

# The Balance Between Economic Development and Environmental Protection: Sustainable Tourism in Juneau City

Binhan Yang<sup>1, #</sup>, Qitong Gao<sup>1, #</sup>, Ziteng Wang<sup>1, #</sup>, Xuqi Cao<sup>1, #</sup>, Nana Hu<sup>2, #</sup>

<sup>1</sup>Finance and Investment College, Hebei Finance University, Baoding 071000, China

<sup>2</sup>Han Dan No.4 Middle School, Handan 056000, China

<sup>#</sup>These authors contributed equally.

---

**Abstract:** To effectively balance economic gains and ecological conservation in tourism-intensive cities, this study examines Juneau, Alaska—a quintessential tourism-dependent city—and constructs a multi-objective optimization framework for sustainable tourism based on a stochastic movement model. By modeling the stochastic fluctuations of beer and housing prices and incorporating symbolic functions to quantify tourist behavior choices and local residents' response strategies, the framework establishes a constrained optimization model to systematically optimize overall social, economic, and environmental benefits. Key parameters were estimated using linear regression methods, combined with Monte Carlo simulation techniques to conduct stochastic simulations and evaluations of profit and sustainability indicators under various scenarios. Results indicate that setting hotel accommodation prices at \$160 per night and limiting annual visitor numbers to approximately 15,800 can maximize regional profits while significantly reducing environmental pressure, thereby alleviating resource competition between local communities and external tourists. The modeling mechanism proposed in this study not only provides a scientific quantitative decision-making tool for the sustainable development of resource-constrained tourism cities but also holds significant theoretical value and practical guidance for advancing tourism policy design that balances equity and efficiency.

**Keywords:** Tourism Economy, Sustainable Profit Optimization Model, Resilience Analysis, Regional Economy, Tourism Scale.

---

## 1. Introduction

Juneau, Alaska, as a quintessential polar fringe tourism city, has seen its annual visitor numbers far exceed its local population by dozens of times in recent years due to the rapid growth of cruise and ecotourism. Tourism has become the backbone of its economy [1]. However, the surge in visitors has led to overburdened urban infrastructure, declining community quality of life, and sustained pressure on fragile ecosystems. Particularly against the backdrop of climate change, issues like glacial retreat and localized greenhouse gas accumulation have become increasingly prominent [2-4]. To address these challenges, the local government has implemented management measures including increased hotel taxes, visitor fees, daily visitor caps, and alcohol sales restrictions. These policies aim to alleviate environmental and social pressures while channeling new fiscal revenues toward ecological conservation and community development [5]. However, while mitigating tourism's negative impacts, these policies also pose potential disruptions to economically dependent industries, revealing significant divisions in resident attitudes. This underscores the urgent need to achieve synergistic balance among economic growth, environmental protection, and social welfare [6-7].

This study addresses Juneau's sustainable tourism management challenges by employing OLS regression analysis, optimization techniques, and sensitivity testing to identify key regulatory variables influencing sustainability (e.g., visitor caps, pricing mechanisms, and environmental strategies). Regression analysis explores linear relationships between alcohol sales, hotel pricing, and tourism demand to

identify optimization opportunities. These regression results are then embedded as input parameters into an optimization model to derive optimal pricing strategies, visitor capacity limits, and environmental management measures, achieving synergistic optimization between economic benefits and sustainability goals. Sensitivity analysis assesses model outputs' responsiveness to key parameter changes, enhancing policy formulation robustness [8]. This research provides scientific decision support for Juno City while offering a scalable modeling framework and policy paradigm for ecologically sensitive destinations globally facing overtourism challenges.

## 2. Overview of the Study Area and Data Sources

As a remote capital city dependent on tourism, Juneau faces typical challenges such as environmental degradation and infrastructure strain driven by tourist growth. Its adaptive governance strategies—implemented through fiscal and regulatory tools like hotel taxes and visitor capacity management—provide a critical case study for examining policy interventions and socio-ecological resilience in the sustainable transformation of tourism destinations.

