美赛O奖文档

论文修改建议

1. 摘要标黄的表述不明确
2. 【P6 4】气候带分析那边给人一种少了内容的感觉。建议在此处直接说明我们选择的两个地区，然后分析为什么选择这两个地区作为评价模型的地区。这里就可以谈气候分析，地区分析了
3. 【Figure 5】颜色
4. 【P9 5.1.2】Normalization of the Primitive Matrix，原始矩阵规范化，可以说明一下原始矩阵怎么构建（**此处以保险模型为例**）

原始矩阵正向化：将所有指标类型统一转化为极大型指标（越大越好的指标）

	自然灾害发生率	建筑密集程度	经济发展数据	房屋贵重程度	历史索赔数据	地形和土地利用
数据1(如：2021)	x	x	x	x	x	x
数据2(如：2022)	x	x	x	x	x	x

5. 【P10 5.2】两个函数中的均值和方差不是一样的，字母可以通过加“'”来区分。具体含义，怎么来的，也要说明：

首先计算数据集均值 μ 和标准差 σ （例如自然灾害发生率，查到的资料是每年的自然灾害次数，那么需要计算这些值的均值和方差即可，其他因素以此类推）

计算正态分布的累积分布函数：

$$\Phi(z)=\frac{1}{2}\left[1+erf\left(\frac{z-\mu}{\sigma\sqrt{2}}\right)\right]$$

假设我们要计算一个自变量为z的值，代入上式求得：$(z,\Phi(z))$ $(\Phi(z),f(\Phi(z)))$

以 $\mu'=\Phi(z)$ ，σ **为0.1（0.1的由来参考下图：当u=0.5时，根据正态分布** $\mu-\sigma<x<\mu+\sigma$ **范围的占比为95.45%，所以应该让这个区间落在我们规定的“可有可无”这一权重中，而“可有可无”的范围是0.4~0.6，所以需要满足** $2\sigma=0.2$ **,** σ **为0.1）**

带入正态分布一般方程：

$$f(x;\mu,\sigma)=\frac{1}{\sigma\sqrt{2\pi}}\exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)。$$

6. 【P11 公式8】等号和后面的删光
7. 【P11 公式8下面说明文字】[a, b]区间最好在下面说明我们选择的五个区间和对应的含义

分别求x=[0, 0.2], [0.2, 0.4], [0.4, 0.6], [0.6, 0.8]. [0.8, 1]上的积分，即为对应非常不需要，不太需要，可有可无，需要保险，非常需要保险的判断矩阵中的对应值，**算完以后进行归一化**

8. 【P11 公式9】为什么是1-v？因为5.2中概率校准后归一化了。
9. 5.2.1的矩阵R中的值要说明一下，比如有一些值是查阅的资料，一些是人工打分的，然后填入R中，也可以在5.1.1中直接跟在因素集后面说明评判方式。意思是不能只告诉人家6个因素，得告诉他们这六个因素是怎么个影响的，怎么来反映情况的，用什么数值来反应？单位是什么？

✅ **保险需求：**

1. 自然灾害发生率：每月气象灾害发生次数
2. 建筑密集程度：城镇常住人口除城区面积
3. 经济发展数据：人均国民总收入，家庭收入中位数，居民失业率
4. 房屋贵重程度：当地平均房价
5. 历史索赔数据：新西兰保险委员会
6. 地形和土地利用：洪泛平原 => 河流长度 * 两岸面积，海岸线，滩涂面积和海拔低的地方容易被淹没

保险风险：

1. 政策和应对能力：政府灾后救济和应对灾害的法律法规（如规定房屋建设相对海平面高度）
2. 金融市场和投资收益：历史索赔数据和当地购保人数
3. 基础设施强度：水渠，堤坝
4. 环保意识：当地议会环保议题居民响应情况，当地发电所用能源中清洁能源占比
5. 科技和创新：当地人均专利申请数
6. 气候变化和长期趋势：来自相关论文分析和新闻报道

10. 【P12 5.3图7下面一段】“包括大量分析数据，如上图所示”，然后上图只有一个storm。。。应该要写个例如：上图反应了……并且，我觉得，要不改成下图？？？
11. 【P12-13 5.3.1】一样的道理，参考上面第9条修改建议和高亮块
12. 【P13 table 2】得解释一下Membership Matrix里的值代表什么

十二种气候类型及对应隶属值由**人为确定：（越接近1变化越复杂）也可以理解为概率分布，对应[**变化非常高，变化高，变化中等，变化低，变化非常低]

13. 【P13 5.3.2表2下方说明文字】矩阵是用来确定模糊综合判断矩阵R的，和熵权计算无关
14. 【P13 5.4】A= [0.3231, 0.0794, 0.3549, 0.0986, 0.1010, 0.1519]
15. 【P14 5.4】不是通过判断矩阵R来判断的，此处结论是用矩阵B来得出的！！！！！！ B = A x R

矩阵B的具体值请参考 此文档 -> 数据计算和结论 -> 模型一 -> 需求模型和风险模型，一共有4个矩阵B

16. 【P15 5.5最下面一段和表5】建议将此段移动到5.4底
17. 【P15 6 第一段最后】怎么提升的？可以在这一段简述，比如灰色预测用来预测未来，关系分析用来分析影响因素重要程度
18. 【P16 表6】表6中的数据代表的含义？？？ 要简要说明.**最关键的一句话：矩阵矩阵中元素aij的意义是，第i个指标相对第j个指标的重要程度**

标度	含义
1	表示两个因素相比，具有同样重要性
3	表示两个因素相比，一个因素比另一个因素稍微重要
5	表示两个因素相比，一个因素比另一个因素明显重要
7	表示两个因素相比，一个因素比另一个因素强烈重要
9	表示两个因素相比，一个因素比另一个因素极端重要
2，4，6，8	上述两相邻判断的中值

矩阵矩阵中元素a_{ij}的意义是，**第i个指标相对第j个指标的重要程度**

19. 【P17 6.1.1】可以加入我们算出来的CR值
20. 【P17 6.1.1】层次分析模型没写完整，权重怎么来的？通过矩阵特征值来的

采用**特征值法求权重**

- **特征值法求权重**

一致矩阵有一个特征值n，其余特征值均为0

另外，我们很容易得到，特征值为n时，对应的特征向量刚好为$k\left[\frac{1}{a_{11}}, \frac{1}{a_{12}}, \cdots, \frac{1}{a_{1n}}\right]^T$ $(k \neq 0)$

假如我们的判断矩阵一致性可以接受，那么我们可以仿照一致矩阵权重的求法。

第一步：求出矩阵A的最大特征值以及其对应的特征向量

第二步：对求出的特征向量进行归一化即可得到我们的权重

21. 【P17 6.2】**a,b通过最小二乘法……得出，简要说明一下**

typically set=> here we set

22. 【P18 表7】将第二列Normalized Eigenvector删除
23. 【P18 6.3】结论标错了，上面一段也是结论啊
24. 【P19 6.4】重点结论不说，说的次要结论，正确的结论如下：

✅ 根据房地产模型，佛蒙德和奥克兰两地建房差异不大，属于可建可不建的状态，但如果要在两地之间选择一个更适合建房的地方，奥克兰最终得分略高于佛蒙特，所以可以选择在奥克兰建房。

预测未来：奥克兰相比于佛蒙特两地建房差异不大，但随着时间发展，奥克兰与佛蒙特两地建房差异逐渐增大，奥克兰相比于佛蒙特越来越适合建房。

25. 【P21 7.4】Strategic Outcomes和表9，建议放在7.3后面，因为7.4是假设应用
26. 【P22 8】灵敏度分析这一段一些重要的词/模型，建议来个加粗
27. 【P25】建议信！上来不自我介绍一下？然后说明一下我们建了三个模，能用来……，然后再告诉模型出来的结果，然后给对策。Plan and Timeline中：人称！！！**We不好，题目中是“向社区推荐一个计划、时间表和成本提案”**

题目和要求

原文PDF

2024 ICM
Problem E: Sustainability of Property Insurance

Photo Credit: Pixabay.com

Extreme-weather events are becoming a crisis for property owners and insurers. The world has endured “more than $1 trillion in damages from more than 1,000 extreme-weather events in recent years.”[1] The insurance industry saw claims for natural disasters in 2022 increase by “115% compared to the 30-year average.”[1] Conditions are expected to get worse as losses from severe weather-related events are likely to increase due to floods, hurricanes, cyclones, droughts, and wildfires. Premiums for insurance coverage are rising quickly, with climate change fueling projected increases of 30-60% by 2040.[1]

