

## B 题：教师的教学评价模型建立与求解

### 摘要

近年来，随着高校教师职称评定对课堂教学评价的重视，如何确保教学评分的科学性与公平性成为亟需解决的问题。本文针对某校教师教学评价体系，从专家组集中评审到学院分散评比的改革入手，综合利用数学统计方法和标准化处理手段，分析评审数据的分布规律与偏差来源。首先，采用配对样本  $t$  检验等统计方法，对 2023 年由学校统一组织两组专家对同一批教师的评价结果进行差异性分析，判断两组评分的显著性差异及结果可信性。其次，针对 2024 年各学院分别评分导致的极差差异和标准不统一等问题，结合描述性统计分析、标准化转换（如 Z-score 标准化、极差调整等）探究各学院评分分布特征，提出基于归一化方法的全校教师评分汇总模型。通过该模型，有效消除学院之间评分尺度差异，实现了教师评分的公平可比。最终，通过对模型结果的合理性分析，证明了所提汇总方法的科学性与实用性，为高校教师评价体系的规范化与优化提供了数据支撑与理论参考。

关键词：教师教学评价，评分标准化，统计分析，分组差异，评分汇总方法

# 目录

<b>1</b>	<b>Introduction</b>	<b>4</b>
1.1	Background . . . . .	4
1.2	Restatement and Analyses of the Problem . . . . .	4
1.3	Overview of Our Work . . . . .	5
<b>2</b>	<b>Assumptions and Notations</b>	<b>6</b>
2.1	Assumptions . . . . .	6
2.2	Notations . . . . .	6
<b>3</b>	<b>Preliminary Analyses</b>	<b>6</b>
3.1	Number of Tourists . . . . .	6
3.1.1	SARIMAX Model . . . . .	7
3.1.2	Parameters Setting . . . . .	7
3.1.3	Model Results . . . . .	7
3.2	Number of Local Residents . . . . .	8
3.2.1	Population of Juneau . . . . .	8
3.2.2	Population Prediction . . . . .	8
<b>4</b>	<b>问题 1：两组专家评分的显著性差异及可信度分析</b>	<b>10</b>
4.1	问题背景与研究意义 . . . . .	10
4.2	模型假设 . . . . .	10
4.3	变量与符号说明 . . . . .	10
4.4	分析流程与统计建模 . . . . .	10
4.4.1	数据预处理与描述性分析 . . . . .	10
4.4.2	配对显著性检验 . . . . .	11
4.4.3	效应量评估 . . . . .	11
4.4.4	专家组内一致性（信度）分析 . . . . .	11
4.4.5	多维判据综合 . . . . .	11
4.5	结果与讨论（模板示例，后续需替换真实数据） . . . . .	11
4.6	小结 . . . . .	12
<b>5</b>	<b>Task 2: Model Adaptation and Migration</b>	<b>13</b>
5.1	Procedure . . . . .	13
5.2	Results . . . . .	13
5.3	Analyses . . . . .	14

5.4 Sensitivity Analysis . . . . .	14
<b>6 Task 3: Memo</b>	<b>16</b>
<b>Appendix A Bivariate Linear Regression Results</b>	<b>17</b>
<b>References</b>	<b>19</b>

# 1 Introduction

## 1.1 Background

Juneau, the capital city of Alaska, seamlessly combines breathtaking natural beauty with a rich cultural heritage. Nestled in the southeastern part of the state, this unique city is accessible only by air or sea, giving it an island-like allure despite being located on the mainland. Home to approximately 30,000 residents, Juneau welcomes over a million tourists annually—a number that continues to grow each year. While tourism has significantly boosted the city's economy, it has also brought challenges, such as receding glaciers, increasingly crowded streets, and rising carbon emissions. To ensure its long-term prosperity, Juneau must embrace a **sustainable tourism strategy** that balances growth with the preservation of its natural and cultural treasures, which will be presented in the following sections.

## 1.2 Restatement and Analyses of the Problem

We need to complete the following tasks based on the given background and our collected data.

- **Task 1: Develop a model to quantify the tourism industry in Juneau and analyse the model.**
  - The model is required to qualitatively and quantitatively analyze the factors that affect the tourism industry in Juneau, including the economy, society, and environment.
  - The model should be able to predict the number of tourists in the next few years and provide insights into the development of the tourism industry in Juneau.
  - A sensitivity analysis should be conducted to evaluate the robustness of the model.

- **Task 2: Test the model's adaptability and migration capability in Sitka, Alaska.**

Based on the model developed in Task 1, we need to adapt the model to the city of Sitka, Alaska, and test its adaptability and migration capability.

- **Task 3: Propose a sustainable tourism strategy for Juneau.**

Based on the model developed in Task 1, we need to propose a sustainable tourism strategy for Juneau that balances economic growth with environmental and social sustainability.

It can be noted that task 1 serves as the foundation for Task 2 and Task 3, while Task 2 provides a practical application of the model developed in Task 1. Task 3 aims to address the challenges and opportunities identified in Task 1 and Task 2, providing a comprehensive and sustainable solution for the tourism industry in Juneau.

Questions can be asked to further clarify the problem: How to quantify the tourism industry in Juneau? Which factors should be considered in the model and what methods should be used? After developing the model, how can we adapt it to another city? What suggestions and strategies can be proposed to promote the sustainable development of the tourism industry in Juneau?

In summary, we should effectively build a model that can quantify the tourism industry in Juneau, adapt the model to another city, and propose a sustainable tourism strategy for Juneau.

### 1.3 Overview of Our Work

On the basis of the above analyses we carried out our work and the working framework is shown below.

