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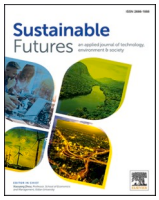

Sustainable tourism supply chain in economic recession: Analysis of government intervention using game theory approach

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ABSTRACT

The tourism industry plays a vital role in both economic development and environmental sustainability but remains highly vulnerable to economic shocks. Government interventions, particularly tax policies, can significantly influence the stability and sustainability of tourism supply chains. This study investigates how government taxation and policy strategies affect a supply chain involving two five-star hotels, one adopting green practices and one operating conventionally, and an online travel agency (OTA). Using a game-theoretic approach, the model analyzes interactions under both stable and recessionary economic conditions. The results show that taxation often reduces the profitability of hotels without meaningfully increasing government revenue, especially during economic downturns. Green hotels are more severely affected, as they face higher costs while struggling to maintain competitive pricing in times of crisis. Meanwhile, OTAs benefit disproportionately from government interventions, amplifying structural imbalances in the supply chain. These findings highlight the need for more nuanced government policies, including targeted tax relief and sustainability incentives, to support green innovation while preserving the financial health of tourism businesses.

1. Introduction

The tourism industry is highly sensitive to economic fluctuations, environmental concerns, and government policies. Over the past decades, tourism has faced several crises, including wars, natural disasters, and pandemics, which have severely impacted its operations [1,2]. The recent COVID-19 pandemic has significantly disrupted global tourism, leading to an estimated 78 % decline in travel activity, a $1.2 trillion revenue loss, and a 120-million-dollar reduction in direct employment in the sector [3–5]. Because tourism businesses face such huge losses during crises, government support becomes very important, especially for hotels. Governments use tax reductions, financial aid, and other supportive programs to help businesses recover. However, there is debate about whether taxes help or hurt the tourism industry in times of crisis. Some believe that reducing taxes helps businesses survive, while others argue that taxes are needed to keep public services running [5–7]. Still, it is unclear how taxes affect tourism industries, especially when it comes to balancing financial recovery with environmental protection. Many hotels are trying to save money and stay competitive by using eco-friendly practices, but their success often depends on government policies and customer choices [8]. This brings us to an important question: How do government-imposed taxes impact both conventional and green hotels during economic crises?

Sustainable tourism is increasingly recognized as essential for long-term economic and environmental stability [9]. It aims to meet present needs without compromising the ability of future generations to do the same [10,11]. Tourism can contribute to economic growth, but it also poses environmental risks if not managed properly [9,12,13]. Hotels, as major energy consumers in the tourism sector, require large amounts of non-durable goods, water, and energy, making their operations a key focus for sustainability efforts [14–17]. While green practices can improve environmental performance and enhance a hotel's reputation, their financial viability depends on government policies and customer demand [14,11]. This study examines whether government taxation policies encourage or discourage hotels from adopting sustainability practices, given that today's customers not only seek quality service but also prefer environmentally responsible businesses [14,18].

This article examines the government's role in guiding tourism supply chains (TSCs) during economic crises. While hotels have started adopting green service offerings, there is a gap in understanding how

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government financial interventions impact the sustainability and profitability of these businesses. This study compares the interaction between green and non-green hotels under direct and indirect government intervention, particularly in recession periods. Since the tourism industry is a significant revenue source for governments, economic crises, such as pandemics, natural disasters, or financial downturns can severely disrupt its operations. Governments must balance revenue collection with providing financial support to prevent long-term damage to the tourism sector. To address this gap, this study seeks to answer the following key questions:

- Government intervention: How can government regulations support GTSC profits, green hotel services, and TSC resiliency? How can the government, as a legislator, support TSCs performance in terms of price, profit, and customer acquisition after the economic crises?
- SCM and green servicing innovation: How can green activity-based GTSC service solutions enhance TSCs financial, operational, and environmental performance?
- Power structure: How does the situation of the leader in the Stackelberg game in a two-level supply chain affect the performance of the proposed TSC mechanism? How does the hotel's sub-leader's situation affect the performance of OTAs as players?

This study is organized as follows: Section 2 presents the literature review. Section 3 introduces the conceptual framework and outlines the model's prerequisites and assumptions. Section 4 provides the mathematical formulations and the state model. Section 5 presents a numerical example to illustrate the model. Section 6 discusses the results and offers managerial insights. Finally, Section 7 concludes the study and suggests directions for future research.

2. Literature review

In this section, first, the effect of government in the tourism industry is investigated, especially the role of government management in controlling the economic recessions. In the second part, detailed explanations about the TSC and the GTSC are provided. The third section reviews the literature, the history of dual-channel and online travel agencies. Finally, in Section 2-4, research gaps are presented.

2.1. The role of the government in the tourism supply chain in economic crises

Governments often intervene in tourism, but little research has explored their direct cooperation with hotels. Tourism is a major economic sector, and government policies strongly influence its growth and stability [19]. Researchers classify government involvement into two types: passive and active. In passive involvement, a government may perform activities that could have consequences for the tourism industry, even if they are not specifically aimed at the development of the industry. In active involvement, not only does the government get to know tourism requirements, but it also tries to cooperate in operational activities to help tourism reach predetermined goals [20].

Since the tourism industry is sensitive to demand, various factors affect it, such as disease, war, and the economic conditions of the host country. For example, during the COVID-19 pandemic, governments worldwide closed borders and enforced travel restrictions. This led to severe financial losses and fears of an economic recession [3,21]. Halting international travel created serious financial difficulties for tourism businesses, pushing many toward debt crises and potential bankruptcy. Sigala, M [5], argued that crises can force the tourism industry to rethink its strategies, leading to new opportunities for innovation and resilience. Sharma, A. and Nicolau, J. L [22], addressed the role of the government in the tourism industry recovery and showed that governments can act as a key element in developing the industry by offering support such as subsidies, tax breaks, rent reduction policies, and supportive budget policies [5,7,8,23]. In this regard, it is believed that opening new channels, providing opportunities to extend debt maturity, and creating reinvestment options by the government may help travel companies escape economic crises caused by disease, war, or earthquakes. Therefore, the government plays an important role in the socioeconomic development of companies in times of crisis [2,6,24]. Thus, in critical situations, the government can enhance the quality of investment information and reduce economic policy uncertainty, thereby restoring investor and business confidence to resume operations [25]. Identifying the economic damage to the tourism industry allows the government to mitigate risks such as bankruptcy, financial crises, and widespread unemployment among industry employees.

2.2. Green tourism supply chains (GTSC)

A Tourism Supply Chain (TSC) is defined as a network of interconnected tourism organizations. It typically consists of four main components: tourism suppliers, tour operators, travel agencies, and customers, all linked together in a coordinated chain [26]. Tourism services are inherently complex, as they involve the integration of multiple elements such as accommodation, transportation, food services, and retail. Unlike many other industries, tourism faces greater uncertainty due to factors such as seasonality, economic fluctuations, and external shocks [26,27].

Tourism supply chains (TSCs) are expanding, but their growth faces several challenges, particularly strict environmental regulations and high competition. These challenges force businesses to reduce waste and improve efficiency to remain competitive [11,28,29]. A key area of research within Green Tourism Supply Chains (GTSCs) has been the management of green hotels. Studies show that tourists often prioritize the environmental quality of services over price, meaning that hotels with strong sustainability efforts can attract more customers. However, the success of green initiatives depends on market factors such as pricing strategies and promotional efforts [15,16,30,31]. In this regard, Asadi, S. *et al.* [32] explored which factors most influence green hotel management and found that environmental and financial performance are the strongest drivers of green innovation. This suggests that hotels will adopt eco-friendly practices only if they see clear financial benefits, a challenge that government policies could address. Similarly, Chiwaridzo, O. T [10] highlights that investments in green technologies not only reduce environmental impact but also enhance energy security and efficiency. Looking beyond just hotels, government incentives can play a major role in shifting the entire tourism industry toward sustainability. He, P., He, Y. and Xu, F [33] developed a green incentive model using game theory, showing how governments, tour operators, and tourists interact to promote sustainability. Their findings suggest that targeted government incentives such as tax breaks for eco-friendly hotels are especially effective in smaller tourism markets where businesses might otherwise struggle to invest in green initiatives. Environmental sustainability is now a key factor in assessing the performance of supply chains. Xu, A. *et al.* [34] argue that current sustainability assessments in tourism often fail to reflect real-world conditions because they follow a simplified, linear approach. Sustainability efforts not only impact a company's past performance but also serve as a strong predictor of future profitability and business growth [15,35]. In this regard, Wang, J. *et al.* [16] examined how the "green image" of hotels influences customer recommendations in the Chinese hotel industry. They also analyzed how factors like green satisfaction and green trust affect consumer behavior. Their findings revealed that a strong green image significantly increases customer satisfaction and trust. Overall, green supply chain management helps hotels minimize their environmental impact by improving energy efficiency and reducing resource consumption.

2.3. Dual-channel and OTA

Studies showed that most customers are interested in purchasing

tourism products online because they can get information about price, level of services, and quality of products; this could be a very good opportunity for companies in the tourism field [29,36–38]. Also, studies have shown that OTAs are one of the most popular distribution channels for the hotel industry, transferring reservations to hotels and receiving pre-defined commissions for each transaction [39]. In addition to processing bookings, OTAs help hotels increase their online visibility, contributing to around 70 % of total hotel sales. On the one side, hotels have greater access to a large number of customers (because of the good reputation and high visibility that OTAs have, while offering competitive prices and a suitable and reliable booking environment), while on the other, each room sold through OTAs charges hotels an agreed commission rate, or offers the OTAs a lower a wholesale price [39,40].