2024_ICM_Problem_E.pdf

E题GPT4翻译

极端天气事件正成为房地产所有者和保险公司的危机。近年来，世界经历了“超过1000起极端天气事件造成的损失超过1万亿美元。”[1] 保险行业在2022年自然灾害的索赔量比30年平均水平增加了“115%”[1]。预计情况将变得更糟，因为由于洪水、飓风、气旋、干旱和野火等严重天气相关事件造成的损失可能会增加。保险费用正在迅速上涨，气候变化预计会在2040年前导致保险费用增加30-60%[1]。

物业保险不仅变得更加昂贵，而且变得更难找到，因为保险公司改变了他们愿意承保的方式和地点。推动物业保险费用上升的天气相关事件因你所在的世界地区而异。此外，全球保险保护缺口平均为57%，且在增加[2]。这突显了该行业的困境——保险公司的盈利能力危机和房地产所有者的可负担性危机。

COMAP的灾害保险模型师(ICM)对物业保险行业的可持续性感兴趣。随着气候变化增加了更严重的天气和自然灾害的可能性，ICM希望确定如何最好地调整现在的物业保险，以确保系统有韧性来覆盖未来索赔的成本，同时也确保保险公司的长期健康。**【任务1】如果保险公司不愿意在太多情况下承保政策，它们会因为客户太少而倒闭。相反，如果他们承保的政策风险太大，他们可能会支付过多的索赔。保险公司在什么条件下应该承保政策？他们应该什么时候选择承担风险？房地产所有者能做些什么来影响这一决定？**开发一个模型，以帮助保险公司确定是否应该在极端天气事件不断增加的地区承保政策。使用两个经历极端天气事件的不同大洲的地区来演示你的模型。

展望未来，社区和房地产开发商需要询问自己如何以及在何处建设和发展。**【任务2】随着保险格局的变化，必须做出未来房地产决策，以确保物业更具韧性并有意地建造，包括向不断增长的社区和人口提供适当服务的能力。你的保险模型如何适应评估在特定地点建造、如何建造以及是否建造的问题？**

可能有一些社区，你的保险模型建议不承保当前或未来的物业保险政策。这可能导致社区领导面临有关具有文化或社区重要性的财产的艰难决定。例如，为了保护这座历史灯塔以及围绕它的当地旅游业，北卡罗来纳州外海岸的卡普哈特拉斯灯塔被迁移了[3]。**【任务3】作为一个社区领导者，你如何识别社区中应该因其文化、历史、经济或社区重要性而被保存和保护的建筑物？开发一个社区领导者使用的保护模型，以确定他们应采取何种措施来保护他们社区的建筑物。**

选择一个位于经历极端天气事件的地点的历史地标——不是卡普哈特拉斯灯塔——应用你的保险和保护模型来评估这一地标的价值。**【任务4】撰写一封一页的信，向社区推荐一个计划、时间表和成本提案，考虑到你从保险和保护模型的结果中获得的见解，为他们珍视的地标的未来。**

Glossary（术语表）

Insurance Protection Gap（保险保障缺口）: the difference in protection coverage between economic losses brought about

by natural disasters and the amount of those losses that are covered.

Underwrite（承保）: accept liability for, thereby guaranteeing payment in the case of loss or damage

四个总体任务

✅ - [ ] 建造模型，确定保险公司在什么条件下应该承保政策？他们应该什么时候选择承担风险？**房地产所有者能做些什么来影响这一决定？**
- [ ] 保险模型如何适应评估在特定地点建造、如何建造以及是否建造的问题？
- [ ] 开发一个社区领导者使用的保护模型，识别社区中应该因其文化、历史、经济或社区重要性而被保存和保护的建筑物？**开发一个社区领导者使用的保护模型，以确定他们应采取何种措施来保护他们社区的建筑物。**
- [ ] **撰写一封一页的信，向社区推荐一个计划、时间表和成本提案，考虑到你从保险和保护模型的结果中获得的见解，为他们珍视的地标的未来。**

建模

✅模型一：保险模型的开发及在不同地理区域的应用

目标：创建一个模型，帮助保险公司决定是否应该在极端天气事件数量不断增加地区承保保单。

主要考虑因素：

- 风险评估：模型需要准确评估与不同地理区域承保保单相关的风险，同时考虑极端天气事件的频率和严重程度。
- 可持续性：该模型应通过平衡高风险领域承保保单的风险与公司的盈利能力和生存能力来确保保险公司的长期可持续性。
- 业主的影响：模型应考虑业主采取的行动（例如实施风险缓解策略）如何影响承保保单的决定。

目标：通过将模型应用于不同大陆上经历极端天气事件的两个地区，展示该模型的功能和适应性。

主要考虑因素：

- 区域分析：模型应足够灵活，能够考虑到气候、建筑标准和各种自然灾害发生率的区域差异。
- 数据集成：将准确的、特定于区域的数据集成到模型中，以确保风险评估对于每个位置都是相关且精确的。

需求模型采用模糊综合评价

✅ **保险需求：**

1. 自然灾害发生率（越高越需要保险）：该地区的自然灾害发生数量或频率
2. 建筑密集程度（越密集越需要保险）：决定是否需要买保险，也可以用城市化率/人口密集程度代替
3. 经济发展数据（越发达越需要保险）：买不买得起保险，相对发达地区/相对不发达地区的GDP
4. 房屋贵重程度（越贵越需要保险）：需不需要买保险
5. 历史索赔数据（之前有赔过的越需要保险）：分析过去几年的索赔数据可以帮助确定不同地区的风险水平和索赔频率。这可以为模型提供一个基准，用来评估未来可能的索赔量。
6. 地形和土地利用（地形越复杂越需要保险）：洪泛平原 => 河流长度 * 两岸面积，海岸线，滩涂面积和海拔低的地方容易被淹没

1. **确定三个集合**

因素集 U={自然灾害发生率，建筑密集程度，经济发展数据，房屋贵重程度，历史索赔数据，地形和土地利用}

评语集 V={非常需要保险，需要保险，可有可无，不太需要，非常不需要}

权重集 A={对应因素集U的权重}

权重A的确定方法：熵权法

（1）原始矩阵正向化：将所有指标类型统一转化为极大型指标（越大越好的指标）

	自然灾害发生率	建筑密集程度	经济发展数据	房屋贵重程度	历史索赔数据	地形和土地利用
数据1(如：2021)	x	x	x	x	x	x
数据2(如：2022)	x	x	x	x	x	x

指标名称	指标特点	例子
极大型（效益型）指标	越大（多）越好	颜值、成绩、GDP增速
极小型（成本型）指标	越小（少）越好	脾气、费用、坏品率、污染程度
中间型指标	越接近某个值越好	身高、水质量评估时的PH值
区间型指标	落在某个区间最好	体重、体温

- 将原始矩阵正向化，就是要将所有的指标类型统一转化为**极大型指标**。

指标名称	公式
极大型（效益型）指标	/
极小型（成本型）指标	$\hat{x} = max - x$，$\hat{x}$为转化后指标，max为指标最大值，x为指标值
中间型指标	$\{x_i\}$是一组中间型序列，最优值是x_{best} $M = max\{\lvert x_i - x_{best}\rvert\}$，$\hat{x}_i = 1 - \frac{\lvert x_i - x_{best}\rvert}{M}$
区间型指标	$\{x_i\}$是一组区间型序列，最佳区间为$[a,b]$，正向化公式如下 $M = max\{a - min\{x_i\}, max\{x_i\} - b\}$，$\tilde{x}_i = \begin{cases} 1 - \frac{a - x_i}{M}, & x_i < a \\ 1, & a \le x_i \le b \\ 1 - \frac{x_i - b}{M}, & x_i > b \end{cases}$

（2）正向矩阵标准化

- 标准化的目的是**消除不同指标量纲**的影响。

假设有n个要评价的对象，m个评价指标（已正向化）构成的正向化矩阵如下：

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1m} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nm} \end{bmatrix}$$

那么，对其标准化的矩阵记为Z，Z中的每一个元素：

$$z_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \text{(每一个元素}/\sqrt{\text{其所在列的元素的平方和}}\text{)}$$

