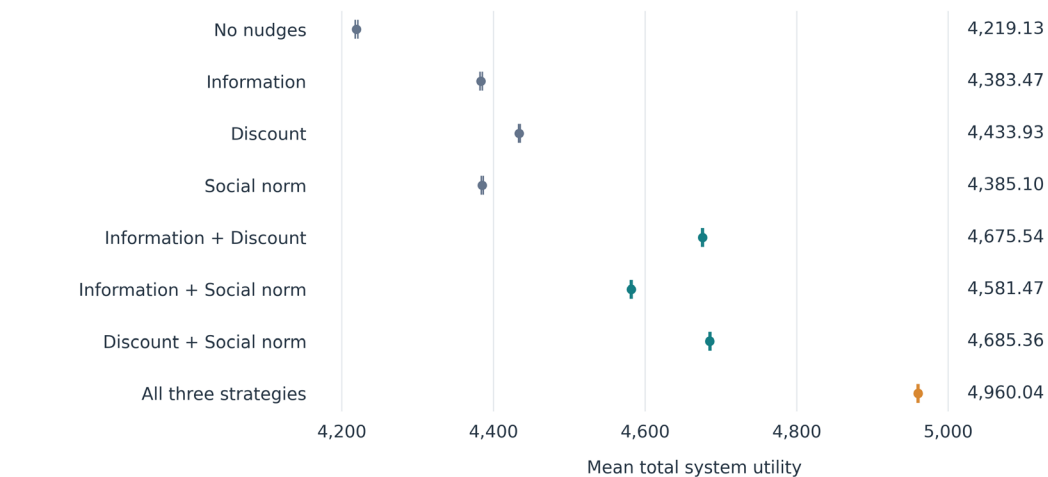
4.1 Coalition Analysis Findings

The coalition utility function $v(S)$ reflects the mean total system utility generated by different combinations of nudge strategies (Table 2 and Figure 1). Among the individual strategies, discount produces the highest mean utility (4,433.93),

followed by social norms (4,385.10) and information (4,383.47). The estimates for information and social norms are close, and their 95% confidence intervals overlap. These results describe performance under the selected model parameters.

Coalition utility under the baseline scenario

Means and 95% Monte Carlo confidence intervals



1,000 replications per coalition · Fixed synthetic population of 1,000 tourists
Intervals describe simulation uncertainty; exact limits are reported in Table 2.

Figure 1. Mean total system utility for nudge strategy coalitions with 95% Monte Carlo confidence intervals.

Note for Figure 1: The intervals are based on 1,000 replications for each coalition, conditional on the fixed synthetic population and model parameters. Exact interval limits are reported in Table 2.

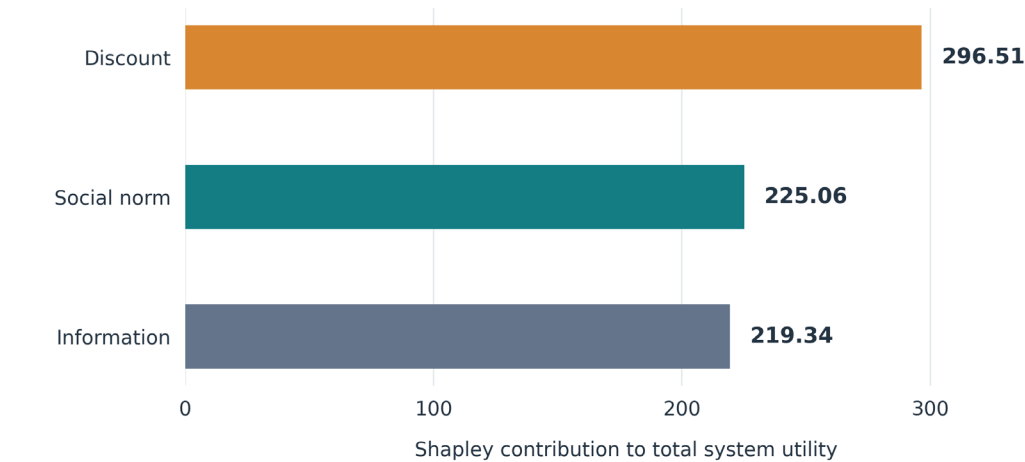
Combined strategies produce higher mean total utility than individual strategies in the baseline simulation. Information and discount together produce a mean utility of 4,675.54, while discount and social norms together produce 4,685.36. Information and social norms together produce 4,581.47. The highest mean utility is obtained with all three strategies (4,960.04), compared with 4,219.13 without nudges. These results indicate gains from combining interventions within the model.

