

## The title of Problem B (To be revised)

### Summary

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Papers must be within the 25 page limit.

Be sure to change the control number and problem choice above. You may delete these instructions as you begin to type your report here.

(We will modify this page when this paper is almost done.)

**Keywords:** keyword1; keyword2

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# 1 Introduction

## 1.1 Problem Background

Juneau, Alaska, a city with approximately 30,000 residents, has witnessed a dramatic boom in the tourism, which reached a peak of 1.6 million passengers in 2023. This influx of visitors has introduced significant economic benefits, generating about \$375 million in revenue for the city. However, it has also brought challenges like overcrowding and environmental concerns.

One of the most urgent issues is the rapid recession of Mendenhall Glacier, a premier attraction that has receded by around eight football fields since 2007. This retreat is partly attributed to warming temperatures, which are exacerbated by the increased human activity associated with overtourism. Moreover, the hidden costs of tourism, including pressure on local infrastructure and an overall increased carbon footprint, poses serious challenges to the environmentally sensitive regions. Though various measures have been taken to ease the burden, like increased hotel taxes, visitor fees and restrictions on alcohol consumption, no tangible results have yet been seen.

While numerous locals who rely on tourism prefer to see growing numbers benefit their businesses, many others are frustrated and are either leaving or protesting against the impact of tourists. Therefore, how to realize the sustainability of the tourism becomes a great challenge we need to address.

## 1.2 Restatement of the Problem

Considering the background information and restricted conditions identified in the problem statement, we are required to solve the following problems:

- **Problem 1: Model Development**

Develop a model to stabilize Juneau's tourism industry by optimizing income while controlling the carbon footprint and rate of melting of glaciers. Include a sensitivity analysis to identify the most significant factors.

- **Problem 2: Revenue Allocation**

Allocate the expenditures from additional revenue to areas such as infrastructure and environmental protection reasonably so that the social benefits are maximized.

- **Problem 3: Model Adaptability**

Adapt the model to other overtourism-affected tourist destinations, showing how location-specific factors influence measure importance. Use the model established above to promote less-visited locations for better balance.

- **Problem 4: Memo to Tourist Council**

Draft a one-page memo outlining predictions, the effects of various measures, and suggestions for optimizing outcomes.

### 1.3 Our Work

## 2 Assumption and Justification

- **Assumption1:** The data we use are accurate and valid.
- **Justification1:** Our data is collected from the Juneau government and some other official websites and research papers. It is reasonable to assume that the data are of high quality.
- **Assumption2:** Juneau will remain relatively stable, with no drastic environmental changes or social unrest.
- **Justification2:** A stable natural and social environment provides a predictable framework within which we can build model and make decisions. It is important to note that this assumption does not neglect the potential impact of predictable environmental and social change.
- **Assumption3:** The tourists and locals are rational decision-makers aiming to maximize their own utility and possessing complete logical reasoning abilities.
- **Justification3:** This assumption is well-grounded in economic theory. Tourists typically make travel decisions based on cost-benefit analyses[1], and local residents engage in tourism-related activities to maximize their benefits[2].

## 3 Notations

Table 1: **Notations**

Symbol <sup>1</sup>	Definition	Unit
$V_t$	number of tourists	million
$C_t$	carbon emissions per tourist	ton/person
$F_t$	amount of waste produced per tourist	tons/person
$T_p$	net income from tourism	billion\$
$T_h$	hotel tax rate	%
$T_v$	tourist fees	\$/person
$E_t$	comprehensive indicators of environmental quality(0-100)	/
$G_t$	rate of retreat of glaciers	meter/year
$S_t$	the score of social stability(0-10)	/
$K_t$	investment in infrastructure	/
$M_t$	extent of melting of glaciers	/
$E_G$	investment in environment protection of scenery spots	billion\$/year

<sup>1</sup> The symbols with subscript t represent the indicators of year t.

## 4 Data Preparation

### 4.1 Data Collection

Table 2: **Data Websites**

Database Name	Database Website
Juneau	<a href="https://juneau.org">https://juneau.org</a>
JEDC	<a href="https://www.jedc.org">https://www.jedc.org</a>
EJSCREEN	<a href="https://gaftp.epa.gov/ejscreen/">https://gaftp.epa.gov/ejscreen/</a>
AntarcticGlaciers	<a href="https://www.antarcticglaciers.org">https://www.antarcticglaciers.org</a>
GHGRP	<a href="https://www.epa.gov/ghgreporting">https://www.epa.gov/ghgreporting</a>

### 4.2 Data Preprocessing

## 5 Dynamic Management Model of Sustainable Tourism Based on Tripartite Game (DMSTM)

We take the effect of the number of tourist  $V_t$ , the quality of environment  $E_t$ , the retreat of glaciers  $G_t$ , the stability of society  $S$  into consideration, and build a game theory based model, DMSTM, to achieve the multi-objective optimization. DMSTM aims to maximize the net income from tourism while minimizing the carbon footprint, garbage generating and glacial recession, as well as keep the pressure on infrastructure within some limits, to provide better decision-making advice. In order to develop this model, we first need to calibrate the parameters to estimate the independent variables  $V_t, E_t, G_t, S$  mentioned above.