（3）计算概率矩阵P（归一化）

- 计算标准化矩阵第j项指标下第i个样本所占的比重$p_{ij} = \frac{z_{ij}}{\sum_{i=1}^{n} z_{ij}}$

（4）计算熵权

计算熵权

- 对于第j个指标，信息熵的计算公式为：$e_j=-\frac{1}{\ln n}\sum_{i=1}^{n} p_{ij}\ln(p_{ij})\,(j=1,2,\ldots,m)$
- 易知，当$p_{1j}=p_{2j}=\cdots=p_{nj}=\frac{1}{n}$时，$e_j=1$，此时**信息熵最大，但其信息效用值最小**
- 定义信息效用值d_j=$1-e_j$，此时效用值越大，权重越大
- 将信息效用值进行归一化，得到熵权 $W_j=\frac{d_j}{\sum_{j=1}^{m} d_j}$

2. **确定隶属函数，此处借助已有的客观尺度：**

地形和土地利用由人为确定隶属矩阵，例如山地可以指定[0.5，0.3，0.2，0，0]

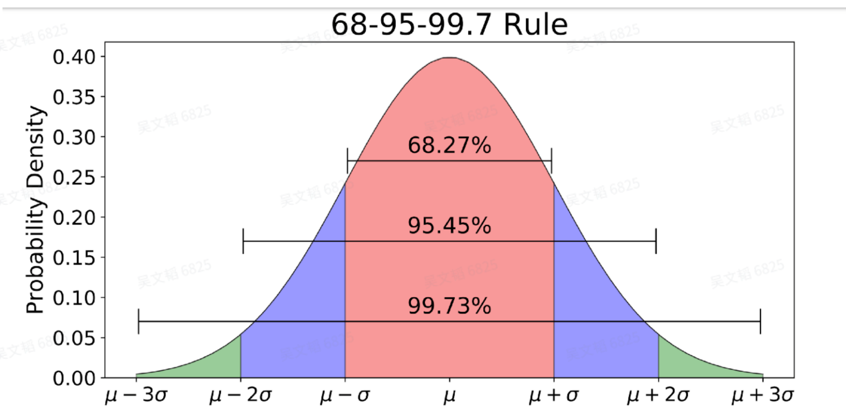
首先计算数据集均值 μ 和标准差 σ（例如自然灾害发生率，查到的资料是每年的自然灾害次数，那么需要计算这些值的均值和方差即可，其他因素以此类推）

计算正态分布的累积分布函数：

$$\Phi(z)=\frac{1}{2}\left[1+erf\left(\frac{z-\mu}{\sigma\sqrt{2}}\right)\right]$$

假设我们要计算一个自变量为z的值，代入上式求得：$(z,\Phi(z))$ $(\Phi(z),f(\Phi(z))$

以 $\mu'=\Phi(z)$，σ **为0.1（0.1的由来参考下图：当u=0.5时，根据正态分布 $\mu-\sigma<x<\mu+\sigma$ 范围的占比为95.45%，所以应该让这个区间落在我们规定的“可有可无”这一权重中，而“可有可无”的范围是0.4~0.6，所以需要满足 $2\sigma=0.2$，σ 为0.1）**



带入正态分布一般方程：

$$f(x;\mu,\sigma)=\frac{1}{\sigma\sqrt{2\pi}}\exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)。$$

然后分别求x=[0, 0.2], [0.2, 0.4], [0.4, 0.6], [0.6, 0.8]. [0.8, 1]上的积分，即为对应非常不需要，不太需要，可有可无，需要保险，非常需要保险的判断矩阵中的对应值

算完以后要进行归一化

```
import numpy as np
```

```python
import sympy as sp

z = np.array([100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250, 260, 270, 280, 290, 300,
              310, 320, 330, 340, 350, 360, 370, 380, 390, 400, 410, 420, 430, 440, 450, 460, 470, 480, 490, 500, 510, 520, 530])
std_deviation = np.std(z)
mean = np.mean(z)
formatted_mean = "{:.4f}".format(mean)
formatted_std_deviation = "{:.4f}".format(std_deviation)

print("平均值: " + formatted_mean + "\t标准差: " + formatted_std_deviation)

def probability(i):
    j = 0.5 * (1 + sp.erf((i - mean) / (std_deviation * sp.sqrt(2))))
    x = sp.symbols('x')
    f = (1 / (0.1 * sp.sqrt(2 * sp.pi))) * \
        sp.exp(-0.5 * ((x - j) / 0.1) ** 2)
    p = [
        sp.integrate(f, (x, 0, 0.2)),
        sp.integrate(f, (x, 0.2, 0.4)),
        sp.integrate(f, (x, 0.4, 0.6)),
        sp.integrate(f, (x, 0.6, 0.8)),
        sp.integrate(f, (x, 0.8, 1.0)),
    ]

    p = [val / sum(p) for val in p]
    p_rounded = [round(val.evalf(), 4) for val in p]
    p_rounded.reverse()
    return p_rounded

input_value = float(input("请输入自变量数值: "))
result = probability(input_value)
print("非常需要保险，需要保险，可有可无，不太需要，非常不需要")
print(result)

```

```csharp
using MathNet.Numerics;
public class Question1
{
    public (double, double) GetAverageValueAndStandardDeviation()
    {
        var result = (0.0, 0.0);
        List<int> list = new List<int> { };
        while (true)
```

```
        {
            var input = Console.ReadLine();
            if (input == "quit")
            {
                break;
            }

            list.Add(int.Parse(input));
            Console.WriteLine("您添加了一个数" + input);
        }

        result.Item1 = list.Average();
        result.Item2 = Math.Sqrt(list.Select(x => Math.Pow(x - result.Item1, 2)).Sum() / list.Count);
        return result;
    }

    public double GetCumulativeDistributionFunctionOfNormalDistribution(double z, double a, double s)
    {
        return 0.5 * (1 + SpecialFunctions.Erf((z - a) / (s * Math.Sqrt(2))));
    }

    public void Anticipate(double a)
    {
        List<double> res = new();
        double s = 0.4472136;
        Func<double, double> function = x =>
            SpecialFunctions.Erf(-Math.Pow((x - a), 2) / (2 * Math.Pow(s, 2))) / (Math.Sqrt(2 * Math.PI) * s);
        for (int i = 0; i < 5; i++)
        {
            res.Add(Integrate.GaussLegendre(function, i * 0.2f, (i + 1) * 0.2f));
        }

        List<double> res2 = new List<double>();
        foreach (var v in res)
        {
            res2.Add(Math.Round((v / res.Sum()),4));
        }
        foreach (var result in res2)
        {
            Console.Write(result+" ");
        }
    }
}
```

```
public class Program
{
    public static void Main()
    {
        var question1 =new Question1();
        double a, s;
        Console.WriteLine("请输入数据计算均值和方差");
        (a, s) = question1.GetAverageValueAndStandardDeviation();
        Console.WriteLine("请输入 z");
        var z = double.Parse(Console.ReadLine());
        Console.WriteLine("您输入了值" + z);
        question1.Anticipate(
question1.GetCumulativeDistributionFunctionOfNormalDistribution(z, a, s));
    }
}
```

3. 确定模糊综合判断矩阵R：

特别注意：所有的值都要转化为极大值，若是极小值，需要用1-极大值来转换

U\V	非常需要	需要	可有可无	不太需要	非常不需要
自然灾害发生					
建筑密集程度					
经济发展数据					
房屋贵重程度					
历史索赔数据					
地形和土地利用					

4. 建立综合评价模型

在确定R和A之后，通过模糊变化将U上的模糊向量A变为V上的模糊向量B，$B = A \times R$

为什么是BxR？具体看下图，原理用来吹牛逼就行，不用看懂

(5) 选择评价的合成算子，将 A 与 R 合成得到 $B=(b_1,b_2,\cdots,b_m)$。

$$B = A \circ R = (a_1,a_2,\cdots,a_n) \circ \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{pmatrix}$$

$$b_j = (a_1 \underset{\cdot}{\bullet} r_{1j}) \underset{\cdot}{+} (a_2 \underset{\cdot}{\bullet} r_{2j}) \underset{\cdot}{+} \cdots \underset{\cdot}{+} (a_n \underset{\cdot}{\bullet} r_{nj}), \quad j=1,2,\cdots,m$$