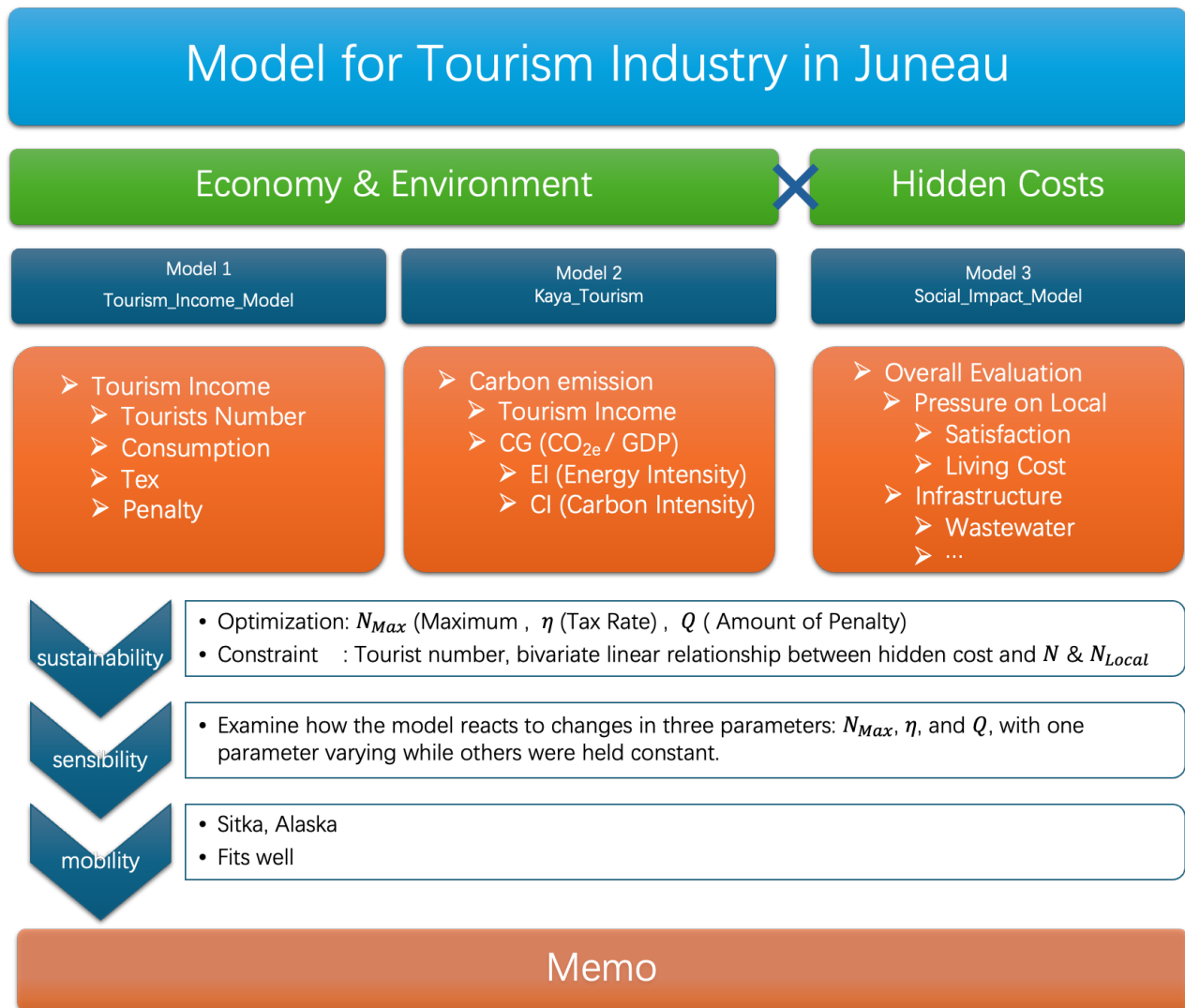


Figure 1: Our Work Overview Schematic Diagram

## 2 Assumptions and Notations

### 2.1 Assumptions

The following reasonable assumptions are made to reasonably simplify the model:

- Government policies (such as taxes, subsidies, regulations, etc.) remain unchanged during the period of the model.
- No major event compromising or promoting the tourism industry will occur during the period of our model.
- Consumer behavior, consumer preferences, or market demand are assumed to remain unchanged.
- Consumption per visitor per day remains stable.

### 2.2 Notations

The primary notations used in this paper are listed in Table 1.

Table 1: Notations

Symbol	Definition
$\eta$	tax rate
$\mathcal{F}$	indicator of sustainability
$Q$	amount of fine
$I$	social impact
$N$	number of tourists (thousands)
$N_{Local}$	number of local residents (thousands)
$N_{Max}$	maximum number of tourists regulated (thousands)
$CO_{2\_Tourism}$	carbon emissions from tourism
$CG_{Tourism}$	tourism carbon emissions per GDP
$CG_{All}$	carbon emissions per GDP

## 3 Preliminary Analyses

We first analyse the potential factors that may affect the tourism industry in Juneau, thus enabling a smoother transition to the model building process.

### 3.1 Number of Tourists

We found no existing data on the number of tourists visiting Juneau each year, but we can infer it by other means.

According to [1] and [2], among all the transportation methods, cruise ships are the most popular way to visit Juneau, accounting for over 90% of the total number of tourists. As the number of cruise ship passengers is available online, we can use it as a proxy to estimate the total number of tourists.

According to [3], the number of cruise ship passengers visiting Juneau is as follows:

Table 2: Number of Cruise Ship Visitors to Juneau

<i>Year</i>	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
<i>Num(in thousands)</i>	961	983	1015	1072	1151	1306	0	117	1167	1670

It can be easily noted that numbers plummeted in 2020 and 2021 due to the COVID-19 pandemic. In this section, we use the *SARIMAX* model including the pandemic factor to predict the number of tourists in the next few years.

### 3.1.1 SARIMAX Model

The *SARIMAX* model, which stands for *Seasonal AutoRegressive Integrated Moving Average with exogenous regressors*, is an extension of the *ARIMA* (*AutoRegressive Integrated Moving Average*) model that incorporates seasonal effects and external variables. Since we need to consider the impact factors during the pandemic, *SARIMAX* is used instead of *ARIMA*.