4.2 Shapley Value Findings

Shapley values measure the average marginal contribution of each strategy to total system utility across all coalitions. Discount has the largest contribution (296.51), followed by social norms (225.06) and information (219.34). All three contributions are positive. Their sum is 740.91, equal to the increase in mean utility between the full coalition and the coalition without nudges, before rounding. This ranking depends on the selected response probabilities, preference coefficients, and utility assumptions. The model examines information and social influence mechanisms discussed by Thaler and Sunstein (2009) and Cialdini and Goldstein (2004), but does not test their long-term effects.

Marginal contributions of the interventions

Shapley values calculated from the eight coalition means



Total utility gain relative to no nudges: 740.91

Baseline scenario · Contributions reflect the selected model assumptions.

Figure 2. Shapley contributions of nudge strategies to total system utility.

4.3 Policy Implications

The baseline simulation suggests that managers could consider combining discount, information, and social norm interventions. Combined strategies produce higher total system utility than individual strategies under the selected assumptions. These findings provide a basis for testing intervention combinations in practice.

The model does not estimate the speed or duration of behavioral change. Therefore, the results cannot establish whether one strategy performs better in the short term or the long term. Such comparisons require evidence from repeated observations over time.

Income and education are included in the synthetic population through assumed differences in price sensitivity and sustainability awareness. However, the analysis reports aggregate intervention contributions and does not establish which intervention performs best within income, education, price-sensitivity, or awareness groups. Recommendations for specific tourist groups therefore require separate subgroup analyses and evidence from the target setting.

Managers should assess intervention costs and test combinations in their own settings before implementation. The reported system utility includes a fixed sustainability investment cost, but does not include separate implementation costs for the three interventions.

The sensitivity analysis shows that the leading intervention can change when response probabilities and preference coefficients change. Managers should therefore assess these parameters in their own settings before selecting an intervention.

4.4 Sensitivity analysis

Discount has the largest Shapley contribution at baseline and in 11 of the 14 alternative scenarios (Table 3). This position is maintained under the selected low- and high-effect scenarios, price-sensitivity and awareness changes, investment-cost changes, population-size changes, and equal preference coefficients. However, social norms rank first when response probabilities are equal, both with the original coefficients and with equal coefficients. Information ranks first in the information-favored scenario. These changes show that the ranking depends on the assumed intervention parameters.

When probabilities and coefficients are equal, differences can still occur because the fixed synthetic sample contains different realized nudge responses and different relationships between those responses and tourist characteristics. Small numerical differences should therefore not be interpreted as general evidence that one equally parameterized intervention is superior. The price-sensitivity scenarios change tourist utility, while price sensitivity does not directly enter the hotel-choice probability equation.

Changing the investment cost from 200 to 100 or 400 shifts all coalition utilities equally and leaves Shapley contributions unchanged. The common fixed cost cancels in every marginal contribution. This does not imply that investment cost is unimportant for hotel profitability. The population-size scenarios change the scale of the contributions; comparisons between population sizes should also consider utility contribution per tourist.

5. CONCLUSION

In this study, the impact of different nudge strategies on the preferences of tourists for eco-friendly hotels was examined within the framework of game theory. Integrating simulation modeling with cooperative game theory, this study presented a structured approach to evaluate the individual and combined effects of nudges based on information, social norms, and discounts.

Under the baseline assumptions, discount has the largest Shapley contribution, followed by social norms and information. The combination of all three interventions produces the highest mean total system utility. These findings describe outcomes within the simulation and should not be interpreted as evidence of lasting behavioral change.

Sensitivity analysis confirms that the leading intervention depends on the selected parameter settings, with alternative scenarios producing different rankings.

The study provides a framework for comparing the marginal contributions of interventions and their combinations. The simulation uncertainty estimates improve the transparency of the reported results. The ranking remains conditional on the assumed parameters, while real-world effectiveness and long-term outcomes require further validation.