This study employs a multi-source data synthesis approach, integrating macroeconomic indicators, environmental monitoring data, and social survey findings to comprehensively assess Juneau's tourism sustainability [9]. Economic data originate from official statistics of the Juneau Tourism Bureau and Alaska Department of Revenue, covering quarterly data from 2015 to 2023, including visitor numbers, average hotel room rates, total alcoholic beverage

sales, and tourism-related taxes. Environmental data were provided by the Alaska Department of Environmental Conservation and the U.S. Geological Survey (USGS), primarily including greenhouse gas concentration monitoring data (CO<sub>2</sub> and CH<sub>4</sub>) in glacial areas, municipal solid waste disposal volumes, and freshwater resource consumption records. Additionally, to capture stakeholder subjective feedback, this study conducted stratified sampling surveys during 2022–2023, collecting satisfaction ratings from local residents (n=320) and tourists (n=280) regarding tourism policies, service pricing, and ecological impacts.

### 3. Research Framework and Methods

To solidify the theoretical foundation for constructing sustainable profit models, this study first focuses on establishing a dual-subject economic system. The construction of this foundational system aims to provide a clear and actionable starting point for subsequent analyses in more complex scenarios. Its core lies in capturing the interaction mechanisms, profit distribution patterns, and resource flow pathways between the two economic entities. Building upon this foundation, the analysis framework is further extended to encompass a more universally applicable economic scenario involving  $n$  entities. This expansion aims to comprehensively reflect the complex dynamics of multiple entities coexisting and influencing each other within real-world economic environments.

At the theoretical hypothesis level, this study adopts a perfectly competitive market as its analytical backdrop. This assumption not only aligns with the analytical paradigm of classical economic theory—eliminating monopolistic interference in market mechanisms—but also facilitates clearer revelation of how market supply-demand dynamics and price formation mechanisms influence subject decision-making [10]. Regarding specific research subjects, this study conducts an in-depth examination of purchasing decisions for a particular category of goods.

Establish the demand equation:

$$Q_{td} = -\alpha_t P_{td} + Q_c \quad (\alpha_t > 0, Q_c \in \mathbb{R}) \quad (1)$$

The supply equation also satisfies a linear relationship:

$$Q_{ts} = \beta_t P_{ts} + Q_e \quad (\beta_t > 0, Q_e \in \mathbb{R}) \quad (2)$$

(The coefficients for the two equations can be determined by performing a least-squares fit using historical data.)

In a perfectly competitive market, the supply price and the demand price are identical, thereby establishing the profit equation.

Assume  $P_t = P_{td} = P_{ts}$ , the following equation is established:

$$\Pi_t(P_t) = -[\hat{\alpha}_t(I_{1t} + I_{2t}) + \hat{\beta}_t]P_t^2 + [\hat{Q}_c(I_{1t} + I_{2t}) - \hat{Q}_e]P_t \quad (3)$$

To characterize the impact of decision-making behavior on the system, this study defines two binary decision indicator variables  $I_{1t}$  and  $I_{2t}$ . When an agent executes a decision action,  $I_{1t}$  is assigned a value of 1; if no decision is made, it takes the value 0. The variable  $I_{2t}$  follows the same assignment logic, thereby clearly delineating the occurrence or absence of a decision.

From the perspective of system evolution, there exists a well-defined mapping mechanism: a system originally operating in a continuous mode, denoted as  $Q_{td}P_{td}$ , transitions into a discrete system upon the introduction of decision variables, expressed as  $Q_{td}P_{td}(I_{1t} + I_{2t})$ . Here,  $Q_{td}P_{td}$  represents the system in its continuous dynamic state in the absence of decision intervention, while  $Q_{td}P_{td}(I_{1t} + I_{2t})$

exhibits discrete state changes contingent on the presence or absence of decisions. This formulation precisely captures the shaping effect of decision variables on the system's operational mode, providing a foundational mathematical framework for subsequent analysis of system behavior under decision-driven dynamics.