常用的模糊算子有：

① $M(\wedge,\vee)$， 即用 $\wedge$ 代替 $\underset{\cdot}{\bullet}$，用 $\vee$ 代替 $\underset{\cdot}{+}$，式中 $\wedge$ 为取小运算，$\vee$ 代表取大运算；

② $M(\bullet,\vee)$， 即用实数乘法 $\bullet$ 代替 $\underset{\cdot}{\bullet}$， 用 $\vee$ 代替 $\underset{\cdot}{+}$；

③ $M(\wedge,\oplus)$，即用 $\wedge$ 代替 $\underset{\cdot}{\bullet}$， 用 $\oplus$ 代替 $\underset{\cdot}{+}$， 其中 $a \oplus b = \min(1, a+b)$；

④ $M(\bullet,\oplus)$，即用实数乘法 $\bullet$ 代替 $\underset{\cdot}{\bullet}$， 用 $\oplus$ 代替 $\underset{\cdot}{+}$。

经过比较研究， $M(\bullet,\oplus)$ 对各因素按权数大小，统筹兼顾，综合考虑，比较合理。

	非常需要	需要	可有可无	不太需要	非常不需要
矩阵B					

选择上述五个指标中，值最高的作为评价结果。

风险模型采用模糊综合评价

✅ **保险风险：**

1. 政策和应对能力（能力越高，风险越小）：一些社区可能已经采取了措施来减轻自然灾害的影响，例如建设防洪堤、采取火灾防范措施等。这些因素可以影响保险公司对特定地区的风险认知。
2. 金融市场和投资收益（地区经济越发达，越可以买保险，风险越小）：保险公司还需要考虑他们的投资收益和资金状况。在某些情况下，保险公司可能会更愿意承担高风险，因为这可能会带来更高的保费收入，但也伴随着更高的索赔风险。
3. 基础设施强度（基础设施越强，损失越小，风险越小）：考虑地区的基础设施强度，包括抗震建筑、防洪措施等。基础设施的质量可以降低潜在的损失，并影响保险的承保决策。

4. 环保意识（环保意识越高，风险越小）：考虑地区居民对于环境问题和气候变化的意识水平。高度的环保意识可能导致更多的风险缓解措施，影响风险评估。
5. 科技和创新（技术越高，风险越小）：考察地区的科技水平和创新能力，因为先进的技术和创新可能有助于减轻灾害带来的损失，从而影响保险公司的决策。
6. 气候变化和长期趋势（气候变化越复杂风险越高，考虑气候类型）：考虑气候变化对自然灾害频率和严重程度的潜在影响。长期趋势分析可以帮助预测未来可能的风险和索赔情况。

- 十二种气候类型及对应隶属值由**人为确定：（越接近1变化越复杂）**

变化非常高，变化高，变化中等，变化低，变化非常低

气候类型	隶属矩阵	气候类型	隶属矩阵
热带雨林气候	[0.7,0.2,0.1,0,0]	温带海洋性气候	[0.1.0.1,0.5,0.2,0.1]
热带草原气候	[0.2,0.4,0.35,0.05,0]	温带大陆性气候	[0.2,0.25,0.5.0.05,0]
热带沙漠气候	[0.5,0.3,0.2,0,0]	温带季风气候	[0.3,0.25,0.25,0.15,0.05]
热带季风气候	[0.6,0.3,0.1,0,0]	亚寒带针叶林气候	[0.4,0.15,0.25,0.15,0.05]
地中海气候	[0.1,0.1,0.4,0.3,0.1]	极地气候	[0.8,0.2,0,0,0]
亚热带季风气候和季风性湿润气候	[0.4,0.2,0.25,0.1,0.05]	高原山地气候	[0.5,0.3,0.2,0,0]

1. **确定三个集合**

因素集 U={政策和应对能力，金融市场和投资收益，基础设施强度，环保意识，科技和创新，气候变化和长期趋势}

评语集 V={风险非常高，风险高，风险中等，风险低，风险非常低}

权重集 A={对应因素集U的权重}

权重A的确定方法：熵权法

2. **确定隶属函数，此处借助已有的客观尺度：**

首先计算数据集均值 μ 和标准差 σ

计算正态分布的累积分布函数：

$$\Phi(z)=\frac{1}{2}\left[1+\operatorname{erf}\left(\frac{z-\mu}{\sigma\sqrt{2}}\right)\right].$$

假设我们要计算一个自变量为z的值，代入上式求得：$(z, \Phi(z))$

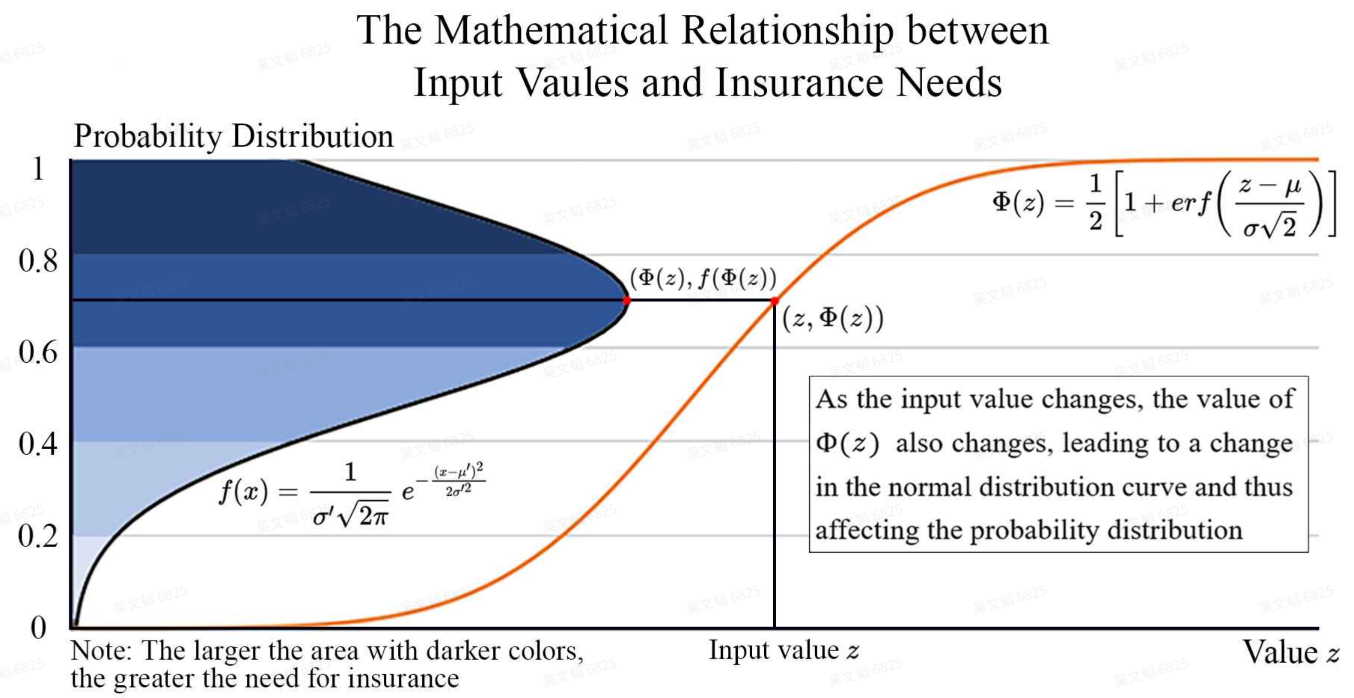
以 $\mu' = \Phi(z)$，σ 为0.1（0.1的由来参考下图：当u=0.5时，根据正态分布 $\mu - \sigma < x < \mu + \sigma$ 范围的占比为95.45%，所以应该让这个区间落在我们规定的“可有可无”这一权重中，而“可有可无”的范围是0.4~0.6，所以需要满足 $2\sigma = 0.2$，σ 为0.1）

带入正态分布一般方程：

$$f(x; \mu, \sigma) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)。$$

然后分别求解[0, 0.2], [0.2, 0.4], [0.4, 0.6], [0.6, 0.8]. [0.8, 1]上的积分，即为对应风险非常高，风险高，风险中等，风险低，风险非常低的判断矩阵中的对应值