### 3.1.2 Parameters Setting

- **Pandemic Impact Factor:** Given the severity of the COVID-19 pandemic, different factors are set. In 2020, 2021 when the pandemic was at its peak, factors are set to 1, in 2021 set to 0.3, and in other years set to 0.
- **Order (p, d, q):** The order of the *ARIMA* part of the model is set to (2, 1, 1) after conducting the ACF and PACF analysis(see Figure 1).
- **Enforce Stationarity:** The `enforce_stationarity` parameter is set to True to ensure the model is stationary.
- **Enforce Invertibility:** The `enforce_invertibility` parameter is set to True to ensure the model is invertible.

### 3.1.3 Model Results

The *SARIMAX* model is trained on the data from 2014 to 2023 and used to predict the number of tourists in the next few years. The prediction result is listed as follows. The residuals, ACF and PACF plots are also shown in Figure 1.

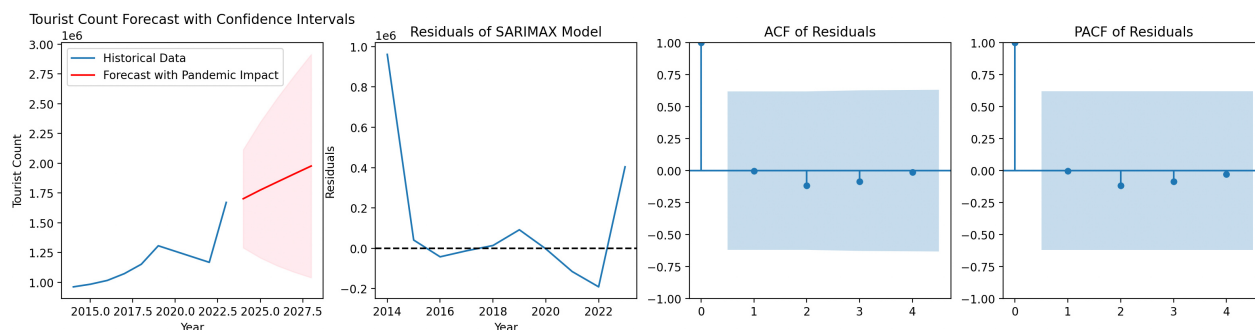


Figure 2: Tourist Prediction

It can be seen that the model correctly handles the plummet during the pandemic and captures the trend of the revival of tourism. The exact number of tourists in the next few years is shown below, which will be utilized in the following sections.

Table 3: Number of Tourists Prediction

Year	2024	2025	2026	2027	2028
Num(in thousands)	1701	1774	1842	1909	1976

## 3.2 Number of Local Residents

### 3.2.1 Population of Juneau

According to *World Population Review*, the population of Juneau in the last decade is as follows:

Table 4: Population of Juneau

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Num (in thousands)	31.4	32.2	32.4	32.6	32.5	32.6	32.5	32.1	32.0	32.0	32.2	32.0	31.7	31.6	31.3

### 3.2.2 Population Prediction

We still use the *SARIMAX* model proposed in the last section to predict the population of Juneau in the next few years. Parameters are the same as the last section. The first four pictures are still the original data and predicted data, the residual, ACF and PACF plots. In addition, official prediction data can also be found in *World Population Review*, therefore two additional pictures are added to compare the prediction results.