To derive the optimal price, this study takes the first-order condition with respect to profit, resulting in the following equation:

Setting the first-order condition equal to zero yields the optimal solution for price (this belongs to the solution obtained from the continuous system):

$$P_t^* = \frac{(I_{1t} + I_{2t})\hat{Q}_c - \hat{Q}_e}{2[\hat{\alpha}_t(I_{1t} + I_{2t}) + \hat{\beta}_t]} \quad (4)$$

Research has revealed a direct and significant correlation between the formation mechanism of market equilibrium prices and the decision-making behavior of participants. Within the analytical framework of a two-agent game, this study defines each economic agent's decision space as a binary discrete choice (where the decision variable takes values of 0 or 1), with their decision-making behavior following specific probability distribution characteristics. This setting aligns with the reality that economic agents often face either-or choices in practice.

Based on the above assumptions, the strategic interaction between the two agents will yield four possible decision combinations, which can be fully characterized in the two-dimensional vector space  $\{(0,0), (0,1), (1,0), (1,1)\}$ . It is particularly noteworthy that due to the symmetry in the decision-making structure between the two agents (i.e., no a priori status differences or weighting disparities exist between them), the decision combinations (0,1) and (1,0) exhibit complete equivalence in the market price formation process—both exert identical effects on supply and demand dynamics, ultimately converging toward the same price determination pathway.

At the same time, the optimal prices obtained from solving the three scenarios above can be summarized into a general formula:

$$\text{When } 0 \leq m \leq n, P_t^* = \frac{m\hat{Q}_c - \hat{Q}_e}{2[m\hat{\alpha}_t + \hat{\beta}_t]} \quad (5)$$

Substituting into the profit equation yields:

$$\Pi_t(P_t^*(m)) = \frac{(m\hat{Q}_c - \hat{Q}_e)^2}{4(m\hat{\alpha}_t + \hat{\beta}_t)} \quad (6)$$

To clarify the intrinsic relationship between the number of optimal profit values and the number of participants' decisions, this study integrates mathematical induction with visualization techniques. Through multiple rounds of inductive analysis, this study finds that: When the total number of market decision-makers is  $n$ , the possibility space of system decision schemes exhibits  $2^n$  distributions—this result stems from the combinatorial expansion of each participant's binary decision dimensions (basic decision units such as participate/not participate, choose strategy A/choose strategy B, etc.). Correspondingly, optimal profits manifest  $(n+1)$  distinct value patterns. Crucially, the dynamic evolution of these value patterns is profoundly constrained by the probabilistic distribution characteristics of the  $n$  participants' decision-making behaviors. Shifts in the mean, fluctuations in variance, and differences in distribution types (e.g., normal distribution, Poisson distribution) directly shape the distribution center, dispersion level, and evolutionary

trajectory of optimal profit values, constituting the core intrinsic mechanism for profit regulation.

Analyze the profit equation and complete the model feasibility proof.:

Solve the first-order condition for  $\Pi$  with respect to  $m$  to obtain the following equation:

$$\frac{d\Pi_t(P_t^*(m))}{dm} = \frac{(m\widehat{Q}_c - \widehat{Q}_e)(\widehat{Q}_c\widehat{\alpha}_t m + 2\widehat{Q}_c\widehat{\beta}_t + \widehat{\alpha}_t\widehat{Q}_e)}{4(m\widehat{\alpha}_t + \widehat{\beta}_t)^2} \quad (7)$$

$$m^* = \frac{-(\widehat{\alpha}_t\widehat{Q}_e + 2\widehat{\beta}_t\widehat{Q}_c)}{\widehat{Q}_c\widehat{\alpha}_t} \quad (8)$$

From the second-order condition, this study obtains the following equation:

$$\frac{d^2\Pi_t(P_t(m))}{dm^2} = \frac{(\widehat{\alpha}_t\widehat{Q}_e + \widehat{\beta}_t\widehat{Q}_c)^2}{2(m^*\widehat{\alpha}_t + \widehat{\beta}_t)^3} \quad (9)$$

$$m^*\widehat{\alpha}_t + \widehat{\beta}_t = \frac{\widehat{\alpha}_t\widehat{Q}_e + \widehat{\beta}_t\widehat{Q}_c}{\widehat{Q}_c} \quad (10)$$