算完以后要进行归一化



3. 确定模糊综合判断矩阵R：

特别注意：所有的值都要转化为极大值，若是极小值，需要用1-极大值来转换

U\V	风险非常高	风险高	风险中等	风险低	风险非常低
政策和应对能力					
金融市场和投资收益					
基础设施强度					

环保意识					
科技和创新					
气候变化和长期趋势					

4. 建立综合评价模型

在确定R和A之后，通过模糊变化将U上的模糊向量A变为V上的模糊向量B，$B = A \times R$

	风险非常高	风险高	风险中等	风险低	风险非常低
矩阵B	xxx	xxx	xxx	xxx	xxx

选择上述五个指标中，值最高的作为评价结果。

✅ 最后需要将上面两个模型结合起来，人为制定一个区间，满足：

- 保险需求越高，并且保险风险越小时，保险公司可以承担承保
- 保险需求越低，并且保险风险越大时，保险公司不应该承担承保

✅模型二：房地产开发保险模式

目标：调整保险模型以指导未来的房地产开发决策，确保房地产的建设具有弹性和战略性，以减轻极端天气事件的风险。

主要考虑因素：

- 弹性建筑实践：鼓励能够抵抗极端天气事件的建筑实践，以降低总体风险，从而降低保险费。
- 战略开发：根据模型的风险评估和对未来气候变化影响的预测，指导开发人员在何处、如何以及是否进行构建。

房地产模型采用层次分析

✅ **因素分析：**

1. 气候韧性建筑标准（由**房屋本身**决定）： 引入气候韧性建筑标准，以确保在特定地点建造的房地产能够抵抗极端天气事件。这包括使用抗震建材、防水设计、抗风设计等。
2. 风险缓解策略（即**防灾工程数量**）： 培育开发者采取风险缓解策略，如绿色基础设施、防洪工程、气候适应性景观设计等，以减轻房地产项目所面临的自然灾害风险。

3. 模型的参与（将**保险模型和风险模型运用进来**，保险需求不高，风险小的地区适合建房）： 将保险模型融入房地产决策过程中，使其成为一个重要的风险评估工具。模型可以提供特定地点的气候风险评估，帮助开发者决定是否在该地区进行建设。
4. 可持续发展考虑（**绿色能源利用占比**）： 鼓励可持续发展实践，包括能源效益、绿色建筑认证等，以确保房地产项目在经济、社会和环境层面都具有可持续性。
5. 社区政府参与（**社区和政府的参与程度，建筑许可**）： 与当地社区合作，了解他们的需求和关切。通过考虑社区的反馈，可以更好地调整房地产开发决策，确保项目符合当地的实际情况和期望。与政府合作，共同制定和执行有助于提高区域韧性的政策。政府的支持和合作可以在建设阶段提供更多的资源和指导。
6. ……

根据风险模型结果采取措施

1. 监测与调整： 持续监测气候变化和极端天气事件的趋势，不断调整保险模型和房地产开发策略。灵活性和适应性是确保长期成功的关键。
2. 定制化保险产品： 根据具体的房地产项目和地理位置，开发定制化的保险产品。这些产品可以基于模型的输出，提供更精确的保险费率和保险条款。

1. 建立层次结构模型

目标层：房地产造房子

准测层：气候韧性建筑标准，风险缓解策略，风险模型参与，能源可持续发展，社区政府……

方案层：适合建房，不适合建房

2. 构造判断矩阵（人为确定）

对指标进行两两比较，构造判断矩阵，矩阵中元素aij表示第i个指标相对第j个指标的重要程度

i \ j	气候韧性建筑标准	风险缓解策略	风险模型参与	能源可持续发展	社区政府
气候韧性建筑标准	**1**	3	1/5	4	2
风险缓解策略	1/3	**1**	1/3	3	2
风险模型参与	5	3	**1**	7	5
能源可持续发展	1/4	1/3	1/7	**1**	2
社区政府	1/2	1/2	1/5	1/2	**1**

标度	含义
1	表示两个因素相比，具有同样重要性
3	表示两个因素相比，一个因素比另一个因素稍微重要
5	表示两个因素相比，一个因素比另一个因素明显重要
7	表示两个因素相比，一个因素比另一个因素强烈重要
9	表示两个因素相比，一个因素比另一个因素极端重要
2，4，6，8	上述两相邻判断的中值

矩阵矩阵中元素a_{ij}的意义是，**第i个指标相对第j个指标的重要程度**

主对角线两侧元素呈**倒数关系（关系相反）**

比如：$a_{41}=5$，那么$a_{14}=\dfrac{1}{5}$

3. 一致性检验

判断构造的判断矩阵和一致矩阵是否有太大差别

- 证明过程

$$\begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix} \text{为一致矩阵的条件} \begin{cases} a_{ij} > 0 \\ a_{11} = a_{22} = \cdots = a_{nn} = 1 \\ [a_{i1},\ a_{i2},\ \ldots,\ a_{in}] = k_i[a_{11},\ a_{12},\ \ldots,\ a_{1n}] \\ a_{ij} = a_{ik} \times a_{kj} \end{cases}$$

- 引理：A为n阶方阵，且r(A)=1，则A有一个特征值为tr(A)$=n$，其余特征值均为0
- 因为一致矩阵的各行成比例且不是零矩阵，所以一致矩阵的秩一定为1
- 由引理可知：一致矩阵有一个特征值为n，其余特征值均为0
- 易得，特征值为n时，对应的特征向量刚好为$k\left[\frac{1}{a_{11}},\ \frac{1}{a_{12}},\ \ldots,\ \frac{1}{a_{1n}}\right]^T$
- 引理：n阶正互反矩阵A为一致矩阵时当且仅当最大特征值$\lambda_{\max} = n$。且当正互反矩阵A非一致时，一定满足$\lambda_{\max} > n$，判断矩阵越不一致时，最大特征值与n相差就越大。

求上述判断矩阵的所有特征值 λ，记最大特征值为 λ_{max}，计算一致性指标CI，n为影响因素的数量

$$CI = \frac{\lambda_{max} - n}{n-1}$$

查找对应的平均随机一致性指标RI

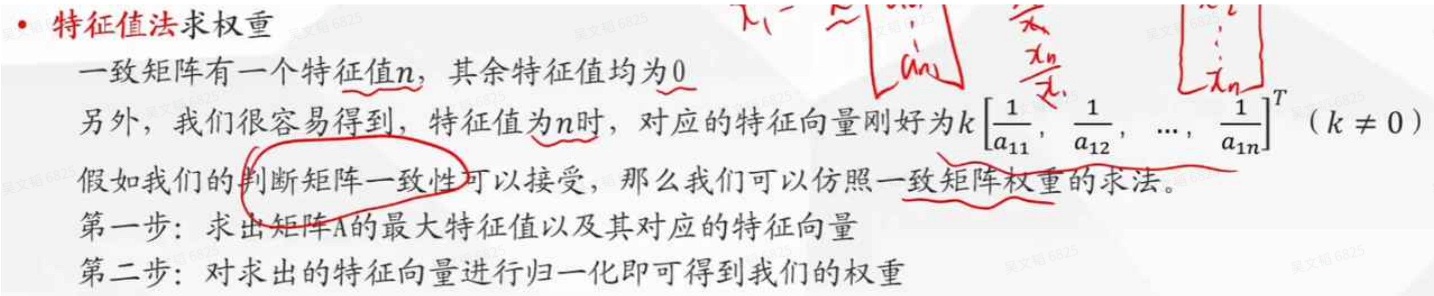
n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41	1.46	1.49

计算一致性比例CR：若算出来判断矩阵不一致，需要修改，确保一致才能进行下一步

$$CR = \frac{CI}{RI} \begin{cases} 0, \text{判断矩阵为一致矩阵} \\ < 0.1, \text{判断矩阵一致} \\ \geq 0.1, \text{判断矩阵不一致} \end{cases}$$

4. 求权重

采用**特征值法求权重**



- 特征值法求权重

一致矩阵有一个特征值n，其余特征值均为0

另外，我们很容易得到，特征值为n时，对应的特征向量刚好为 $k\left[\frac{1}{a_{11}}, \frac{1}{a_{12}}, \cdots, \frac{1}{a_{1n}}\right]^T \quad (k \neq 0)$