But what is important in the tourism supply chain is how OTAs and hotels interact. In this regard, Chang, Y. and Hsu, P [41] analyzed the balance between cooperation and competition in OTA-hotel relationships. Their findings suggest that OTAs attract both new and repeat customers through well-designed website services, whereas hotels build guest loyalty by effectively communicating their brand values. While OTAs are valuable for attracting new customers, many hotels prefer direct bookings through their own websites to avoid commission fees [41,42]. In this matter Zhu, Y. *et al.* [29] explored how fairness concerns shape hotel-OTA relationships, particularly regarding environmental commitments and commission structures. In line with the interaction of tourism supply chain channels and its impact on income, Wang, X. *et al.* [23] examined how different decision-making structures impact revenue distribution in the tourism supply chain. Their comparative analysis of centralized and decentralized models revealed that decentralized systems often fail to achieve optimal outcomes. Their study suggests that optimizing the tourism supply chain requires fair profit-sharing mechanisms among all participants. Similarly, Ma, S., He, Y. and Gu, R [30] investigated how OTAs can maximize their revenue by developing effective pricing strategies. In general, OTAs provide a simple way for tourists around the world to plan and book the various parts of their trip, while these agencies provide hoteliers with an unprecedented opportunity to be visible to tourists globally. However, hotels face significant challenges when competing with OTAs. Since OTAs primarily list available services rather than promoting individual brands, hotels must invest heavily in marketing to attract customers away from OTAs.

2.4. Research gap and contribution

In this article, three research streams, including the GTSC, government intervention in the TSC, and the interaction of the tourism industry in times of crisis or economic recession have been examined. Table 1 summarizes past studies, and shows the relevant research according to the intended flow. Taking into account the competition of hotels, Mousavi, E. S., Hafezalkotob, A. and Makui, A [43] proposed an optimal pricing model for hotels, in which the government, as a leader in the Stackelberg game, introduced subsidy or tax policies to protect the environment from hazardous tourism expansion. In these models, hotels as followers are competing with each other to attract customers, using the Nash equation. On the other hand, Long, Y. and Shi, P [44] examined optimal pricing strategies for a tour operator (TO) and an Online Travel Agency (OTA), focusing on timing decisions within an online-to-offline (O2O) model that integrates online sales with offline service cooperation. They proposed a competition model and analyzed cooperation conditions, pricing strategies, and incomes in Stackelberg and Bertrand games, and compared the results of each game. The impact of the government on the success of the TSC during the economic recession, as well as the level of motivation of chain members to provide green services to tourists, have rarely been addressed; these effects should be widely studied in examining GTSC models.

To address the research gaps identified above, the main contributions of this study are as follows:

This paper proposes a GTSC model in which the government acts as the primary leader, hotels serve as sub-leaders, and the Online Travel Agency (OTA) functions as the follower. The study investigates the government's role during crises or subsequent economic recessions affecting the hotel industry. It also explores how government

Table 1
A summary of previous studies in the tourism industry and current article position.

Researchers	GTSC	OTA	TSC	Method		Case Oriented	Pricing Strategy in TSC	Recession Response Policy
				Game	OR			
Wang *et al.*, [23]	×	✓	✓	✓	×	×	✓	×
Mao, Liu and Li, [37]	×	✓	✓	✓	×	×	✓	×
Yang *et al.*, [11]	✓	×	✓	×	×	×	×	×
Asadi *et al.*, [32]	✓	×	✓	✓	×	×	×	×
He, He and Xu, [33]	✓	×	×	×	×	×	✓	×
Xu *et al.*, [34]	✓	×	✓	×	✓	×	×	×
Kizys, Tzouvanas and Donadelli, [25]	×	×	×	×	✓	×	×	✓
Xu, Zhao and Xu, [55]	×	✓	✓	✓	✓	×	✓	×
Bernstein, F. and Federgruen, A [51]	×	×	✓	✓	✓	×	✓	×
Zhang, Song and Huang, [26]	×	×	✓	×	×	×	×	×
Ahmadimanesh, Paydar and Asadi-Gangraj, [27]	×	×	✓	×	✓	✓	×	×
Jena and Jog, [53]	×	×	✓	✓	×	×	×	×
Sari and Suslu, [31]	✓	×	×	×	✓	×	×	×
Wang *et al.*, [16]	✓	×	×	×	×	✓	×	×
Al-Aomar and Hussain, [17]	✓	×	×	×	×	✓	×	×
He *et al.*, [38]	×	✓	×	✓	×	×	×	×
Ye, Zhang and Li, [39]	×	✓	×	✓	×	×	×	×
Yang, Ji and Chen, [40]	×	✓	×	✓	×	×	×	×
Zhu *et al.*, [29]	✓	✓	✓	✓	×	×	✓	×
Li, Xu and Liu, [35]	✓	✓	✓	✓	×	×	✓	×
Chang and Hsu, [41]	×	✓	×	×	×	×	×	×
Ling *et al.*, [42]	×	✓	×	×	✓	×	×	×
Chiwaridzo, [10]	✓	×	✓	✓	×	✓	×	✓
Rahman *et al.*, [14]	✓	×	✓	×	×	✓	×	×
Long and Shi, [44]	×	✓	×	✓	×	×	×	×
Mousavi, Hafezalkotob and Makui, [43]	×	×	✓	✓	×	×	×	×
Guo et al., [52]	×	×	✓	✓	×	×	×	×
Raguseo, Neirotti and Paolucci,[54]	×	✓	×	×	×	✓	×	×
Jamali and Rasti-Barzoki, [46]	×	✓	×	✓	×	×	×	×
Present Research	✓	✓	✓	✓	×	✓	✓	✓

intervention can encourage hotels to adopt green practices and contribute to environmental sustainability amid tourism industry expansion. Additionally, the model calculates and presents the optimal hotel pricing, the ideal level of government subsidies and tax strategies, and the optimal green index for hotels under both recessionary and normal economic conditions. A real-world case study was conducted on Kish Island, a major tourist destination in Iran, to validate the proposed model. This research is the first of its kind to examine the government's role in supporting and reviving the tourism industry following crises such as disease outbreaks, war, or natural disasters. To date, no prior studies have explored governmental motivations and strategies in such conditions.

3. Conceptual framework

In this section, the conceptual model and main assumptions of the problem are introduced. Afterwards, the mathematical model of the problem is presented. Table 2 shows the notations and abbreviations of the problem.

3.1. Problem definition

A two-tier Tourism Supply Chain (TSC) involving hotels and an Online Travel Agency (OTA) is considered, structured as a Stackelberg game. In this model, the government acts as the primary leader, setting taxation and subsidy policies to influence the tourism market. The hotels function as sub-leaders, making pricing and sustainability investment decisions in response to government interventions. Finally, the OTA serves as the follower, adjusting its retail pricing based on the wholesale prices set by the hotels. Each member of the TSC seeks to maximize its own profit, while the government's objective is to foster the development of green tourism practices and stabilize the supply chain during economic fluctuations. The interaction in the TSC follows a hierarchical structure: customers can either book hotel rooms directly from hotels or use the OTA as an intermediary. The OTA, in turn, acts as a retailer, offering hotel bookings while charging commissions for its services. This decentralized decision-making process follows a sequential order, where the government's decisions influence hotel strategies, and hotel strategies shape OTA pricing. Fig. 1 illustrates this conceptual model, highlighting the structured leader-follower relationships that define the Stackelberg game dynamics in the tourism supply chain.

This problem is examined from two perspectives: with economic recession and without economic recession. Additionally, the role of government in the GTSC is explored across four scenarios. Fig. 2 presents government involvement and economic recession across these different scenarios. Since this study considers two distinct periods, the first represents a time of high tourism activity without economic recession, covering the spring and summer months (six months) when tourism demand is at its peak. The second period examines the supply chain during an economic downturn following the COVID-19 pandemic, yet still within the spring and summer months. This approach ensures a consistent seasonal comparison while assessing the impact of economic fluctuations on the tourism supply chain.

Table 2
Symbols and prerequisites.

Description	Notation	Unit
i	index of hotels ($i = 1,2$)	Dimensionless
j	index of channels: indirect channel (j=OTA=o) or direct (j= hotels)	Dimensionless
α_{ij}	base coefficient of demand for hotel i in channel j	Dimensionless
δ	elasticity of demand to self-price	Dimensionless
θ	elasticity of demand to cross-price	Dimensionless
γ_i	sensitivity coefficient value in green-level hotels for providing each unit of hotel services related to demand	Dimensionless
φ	sensitivity coefficient of economic recession,$0 \leq \varphi \leq 1$	Dimensionless
η	Multiplier for cost impact of green initiative in hotels	Dimensionless
w_i	wholesale prices of rooms for hotels i	Dimensionless
c_i	changing costs for hotel i	Dimensionless
P_{ij}	final price for rooms of hotel $i$in channel j	EUR per room
s	the account of greenness of hotels services	Dimensionless: index value
d_{ij}	demand for rooms of hotel $i$in channel j	Number of rooms
π_{hi}	profit function of hotel i	EUR per period
π_{oi}	profit function of OTA i	EUR per period
P'_{ij}	price of rooms for hotel i in each channel j by considering government tariff	EUR per room
t_{ij}	government tariff for rooms of hotel i in channel j	EUR per room
ε_i	bargaining power of OTA for rooms of hotel i	Dimensionless
D	total demand for hotel rooms	Number of rooms
GNR	government profit function	EUR per period
CBP	profit function of chains that include hotels, and OTA	EUR per period
U	total utility function of chains	EUR per period
λ	balancing coefficient between government's profit and chains' profits	Dimensionless

3.2. Prerequisites and assumptions

The interactions and decision-making processes among these entities are analyzed using game theory, specifically employing the Stackelberg strategy where the government sets the direction, and hotels and OTA adjust their strategies accordingly. Here, the government assumes the primary leadership role, with hotels acting as sub-leaders and OTA as followers. Within this decentralized GTSC framework, each participant independently pursues profit and market share optimization through Nash competition dynamics. Hotels vary in their adoption of green services and energy-saving technologies, with the first hotel integrating green strategies and the second not. The primary objective of this study is to assess how government interventions influence interactions among chain members across varying economic conditions. This study is based on the following assumptions:

Assumption 1. To model demand in TSC, we assume that demand for hotel rooms is influenced by pricing strategies, competition, and external economic conditions. Following Long, Y. and Shi, P [44], Ã, T. X. and Yang, D [45], we consider a linear demand function, which accounts for self-price effects, cross-price elasticity, green service incentives, and the impact of economic recessions. The demand functions for hotels and Online Travel Agencies (OTAs) are formulated as follows:

$$d_{o1} = (1-\varphi)\alpha_{o1} - \delta p'_{o1} + \theta(p'_{h1} + p'_{h2} + p'_{o2}) + \gamma_1 s, \quad (1)$$

$$d_{o2} = (1-\varphi)\alpha_{o2} - \delta p'_{o2} + \theta(p'_{h1} + p'_{h2} + p'_{o1}) - \gamma_2 s, \quad (2)$$

$$d_{h1} = (1-\varphi)\alpha_{h1} - \delta p'_{h1} + \theta(p'_{h2} + p'_{o1} + p'_{o2}) + \gamma_1 s, \quad (3)$$

$$d_{h2} = (1-\varphi)\alpha_{h2} - \delta p'_{h2} + \theta(p'_{h1} + p'_{o1} + p'_{o2}) - \gamma_2 s. \quad (4)$$

The demand for hotel rooms is represented by d_{ij}, where i refers to hotel and $j$denotes the booking Channel ($d$for direct booking, $o$for OTA). The base demand (α_{ij}) represents the natural demand without pricing effects, while δ(self-price-elasticity) shows how demand changes with the hotel's own price (p_{ij}). The term θ(cross- price elasticity) captures the effect of a competitor's price on demand.