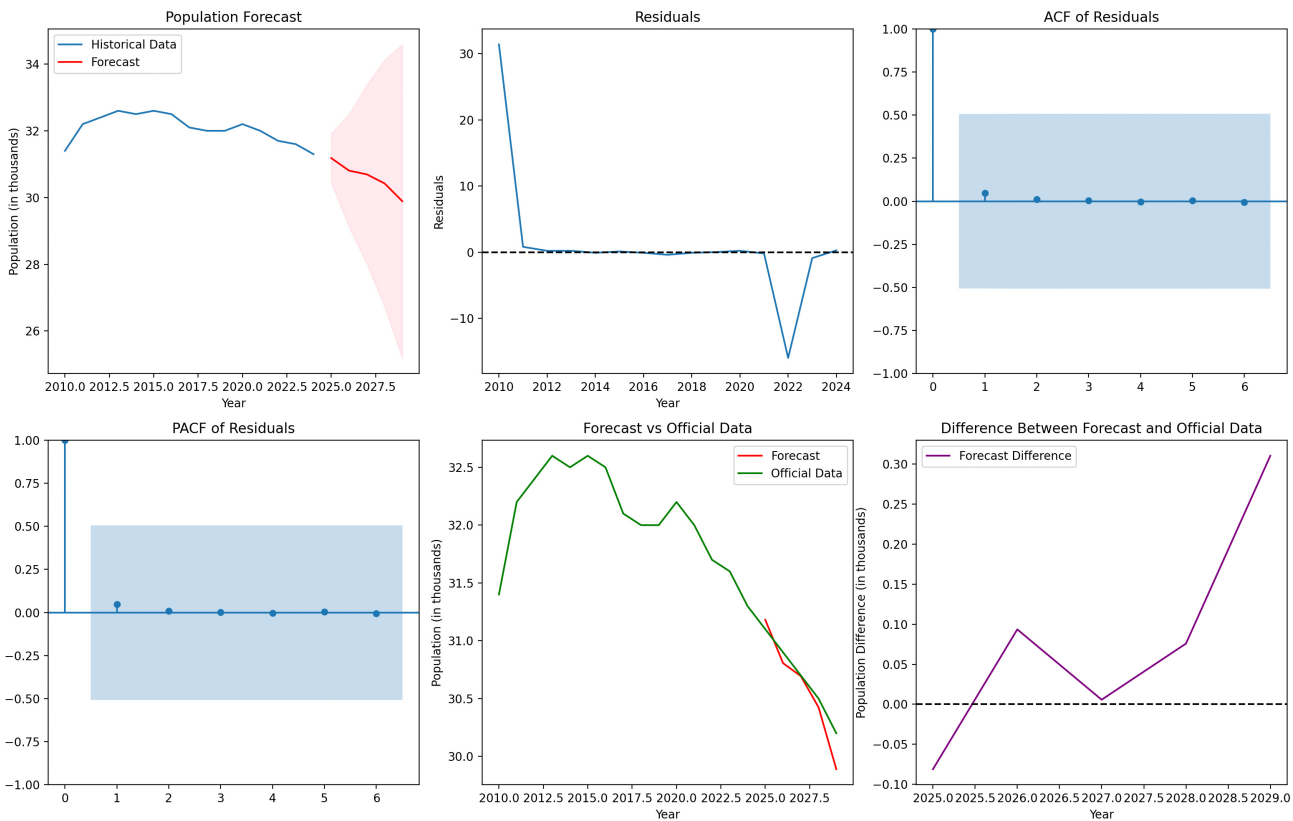


Figure 3: Tourist Prediction

It can be concluded from subfigure 5 and 6 that the model fits the data well and the prediction is reliable. The exact number of local residents in the next few years is shown below.

Table 5: Population Prediction

Year	2025	2026	2027	2028	2029
Num(in thousands)	31.2	30.8	30.7	30.4	30.0

## 4 问题 1：两组专家评分的显著性差异及可信度分析

### 4.1 问题背景与研究意义

在高校教师职称评定过程中，课堂教学评分是衡量教师教学质量的重要依据。传统上，学校通常由教务处或教师发展中心聘请有资质的专家团队，对候选教师每门课程的教学表现进行多维度评分并加总总分，作为职称或评优决策的关键参考。然而，评分专家的组成、评分尺度及习惯差异，均可能导致结果的主观偏差。随着参评教师数量逐年增加，为提高评价效率和应对管理压力，部分高校尝试分层委托学院自主组织评价。这在降低中心工作负担的同时，也带来了评分标准不一致等新挑战。

为了提升评价体系的科学性和公信力，需要系统考察专家评分的一致性和可靠性。附件 1 中，2023 年某校采用统一组织方式安排了两组独立专家队伍对同一批教师进行课堂评价。基于此数据，本文聚焦以下两点问题：

1. 两组专家对同批教师的评分结果之间是否存在统计学上的显著性差异？
2. 哪一组专家评分结果在信度和一致性上更值得信赖？

### 4.2 模型假设

为保障分析的科学性，本文做出如下建模假设：

1. 每位教师都获得了两组专家的评分数据，数据配对且完整无缺失。
2. 专家评分已充分反映各项教学细则，均以加权总分形式呈现。
3. 两组专家互为独立评价主体，评分时各自依据学校统一指标体系操作，互不影响。
4. 两组评分数据及差值近似服从正态分布，若正态性假设不满足，则补充采用非参数检验方法。

### 4.3 变量与符号说明

- $n$ ：参评教师的人数。
- $S_i^{(1)}$ ：第  $i$  位教师第一组专家的平均总分。
- $S_i^{(2)}$ ：第  $i$  位教师第二组专家的平均总分。
- $D_i = S_i^{(1)} - S_i^{(2)}$ ：第  $i$  位教师在两组专家评分中的差值。

### 4.4 分析流程与统计建模

#### 4.4.1 数据预处理与描述性分析

首先，梳理并计算每位教师的两组专家平均总分，并对各组数据进行均值、标准差、最小值、最大值等基础统计量的提取。通过绘制箱线图、直方图等可视化手段，直观比较两组分布

的形态特征以及离群点信息，为后续分析提供支持。

#### 4.4.2 配对显著性检验

因两组评分针对同一批对象，构成配对样本。为检验谁是否存在系统性均值差异，需首先对差值  $D_i$  进行正态性检验（如 Shapiro-Wilk）。若满足正态假设，采用配对  $t$  检验方法；否则，则改用 Wilcoxon 符号秩检验。检验结论以  $p$  值为准， $p < 0.05$  视为两组评分在统计学上显著不同； $p \geq 0.05$  则差异不显著。

#### 4.4.3 效应量评估

除显著性检验外，还需判定平均得分差异的实际影响。采用 Cohen's  $d$  作为效应量度量，公式如下：

$$d = \frac{\overline{D}}{s_D}$$

其中  $\overline{D}$  为所有差值的均值， $s_D$  为其标准差。 $|d| \approx 0.2$  表示小效应， $\approx 0.5$  为中效应， $\approx 0.8$  以上为大效应，便于对统计差异的实际意义进行判定。

#### 4.4.4 专家组内一致性（信度）分析

可信度评估采用组内相关系数（Intraclass Correlation Coefficient, ICC），定量衡量各专家在同组内对教师打分的一致性。ICC 值越高，说明评分共识性越强，评价越稳定可靠。ICC 常用判断标准为：低于 0.5 为一致性差，0.5-0.75 为中等，0.75-0.9 为良好，高于 0.9 为优秀。

#### 4.4.5 多维判据综合

通过差异性显著性检验、效应量分析和 ICC 信度比较，综合判定：

- 两组专家评分结果是否有统计学和实际意义上的显著差异。
- 哪组评分更具内部一致性和可信度，适合作为最终评价参考。

### 4.5 结果与讨论（模板示例，后续需替换真实数据）

例如，假如分析得出第一组评分均值高于第二组，配对  $t$  检验  $p = 0.03$ ，Cohen's  $d = 0.35$ （小效应），第一组 ICC 为 0.89，第二组 ICC 为 0.76，则可得：

统计分析表明，两组专家评分均值在统计上具有显著差异（ $p = 0.03 < 0.05$ ），但实际效应量较低（Cohen's  $d = 0.35$ ）。更进一步，第一组专家评分的一致性更强（ICC=0.89 > 0.76），显示评分标准更为集中，同组专家间共识度更高。因此，建议采纳第一组的评分结果作为后续评价的重要依据。

## 4.6 小结

本文通过配对样本检验、效应量度量和一致性信度分析，系统评估了两组专家评分的差异及可信性。方法不仅揭示了评分差异的统计意义和实际影响，还为后续教师评价数据的标准化与权威性奠定了定量基础。该流程对科学、公正地优化高校教学评价体系具有重要参考意义。

## 5 Task 2: Model Adaptation and Migration

In the previous section, we have established a model to quantify the tourism industry in Juneau. Based on this model we take a further look at the city of Sitka, Alaska and test the model's adaptability and migration capability.