假如我们的判断矩阵一致性可以接受，那么我们可以仿照一致矩阵权重的求法。

第一步：求出矩阵A的最大特征值以及其对应的特征向量

第二步：对求出的特征向量进行归一化即可得到我们的权重

5. 计算最终得分

采用多元线性回归来求最终得分，其中Y为得分， $b_1, b_2, \ldots, b_n$ 为求得的权重， b_0 为常数项，最后一项为偏差。

$$Y = b_0 + b_1 x_1 + b_2 x_2 + \cdots + b_p x_p + \varepsilon\sigma^2$$

如果评价能否建房的地区不止一个，也可以对这些地区得分进行归一化并换成百分制，最终根据得分判断能否建房。

$$\tilde{Y}_i = \frac{Y_i}{\sum_{i=1}^{n}} \times 100$$

```python
import numpy as np

# 判断矩阵P，不用修改
P = np.array([
    [1,     3,      1/5,    4,      2],
    [1/3,   1,      1/3,    3,      2],
    [5,     3,      1,      7,      5],
    [1/4,   1/3,    1/7,    1,      2],
    [1/2,   1/2,    1/5,    1/2,    1]
])

# 因素输入：气候韧性建筑标准,风险缓解策略,风险模型参与,能源可持续发展,社区政府
# 有几条输几行
value = np.array([
    [1, 2, 3, 4, 5],
    [2, 3, 4, 5, 1],
    [3, 4, 5, 1, 2],
])

def tryP(P):
    # 求P的特征值和特征向量
    eigenvalue, featurevector = np.linalg.eig(P)
    # 求最大特征值
```

```python
    max_eigenvalue = max(eigenvalue)
    # 求一致性指标
    CI = (max_eigenvalue - len(P)) / (len(P) - 1)
    RI = [0, 0, 0.52, 0.89, 1.12, 1.26, 1.36, 1.41, 1.46, 1.49]
    CR = CI / RI[len(P)-1]

    print("CI:", CI, end="\t")
    print("RI:", RI[len(P)-1], end="\t")
    print("CR:", CR)

    if CR < 0.1:
        print("CR < 0.1, 判断矩阵一致")
        normalized_featurevector = featurevector[:, np.argmax(eigenvalue)]
        normalized_featurevector /= np.sum(normalized_featurevector)
        normalized_featurevector = np.real(normalized_featurevector)
        print("归一化特征向量/权重:", normalized_featurevector)
        return normalized_featurevector

    elif CR >= 0.1:
        print("CR >= 0.1, 判断矩阵不一致, 需修改")
        return False

weight = tryP(P)
# 加权求和并换算成百分制
result = weight*value
sum_result = np.sum(result, axis=1)
sum_result = (sum_result / np.sum(sum_result)) * 100
sum_result = np.round(sum_result, 2)
# 转置成列向量
sum_result = sum_result.reshape(-1, 1)
print("加权并换算成百分制后的结果: \n", sum_result)
```

*使用灰色预测模型进行数据预测

灰色预测是一种基于灰色系统理论的预测方法，通常用于处理具有**不完全信息和较少数据的情况**下的预测问题。灰色预测的核心思想是通过建立灰色模型，利用少量数据对未来的发展趋势进行预测。**此处用来预测未来年份的相关因素值，将预测值代入层次分析模型，从而得出未来的一定趋势**

灰色预测最常用的模型之一是GM(1,1)模型，也称为灰色一阶累加生成模型，其数学表达式如下：

$$\hat{X}_{n+1} = (X_1 - \frac{b}{a})e^{-an} + \frac{b}{a}$$

- X_1 是初始值；
- a 是发展系数；
- b 是灰色作用量；

- n 是时间序列的序号；
- $\hat{X}_{n+1}$ 是第 $n+1$ 个预测值。

1.确定原始数据

首先确定一组原始数据如下:

$$X^{(0)} = \{x^{(0)}(1), x^{(0)}(2), \ldots, x^{(0)}(n)\},\quad X^{(0)}(i) \geq 0, i = 1,2,\ldots,n$$

其中 n 为未知数的个数。

2.累加数列和邻均值等权数列

对原始数据进行累加得到新数据:

$$X^{(1)} = \{x^{(1)}(1), x^{(1)}(2), \ldots, x^{(1)}(n)\}$$

$$x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i),\quad k = 1,2,\ldots\ldots n$$

即每一个对应的数值为原始数据序列对应位置的值以及之前的数值的累加和，同时生成一个新数列的邻均值等权数列如下:

$$Z^{(1)} = \{z^{(1)}(2), z^{(1)}(3), \ldots, z^{(1)}(n)\}$$

$$z^{(1)}(k) = \frac{1}{2}[x^{(1)}(k) + x^{(1)}(k-1)]$$

3.建立关于t 的白化形式一阶一元微分方程 GM(1,1)

对于一组单调递增的数据，累加后的数据可以看作是强烈单调增的数据，可以近似认为符合指数增长。对于指数曲线，它一定是某个一阶线性常系数微分方程，于是可以写出如下表达式

$$\frac{dx^{(1)}}{dt} + ax^{(1)} = b$$

其中 a，b是我们所要求解的系数，分别为发展系数和灰色作用量，a 的有效区间是（-2，2）。

三、模型求解

1.利用矩阵求解参数(最小二乘法)

$$令\ \alpha = \begin{bmatrix} a \\ b \end{bmatrix}，且有 B = \begin{bmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \vdots & \vdots \\ -z^{(1)}(n) & 1 \end{bmatrix}, Y = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(n) \end{bmatrix}，则有 Y = B\alpha$$

根据最小二乘法求解得到:

$$\alpha = (B^T B)^{-1} B^T Y$$

2.对一阶微分方程中进行求解

由白化方程可以得到:

$$d(x^{(1)} - \frac{b}{}$$

$$\frac{d(x^{(1)}-\frac{b}{a})}{dt}=-a(x^{(1)}-\frac{b}{a})$$

令$y=x^{(1)}-\frac{b}{a}$代入上式，有

$$\frac{dy}{dt}=-ay$$

即$\int\frac{dy}{y}=\int-adt$

$$\ln y=-at+C$$

即$x^{(1)}(t)=e^{(-at+C)}+\frac{b}{a}$

当$t=1$时$,x^{(1)}(t)=x^{(0)}(t)$

代入解得$C=\ln(x^{(0)}(1)-\frac{b}{a})+a$

将y和C代回ln y = -at+C，最终得到该模型的时间响应式，为：

$$\begin{cases}\hat{x}^{(1)}(k+1)=(x^{(0)}(1)-\frac{b}{a})e^{-ak}+\frac{b}{a},k=1,2,\ldots,n\\ \hat{x}^{(0)}(k+1)=\hat{x}^{(1)}(k+1)-\hat{x}^{(1)}(k)\end{cases}$$

四、模型检验

之后从3项指标检验模型的预测精度，分别是平均相对误差、精度和方差比，计算公式如下：

$$\begin{cases}\text{残差：}\varepsilon(k)=x^{(0)}(k)-\hat{x}^{(0)}(k)\\ \text{相对误差：}\Delta_k=\frac{|\varepsilon(k)|}{x^{(0)}(k)}\\ \text{平均相对误差：}\Delta=\frac{1}{n}\sum_{k=1}^{n}\Delta_k\end{cases}$$

$$\text{精度：}p=(1-\Delta)\times100\%$$

$$\text{原始数列的均方差:}\overline{X}^{(0)}=\frac{1}{n}\sum_{i=1}^{n}X^{(0)}(i)$$

$$S_0^2=\sum_{i=1}^{n}(X^{(0)}-\overline{X}^{(0)})^2$$

$$S_0=\sqrt{\frac{S_0^2}{n-1}}$$

$$\text{残差数列的均方差:}\overline{\varepsilon}^{(0)}=\frac{1}{n}\sum_{i=1}^{n}\varepsilon^{(0)}(i)$$

$$S_1^2=\sum_{i=1}^{n}(\varepsilon^{(0)}-\overline{\varepsilon}^{(0)})^2$$

$$S_1=\sqrt{\frac{S_1^2}{n-1}}$$

$$\text{方差比：}C=\frac{S_1}{S_0}$$

均方差比表明预测值与实际值误差的大小，其值越小则误差越小。

此外，还需计算小概率误差，小误差概率是指即残差与残差均值的差值的绝对值小于0.6745倍原始数据均方差的概率，其值大，则表示精度高。计算方式如下:

$$p = p\left\{\left|\varepsilon(k) - \frac{1}{n}\sum_{k=1}^{n}\varepsilon(k)\right| < 0.6745S_0\right\}$$