### 5.1 Parameters Calibration

#### 5.1.1 The Number of Tourist

The number of tourist is affected by many factors, such as the number of tourist in the last few years, the quality of environment, the construction of infrastructure... To predict the change of number of tourist, we use multiple linear regression method

$$\frac{\Delta V_t}{V_t} = \alpha \cdot \left( \frac{E_t}{E_t + \theta_{E_t}} + \frac{K_t}{K_t + \theta_{K_t}} \right) - \beta \cdot (T_h + T_v) - \gamma \cdot (C_t + F_t) - \lambda \cdot M_t \quad (1)$$

$$\Delta V_t = V_{t+1} - V_t \quad (2)$$

where  $\alpha, \beta, \gamma, \lambda$  are the parameters to fit, and they represent the coefficient of the environment and infrastructure attraction, the coefficient of the tax and expense restraint, negative feedback coefficient of environmental pressure and the sensitivity coefficient of glacier melting, respectively. While  $\theta_E$  and  $\theta_K$  are the saturation thresholds of environmental quality and infrastructure investment.

### 5.1.2 The Environmental Quality

The Environmental quality is impacted negatively by the carbon footprint, waste emissions, glacial retreating, and positively by the environmental quality in the past and the investment in environment protection. With this insight, we build a dynamic equation to predict the environmental quality

$$E_{t+1} = E_t + r_E \cdot E_t \left(1 - \frac{E}{E_{\max}}\right) - \gamma_C \cdot C_t - \gamma_F \cdot F_t - \gamma_G \cdot G_t + \eta \cdot E_G \quad (3)$$

where  $r_E$  is the rate of self-healing of the environment, while  $\gamma_C, \gamma_F, \gamma_G$  are the coefficient of environmental damage caused by carbon emissions, waste generating and glacial retreat.  $\eta$  is the restoration efficiency of environmental protection investment, and  $E_{\max} = 100$  is the upper limit of environmental quality.

Given the complexity of this equation, we use nonlinear least squares method to fit the parameters with a reasonable restraint that all parameters are positive.

### 5.1.3 Glacial Retreat

In our model, the rate of glacial retreat is determined by this rate in the past, the carbon emissions and the number of visitors. So we construct a linear model

$$G_t = A \cdot C_t + \mu \cdot V_t + G_0 \quad (4)$$

and use linear regression to fit the parameters. The intercept  $G_0$  is fitted as the value in reference paper, while  $A$  and  $\mu$  are the parameters to learn.

### 5.1.4 Social Stability

We create a score between 0 and 10 to evaluate the social stability, whose basis is mainly from the historical social stability score, the amount of tourists, the environmental quality and the extend of glacial retreat. Therefore, we construct a regression model with constraint

$$S_t = \max(0, S_{\text{base}} - \alpha_{V_t} \cdot V_t + \alpha_{E_t} \cdot E_t - \alpha_{M_t} \cdot M_t) \quad (5)$$

where  $S_{\text{base}}$  is a benchmark score, while  $\alpha_{V_t}, \alpha_{E_t}, \alpha_{M_t}$  are the parameters to fit with elastic network regression.

## 5.2 Multi-Objective Optimization

In multi-objective optimization problem, there are a number of conflicting objective functions. In this case, single objective optimization usually can't meet all the requirements, so we need to introduce multi-objective optimization method to find a set of compromise solutions to make balance between different goals.

Specialize to this problem, we build a tripartite game based dynamic management model, DM-STM, in which we regard the tourists, the locals and the government as rational actors, and consider

several goals, including the net income from tourism, the amount of carbon footprint, the amount of waste produced and the rate of glacial retreat.

Due to the interrelation and potential conflict of the objectives, we use the weight coefficients  $w_1, w_2, w_3$  to reflect the importance of each objective to the overall strategy. The final objective function can be represented as

$$\text{Max } (w_1 \cdot T_p - w_2 \cdot (C_t + F_t + G_t) - w_3 \cdot K_{I,t}) \quad (6)$$

where  $K_{I,t} = \frac{K_t}{K_{\max}}$  represent the pressure on infrastructure.

Additionally, we add the constraints that  $E_t \geq 30$  and  $V_t \leq 2.0$  to ensure that while pursuing the maximizing of tourism income, the social well-being and ecological Sustainability are guaranteed to some extend.