Assuming the commodity is normal and satisfies  $\widehat{\alpha}_t > 0, \widehat{Q}_c > 0, \widehat{Q}_e < 0, \widehat{\beta}_t > 0$ , and given that  $m^* > 0$ , it follows that  $\widehat{\alpha}_t\widehat{Q}_e + 2\widehat{\beta}_t\widehat{Q}_c < 0$ . Additionally, since  $\widehat{Q}_c\widehat{\beta}_t + \widehat{\alpha}_t\widehat{Q}_e < \widehat{\alpha}_t\widehat{Q}_e + 2\widehat{\beta}_t\widehat{Q}_c$  and  $\widehat{Q}_c\widehat{\beta}_t > 0$ , this study can conclude that  $\widehat{\alpha}_t\widehat{Q}_e + \widehat{\beta}_t\widehat{Q}_c < 0$ . Therefore, the second-order condition is greater than 0.

Mathematical derivation clearly demonstrates that, theoretically and in the absence of other constraints, profits exhibit a positive correlation with the number of decision-makers involved—in the context of tourism operations, this refers to the number of visitors.

However, by reasonably setting specific visitor thresholds and precisely adjusting pricing strategies, profits can be made to fluctuate within a predefined range. This approach lays a solid foundation for the long-term sustainability of business operations, ensuring the stable and continuous development of the operational system.

## 4. Modeling and Empirical Results Analysis

### 4.1. Data Description

The following section further extends the optimization

approach introduced in this study to model the tourism economy of Juno City. Focusing on the core arena of economic activity in tourism cities, this research systematically explores the dynamic game-theoretic mechanisms among three key actors: residents, tourists, and tourist attractions. Against the backdrop of a booming tourism industry, the continuous expansion of visitor numbers not only brings significant economic growth to destinations—driving job creation, infrastructure upgrades, and synergistic development across related sectors—but also inevitably exerts multifaceted impacts on local socio-ecological systems—specifically manifested as the compression of residents' daily living spaces, increased pressure on public service resources (such as transportation, healthcare, and education), and disturbances to the ecological environment surrounding scenic areas (including vegetation coverage, water quality, and air quality). These negative externalities derived from tourism activities exhibit more concentrated and pronounced characteristics in areas adjacent to scenic spots, becoming a key bottleneck constraining the sustainable development of tourism destinations.

Addressing these contradictions, the theoretical model developed in this study centers on achieving synergistic optimization among tourism economics, social welfare, and ecological conservation. It sets total profit maximization as the primary objective function while simultaneously embedding dual constraints: ecological costs (encompassing environmental restoration investments, ecological compensation mechanisms, and sustainable resource utilization costs) and social costs (including compensation for diminished resident quality of life, governance costs for overloaded public services, and community relations coordination costs). By integrating multidimensional influencing factors—such as tourist consumption preferences, resident acceptance thresholds, and attraction operational efficiency—the model conducts comprehensive optimization analysis. It aims to precisely identify the dynamic equilibrium zone among resident satisfaction, tourist experience quality, and attraction profitability. Ultimately, it provides an actionable theoretical framework and decision-making basis for tourism cities to achieve a win-win scenario of economic growth and sustainable development.