根据计算结果对比以下GM（1,1）模型预测精度等级表得到检验结果。

检验指标	优秀	合格	勉强	不合格
均方差比值	[0，0.35)	[0.35,0.5)	[0.5,0.65)	[0.65,+∞)
小误差概率	(0.95,1]	(0.8,0.95]	(0.7,0.8]	(0,0.7]


```
import numpy as np
import math as mt

# 输入原始数据和预测的n值
X0 = ([111, 222, 333, 444, 555])

def GM_11_predict(X0, n):
    # 累加数列
    X1 = [X0[0]]
    add = X0[0] + X0[1]
    X1.append(add)
    i = 2
    while i < len(X0):
        add = add + X0[i]
        X1.append(add)
        i += 1
    # 紧邻均值序列
    Z = []
    j = 1
    while j < len(X1):
        num = (X1[j] + X1[j - 1]) / 2
        Z.append(num)
        j = j + 1
    # 最小二乘法计算
    Y = []
    x_i = 0
    while x_i < len(X0) - 1:
        x_i += 1
        Y.append(X0[x_i])
    Y = np.mat(Y)
    Y = Y.reshape(-1, 1)
    B = []
    b = 0
    while b < len(Z):
```

```python
            B.append(-Z[b])
            b += 1
        B = np.mat(B)
        B = B.reshape(-1, 1)
        c = np.ones((len(B), 1))
        B = np.hstack((B, c))
        # 求出参数
        alpha = np.linalg.inv(B.T.dot(B)).dot(B.T).dot(Y)
        a = alpha[0, 0]
        b = alpha[1, 0]
        # 生成预测模型
        GM = []
        GM.append(X0[0])
        did = b / a
        k = 1
        while k <= n:
            GM.append((X0[0] - did) * mt.exp(-a * k) + did)
            k += 1
        # 做差得到预测序列
        G = [GM[i] - GM[i - 1] for i in range(1, len(GM))]
        return G

def GM_11_correct(X0, G):
        # 计算残差
        e = []
        i = 0
        while i < len(X0):
            e.append(X0[i] - G[i])
            i += 1

        # 计算相对误差
        q = []
        i = 0
        while i < len(X0):
            q.append(abs(e[i] / X0[i]))
            i += 1

        # 计算平均相对误差
        mean_q = np.mean(q)

        # 精度为绝对误差平均值的百分比
        accuracy = round((1 - mean_q) * 100, 2)
        print('精度为: {}%'.format(accuracy))

        # 计算方差比
        s0 = np.var(X0)
        s1 = np.var(e)
```

```python
        S0 = mt.sqrt(s0)
        S1 = mt.sqrt(s1)
        C = S1 / S0
        print('方差比为：', C)

        # 计算小概率误差
        P = np.sum(np.abs(e - np.mean(e)) < 0.6745 * S1) / len(e)
        print('小概率误差为：', P)

m = len(X0)
n = int(input("请输入要预测的数量：")) + m
predicted_values = GM_11_predict(X0, n)
# 将X0的第一位加到predicted_values的首位置
predicted_values.insert(0, X0[0])

print("原始数列为：", X0)
print("预测数列为：", predicted_values)
print()
GM_11_correct(X0, GM_11_predict(X0, m))
```

*使用灰色关联分析评价模型

要求：评价能否建房的地区不止一个，即需要多条数据

灰色关联度分析（Grey Relation Analysis，GRA），是一种多因素统计分析的方法。我们假设已经知道某一个指标可能是与其他的某几个因素**相关**的，那么我们想知道这个指标与其他哪个因素相对来说更有关系，而哪个因素相对关系弱一点，依次类推，把这些因素排个序，得到一个分析结果，我们就可以知道我们关注的这个指标，与因素中的哪些更相关。

第一步：确定分析数列

1. 参考序列（母序列） $Y = Y(k)$
2. 比较序列（子序列） $X_i = X_i(k)|k = 1, 2, ..., n, i = 1, 2, ..., m$

本题中， X_i 为矩阵，每一行代表一个地区，每一列代表一种影响因素

第二步，变量的无量纲化（归一化）

有两种方法：

1. 初值化，把这一个序列的数据统一除以最开始的值

$$x_i(k)' = \frac{x_i(k)}{x_i(1)}, i = 1, ..., m, k = 1, ..., n$$

2. **此处采用均值化，把这个序列的数据除以均值，即每一列元素除以这一列元素的和**

$$x_i(k)' = \frac{x_i(k)}{E(x_i)}, E(x_i) = \frac{1}{n}\sum_{i=0}^{n} = x_i(k)$$

第三步，计算灰色关联系数

$$\zeta_i(k)=\frac{\min\limits_{i}\min\limits_{k}\left|x_0(k)-x_i(k)\right|+\rho\cdot\max\limits_{i}\max\limits_{k}\left|x_0(k)-x_i(k)\right|}{\left|x_0(k)-x_i(k)\right|+\rho\cdot\max\limits_{i}\max\limits_{k}\left|x_0(k)-x_i(k)\right|}$$

$\rho\in(0,\infty)$，称为**分辨系数**。ρ 越小，分辨力越大，一般ρ的取值区间为 (0, 1)，具体取值可视情况而定。当 $\rho\leqslant 0.5463$ 时，分辨力最好，**通常取 ρ = 0.5，此题也取 0.5**

第四步，计算关联度

因为关联系数是比较数列与参考数列在各个时刻（即曲线中的各点）的关联程度值，所以它的数不止一个，而信息过于分散不便于进行整体性比较。因此有必要将各个时刻（即曲线中的各点）的关联系数集中为一个值，即**求其平均值**，作为比较数列与参考数列间关联程度的数量表示。

$$r_i=\frac{1}{n}\sum_{k=1}^{n}\zeta_i(k)$$

第五步，关联度排序

关联度按大小排序，越大越相关

```python
import numpy as np

# 输入母序列和子序列，第一列母序列，其余子序列
A = np.array([
    [52.45, 8, 8, 0.86242926, 3, 8],
    [47.55, 4, 7, 0.93907558, 10, 9]
])

mean = np.mean(A, axis=0)
A_norm = A / mean

Y = A_norm[:, 0]
X = A_norm[:, 1:]

absX0_Xi = np.abs(X - np.tile(Y.reshape(-1, 1), (1, X.shape[1])))
a = np.min(absX0_Xi)
b = np.max(absX0_Xi)
rho = 0.5
gamma = (a+rho*b)/(absX0_Xi+rho*b)

print("子序列中各个指标的灰色关联度分别为：")
print(np.mean(gamma, axis=0))
```

✅模型三：历史文化保护模型

模型采用支持向量机SVM

目标：为社区领导人创建一个模型，以决定他们应采取何种措施来保护具有文化、历史、经济或社区意义的建筑物。

主要考虑因素：

- 文化和历史意义：量化建筑物的无形价值并将这些价值整合到保护模型中。
- 成本效益分析：平衡保护措施的成本与保护社区地标的经济、文化和社会效益。

✅ 因素分析：

1. 文化和历史意义：
    - 历史价值： 评估建筑物的历史性，包括建筑年代、历史事件和人物的相关性。
    - 文化意义： 考察建筑物对当地文化和传统的重要性，是否代表着社区的独特特征。
    - 文化影响： 了解建筑物对社区文化的影响，包括是否与特定社群或活动有关。
2. 社区经济影响：
    - 旅游吸引力： 评估建筑物对旅游业的吸引力，包括是否是旅游景点、是否吸引游客和是否促进了本地经济的发展。
    - 就业机会： 考虑建筑物是否直接或间接创造了就业机会，支持当地居民的生计。
3. 社区社会影响：
    - 社区认同： 考察建筑物是否与社区的认同和身份紧密相关，是否是社区的象征。
    - 社区参与： 评估建筑物是否促进社区的参与和凝聚力，是否是社区集会或活动的场所。
4. 物理状况和可持续性：
    - 建筑物状态： 分析建筑物的当前状态，包括结构稳定性、维护需求和潜在的灾害风险。
    - 可持续性： 考虑建筑物的可持续性，包括是否可以通过合理的维护和更新延长其寿命。
5. 社会咨询与参与：
    - 社会咨询： 进行社区咨询，收集社区居民对于建筑物的看法和期望，以确保决策符合广泛共识。
    - 参与决策： 提供决策机制，使社区居民能够参与保护建筑物的决策过程。
6. 法规与政策：