Assumption 2. By increasing price, the number of customers who leave the channel and do not use their services is more than the number of customers who choose another channel. Therefore, $\delta > \theta > 0$ [46].

Assumption 3. The prices that are determined by OTA for hotels i,j(i, $j = 1,2$)should be more than the price of wholesale determined by the

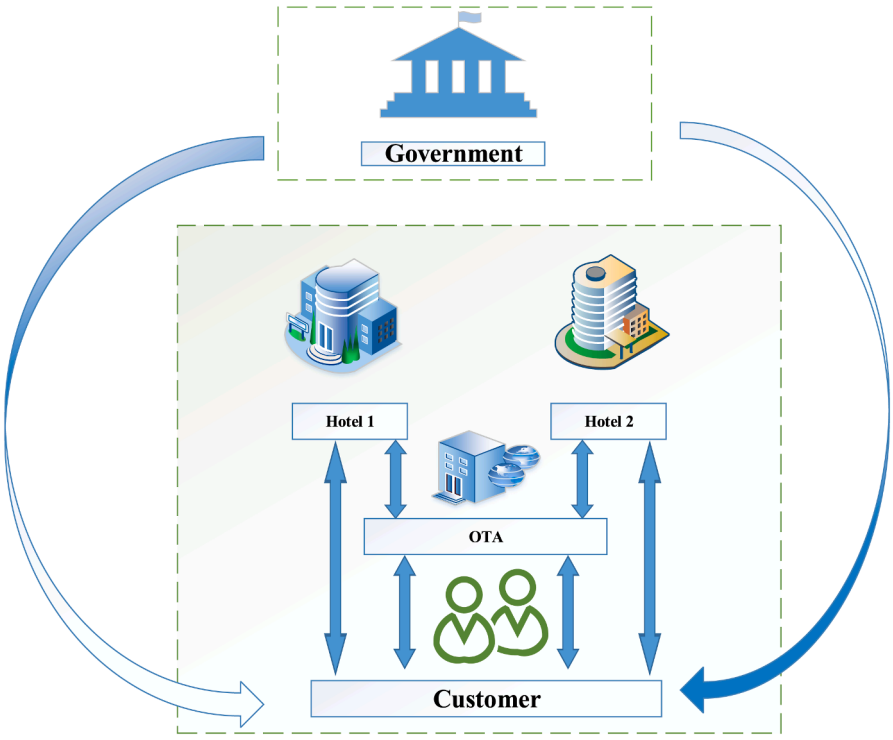

Fig. 1. Government intervention in decentralized hotel competition.

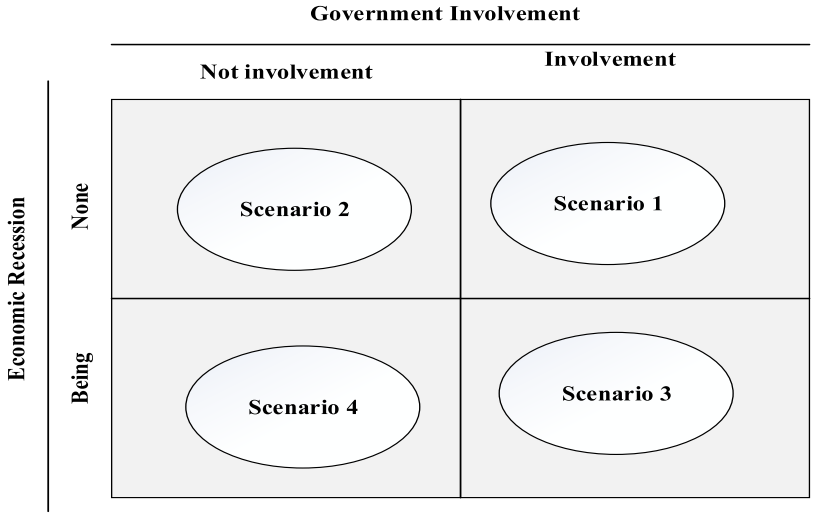

Fig. 2. Economic recession scenarios under government direct and indirect involvement.

hotels. Moreover, the wholesale prices, w_i, should be more than fixed costs, otherwise the profit of OTA and hotels cannot be positive. Therefore, $P_{io} > w_i > C_i$ [46,47].

Assumption 4. γ_1 and γ_2 indices were used to influence the degree of greenness of the first and second hotels to attract tourists. The degree of greenness is an important factor in increasing demand, because hotels that use green services are more attractive to tourists, and tourists prefer to choose hotels that offer green services. If the green hotel is not available or is full, travelers would choose the second hotel, therefore $\gamma_1 > \gamma_2$ [47]. The ratio of people's interest in booking a green hotel is γ_1 and the ratio of people's interest in a non-green hotel is γ_2. However, the first hotel will spend more than the second hotel due to its green strategies, so the cost function $1/2\eta s^2$ should be determined in the profit function of the first hotel.

Assumption 5. In this study, φ is considered as a tourism recession coefficient, so that $0 \leq \varphi \leq 1$. In fact, φ influences the base coefficient of demand for hotel$i$ in channel$j$. When φ is close to zero, there is no economic recession, and the base coefficient of demand increases. However, when φ is close to 1, there is a complete recession, and the base coefficient of demand declines.

Assumption 6. According to Jamali, M. B. and Rasti-Barzoki, M [46], Li, B. *et al.* [47], it is assumed that $\delta > \gamma_i > 0$ because coefficient δ is more important than being at the level of greenness γ.

In this model, d_{o1} is the demand function of the first hotel, which is presented by the OTA as an intermediate for customers. Additionally, d_{h1} is the demand function of the first hotel as requested by customers directly. In the demand equation of the first hotel, γ_1 is considered as a coefficient for the impact of greenness index in the first hotel's services. As seen, being at the green level is an important factor for increasing demand for the first hotel, whether rooms are reserved directly or indirectly. d_{o2} is the demand function of the second hotel determined by OTA for customers; d_{h2} is the demand function for the second hotel when directly reserved by customers. As mentioned before, the second hotel does not use green strategies in its services. Therefore, coefficient γ_2 in demand equation of the second hotel is considered negative. This assumption shows that customers prefer to choose green hotels. P'_{ij} are the prices after taxes or subsidies, so that $p'_{h1} = p_{h1} + t_{h1}, p'_{h2} = p_{h2} + t_{h2}, p'_{o1} = p_{o1} + t_{o1}, p'_{o2} = p_{o2} + t_{o2}$. In these relations, t_{ij} is free, so that a positive value represents tax and a negative value represents subsidy.

4. Model formulation

This problem is formulated under four scenarios for GTSC, each featuring different strategies for the leader and the follower, and each scenario pursuing distinct goals. In each scenario, decisions are primarily initiated at the leader level, and followers make subsequent decisions at lower levels. The final price of hotels is determined through competition between hotels and OTA.

4.1. The interaction model for GTSCs

In this section, we provide a detailed description of four models for chain member interactions. Following the backward induction method, the optimal hotel prices and optimal greenness index are first obtained in Sections 4.1.1 to 4.1.4, then the optimal government strategies will be discussed in Section 4-2. Fig. 3 summarizes the decision-making steps and problem-solving steps.

4.1.1. Scenario one: government involvement, without economic recession

In the first scenario, the government as the main leader intends not only to expand the tourism industry (particularly the hotel industry) but also to increase its own revenue. In this GTSC, hotels are sub-leaders and OTA is a follower, so at this level, hotels and OTA are competing to get more market share. Both hotels have the same star ratings, but the first hotel uses green strategies in its services while the second hotel offers standard services. OTA acts as a retailer so customers can reserve hotels indirectly via OTA, or directly from the hotel website. Considering the market demand (Eqs. 1 to 4), the OTA profit function can be formulated as follows:

$$\max_{p_{h1}, s} \pi_{h1} = p_{h1} d_{h1} + w_1 d_{o1} - c_{h1}(d_{h1} + d_{o1}) - \frac{1}{2}\eta s^2, \tag{5}$$

$$\max_{p_{h2}} \pi_{h2} = p_{h2} d_{h2} + w_2 d_{o2} - c_{h2}(d_{h2} + d_{o2}), \tag{6}$$

$$\max_{p_{o1}, p_{o2}} \pi_o = (p_{o1} - w_1) d_{o1} + (p_{o2} - w_2) d_{o2}, \tag{7}$$

$$w_1 = (1 - \varepsilon_1) p_{h1},\ w_2 = (1 - \varepsilon_2) p_{h2} \tag{8}$$

In competitive situations, the OTA determines the prices of Hotels 1 and 2 to maximize profits. It should be noted that in this scenario there is no economic recession, therefore in Eqs. (1) to (4) there is no sensitivity coefficient for recession, meaning $\varphi = 0$. Thus, a higher value of α_i indicates that GTSC (i) has a comparative advantage in terms of the customer's perspective towards reputation, brand, position, and quality. In function 8, $w_i$represents the wholesale prices of rooms for hotel i, while ε_i represents the bargaining power of the OTA for the rooms of hotel i. The optimal prices for Hotels 1 and 2 that are reserved by OTA are p_{o1} and p_{o2}, which are presented in Lemma1.