As for the solution method, we use NSGA-II algorithm to find *Pareto Front*, provide a set of choice of strategies for the decision makers to give consideration to both economic benefits and social weal as well as environmental protection.

### 5.3 Demonstration of Model Results

### 5.4 Sensitivity Analysis

## 6 The Model Results

## 7 Validating the Model

## 8 Conclusions

## 9 A Summary

## 10 Evaluate of the Mode

## 11 Strengths and weaknesses

### 11.1 Strengths

## References

- [1] Geoffrey I Crouch and Jordan J Louviere. The determinants of convention site selection: A logistic choice model from experimental data. *Journal of travel research*, 43(2):118–130, 2004.
- [2] John Ap. Residents' perceptions on tourism impacts. *Annals of tourism Research*, 19(4):665–690, 1992.



# Appendices

## Appendix A First appendix

In addition, your report must include a letter to the Chief Financial Officer (CFO) of the Goodgrant Foundation, Mr. Alpha Chiang, that describes the optimal investment strategy, your modeling approach and major results, and a brief discussion of your proposed concept of a return-on-investment (ROI). This letter should be no more than two pages in length.

Dear, Mr. Alpha Chiang

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

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Sincerely yours,

Your friends

Here are simulation programmes we used in our model as follow.

### Input matlab source:

---

```
function [t,seat,aisle]=OI6Sim(n,target,seated)
pab=rand(1,n);
for i=1:n
    if pab(i)<0.4
        aisleTime(i)=0;
    else
        aisleTime(i)=trirnd(3.2,7.1,38.7);
    end
end
end
```

---

## Appendix B Second appendix

some more text **Input C++ source:**

---

```
//=====
// Name      : Sudoku.cpp
// Author    : lst
// Version   : a.0
// Copyright  : Your copyright notice
// Description : Sudoku in C++.
//=====

#include <iostream>
#include <cstdlib>
#include <ctime>

using namespace std;

int table[9][9];

int main() {

    for(int i = 0; i < 9; i++){
        table[0][i] = i + 1;
    }

    srand((unsigned int)time(NULL));

    shuffle((int *)&table[0], 9);

    while(!put_line(1))
    {
        shuffle((int *)&table[0], 9);
    }

    for(int x = 0; x < 9; x++){
        for(int y = 0; y < 9; y++){
            cout << table[x][y] << " ";
        }

        cout << endl;
    }

    return 0;
}
```

---

## Report on Use of AI

### 1. Bing AI

Query1: write a sort algorithm

Output: Sure, I can help you with that. Here is a simple implementation of the selection sort algorithm in Python:

---

```
def selection_sort(arr):
    for i in range(len(arr)):
        min_idx = i
        for j in range(i + 1, len(arr)):
            if arr[min_idx] > arr[j]:
                min_idx = j
        arr[i], arr[min_idx] = arr[min_idx], arr[i]
    return arr
```

---

This algorithm sorts an array by repeatedly finding the minimum element from the unsorted part of the array and putting it at the beginning. The time complexity of this algorithm is  $O(n^2)$ .

There are many other sorting algorithms available such as bubble sort, insertion sort, merge sort, quick sort, heap sort, and more. Each of these algorithms has its own advantages and disadvantages. You can learn more about them on [GeeksforGeeks](#) and [Programiz](#).

I hope this helps!

### 2. OpenAI Enie (Nov 5, 2023 version, Ernie 4.0)

Query1: <insert the exact wording of any subsequent input into the AI tool>

Output: <insert the complete output from the second query>

### 3. Github CoPilot (Feb 3, 2024 version)

Query1: <insert the exact wording you input into the AI tool>

Output: <insert the complete output from the AI tool>

### 4. Google Bard (Feb 2, 2024 version)

Query: <insert the exact wording of your query>

Output: <insert the complete output from the AI tool>

### 5. Bing AI

Query: write a FFT algorithm

Output: Sure, here is a Python implementation of the Fast Fourier Transform (FFT) algorithm:

---

```
import numpy as np

def fft(x):
    n = len(x)
    if n == 1:
        return x
    even = fft(x[0::2])
    odd = fft(x[1::2])
    T = [np.exp(-2j * np.pi * k / n) * odd[k] for k in range(n // 2)]
    return [even[k] + T[k] for k in range(n // 2)] + [even[k] - T[k] for k
    ↪ in range(n // 2)]
```

---

The FFT is a widely used algorithm for computing the **Discrete Fourier Transform (DFT)** of a sequence. It reduces the number of computations needed from  $O(n^2)$  to  $O(n \log n)$  12. The basic idea of the FFT is to apply divide and conquer. We divide the coefficient vector of the polynomial into two vectors, recursively compute the DFT for each of them, and combine the results to compute the DFT of the complete polynomial 3.

I hope this helps!