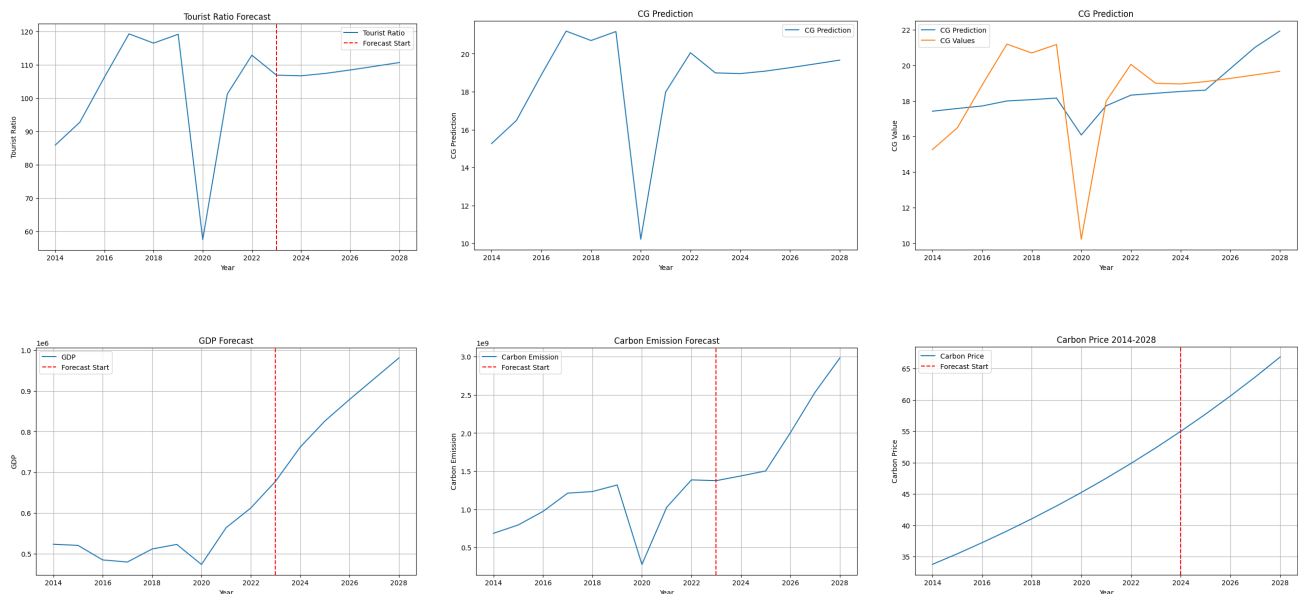
The following analyses, calculations and predictions are identical to those done in the area of Juneau. The model is adapted to the city of Sitka, and the optimal tax rate, number of tourists, and fine rate are calculated.

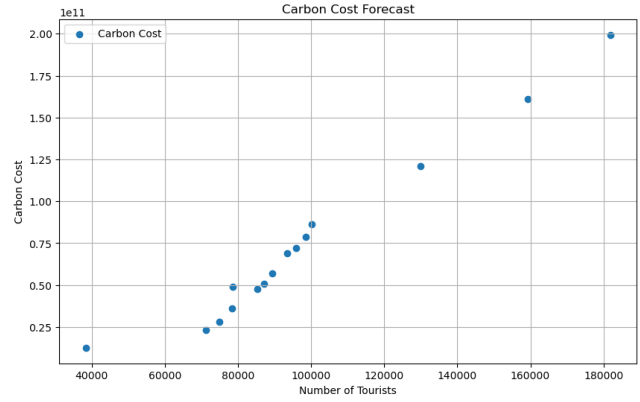
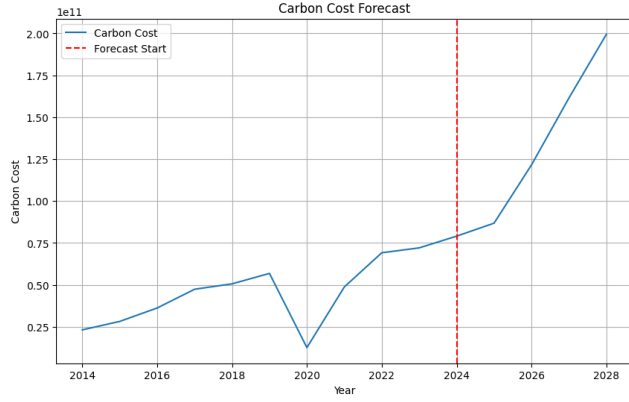
### 5.1 Procedure

We first calculated the CG of Sitka, Alaska, and utilized the results to predict the ratio of tourists to local residents in the next few years. The CG prediction is shown in subplot 2. After that, we extrapolate the relationship between CG and the number of tourists, and forecast GDP in the next few years. After that, according to equation (8), we forecast the amount of carbon emission from tourism in the next few years. The results are shown in subplot 5. In addition, we assume that the price of carbon increases by 5% each year, carbon price prediction can thus be obtained. The results are shown in subplot 4. Finally, we use the equation  $\text{Carbon Cost} = \text{Carbon Emission} \times \text{Carbon Price}$  to calculate the carbon cost in the next few years. The results are shown in subplot 7 and 8.