Lemma 1. Under regulated policy in normal conditions, the profit function of retailer, Eq. (7), is jointly concave on p_{o1} and p_{o2}. Hence the optimal retail prices of the hotel offered by the OTA can be obtained as follows:

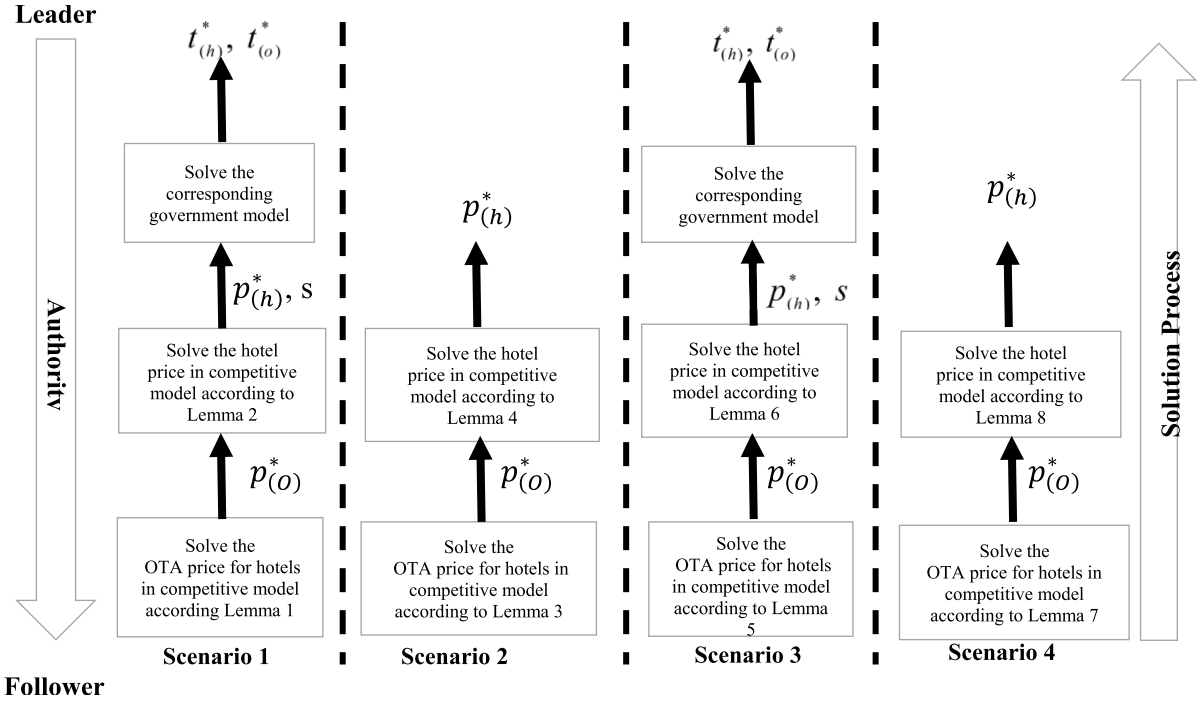

Fig. 3. The decision sequences and problem-solving steps briefly in four scenarios.

$$p_{o1} = -\frac{1}{2}t_{o1} + B(t_{h1} + t_{h2} + p_{h2}) + E_1 p_{h1} + G_1 s + F_1, \tag{9}$$

$$p_{o2} = -\frac{1}{2}t_{o2} + B(t_{h1} + t_{h2} + p_{h1}) + E_2 p_{h2} + G_2 s + F_2. \tag{10}$$

Proposition 1. This lemma establishes the relationship between regulated policies, market dynamics, and optimal pricing strategies for OTAs. The concavity of the retailer's profit function ensures that optimal retail prices exist uniquely and provide stability in pricing decisions. Since the OTA follows a regulated market structure, the equilibrium prices depend on government interventions, sustainability factors, and competition among hotels. The results highlight how regulatory policies shape pricing strategies, ensuring predictable and structured price-setting in the hospitality market.

Lemma 2. In competition between two hotels and considering p_{o1}, p_{o2} that can be obtained by Eqs. (9) and (10), the profit function of the wholesaler, Eqs. (5) and (6), are jointly concave on p_{h1} and p_{h2}. Hence the optimal wholesaler prices of the hotel offered directly by the hotels can be obtained as follows:

$$p_{h1} = U_{11}t_{h1} + U_{12}t_{h2} + V_{11}t_{o1} + V_{12}t_{o2} + X_1, \tag{11}$$

$$p_{h2} = U_{21}t_{h1} + U_{22}t_{h2} + V_{21}t_{o1} + V_{22}t_{o2} + X_2, \tag{12}$$

the next focus is on the greenness indices for GTSCs (Eqs. (5) and (6)), which are jointly concave on s. Therefore, the optimal greenness hotel service index is obtained as follows:

$$S = R_1 p_{h1} - R_2, \tag{13}$$

where the optimal price of hotel 1, p_{h1} is obtained by Eq. (11).

Proposition 2. This lemma highlights the role of hotels in determining equilibrium pricing within the supply chain. Since hotels engage in competition, wholesalers set prices based on market conditions and regulatory factors. The inclusion of the greenness index further reinforces how sustainability policies influence pricing strategies. The following Lemmas provide the best response of the optimal greenness hotel service index.

4.1.2. Scenario two: without government involvement, without economic recession

In this scenario, the government is not involved in the SC and the TSC only consists of hotels and OTA. Therefore, in the TSC, hotels are the main leaders and OTA acts as followers, such that the hotels are competing with each other. Since in this scenario, there is no economic recession, the demand function is different. In demand functions (1) to (4), the sensitivity coefficient of economic recession zero is regarded as $\varphi = 0$. Also, in this scenario, the government does not interfere in the TSC, so prices are in the demand functions regardless of subsidy or tax.

Lemma 3. Under regulated policy in normal conditions, and without government intervention, the profit function of retailer, Eq. (7), is jointly concave on p_{o1} and p_{o2}. Hence the optimal retail prices of the hotel offered by OTAs can be obtained as follows:

$$p_{o1} = G_1 s + E_{11}p_{h1} + Ep_{h2} + F_1, \tag{14}$$

$$p_{o2} = G_2 s + Ep_{h1} + E_{22}p_{h2} + F_2. \tag{15}$$

Proposition 3. This lemma focuses on a competitive pricing structure where hotels act as primary decision-makers, while OTAs adjust retail prices based on predetermined wholesale prices. Since government intervention is absent, pricing dynamics are shaped entirely by market forces and contractual agreements between hotels and OTAs. In this scenario, p_{o1} and p_{o2} are related to s, p_{h1}, p_{h2} and constant values of F_1 and F_2. The concavity condition ensures that the retailer's profit function leads to stable, optimal price levels. This reflects a leader-follower structure, where hotels set their wholesale prices, and OTAs adapt accordingly to maximize their profits while maintaining market competitiveness.

Lemma 4. By considering p_{o1} and p_{o2}, which can be obtained by Eqs. (14) and (15), the profit function of wholesalers, shown in Eqs. (5) and (6), are jointly concave on p_{h1} and p_{h2}. Thus the optimal wholesale prices in competition between two hotels can be obtained as follows:

$$p_{h1} = \frac{L_{12}N_2 - L_{22}N_1}{L_{11}L_{22} - L_{12}L_{21}}, \tag{16}$$

$$p_{h2} = \frac{L_{11}N_2 - L_{21}N_1}{L_{11}L_{22} - L_{12}L_{21}}. \tag{17}$$

Proposition 4. As can be seen from Lemma 4, the optimal prices of Hotels 1 and 2, p_{h1},p_{h2}, are determined solely by the parameters of the supply chain. This lemma describes how hotels determine their own pricing strategies when competing with each other. In other words, the retail prices and greenness indices in this scenario do not affectp_{h1}, $p_{h2}$and these optimal prices depend only on the structural parameters and market conditions of the SC. This reflects a competitive market structure, where each hotel optimizes pricing based on industry conditions rather than external control.

4.1.3. Scenario three: government involvement, with economic recession

In this scenario, there is an economic recession and the government as the main leader is trying to manage the crisis and the resulting bad social effects in the hotel industry. As the second level of decision-making, hotels as sub-leaders are competing with each other in critical situations, while OTA acts as followers. In a competitive situation, OTA determines the prices of Hotels 1 and 2 to maximize their own profits. As the main leader, the government tries to control the economic recession and the prevailing conditions in society. The optimal prices of Hotels 1 and 2 as determined by OTA, $p_{o1}$and p_{o2} are presented in Lemma 5.

Lemma 5. Under the decentralized competition among hotels, the government acts as the main leader to control the economic recession, and hotels are sub-leaders. The profit function of the retailer, Eq. (7), is jointly concave on p_{o1} and p_{o2}. Hence the optimal retail prices of the hotel offered by OTAs can be obtained as follows:

$$p_{o1} = -\frac{1}{2}t_{o1} + B(t_{h1} + t_{h2} + p_{h2}) + E_1 p_{h1} + G_1 s + F_1(\varphi), \tag{18}$$

$$p_{o2} = -\frac{1}{2}t_{o2} + B(t_{h1} + t_{h2} + p_{h1}) + E_2 p_{h2} + G_2 s + F_2(\varphi). \tag{19}$$

Proposition 5. In this scenario, there is a sensitivity coefficient of the economic recession, φ, in all demand Functions (1) to (4). This lemma highlights the impact of government intervention during an economic recession. Since the government leads in stabilizing the economy, hotels adjust pricing strategies accordingly while OTAs react to these price changes. The equilibrium retail prices depend on economic conditions, government strategies, and sustainability factors, illustrating how macroeconomic policies shape pricing decisions in a decentralized competitive environment.