REFERENCES

- Robinson, P., Lück, M., & Smith, S. (2020). *Tourism* (2nd ed.). Wallingford, UK: CABI.
- World Commission on Environment and Development. (1987). *Our common future*. Oxford University Press. Retrieved March 23, 2026, from <https://digitallibrary.un.org/record/139811?v=pdf>
- Gössling, S., Hall, C. M., Peeters, P., & Scott, D. (2010). The future of tourism: Can tourism growth and climate policy be reconciled? A climate change mitigation perspective. *Tourism Recreation Research*, 35(2), 119–130. <https://doi.org/10.1080/02508281.2010.11081628>
- Lenzen, M., Sun, Y.-Y., Faturay, F., Ting, Y.-P., Geschke, A., & Malik, A. (2018). The carbon footprint of global tourism. *Nature Climate Change*, 8(6), 522–528. <https://doi.org/10.1038/s41558-018-0141-x>.
- United Nations Environment Programme. (2005). *Making tourism more sustainable: A guide for policy makers*. Retrieved March 23, 2026, from <https://www.unep.org/resources/report/making-tourism-more-sustainable-guide-policy-makers>
- Thaler, R. H., & Sunstein, C. R. (2009). *Nudge: Improving decisions about health, wealth, and happiness*. New York, NY: Penguin.
- Farshbafiyān Hosseiniñezhad, M., Heidari, M., & Guerra, M. L. (2025). The framing effect and sustainable hotel booking behaviour: A nudge marketing study. *European Journal of Tourism Research*, 39, 1–14. <https://doi:10.54055/ejtr.v39i.3760>.
- Fedeli, G., Tavares, J. M., & Kumail, T. (2024). Bridging information gaps: Public sector intervention in tourism promotion during crises—A game theory approach. *Zeitschrift für Tourismuswissenschaft*, 16(1), 1–14. <https://doi:10.1515/tw-2024-0001>.
- Kopf, D. A., & Hsu, M. K. (2021). Game theory, tourism and land ethics. *Sustainability*, 13(15), 8515. <https://doi.org/10.3390/su13158515>.
- He, P., He, Y., & Xu, F. (2018). Evolutionary analysis of sustainable tourism. *Annals of Tourism Research*, 69, 76–89. <https://doi:10.1016/j.annals.2018.02.002>.
- Chen, M. H., Wei, H., Wei, M., Huang, H., & Su, C. H. J. (2021). Modeling a green supply chain in the hotel industry: An evolutionary game theory approach. *International Journal of Hospitality Management*, 92, 102716. <https://doi.org/10.1016/j.ijhm.2020.102716>.

- Ciano, T., & Ferrara, M. (2024). Shapley value in machine learning modeling: Optimizing decision-making in coworking spaces. *Applied Mathematical Sciences*, 18(9), 419–441. <https://doi.org/10.12988/ams.2024.919155>.
- Fryer, D., Strümke, I., & Nguyen, H. (2021). Shapley values for feature selection: The good, the bad, and the axioms. *IEEE Access*, 9, 144352–144360, <https://doi.org/10.1109/ACCESS.2021.3119110>.
- Li, M., Sun, H., Huang, Y., & Chen, H. (2024). Shapley value: From cooperative game to explainable artificial intelligence. *Autonomous Intelligent Systems*, 4(1), 2, <https://doi.org/10.1007/s43684-023-00060-8>.
- Ni, X., Wang, D., Chang, J., & Li, H. (2025). Digital nudging for sustainable tourist behavior in new media. *Tourism Management*, 107, 105087. <https://doi.org/10.1016/j.tourman.2024.105087>.
- Nowak, M., Alhyme, O., & Heldt, T. (2024). Testing the effectiveness of increased frequency of norm-nudges in encouraging sustainable tourist behaviour: A field experiment using actual and self-reported behavioural data. *Journal of Sustainable Tourism*, 32(7), 1307–1331. <https://doi.org/10.1080/09669582.2023.2220979>.
- Souza-Neto, V., Marques, O., Mayer, V. F., & Lohmann, G. (2023). Lowering the harm of tourist activities: A systematic literature review on nudges. *Journal of Sustainable Tourism*, 31(9), 2173–2194. <https://doi.org/10.1080/09669582.2022.2036170>.
- Jayaraj, M. M., & Chandrakala, A. (2024). Nudging for sustainability: Innovative practices in sustainable tourism and public policy. In *Proceedings of the 3rd International Conference on Reinventing Business Practices, Start-ups and Sustainability (ICRBSS 2023)* (pp. 973–983). Atlantis Press. https://doi.org/10.2991/978-94-6463-374-0_85.
- Olya, H., Kim, N., & Kim, M. J. (2024). Climate change and pro-sustainable behaviors: Application of nudge theory. *Journal of Sustainable Tourism*, 32(6), 1077–1095, <https://doi.org/10.1080/09669582.2023.2201409>.
- Lee, C. K., Olya, H., Ahmad, M. S., Kim, K. H., & Oh, M. J. (2021). Sustainable intelligence, destination social responsibility, and pro-environmental behaviour of visitors: Evidence from an eco-tourism site. *Journal of Hospitality and Tourism Management*, 47, 365–376. <https://doi.org/10.1016/j.jhtm.2021.04.010>.
- Song, H., Wu, H., & Zhang, H. (2024). Can nudging affect tourists' low-carbon footprint travel choices? *International Journal of Contemporary Hospitality Management*, 36(5), 1534–1556. <https://doi.org/10.1108/IJCHM-09-2022-1175>.
- Sharma, A., Saulais, L., & Huang, Y. (2024). Sustainable consumer choices—Critical reflection on hospitality and tourism. *International Journal of Contemporary Hospitality Management*, 36(6), 1784–1797. <https://doi.org/10.1108/IJCHM-08-2022-0998>.
- Yachin, J. M., Margaryan, L., Lexhagen, M., & Ioannides, D. (2025). Nudgeplus in tourism: Reflexive behaviours and reflective attitudes. *Journal of Sustainable Tourism*, 33(12), 2773–2790. <https://doi.org/10.1080/09669582.2024.2436907>.
- Chica Serrano, M., Hernández, J. M., & Perc, M. (2023). Rewarding policies in an asymmetric game for sustainable tourism. *Applied Mathematics and Computation*, 451, 128183. <https://doi.org/10.1016/j.amc.2023.128183>.
- Leopold, A. (1989). *A sand county almanac, and sketches here and there*. Oxford University Press.
- Chica, M., Hernández, J. M., & Perc, M. (2022). Sustainability in tourism determined by an asymmetric game with mobility. *Journal of Cleaner Production*, 355, 131662. <https://doi.org/10.1016/j.jclepro.2022.131662>.
- Lei, X., Guo, W., & Xu, T. (2025). Evolution of stakeholder relationships in heritage tourism following policy changes: A game theory and system dynamics perspective. *Tourism Planning & Development*, 1–20. <https://doi.org/10.1080/21568316.2025.2528894>.