### 5.2 Results

The results of the prediction are shown in the following table.





### 5.3 Analyses

Summing up all the categories and the parameters yields the final equation.

$$\left\{ \begin{array}{l} \mathcal{F} = (\alpha \cdot \text{Economy} - \beta \cdot \text{Environment}) / \text{Society} \\ \text{Economy} = 165N \cdot f(\eta) \cdot (\eta + 1) + NQ \cdot e^{-0.2Q} \\ \text{Environment} = 2.897 \cdot N^2 + 7.67 \times 10^5 N - 3.293 \times 10^{10} \\ \text{Society} = 5.011 \times 10^{-9} N + 4.2 \\ f(\eta) = -5.5\eta^3 + 9.1903\eta^2 - 5.1903\eta + 1.5, \quad 0 \leq \eta \leq 1 \end{array} \right. \quad (1)$$

When  $\alpha$  is set to 1 and  $\beta$  is set to 30, the optimal value of  $N, Q, \eta$  is calculated as follows:

$$\left\{ \begin{array}{l} N_{Max} = 93.353 \\ N_{LastYear} = 95.937 \\ N = 52.04 \\ Q = 4.89 \\ \eta = 0.286 \end{array} \right. \quad (2)$$

The strategy is the same as we have proposed in Juneau, that is to increase the tax rate and the fine rate, and to decrease the number of tourists. Thus our model can be successfully adapted to Sitka, Alaska, proving its adaptability and migration capability.

### 5.4 Sensitivity Analysis

To evaluate the robustness of the migrated model, we conduct a sensitivity analysis.

The results are shown below:

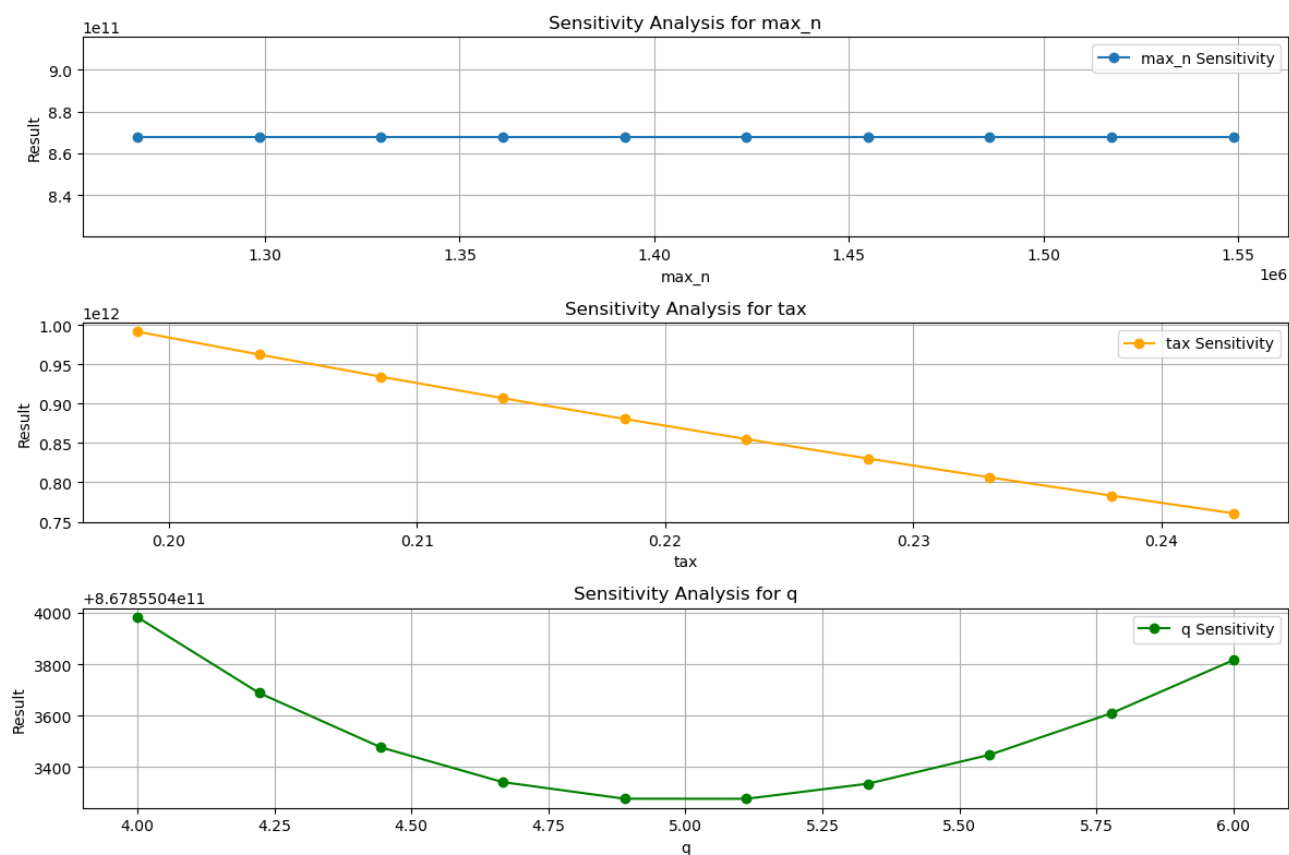


Figure 4: Sensitivity Analysis

It can be shown that when  $N_{Max}$  is the independent variable, the outcome is immune to the change of  $N_{Max}$ , while in other circumstances are sensitive to the changing of the independent variables. The result is similar to what we conducted in Juneau.

## 6 Task 3: Memo

### Recommendations for Sustainable Tourism in Juneau, Alaska

Dear Tourist Council,

It is our great honour to present to you our recommendations for sustainable tourism in Juneau, Alaska. We have conducted a thorough analysis of the current situation in Juneau and have identified several key areas that need to be addressed in order to ensure the long-term sustainability of the tourism industry in the region. Our recommendations are based on the principles of sustainable tourism, which aim to balance the economic, social, and environmental impacts of tourism in order to ensure that it can continue to benefit both the local community and the environment for generations to come. Our approaches, findings and suggestions are as follows.