Lemma 6. In competition between two hotels and considering p_{o1}, p_{o2}, which can be obtained by Eqs. (18) and (19), the wholesaler profit functions (Eqs (5) and (6)) are jointly concave on p_{h1} and p_{h2}. Hence the optimal wholesaler prices of the hotel offered directly by the hotels can be obtained as follows:

$$p_{h1} = U_{11}t_{h1} + U_{12}t_{h2} + V_{11}t_{o1} + V_{12}t_{o2} + X_1(\varphi), \tag{20}$$

$$p_{h2} = U_{21}t_{h1} + U_{22}t_{h2} + V_{21}t_{o1} + V_{22}t_{o2} + X_2(\varphi). \tag{21}$$

Proposition 6. This Lemma states that the severity of recession affect the p_{h1} and p_{h2}. In addition, wholesale prices are heavily influenced by government strategies, and by its role in the ensuing economic crisis. This lemma also highlights how wholesale prices are determined by broader economic forces rather than individual business decisions. Since hotels act as sub-leaders, their pricing at the wholesale level is shaped by government actions and macroeconomic conditions. The results indicate that changes in government intervention, market demand, and sustainability policies directly influence wholesale pricing structures, affecting retail market pricing.

4.1.4. Scenario four: without government involvement, with economic recession

In this scenario, the government is not involved in the tourism industry during the economic recession; hotels manage this situation as main leaders. Here, OTA acts as followers, and in the demand functions (according to Eqs. (1) to (4)), the prices are considered without subsidy or tax. However, the sensitivity coefficient of economic recession, φ, is present in the demand functions. The optimal prices of Hotels 1 and 2 which are determined by themselves are presented in Lemma 7.

Lemma 7. In a competitive situation where hotels compete with each other during an economic recession, OTA determines the prices of Hotels 1 and 2 to maximize their own profits. Therefore, p_{o1} and p_{o2} are determined by Eqs. (22) to (23).

$$p_{o1} = G_1 s + E_{11} p_{h1} + E p_{h2} + F_1(\varphi), \tag{22}$$

$$p_{o2} = G_2 s + E p_{h1} + E_{22} p_{h2} + F_2(\varphi). \tag{23}$$

Proposition 7. This lemma shows that OTAs adjust retail prices according to the pricing strategies set by hotels during a recession. Since hotels compete for market share, their pricing power primarily shapes the OTA's profit-maximizing strategy. The final retail prices are influenced by the severity of the recession and sustainability factors, reinforcing the role of macroeconomic forces in shaping pricing structures.

Lemma 8. The optimal prices of hotels directly determined by themselves are as follows:

$$p_{h1} = \frac{L_{12} N_2(\varphi) - L_{22} N_1(\varphi)}{L_{11} L_{22} - L_{12} L_{21}}, \tag{24}$$

$$p_{h2} = \frac{L_{11} N_2(\varphi) - L_{21} N_1(\varphi)}{L_{11} L_{22} - L_{12} L_{21}}. \tag{25}$$

Proposition 8. This lemma highlights a scenario where hotels independently determine their pricing without direct intervention from OTAs. The equilibrium price depends on market conditions, but is ultimately a decision made at the hotel level. This lemma underscores how hotels adapt to external economic conditions while maintaining control over their pricing strategies in a competitive market environment.

4.2. Government Models

In this section, the best response strategies in TSCs related to defined government reactions are presented. Focusing on the government model allows for the calculation of optimal government subsidy or tax strategies. To determine the optimal level of taxation or subsidies, the government's decision-making model is formulated as follows:

$$Max(u) = \lambda.CBP + (1-\lambda).GNR \tag{26}$$

Subject to: $GNR \leq G$,

$s \geq S$,

$CBP \geq c$.

This model provides a framework for making decisions about subsidy or tax strategies according to different government actions. The decision model of Government (26) shows that the government seeks to encourage hotel managers to apply maximum energy-saving policies or use green energy policies. Due to the economic importance of tourism in all countries, the government will often aim to support this industry. Therefore, by minimizing government profit, Government Net Revenue, (GNR), and maximizing the profits of chains, Chain Business Profit, (CBP), the government seeks to support and develop the tourism industry, particularly the hotel industry. It should be noted that G can be negative, which means that the government might consider a budget for energy-saving programs in the hotel industry. Thus, according to Model (26), constraint $GNR \leq G$ shows that net government income must reach the threshold of G, while the value S is the threshold for energy saving. As a case in point, EU countries have determined energy-saving thresholds in different industries by applying a comprehensive energy-saving program [48]. In this regard, the results of a survey of Sri Lankan hotels in 2010-2014 that used environmentally friendly methods show that hotel efficiency has increased significantly, which is a competitive advantage for hotels and a valuable initiative to provide governments with environmentally friendly activities [49].

Profit of chains, CBP, is determined by the government and, according to $CBP \geq C$, is a predefined threshold. The government seeks stable development goals in the model; according to energy-saving efforts, net government income, and profit of chains, the objective functions are as follows:

$$CBP = \pi_{h1} + \pi_{h2} + \pi_o \tag{27}$$

$$GNR = t_{o1}\, d_{o1} + t_{o2}\, d_{o2} + t_{h1}\, d_{h1} + t_{h2}\, d_{h2}. \tag{28}$$

Eq. 27 defines the CBP, which represents the total profit of the supply chain participants, including both green and non-green hotels and the OTA. This metric captures the economic strength and adaptability of the tourism supply chain in response to policy changes. Eq. 28 calculates the GNR, which accounts for the financial impact of subsidies or taxes imposed by the government. It helps assess whether the intervention strategies are fiscally sustainable for the government itself. Table 3 shows the price changes of hotels relative to government strategies. As it turns out, given the research assumptions, the rate of price changes for the first and second hotels (as determined by the OTA) towards the government strategies depends on a constant amount, which means $\frac{\partial p_{o1}}{\partial t_{h1}} = \frac{\partial p_{o1}}{\partial t_{h2}} = \frac{\partial p_{o2}}{\partial t_{h1}} = \frac{\partial p_{o2}}{\partial t_{h2}} = B$. According to the research hypotheses, the value of B is always positive, so the magnitude of changes p_{o1} and p_{o2} relative to the t_{h1} and t_{h2} is always increasing gradually and regularly. By increasing the government tariffs (subsidy or tax strategies imposed on the hotels as the supplier), the price of retailer will increase. On the other hand, the changes of p_{o1} and p_{o2} with regard to t_{o1} and t_{o2}, $\frac{\partial p_{o1}}{\partial t_{o1}} = \frac{\partial p_{o2}}{\partial t_{o2}} = -\frac{1}{2}$ is always a constant and negative value. This means that by increasing government tariffs imposed to the OTA as a retailer, the retailer price will decrease.

Table 3
Hotel price sensitivity to government strategies.

$\frac{\partial}{\partial}$	p_{o1}	p_{o2}
t_{h1}	$B = \frac{\delta\theta + \theta^2}{2\delta^2 - 2\theta^2} > 0$	$B = \frac{\delta\theta + \theta^2}{2\delta^2 - 2\theta^2} > 0$
t_{h2}	$B = \frac{\delta\theta + \theta^2}{2\delta^2 - 2\theta^2} > 0$	$B = \frac{\delta\theta + \theta^2}{2\delta^2 - 2\theta^2} > 0$
t_{o1}	$-\frac{1}{2} < 0$	-
t_{o2}	-	$-\frac{1}{2} < 0$

5. Results and insights

In this section, a numerical example is presented to validate the proposed model. To better understand the problem, a tourist island in the south of Iran was considered and analyzed, though the results show that this model can be applicable in any tourist area. The parameter values are set based on real-world data which are consistence with the assumptions of the model. Table 4 shows the value of parameters for the numerical example.

Now, the impact of φ on *CBP*, *GNR*, *S*, and*D*is investigated in different scenarios. In scenarios 1 and 3, government acts as a leader in the TSC. Therefore, variables such as *CBP*, *GNR*, *S*, and *D* are investigated in Table 5. In this table, $\varepsilon_1 = 0.1$ and $\varepsilon_2 = 0.3$ are considered. As seen, by increasing φ from 0 to 0.5 (from where there is no recession to where recession is the mean), the profit of chain, *CBP*, decreases dramatically. Since the government's goal is to develop the tourism industry in all cases, the government sees its profit as crossing a negative threshold. But government revenues are increasing with the recession. In the period before the economic slowdown, the government's focus was on the development of the tourism industry and investment for the prosperity of hotels (especially green hotels), but in a situation where the economic recession (caused by various crises) affects society and as a result, there is less travel, the government pays less to maintain the hotel industry [50]. In addition, it can be concluded that by increasing φ, the level of greenness of hotels decreases because green activities pose some costs to hotels, making them decrease their prices during an economic recession. Thus, hotels try to decrease green activities to decrease their costs. However, when there is no economic recession, green activities in hotels are at their highest levels. As seen, by increasing φ, the total demand for hotels, *D*, is decreased dramatically. Investigating t_{h1}, t_{h2}, t_{o1}, and t_{o2} shows that when there is no economic recession, taxes are paid but by increasing the severity of the economic recession, the amount of taxes paid decreases noticeably, because the government tries to overcome economic harm by reducing tax or even by paying subsidies.

Table 6 shows the impact of recession φ on *CBP*,*S*, and *D* in Scenarios 2 and 4. Since the government is not involved as leader in Scenarios 2 and 4, and hotels are main leaders, there is no *GNR*, *U*, t_{h1}, t_{h2}, t_{o1}, and t_{o2}. In these scenarios, by increasing φ, the profit of chains, *CBP*, is reduced dramatically. Likewise, the amount of *S* or greenness declines noticeably, because hotels try to depress their prices by reducing their green activities. During an economic recession, demand has been reduced by half.

Fig. 4 shows the simultaneous effect of government profit balance ratio, λ, and the severity of the recession, φ, on government revenue, GNR, and profit of chains, CBP. What can be seen from Fig. 4 is that as the recession occurs, φ and λ increase simultaneously, leading to enhanced government revenue and declining chain profits. The rise of λ sends the signal in this tourism chain that increasing the profits of the chains is more important than the profits of the government, and the government gives up its revenue-generation policies in order to increase the profits of the chains. Therefore, as the economic recession increases, if the government is indifferent to the revenue generation of the chains and only cares about its own revenue, the chains become weaker and poorer day by day, but the government's revenue improves. However, as the recession intensifies (φ), if the government's goal is to survive and strengthen the profits of the chains, it must abandon its revenue-generation goal.