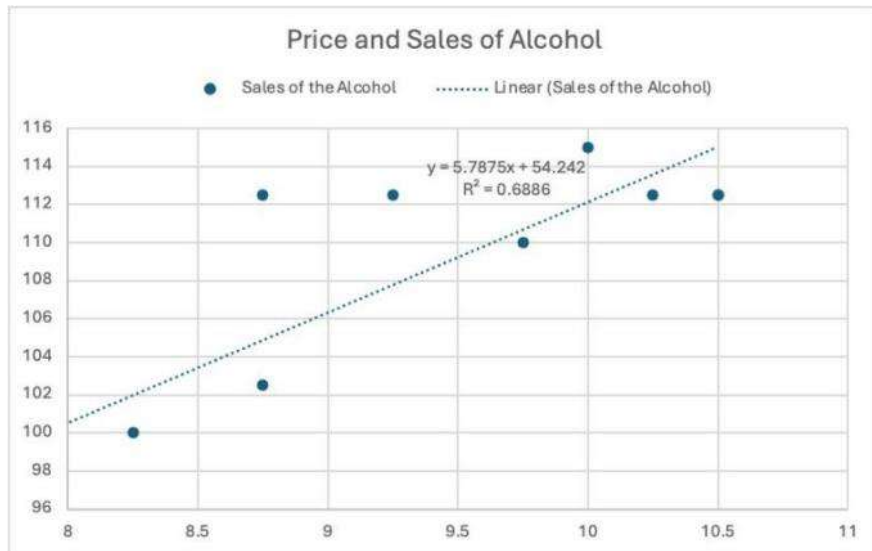


Figure 1. Price and sales of alcohol

Figure 1 visually demonstrates a significant positive correlation between the sales volume of alcoholic beverages and their prices. This phenomenon carries particular economic significance in tourism contexts, revealing that tourist demand for alcoholic beverages exhibits high price elasticity during price fluctuations—meaning minor price

changes trigger more pronounced corresponding adjustments in sales volume. This sensitive demand-side response mechanism provides crucial empirical evidence for understanding the supply-demand dynamics of alcoholic beverages in tourism markets and lays a vital demand-side foundation for subsequent profit function modeling.

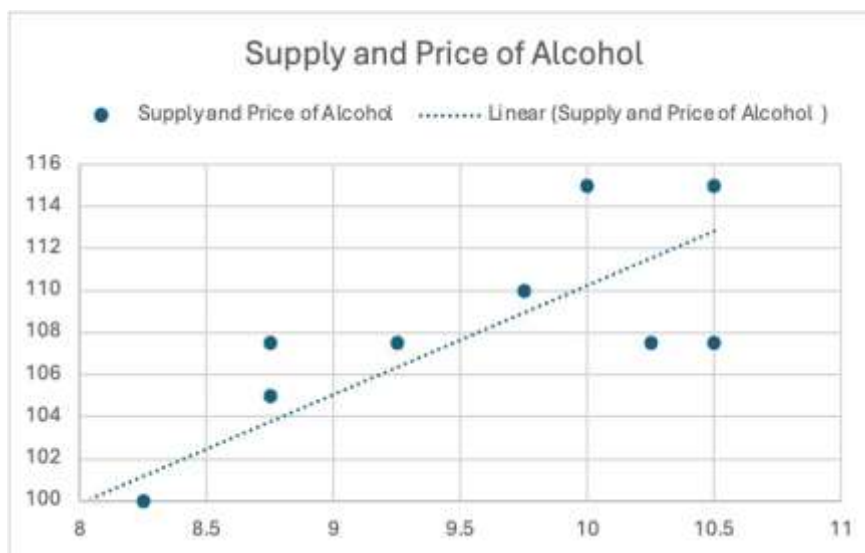


**Figure 2.** Supply and price of alcohol

Figure 2 clearly reveals the correlation pattern between the supply volume and price of alcoholic beverages: the two exhibit an overall positive linkage trend, meaning that when prices rise, supply tends to increase, and vice versa. This aligns with the incentive mechanism of price on supply in classical supply theory. However, the data series exhibits

significant volatility, indicating that the supply curve does not follow a strictly monotonic, smooth trajectory but is instead influenced by multiple exogenous variables beyond price.

The complex volatility observed on the supply side underscores the necessity for systematic modeling of supply uncertainty when constructing theoretical frameworks.



**Figure 3.** Price and need of hotel

Figure 3 shows the dynamic interplay between supply volume and price within the alcoholic beverage supply system. Overall, the two exhibit a pronounced positive correlation: as price levels rise, supply volume generally increases. This aligns with the core proposition of classical supply theory that “price signals guide production decisions.” However, the data series exhibits pronounced volatility—manifested in large and uneven residuals deviating from the fitted regression line. This indicates that dynamic adjustments on the supply side

are driven not only by price as the core independent variable but also significantly influenced by a series of exogenous disturbance factors.