Firstly we summarized a general equation aiming to balance the economic, social, and environmental impacts of tourism. Then we looked into these aspects and devised a model accordingly for each. *SARIMAX*, *Linear-Regression* models were used to ensure the accuracy and reliability of our findings and suggestions.

Here are some findings based on our predictions.

- The emission of carbon dioxide from tourism is increasing at an alarming rate, and it is highly correlated with the square number of tourists.
- Current tax rates may not be optimal for maximizing tourism income and environmental sustainability.
- The number of tourists is higher than the optimal number that can be accommodated by the local environment.

Based on these findings, we put forward the following recommendations and measures.

- Impose a carbon tax of around 20% on tourism to reduce carbon emissions and encourage sustainable practices.
- Increase the fine amount to 20\$ for tourists who violate environmental regulations to deter harmful behavior.
- Set the upper limit of tourists to 1.5 million per year to protect the local environment and culture. Reduce the number of tourists by 10% each year to around 1.2 million by 2030.

I hope you find our recommendations useful and that they will help to guide the development of sustainable tourism in Juneau. We believe that by working together, we can create a more sustainable future for the tourism industry in the region. Thank you for your attention and consideration. Feel free to contact us for any further information.

Sincerely,

Team # 2503720 Members



## Appendix A Bivariate Linear Regression Results

The Bivariate Linear Regression results are as follows:

***Model for stsfy:***

$$\text{stsfy} = -4.693528652706527 \times 10^{-5} N - 0.0060844912311383 \times N_{\text{local}} + 407.6518514$$

***Model for Crowding at Mendenhall Glacier:***

$$\text{Crowding\_at\_Mendenhall\_Glacier} = 1.1573084349139379 \times 10^{-5} N - 0.0017873857238289111 \times N_{\text{local}} + 100.15433801$$

***Model for Crowding on sidewalks downtown:***

$$\text{Crowding\_on\_sidewalks\_downtown} = 6.429491305077434 \times 10^{-6} N + 0.0023403412645394937 \times N_{\text{local}} - 25.69203444$$

***Model for Vehicle congestion downtown:***

$$\text{Vehicle\_congestion\_downtown} = 2.3146168698278767 \times 10^{-5} N + 0.01642522855234218 \times N_{\text{local}} - 496.69132398$$

***Model for Flightseeing noise:***

$$\text{Flightseeing\_noise} = -9.001287827108412 \times 10^{-6} N - 0.015276477770355294 \times N_{\text{local}} + 540.76884821$$

***Model for Air emissions from cruise ships:***

$$\text{Air\_emissions\_from\_cruise\_ships} = -1.543077913218585 \times 10^{-5} N - 0.017616819034894794 \times N_{\text{local}} + 618.46088265$$

***Model for Vehicle congestion outside of downtown:***

$$\text{Vehicle\_congestion\_outside\_of\_downtown} = 1.9288473915232255 \times 10^{-6} N - 0.02029789762063815 \times N_{\text{local}} + 683.19238967$$

***Model for Whale watching boat traffic and wakes:***

$$\text{Whale\_watching\_boat\_traffic\_and\_wakes} = 1.4144880871170358 \times 10^{-5} N + 0.0011487507819868843 \times N_{\text{local}} - 12.92247577$$

***Model for Crowding on trails:***

$$\text{Crowding\_on\_trails} = 1.2858982610154833 \times 10^{-6} N - 0.013531931747092107 \times N_{\text{local}} + 465.46159311$$

***Model for Street Services:***

$$\text{Street\_Services} = 0.7716946724830306 \times N - 1098.7869298693258 \times N_{\text{local}} + 39720019.96870749$$

***Model for Wastewater:***

$$\text{Wastewater} = 2.0506436350699593 \times N - 2977.4037361145515 \times N_{\text{local}} + 1.06567591 \times 10^8$$

***Model for Public Transit:***

$$\text{Public\_Transit} = -0.11276464701428993 \times N - 1619.7640126090985 \times N_{\text{local}} + 58718764.15347296$$

***Model for Parks and Recreation:***

$$\text{Parks\_and\_Recreation} = 2.7473696565739054 \times N - 2597.301898470375 \times N_{\text{local}} + 92393330.57040936$$

***Model for Docks:***

$$\text{Docks} = 2.0782557994938906 \times N + 424.7535749514112 \times N_{local} - 14090559.71680191$$

***Model for Ports:***

$$\text{Ports} = 0.708958939693741 \times N - 944.9238521963889 \times N_{local} + 33938861.95916443$$

***Model for JNU Composite:***

$$\text{JNU\_Composite} = 9.644236957615973 \times 10^{-7} N + 0.003851051189680889 \times N_{local} + 4.69619483$$

***Model for Grocery Items:***

$$\text{Grocery\_Items} = -2.1860270437263293 \times 10^{-5} N + 0.026042839700565677 \times N_{local} - 663.74708291$$

***Model for JNU Housing:***

$$\text{JNU\_Housing} = -2.0702962002349386 \times 10^{-5} N + 0.0018641011281828252 \times N_{local} + 107.36835089$$

***Model for Utilities:***

$$\text{Utilities} = 1.3951996132018008 \times 10^{-5} N + 0.008178540544050684 \times N_{local} - 142.54171473$$

***Model for Transportation:***

$$\text{Transportation} = 1.6909562132353666 \times 10^{-5} N - 0.01094490247426114 \times N_{local} + 442.51994943$$

***Model for Healthcare:***

$$\text{Healthcare} = -3.2147456525386777 \times 10^{-6} N + 0.006829829367730268 \times N_{local} - 59.05398278$$

