为评估模型的稳健性并分析关键参数对结果的影响，本文对游客容量、环保税率和满意度阈值三个参数进行了敏感性分析。分析结果表明，模型在参数变动下具有较强的稳定性，各指标变化范围均在可接受范围内。

To evaluate the model robustness and analyze the impact of key parameters on the results, this study conducted a sensitivity analysis on three parameters: tourist capacity, environmental tax rate, and satisfaction threshold. The analysis results demonstrate that the model exhibits robust stability under parameter variations, with the variations of all indicators remaining within acceptable ranges.

**4.3.1 参数影响分析**

Parameter Impact Analysis  
通过对比原始结果与敏感性分析后的结果，观察到以下变化：

* **经济效益**：均值稳定在129.5M，波动范围由109.7M至109.8M，表明经济效益对参数变动具有较高的稳定性。
* **碳排放**：均值略微上升至78495t（增幅约0.02%），波动范围从242451t变动至242437t，表明碳排放控制政策具有较强的鲁棒性。
* **税收比率**：均值保持76.7%，波动范围稳定在54.4%-100%，表明税收政策具有较好的适应性和稳定性。
* **游客数量**：年均游客量维持在2.32M/yr，表明游客管理策略具有可持续性。

By comparing the original results with those from the sensitivity analysis, the following variations were observed:

• Economic benefits: The mean value remained stable at 129.5M, with fluctuation range narrowing from 109.7M to 109.8M, indicating high stability of economic benefits under parameter variations.

• Carbon emissions: The mean value slightly increased to 78,495t (approximately 0.02% growth), with fluctuation range shifting from 242,451t to 242,437t, demonstrating strong robustness of carbon emission control policies.

• Tax ratio: The mean value maintained at 76.7%, with stable fluctuation range between 54.4% and 100%, reflecting favorable adaptability and stability of tax policies.

• Tourist volume: Annual average tourist numbers remained at 2.32M/yr, suggesting sustainable performance of tourist management strategies.

**4.3.2 敏感性分析方法**  
敏感性分析采用分层采样策略：

* **中等区间**（游客容量12000-16000、税率70%-85%、满意度13-17）选取20个采样点，以更精确地捕捉该区间内的细微变化。
* **高低区间**（即边界区间）表现为较为极端的情况，采样点设置为15个，以提高计算效率并保障分析质量。  
  该方法确保了关键区间的精确分析，同时优化了计算资源的分配，提高了敏感性分析的实际应用价值。

4.3.2 Sensitivity Analysis Methodology

The sensitivity analysis employed a stratified sampling strategy:

• Moderate interval (tourist capacity: 12,000–16,000, tax rate: 70%–85%, satisfaction threshold: 13–17) was sampled with 20 points to precisely capture subtle variations within this range.

• High-low intervals (i.e., boundary intervals) representing extreme scenarios were sampled with 15 points to balance computational efficiency and analytical quality.

This approach ensured precise analysis of critical parameter ranges while optimizing the allocation of computational resources, thereby enhancing the practical applicability of the sensitivity analysis.

**4.3.3 与原始模型的差异**

* **游客容量约束**：原始模型为0至16000人/年，灵敏度分析调整为8000至20000人/年。
* **税率约束**：原始模型为0至1（0-100%），灵敏度分析调整为0.5至1（50-100%）。
* **满意度阈值**：原始模型为固定值，灵敏度分析中范围调整为10至20。
* **采样方法**：原始模型采用连续优化，灵敏度分析采用分层采样（15/20/15点）。

**4.3.4 稳健性结论**  
根据敏感性分析结果，得出以下结论：

* **模型稳定性**：关键指标在参数变化下保持稳定，波动范围可控，表明模型具有较强的稳定性。
* **参数敏感度**：游客容量对经济效益和碳排放的影响最为显著，税率变化对经济效益的影响较为温和，满意度阈值对各指标的影响较为均衡。

4.3.3 Differences from the Original Model

• Tourist capacity constraint: The original model ranged from 0–16,000 persons/year, while the sensitivity analysis adjusted it to 8,000–20,000 persons/year.

• Tax rate constraint: The original model used a range of 0–1 (0–100%), whereas the sensitivity analysis narrowed it to 0.5–1 (50–100%).

• Satisfaction threshold: The original model employed a fixed value, while the sensitivity analysis expanded it to a range of 10–20.

• Sampling method: The original model adopted continuous optimization, whereas the sensitivity analysis utilized stratified sampling (15/20/15 points).

4.3.4 Robustness Conclusions

Based on the sensitivity analysis results, the following conclusions were drawn:

• Model stability: Key indicators remained stable under parameter variations, with controllable fluctuation ranges, demonstrating strong stability of the model.

• Parameter sensitivity:Tourist capacity exhibited the most significant impact on economic benefits and carbon emissions, tax rate changes had a moderate effect on economic benefits, and satisfaction threshold showed a balanced influence across all indicators.