Table 4
Value of parameters.

Parameter	Value	Parameter	Value
$(\alpha_{o1}, \alpha_{o2})$	$(12, 10)$	$(\alpha_{h1}, \alpha_{h2})$	$(14, 13)$
(γ_1, γ_2)	$(0.05, 0.02)$	(δ, θ, η)	$(0.09, 0.02, 0.3)$
λ	0.2	φ	$0 \leq \varphi \leq 1$
(w_1, w_2)	$(125, 110)$	(C_{h1}, C_{h2})	$(78, 65)$

Fig. 5 shows the impact of retailer marginal profit, ε_1 and ε_2 on supplier prices. Comparing the prices of Hotels 1 and 2 in different scenarios, it can be concluded that the price of the second hotel in scenario two is higher than the first scenario, while there is not much difference between the price of the first hotel in Scenarios 1 and 2. In other words, the second scenario is more favorable for the second hotel in terms of price, but Scenarios 1 and 2 are equally desirable for the first hotel.

According to Fig. 5, the hotel price difference between Scenarios 1 and 2 is significant compared to Scenarios 3 and 4, which means that hotel prices have fallen sharply as the recession has escalated. In general, the price of the first hotel is higher than the price of the second hotel, but the behavior of both hotels is similar in terms of price in the third and fourth scenarios. From the figure, it can be easily seen that with the reduction of marginal profit by the OTA, the price of both hotels will decrease in all scenarios. Therefore, in the game between supplier and retailer, whatever the OTA (as a retailer) requests in terms of lower marginal profit, the hotels (as suppliers) can offer a lower price to the customer as a supplement.

As shown in Fig. 6, the price of the first hotel offered by the OTA, acting as an intermediary, is generally higher than that of the second hotel across all scenarios. The hotel prices presented by the OTA remain relatively consistent throughout the different scenarios, indicating that there is no significant variation in pricing for the hotels under changing conditions.

It is noteworthy that as the marginal profits offered by the OTA to hotels increase, the prices of hotels presented to customers by the OTA decrease. In other words, within the competitive dynamics of the tourism supply chain, the OTA demands a higher marginal profit from hotels as suppliers, which in turn enables it to offer hotel accommodations to customers at lower prices.

The changes of $\varepsilon_1$and ε_2 related to π_{h1},π_{h2} and π_o are shown in Figs 7 to 9. In Fig. 7, the changes of $\varepsilon_1$and ε_2 are investigated related to π_{h1}. Fig. 7 shows that the difference of the profits of Hotel 1 between Scenarios 1 and 2 are very low. Likewise, the difference of profits between Scenarios 3 and 4 is very low. However, there is high difference between the profits of Hotel 1 in Scenarios 1 and 2, in comparison with Scenarios 3 and 4. By increasing$\varepsilon_1$and $\varepsilon_2$simultaneously, Scenario 1 is more desirable for Hotel 1, and decreasing $\varepsilon_1$and $\varepsilon_2$simultaneously makes Scenario 2 more desirable for Hotel 1. With low value of ε_1 and a high value of ε_2, Scenario 3 is a desirable for Hotel 1. However, by increasing ε_1, the profit of Hotel 1 in Scenario 4 is higher than the profit of Hotel 1 in Scenario 3. It can be seen that Scenarios 1 and 2 receive higher profits compared to Scenarios 3 and 4. Thus, Scenarios 3 and 4 are highly unpleasant for Hotel 1.

Fig. 8 shows the changes of ε_1 and ε_2 for the profit function of the second hotel. As seen, Scenario 2 is highly desirable for Hotel 2 in comparison with Scenario 1. However, the difference between profits of Hotel 2 in Scenarios 3 and 4 is very low. In general, the profit of Hotel 2 in Scenario 2 is higher compared to Scenarios 3 and 4 (i.e., recession situation). In general, the profit of Hotel 2 changes slightly by increasing ε_1 and ε_2, which shows that the profit is not highly sensitive to ε_1 and ε_2. Fig. 8 shows that Scenarios 3 and 4 are not desirable for Hotel 1, because its profits in these scenarios are very low due to the recession impacts.

Fig. 9 shows the profit of OTA a as retailer, related to the changes of ε_1 and ε_2. In general, the profit of OTA in Scenario 1 is greater than the profit of OTA in other scenarios. However, scenario 1 is highly sensitive to increasing ε_1, so that when ε_1 increases, the profit of OTA decreases dramatically. With a low value of ε_1 and a high value of ε_2, the profit of OTA is very high. It should be noted that the profit of OTA in Scenario 2 increases by increasing ε_1 and ε_2, so that the profit of OTA in Scenario 2 gets closer to the profit of OTA in Scenario 1. In general, Scenarios 3 and 4 (recession situation) are unpleasant for OTA, because the profits of Hotel 2 in these scenarios are very low. Scenario 3, in which the government supports the TSC, is better for OTA compared to Scenario 4, but by increasing ε_1, the profit of OTA in Scenarios 3 and 4 are the same.

Table 5
The impact of recession φon different factors in scenario 1 and 3.

φ	CBP	GNR	S	t_{h1}	t_{h2}	t_{o1}	t_{o2}	d_{o1}	d_{o2}	d_{h1}	d_{h2}
0	4390.3	-1318.1	34.2	13.7	72.2	-95.5	29	7.3	9.3	7.1	2.5
0.1	3447.1	-1108.3	30.8	10.4	62.3	-87.4	25.6	6.5	8.4	6.2	2.1
0.2	2617.6	-912.5	26.2	5.4	51.7	-79	22.8	5.7	7.4	5.4	1.8
0.3	1917	-755.2	22.2	0.6	41.5	-71.9	19.9	4.9	6.5	4.6	1.5
0.4	1335.7	-623.4	18.4	-4.7	31.5	-65.8	17.3	4	5.6	3.7	1
0.5	878.6	-528.2	14.7	-11.5	22.6	-61.9	16.1	3.3	4.8	3	0.5

Table 6
The impact of recession φ on different factors in scenario 2 and 4.

φ	CBP	S	d_{o1}	d_{o2}	d_{h1}	d_{h2}	D	GNR	U
0	3292.2	32.2	3.7	4.5	9.6	8	25.9	-	-
0.1	2544.9	28.2	3.3	4	8.4	7	22.8	-	-
0.2	1893.5	24.1	2.8	3.6	7.1	6	19.6	-	-
0.3	1338	20	2.3	3.1	6	5	16.5	-	-
0.4	878.5	16	1.9	2.7	4.7	4	13.4	-	-
0.5	515	12	1.4	2.2	3.5	3	10.3	-	-

6. Discussion

This section discusses the study's key results and interprets their implications for both theory and practice. First, a set of corollaries derived from the model are presented, highlighting how pricing strategies, government policies, and supply chain power structures affect profitability and sustainability in different economic scenarios. Following that, practical managerial insights are offered, aimed at guiding tourism stakeholders (particularly hotels, OTAs, and policymakers) on how to respond effectively to crises and support sustainable

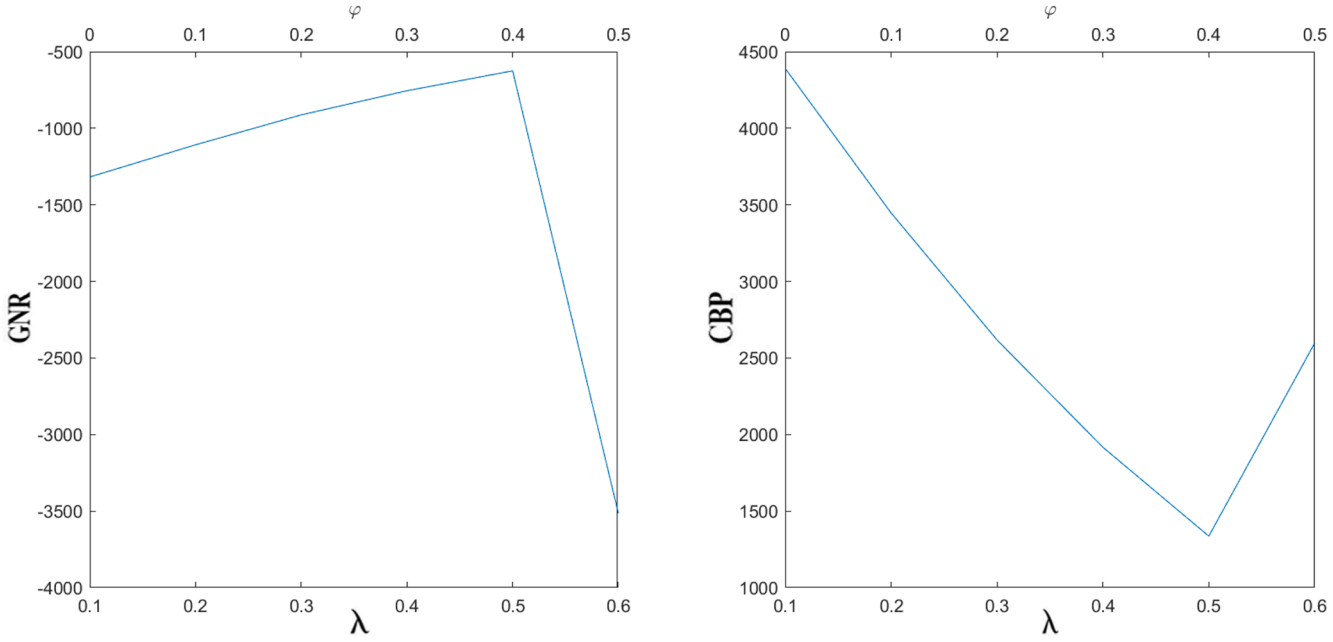

Fig. 4. The impact of government intervention on chain revenue and government revenue in a recession λ.