***Model for Misc. Goods and Services:***

$$\text{Misc\_Goods\_and\_Services} = 1.9931423045740026 \times 10^{-5} N - 0.018744942079927586 \times N_{local} + 681.15469324$$

## References

- [1] McDowell Group. (2016). *Juneau Visitor Profile and Economic Impact Study*.
- [2] Southeast Conference. (2023). *Juneau Tourism Survey 2023*.
- [3] City and Borough of Juneau. (2016). *Juneau's Visitor Industry: Positive Economic Benefits for Our Community*.
- [4] Juneau Economic Development Council (JEDC). (2024). *Juneau SEAK Economic Indicators and Outlook Report*.
- [5] City and Borough of Juneau. (2021). *Juneau Tourism Survey 2021*.
- [6] City and Borough of Juneau. (2022). *Juneau Tourism Survey 2022*.
- [7] City and Borough of Juneau. (2023). *Juneau Tourism Survey 2023*.
- [8] City and Borough of Juneau. (2024). *Juneau Visitor Circulator Study: Final Report*.
- [9] City and Borough of Juneau Assembly. (2016). *Biennial Budget Fiscal Year 2016: Year 2 of the FY15/FY16 Biennial Budget*.
- [10] City and Borough of Juneau. (2018). *Biennial Budget Adopted Fiscal Year 2018: Year 2 of the FY17/18 Biennial Budget*.
- [11] City and Borough of Juneau. (2020). *Biennial Budget Adopted Fiscal Year 2020: Year 2 of the FY19/20 Biennial Budget*.
- [12] City and Borough of Juneau. (2022). *Biennial Budget Adopted Fiscal Year 2022: Year 2 of the FY21/22 Biennial Budget*.
- [13] City and Borough of Juneau. (2024). *Biennial Budget Adopted Fiscal Year 2024: Year 2 of the FY23/24 Biennial Budget*.
- [14] Alaska Department of Environmental Conservation Division of Air Quality. (2023). *Alaska Greenhouse Gas Emissions Inventory*.
- [15] Alaska Municipal League (2024). *State of Alaska Priority Sustainable Energy Action Plan*
- [16] UK NIR (2008). *Detailed discussion of methodology and data for estimating CO<sub>2</sub> emissions from fossil fuel combustion*
- [17] Final Alaska Greenhouse Gas Inventory and Reference Case Projections (2009). *Greenhouse Gas Emissions Inventory and Reference Case Projections*

# Report on Use of AI

## GPT4o

Messages below are conversations between a human and GPT-4o. The human is represented by *Q* and GPT-4o is represented by *A*.

*Q1:* Write me an introduction of Juneau, Alaska. Talk about its residents, tourists and attractions.

*A1:* Juneau, Alaska, the state's capital, is a city that blends breathtaking natural beauty with rich cultural heritage. Nestled in the southeastern part of the state, Juneau is uniquely accessible only by air or sea, giving it an island-like charm despite being part of the mainland. The city is home to approximately 30,000 residents who enjoy a lifestyle deeply connected to nature, with fishing, hiking, and outdoor exploration forming an integral part of daily life.

*Q2:* Can you tell me about the tourism industry in Juneau?

*A2:* Juneau is a popular destination for tourists from around the world, attracting over a million visitors annually. The city's natural wonders, including glaciers, rainforests, and abundant wildlife, make it a magnet for outdoor enthusiasts and nature lovers. Tourists can explore the Mendenhall Glacier, go whale watching, or take a scenic flight over the stunning landscape. The city also offers a vibrant arts and culture scene, with museums, galleries, and theaters showcasing the region's history and creativity.

*Q3:* What does Thousands of Chained 2017 U.S. Dollars mean?

*A3:* Thousands of Chained 2017 U.S. Dollars is a measure of economic value that adjusts for inflation and changes in purchasing power over time. By using the 2017 dollar as a base year, the measure allows for more accurate comparisons of economic data across different years, accounting for the effects of inflation on prices and wages.

*Q4:* What is the Kaya Identity?

*A4:* The Kaya Identity is a mathematical formula used to decompose the factors driving changes in carbon dioxide emissions. It breaks down emissions into four components: population, GDP per capita, energy intensity of the economy, and carbon intensity of energy. By analyzing these factors, policymakers can identify the key drivers of emissions growth and develop strategies to reduce carbon footprints.

*Q5:* Cost of converting CO2 to non-greenhouse gases?

*A5:* The cost of converting CO2 to non-greenhouse gases depends on the method used and the scale

of the operation. Technologies such as carbon capture and storage (CCS) and direct air capture (DAC) can be expensive due to the energy and resources required to capture and convert CO<sub>2</sub>. However, as these technologies become more advanced and widespread, the cost of converting CO<sub>2</sub> to non-greenhouse gases is expected to decrease, making it a more viable solution for reducing emissions.

## GPT4o-mini

Messages below are conversations between a human and GPT4o-mini. The human is represented by *Q* and GPT4o-mini is represented by *A*.

*Q6*: What does MTCO<sub>2</sub>e mean?

*A6*: MTCO<sub>2</sub>e stands for metric tons of carbon dioxide equivalent, a unit of measurement used to quantify the global warming potential of greenhouse gases. By expressing emissions in terms of CO<sub>2</sub> equivalents, different gases can be compared based on their impact on the climate, allowing for a more comprehensive assessment of a country or region's carbon footprint.

*Q7*: How to quantify the damage humans have done to the environment?

*A7*: Quantifying the damage humans have done to the environment is a complex and multifaceted task that requires a combination of scientific, economic, and social analyses. Environmental impact assessments, life cycle assessments, and ecological footprint analyses are some of the tools used to measure the effects of human activities on ecosystems, biodiversity, and natural resources. By evaluating factors such as pollution, habitat destruction, and resource depletion, researchers can estimate the extent of environmental damage and develop strategies to mitigate its impact.