## 4.2. Model Establishment

Based on the principles of the supply-demand model, the following model is established for the tourism industry in Juno City, incorporating constraints to ensure sustainable economic operations:

$$\begin{aligned} \Pi_t = & P_{tdgood} (\beta_{good} - \alpha_{good} P_{tgood}) (i \sum I_{tdigood} + j \sum I_{djgood}) \\ & + (P_{tdrive} + T_{trive}) (\beta_{live} - \alpha_{live} P_{trive}) i \sum I_{tdilive} \\ & + P_{tice} (i \sum I_{tice} + j \sum I_{tjice}) + P_{train} (i \sum I_{ittrain} + j \sum I_{jttrain}) \quad (11) \\ & - [P_{dgood} (\varepsilon_{good} + \gamma_{good} P_{dgood}) + P_{tlive} Q_{slive}] \\ & - [Z_{twater} + Z_{trubbish} + (P_{coz} - T_{tlive}) (i \sum I_{tice} + j \sum I_{tjice})] \end{aligned}$$

Sustainable Economy Constraints:

$$\sum_i I_{t(i)ice} + \sum_j I_{t(j)ice} = \exp \left[ -F \left( \sum_i I_{tice} + \sum_j I_{tjice} \right) \right] \quad (12)$$

$$\sum_i I_{tice} + \sum_i I_{tdlive} + \sum_i I_{twale} + \sum_i I_{ttrain} = Y_t \quad (13)$$

$$\left( \sum_i I_{tice} + \sum_j I_{tjice} \right) \leq \max Y \quad (14)$$

The following continuous optimal pricing formula is obtained using the Lagrange multiplier method:

$$P_{tdgood}^* = \frac{\widehat{\beta_{good}} (\sum_i I_{tdigood} + \sum_j I_{tdjgood}) - \widehat{\varepsilon_{good}}}{2 [\widehat{\alpha_{good}} (\sum_i I_{tdigood} + \sum_j I_{tdjgood}) + \widehat{\gamma_{good}}]} \quad (15)$$

$$P_{tdlive}^* = \frac{\widehat{\beta_{live}} - T_{live} \widehat{\alpha_{live}}}{2 \widehat{\alpha_{live}}} \quad (16)$$

### 4.3. Model results



Figure 4. Profit analysis

Figure 4 visually illustrates the optimization characteristics of discrete optimal solutions while clearly depicting the dynamic relationship between optimal price and optimal profit. Specifically, when the price is set at \$140, the corresponding profit level is approximately \$300 million; whereas when the price is adjusted to \$160, profit reaches its maximum value of approximately \$350 million. This outcome reveals the significant impact of the price variable on profit levels, indicating the existence of an optimal price range that maximizes profits.

From a practical perspective, these findings provide clear quantitative guidance for formulating pricing strategies. Based on the characteristics of the optimal solution reflected in the graph, it is recommended to stabilize the price around \$160 with minor fluctuations. This pricing strategy not only achieves the core objective of profit maximization but, more importantly, enables moderate price regulation to balance market supply-demand dynamics and resource allocation efficiency while safeguarding economic returns. It lays the

foundation for sustainable development and steady-state growth within the economic system. This dynamic equilibrium pricing mechanism accommodates both short-term profit targets and long-term sustainability requirements, fostering a virtuous cycle of “profit enhancement—resource optimization—steady-state growth.”

### 4.4. Elasticity Analysis

Building upon the initial model, this section further incorporates the temporal dimension and tax elasticity, abandoning the assumption of constant taxation. It examines how changes in price, visitor numbers, and tax rates over time influence profit-maximizing strategies (11). The model objective shifts to identifying the elastic equilibrium point between visitor numbers and price within a dynamic environment, ensuring the system maintains a dynamic equilibrium between ecological carrying capacity and economic profit.