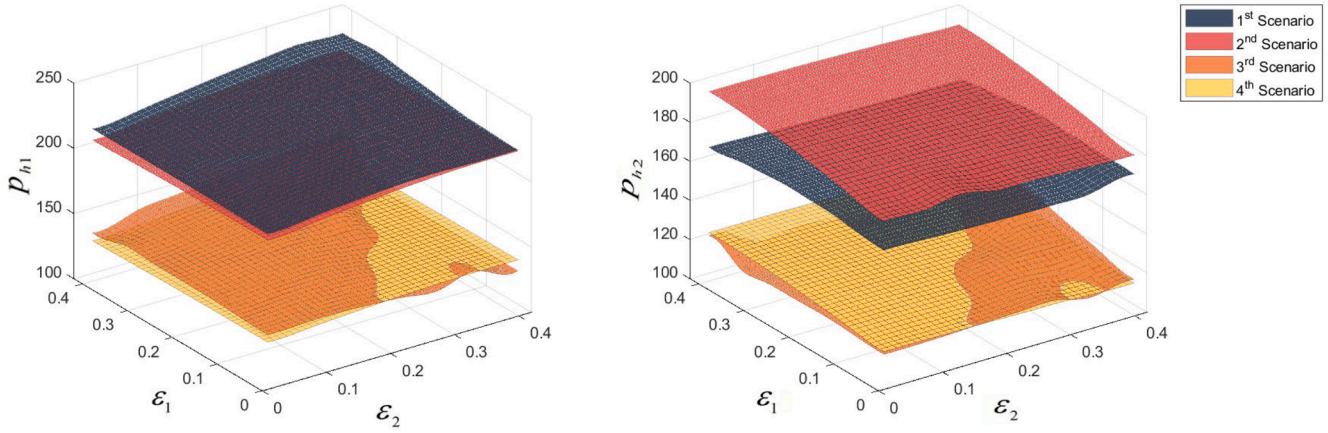

Fig. 5. The impact of OTA bargaining power on the price of the first hotel p_{h1} and p_{h2}.

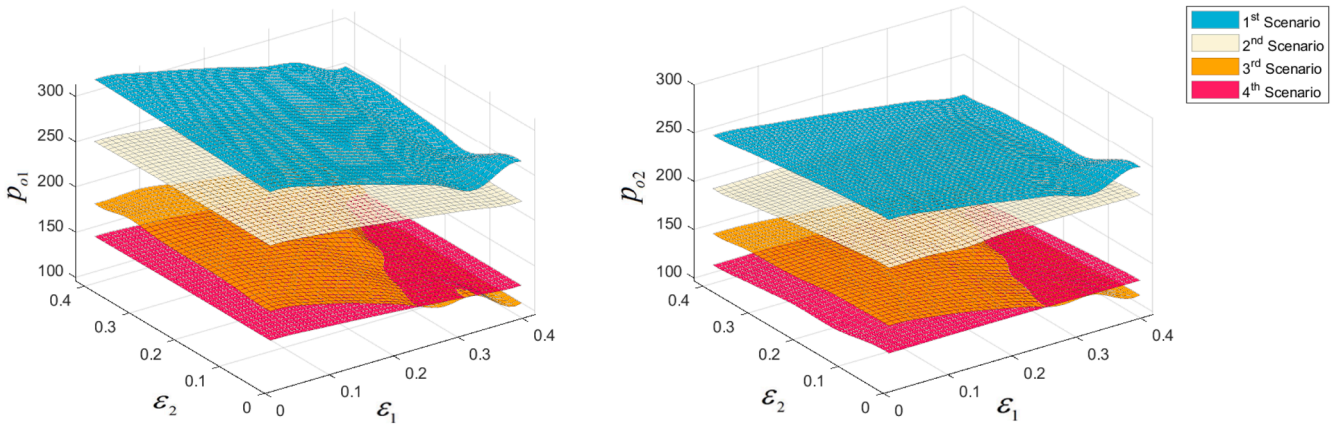

Fig. 6. The impact of bargaining power of OTA on the price of the first hotel p_{o1} and p_{o2}.

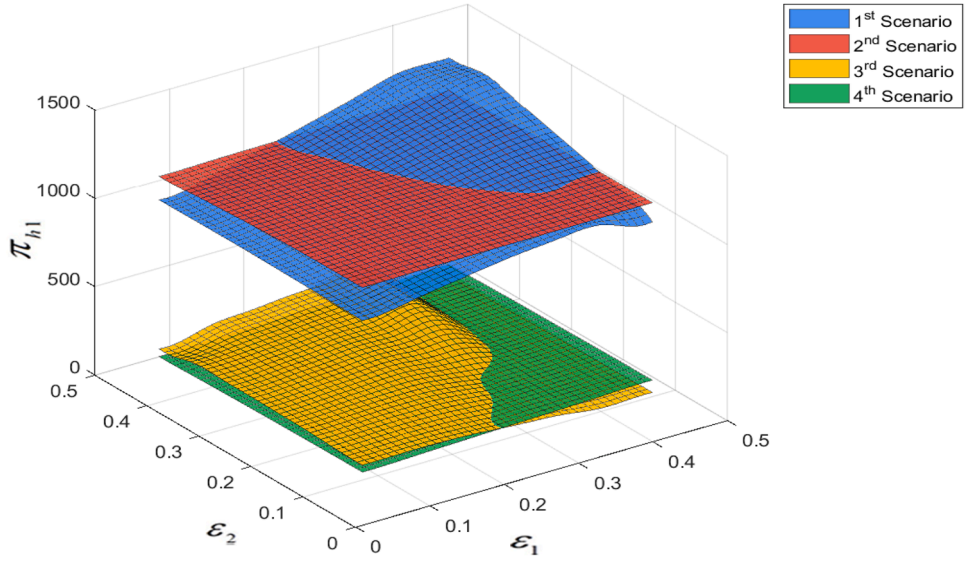

Fig. 7. The changes of ε_1 and ε_2 related to π_{h1}.

tourism supply chains.

6.1. Key findings and corollaries

- Corollary 1. The Price Sensitivity of Green Hotels During Economic Recessions

The results show that green hotels tend to offer higher prices in stable economic conditions, as many consumers are willing to pay more for environmentally responsible services. This supports previous findings that highlight the market value of green practices [14–16]. However, during economic downturns, the price gap between green and conventional hotels narrows significantly. As observed in Table 5, when the recession coefficient increases, green hotels like Hotel 1 are forced to lower their prices substantially, bringing them closer to those of non-green competitors. This behavior reflects how recession-driven financial pressure reduces customer willingness to pay for sustainability, placing pricing constraints on eco-friendly hotels. Since sustainability investments often involve long-term returns, green hotels are more exposed to pricing challenges during demand slumps [49]. To help mitigate this effect, policy tools like temporary subsidies or tax breaks targeted at green hotels could provide a buffer during crises. Additionally, strategic pricing tools, such as demand-based dynamic pricing or exclusive loyalty programs, can help green hotels maintain both profitability and competitiveness without compromising their sustainability commitments.

- Corollary 2. How OTA Margins Influence Hotel Pricing Behavior

Since the prices set by Hotels 1 and 2 as suppliers are independent of the final retail price, they tend to charge higher rates when offering rooms directly to consumers than when working through OTAs. This is because hotels retain full control of revenue through direct bookings, whereas OTAs apply commission-based pricing models. As OTA margins increase, the wholesale prices offered by hotels decrease in all scenarios, placing further pressure on hotels to reduce costs and remain listed competitively. This outcome reflects a broader challenge: while OTAs expand a hotel's reach and improve visibility, they also reduce pricing flexibility and squeeze profit margins. Research supports this trend, showing that OTAs often capture a large share of hotel bookings while simultaneously dictating price conditions that limit supplier autonomy [29,36–38]. For long-term financial resilience, hotels must reduce overreliance on OTAs by strengthening direct sales channels, including personalized marketing, loyalty programs, and bundled pricing strategies that are harder for OTAs to replicate.

- Corollary 3. Government Support Is Crucial for Green Hotel Profitability During Crises

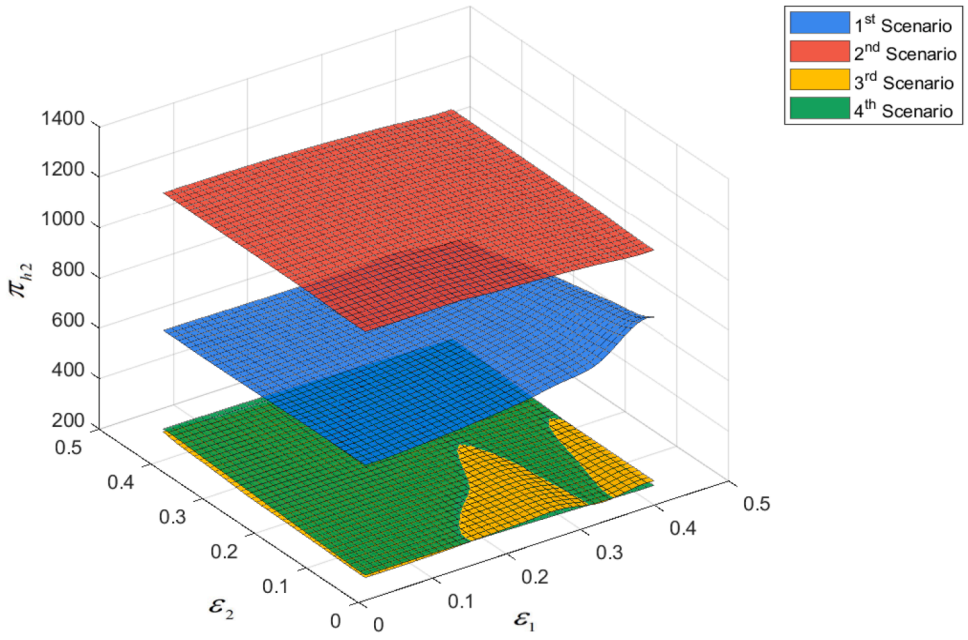

Fig. 8. The changes of ε_1 and ε_2 related to π_{h2}.