Sun, Y., Liu, B., Fan, J., & Qiao, Q. (2021). The multi-player evolutionary game analysis for the protective development of ecotourism. *Environmental Science & Policy*, 126, 111–121. <https://doi.org/10.1016/j.envsci.2021.09.026>.

Zhang, R., & Li, Z. (2023). Stackelberg game model of green tourism supply chain with governmental subsidy. *INFOR: Information Systems and Operational Research*, 61(2), 141–168. <https://doi.org/10.1080/03155986.2022.2164438>

Mousavi, E. S., Hafezalkotob, A., Makui, A., & Sayadi, M. K. (2021). Hotel pricing decision in a competitive market under government intervention: A game theory approach. *International Journal of Management Science and Engineering Management*, 16(2), 83–93. <https://doi.org/10.1080/17509653.2021.1873202>.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, 47(2), 263–291. <https://doi.org/10.2307/1914185>.

Benartzi, S., Beshears, J., Milkman, K. L., Sunstein, C. R., Thaler, R. H., Shankar, M., Galing, S., Galing, S., Galing, S., ... (2017). Should governments invest more in nudging? *Psychological Science*, 28(8), 1041–1055. <https://doi.org/10.1177/0956797617702501>.

Goldstein, N. J., Cialdini, R. B., & Griskevicius, V. (2008). A room with a viewpoint: Using social norms to motivate environmental conservation in hotels. *Journal of Consumer Research*, 35(3), 472–482. <https://doi.org/10.1086/586910>.

Cialdini, R. B., Reno, R. R., & Kallgren, C. A. (1990). A focus theory of normative conduct: Recycling the concept of norms to reduce littering in public places. *Journal of Personality and Social Psychology*, 58(6), 1015–1026. <https://doi.org/10.1037/0022-3514.58.6.1015>.

Gössling, S., & Peeters, P. (2015). Assessing tourism's global environmental impact 1900–2050. *Journal of Sustainable Tourism*, 23(5), 639–659. <https://doi.org/10.1080/09669582.2015.1008500>.

Kah, J. A., Lee, S. H., & Kim, J. S. (2022). The effects of travelers' price sensitivity on information search behaviors. *Sustainability*, 14(7), 3818. <https://doi.org/10.3390/su14073818>.

Dominique-Ferreira, S., & Antunes, C. (2020). Estimating the price range and the effect of price bundling strategies: An application to the hotel sector. *European Journal of Management and Business Economics*, 29(2), 166–181. <https://doi.org/10.1108/EJMBE-04-2019-0066>.

Cialdini, R. B., & Goldstein, N. J. (2004). Social influence: Compliance and conformity. *Annual Review of Psychology*, 55(1), 591–621. <https://doi.org/10.1146/annurev.psych.55.090902.142015>.