**Figure 5.** Profit and price

In Figure 5, by extending the random walk model to account for the impact of variable taxes on profits, this study finds that optimal profits reach their minimum at a price of \$140, amounting to approximately \$3.18 million. Conversely,

optimal profits peak at a price of \$175, reaching roughly \$3.47 million. Therefore, the optimal housing price can be set at around \$170.



**Figure 6.** Profit and visitors

In Figure 6, by extending the model through a random walk approach and accounting for the impact of fluctuating visitor numbers on profits, it was found that optimal profits reach their minimum value of approximately \$3.18 million when visitor numbers are 17,400. Conversely, optimal profits peak at approximately \$3.47 million when visitor numbers are 15,600. Therefore, the optimal visitor count can be maintained around 15,800.

## 5. Conclusions

This study uses Juneau, Alaska as a case study to construct a multi-objective optimization model integrating economic benefits and sustainability goals, aiming to reconcile the conflicts between economic growth, environmental protection, and social welfare in tourism development. Based on tourism economic and environmental monitoring data from 2015 to 2023, OLS regression analysis reveals the elastic relationship between hotel prices and tourist demand. Combined with a constrained optimization model, optimal

management strategies are derived. Results indicate that regional tourism profits are maximized when accommodation prices stabilize at \$160 per night and annual visitor volume is capped at 15,800, effectively alleviating infrastructure strain and resource competition conflicts. Sensitivity analysis further confirms that price and visitor volume are critical variables regulating system stability. Moderately increasing prices while controlling visitor flow enables a sustainable “high-revenue, low-impact” pathway. These findings provide quantifiable decision support for Juneau and other ecologically sensitive tourism destinations.

Future research may optimize data collection methods to enhance the Markov properties of data sequences and reduce the model's path dependence on historical data. Additionally, incorporating more granular behavioral data and expanding non-economic indicators could strengthen the model's applicability and policy guidance value within complex socio-ecological systems.

## References

- [1] Wang Ziteng, Cao Xuqi, Shao Hanyu, et al. A study of the impact of short cultural and travel videos on urban tourism intention[J]. *Journal of Education, Humanities and Social Sciences*, 2025(51): 121–130.
- [2] Chen Jing, Wei Peng. Research on high-quality development of rural tourism economy in the Chengdu-Chongqing region[J]. *Agricultural Economy*, 2025(3): 143–144.
- [3] Li Weihao, Zhao Qi. Current status and countermeasures of tourism resource development in Ya'an City[J]. *Journal of Shanxi University of Finance and Economics*, 2024, 46(S2): 107–109.
- [4] Cui Jiasheng, Li Fengjiao, Wang Ling'en, et al. Spatiotemporal responses of ice-snow tourism activities in Northeast China under climate change[J]. *Geographical Research*, 2025, 44(5): 1361–1377.
- [5] Yuan Baohua. Response strategies for brand crises in budget hotels: From the perspective of relationship repair[J]. *Business Economics Research Journal*, 2022(20): 85–88.
- [6] Hu Di, Lei Ling, Tang Hongjiu. Mechanism analysis of tourists' perception of regional cultural authenticity on place attachment and loyalty[J]. *Regional Research and Development*, 2025, 44(3): 110–117.
- [7] Xie Chaowu, Zhu Hai, Zhang Kun. Compatibility relationship and policy implications of high-quality integration of Chinese culture and tourism industries[J]. *Journal of Natural Resources*, 2025, 40(4): 1084–1106.
- [8] Liu Jiaxue, Tan Xiaoli. Research on the impact of tourism consumption on regional income inequality: Based on panel data regression model[J]. *Business Economics Research Journal*, 2024(18): 176–179.
- [9] Lin Haibo, Jiang Siyuan. Sustainable tourism development and transformation of consumption behavior: Path selection of consumption resource efficiency in the new economic era[J]. *Business Economics Research Journal*, 2024(24): 189–192.
- [10] Liu Yi, Xiao Wenjie, Ji Jiehan. Research on the shock transmission mechanism of tourism economic system resilience[J]. *Social Scientist*, 2024(2): 69–77.