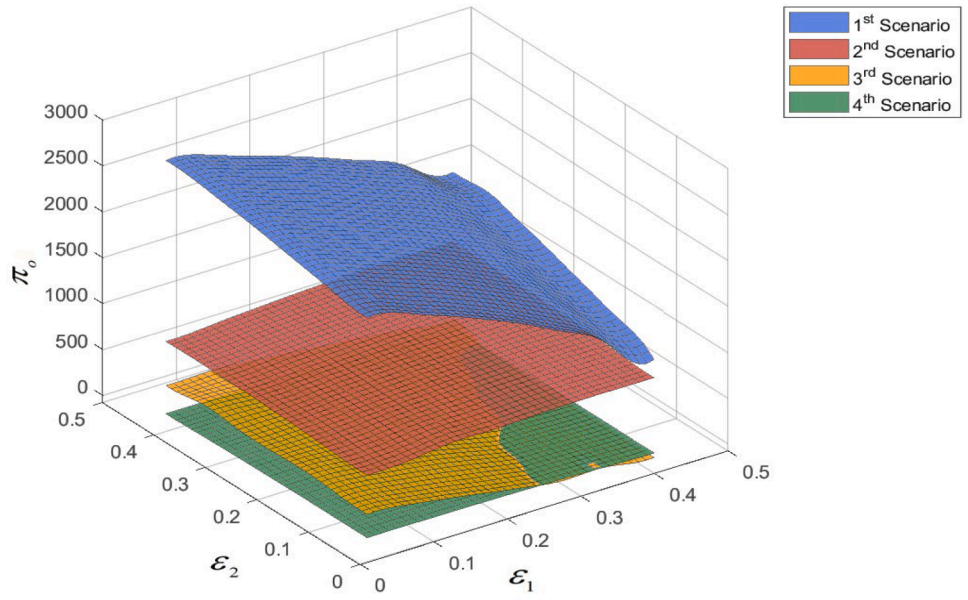

Fig. 9. The changes of ε_1 and ε_2 related to π_o.

Since Hotel 1 offers green services, its profits remain nearly the same in Scenarios 1 and 2 under normal conditions, suggesting that sustainability efforts can support profitability when the economic environment is stable. However, this resilience weakens during periods of economic recession. When demand declines and price sensitivity rises, profits fall for all hotels. In this context, Scenario 3 (government-led recovery) demonstrates that green hotels can regain financial ground, but only if OTAs also reduce their profit margins, allowing more revenue to remain with the hotel. In contrast, Hotel 2, which operates without green practices, performs better in Scenario 2, where hotels lead the market and the government does not intervene. This points to a significant vulnerability: green hotels depend more on external support, including both policy assistance and fairer supply chain relationships, to maintain profitability during downturns. These findings reinforce previous studies on the role of public policy in stabilizing the tourism supply chain and supporting environmentally focused firms [16,43]. They also echo concerns raised by Sharma, A. and Nicolau, J. L [22], who found that when tax policies treat all firms equally, green businesses, despite higher costs, face greater financial risks.

- Corollary 4. OTAs Benefit More Than Hotels from Government Policies

In all scenarios, OTAs consistently maintain the highest profits in the tourism supply chain, reinforcing their dominant role as intermediaries. This is most evident in Scenario 1, where government support is intended to stabilize the industry. Surprisingly, the policies benefit OTAs more than hotels, as their profit margins increase significantly in Scenarios 1 and 3 (with government involvement), compared to Scenarios 2 and 4 (without intervention). This pattern suggests that government

stimulus efforts, though designed to revive the sector, do not directly address the structural imbalance between OTAs and hotels. OTAs, which operate without physical assets and carry minimal overhead, can capitalize on increased booking activity sparked by tourism recovery policies. Meanwhile, hotels continue to bear fixed costs and operational responsibilities but see only marginal improvements in revenue. While prior studies have explored OTA pricing power [29,36–38], this research highlights how government intervention may unintentionally amplify the financial advantage of intermediaries. To correct this, policymakers should consider reforms such as temporary caps on OTA commissions during recovery phases or directing financial support more precisely to accommodation providers. Without such adjustments, hotels, particularly those investing in sustainability, will continue to face structural disadvantages, even during periods of policy-driven market recovery.

This study extends previous research on tourism supply chains (TSCs) by explicitly incorporating the role of government intervention during economic crises. While earlier studies by Mousavi, E. S., Hafezalkotob, A. and Makui, A [43], and Long, Y. and Shi, P [44] have examined pricing strategies for hotel competitiveness, they have not analyzed how taxation disproportionately can affect green hotels or how government intervention shapes OTA-hotel dynamics. Furthermore, this research fills the gap in understanding how recession periods reshape hotel profitability and sustainability efforts. Unlike previous works that focused on single-period pricing models, this study evaluates multiple economic scenarios (with and without recessions) to provide a more comprehensive view of the tourism supply chain.

While many of our findings align with established theories in tourism supply chain management, this study also reveals counterintuitive insights, such as the disproportionately negative impact of taxation on green hotels, the unintended advantage gained by OTAs from government interventions, and the paradoxical short-term increase in government revenue during economic recessions. These findings challenge conventional assumptions and highlight the need for more nuanced policy approaches to sustain the tourism industry in times of economic uncertainty.

- Taxation policies disproportionately harm green hotels. Contrary to the expectation that sustainable hotels remain competitive due to eco-conscious consumer demand, our findings indicate that taxation places a heavier financial burden on green hotels, which may discourage their sustainability efforts. This is especially true during economic recessions when price sensitivity increases.
- Government interventions benefit OTAs more than hotels. While governments aim to stabilize the tourism sector, OTAs gain more than hotels due to their flexibility in adjusting prices and commission structures. This suggests that policy measures should be more targeted toward hotel sustainability rather than broad supply chain interventions.
- Government revenue temporarily increases despite economic recessions. In contrast to conventional economic assumptions, our study finds that taxation can lead to short-term revenue growth for governments, even during downturns. However, this revenue gain may come at the cost of long-term tourism sustainability, as increased financial pressure weakens businesses.

These findings provide new perspectives on policy design for tourism supply chains, highlighting the need for more nuanced fiscal strategies.

6.2. Management insights

This study provides several practical insights for decision-makers in the tourism industry, particularly during economic recessions:

- Targeted Government Support: Governments play a crucial role in stabilizing tourism supply chains. Policies such as temporary tax relief, subsidies for green initiatives, and financial aid during crises can help hotels, especially green hotels, maintain operations and continue their environmental efforts.
- Strategic Pricing and Cost Management for Hotels: Green hotels must prepare for price pressures during downturns. Implementing dynamic pricing strategies and cost-effective green investments can help sustain profitability while upholding environmental commitments.
- Reducing OTA Dependency: Hotels should boost direct booking channels and build customer loyalty programs to reduce reliance on OTAs, which tend to gain more from government interventions and may erode hotel margins.
- Fair Commission Models and Collaboration with OTAs: OTAs are critical intermediaries but should consider adjusting their commission structures during crises to support hotel partners. Greater collaboration and transparency between hotels and OTAs can improve supply chain resilience.
- Green Investment as a Long-Term Strategy: While recession periods reduce the profitability of green hotels, investing in sustainability remains beneficial in the long run. Governments and businesses should view green initiatives not only as cost factors but also as competitive differentiators and future-proofing measures.
- Scenario-Based Planning: Hotel managers and policymakers should adopt scenario-based strategic planning, as demonstrated in this study's four modeled conditions. Understanding how different levels of government involvement and economic severity affect supply chain dynamics enables better preparedness and response strategies.

7. Conclusion

This study investigated the impact of government intervention policies on tourism supply chains, focusing on the interactions between green and non-green hotels and online travel agencies (OTAs) under both stable and recessionary economic conditions. Using a game-theoretic framework, the research modeled strategic decision-making within the supply chain and evaluated outcomes across four distinct scenarios. The results show that taxation policies, particularly during economic downturns, disproportionately reduce the profitability of green hotels, potentially discouraging sustainability investments. While government interventions aim to stabilize the tourism sector, the benefits often shift toward OTAs, who typically gain more than hotels under these policies. Green hotels, though more competitive in normal market conditions due to higher demand and pricing power, face greater vulnerability during recessions unless supported by targeted policy measures. This study addressed three central research questions:

- Government intervention: The findings demonstrate that well-designed public policies, such as tax relief or subsidies, can strengthen supply chain resilience, enhance hotel competitiveness, and promote green service adoption.
- Green servicing innovation: Environmentally friendly practices improve hotel reputation and attract eco-conscious customers, but their long-term viability depends on favorable market conditions and policy support.
- Power structure: The hierarchical relationships modeled through the Stackelberg game significantly affect pricing, demand allocation, and profit margins within the supply chain, especially during crises.

For future research, the proposed model can be extended in several meaningful directions. First, the framework could incorporate heterogeneous hotel classes (e.g., 3-star, 4-star, and 5-star hotels), which would reflect more realistic market competition and customer segmentation. Second, introducing dynamic or uncertain demand patterns, such as inflation, or rapid market shifts, would enhance the model's predictive power in real-world conditions. Third, the problem of seasonal fluctuations, discount policies, and customer loyalty programs could provide deeper insights into pricing strategies and customer retention

during both peak and off-peak periods. Additionally, the model could be adapted to account for carbon pricing mechanisms or green certification incentives, enabling a more comprehensive evaluation of environmental policy tools. Considering international tourism flows and cross-border supply chains, especially in regions heavily dependent on foreign tourists, could further increase the model's global relevance. Finally, exploring multi-agent or platform-based decision-making structures, where OTAs and hotels dynamically negotiate commissions or collaborate on green marketing strategies, may reveal new opportunities for improving coordination and sustainability in tourism supply chains.

Ultimately, the findings highlight the importance of well-designed public policies and collaborative strategies among tourism stakeholders. Ensuring financial stability and promoting sustainability in this sector, particularly during economic downturns, requires coordination, innovation, and adaptive policy-making.

CRediT authorship contribution statement

Elham Sadat Mousavi: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors are unable or have chosen not to specify which data has been used.

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