- 历史保护法规：了解相关的历史保护法规和政策，以确保决策与法规一致。
- 濒危建筑物认定：查看是否有相关机构对建筑物的濒危程度进行认定，并采取相应的保护措施。

7. 未来发展：
   - 城市规划：考虑建筑物所在区域的城市规划和发展计划，以确定未来可能的影响。
   - 更新计划：考虑是否有合理的更新计划，以使建筑物适应未来需求。

经过筛选，决定将以下因素作为输入因素

输入：历史价值，文化意义和影响，经济价值（包括就业机会/旅游吸引力等），社会认同，建筑物状态，法律政策，城市规划（即建筑物位置）

1. **历史价值**：当前年份减去建筑建造的年代
2. **文化法律**：是否列入国家遗产或是否受到法律保护（列入国家遗产：2，受到法律保护：1，无保护/无遗产：0）
3. **经济价值**：是否开发旅游业，博物馆（人工打分，0-10分打分）
4. **社会认同**：社区认同度，是否用于文化活动（人工打分，0-10分打分）
5. **建筑物状态**：维护修复情况，破坏程度（人工打分，0-10分的打分）
6. **自然灾害**：根据年自然灾害数量得出
7. **城市规划**：产业结构
8. **可见性**：是否可见（可见：1，不可见：0）
9. **结论**：是否保护（1：保护，0：不保护）

输出：保护/不保护（0-1分布）

将上述部分因素量化后作为数据集，采用支持向量机，得出模型，然后输入某地相关指标，即可决定是否进行保护。

下方为需要的数据集表格，**数据条数越多越好**

此外，需要将数据集做成csv文件，文件表头如下

支持向量机数据集.xlsx
46.81KB

```
import numpy as np
import matplotlib.pyplot as plt
from sklearn import svm
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
```

```python
from sklearn.metrics import roc_curve, auc, precision_recall_curve, classification_report, confusion_matrix
import pandas as pd
import joblib
from sklearn.decomposition import PCA

# 加载数据
data = pd.read_csv('dataset.csv')
X = data[['data1', 'data2', 'data3', 'data4',
          'data5', 'data6', 'data7', 'data8']]
y = data['result']

introduction = """
输入说明:
1. 历史价值: 当前年份减去建筑建造的年代
2. 文化法律: 是否列入国家遗产或是否受到法律保护（列入国家遗产: 2, 受到法律保护: 1, 无保护/无遗产: 0)
3. 经济价值: 是否开发旅游业, 博物馆（人工打分, 0-10分打分)
4. 社会认同: 社区认同度, 是否用于文化活动（人工打分, 0-10分打分)
5. 建筑状态: 维护修复情况, 破坏程度（人工打分, 0-10分的打分, 分数越低越差)
6. 自然灾害: 根据年自然灾害数量得出
7. 城市规划: 产业结构（第一产业: 1, 第二产业: 2, 第三产业: 3)
8. 可见性: 是否可见（可见: 1, 不可见: 0)
"""


# 划分数据集
X_train, X_test, y_train, y_test = train_test_split(
    X, y, test_size=0.2, random_state=42)

# 特征缩放
scaler = StandardScaler()
X_train = scaler.fit_transform(X_train)
X_test = scaler.transform(X_test)

# 训练SVM模型
model = svm.SVC(kernel='rbf', probability=True)
model.fit(X_train, y_train)

# 保存模型到文件
joblib.dump(model, 'svm_model.pkl')
loaded_model = model  # 将训练好的模型赋值给loaded_model

# 预测
y_pred = loaded_model.predict(X_test)
y_proba = loaded_model.predict_proba(X_test)[:, 1]

# 计算准确率, 精确度, 召回率, F1分数
```

```python
print(classification_report(y_test, y_pred))

# 混淆矩阵
cm = confusion_matrix(y_test, y_pred)
print("Confusion Matrix:\n", cm)

# ROC曲线和AUC
fpr, tpr, thresholds = roc_curve(y_test, y_proba)
roc_auc = auc(fpr, tpr)
print("AUC:", roc_auc)
# ROC曲线
plt.figure()
plt.plot(fpr, tpr, color='darkorange', lw=2,
         label='ROC curve (area = %0.2f)' % roc_auc)
plt.plot([0, 1], [0, 1], color='navy', lw=2, linestyle='--')
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver operating characteristic')
plt.legend(loc="lower right")
plt.savefig('roc_curve.png', format='png')  # 保存为ROC曲线的PNG文件

# PR曲线
precision, recall, _ = precision_recall_curve(y_test, y_proba)
plt.figure()
plt.plot(recall, precision, color='blue', lw=2, label='PR curve')
plt.xlabel('Recall')
plt.ylabel('Precision')
plt.title('Precision-Recall curve')
plt.legend(loc="lower left")
plt.savefig('pr_curve.png', format='png')  # 保存为PR曲线的PNG文件

# 在数据预处理后进行PCA降维
pca = PCA(n_components=2)  # 降至2维以便可视化
X_train_pca = pca.fit_transform(X_train)
X_test_pca = pca.transform(X_test)
# 重新训练SVM模型)使用降维后的数据(
model_pca = svm.SVC(kernel='rbf', probability=True)
model_pca.fit(X_train_pca, y_train)

# 绘制决策边界
plt.figure()
h = .02  # 网格中的步长
x_min, x_max = X_train_pca[:, 0].min() - 1, X_train_pca[:, 0].max() + 1
y_min, y_max = X_train_pca[:, 1].min() - 1, X_train_pca[:, 1].max() + 1
xx, yy = np.meshgrid(np.arange(x_min, x_max, h),
```

```
                        np.arange(y_min, y_max, h))

Z = model_pca.predict(np.c_[xx.ravel(), yy.ravel()])
Z = Z.reshape(xx.shape)
plt.contourf(xx, yy, Z, cmap=plt.cm.coolwarm, alpha=0.8)
# 绘制数据点
plt.scatter(X_train_pca[:, 0], X_train_pca[:, 1],
            c=y_train, cmap=plt.cm.coolwarm)
plt.xlabel('Principal Component 1')
plt.ylabel('Principal Component 2')
plt.xlim(xx.min(), xx.max())
plt.ylim(yy.min(), yy.max())
plt.xticks(())
plt.yticks(())
plt.title('SVM Decision Boundary with PCA-transformed data')
# 保存为PNG文件
plt.savefig('decision_boundary.png', format='png')

def predict_outcome(features):  # 预测
    features = np.array(features).reshape(1, -1)
    features = scaler.transform(features)  # 应用同样的缩放
    proba = loaded_model.predict_proba(features)[0, 1]
    return loaded_model.predict(features), proba

is_predictic = input("是否需要预测结果? (Y/N)")
if is_predictic.upper() == 'Y':
    print(introduction)
    print("请输入8个因素数据，用空格隔开：")
    print("历史价值  文化法律  经济价值  社会认同  建筑状态  自然灾害  城市规划  可见性")
    user_input = input().split()
    user_input = [float(x) for x in user_input]  # 将输入转换为浮点数列表
    if len(user_input) != 8:
        print("输入错误")
    else:
        prediction, probability = predict_outcome(user_input)
        print("模型预测结果:", prediction[0])
        print("模型概率:", probability)
else:
    pass

```

模型在历史地标中的应用

目标：将保险和保护模型应用于经历极端天气事件的地点的特定历史地标，并提出其未来计划。

主要考虑因素：

- 综合评估：结合两个模型的见解来评估地标的价值并确定最合适的行动方案。
- 利益相关者沟通：向社区撰写一封引人注目且信息丰富的信件，清楚地解释模型的研究结果，并为地标的保护和保险提供合理的计划、时间表和成本建议。

这个问题是跨学科的，需要数学建模、风险管理、气候科学、经济学和政策制定方面的综合技能。 解决这个问题不仅需要技术熟练程度，还需要创造力以及对气候变化和保险对社区的社会影响的深刻理解。

*评价SVM模型

评价一个支持向量机（SVM）模型的好坏通常依赖于许多不同的指标和因素，具体取决于问题的性质和目标。以下是一些常见用于评估SVM模型性能的主要指标：

1. 准确率（Accuracy）：准确率是一个最基本的指标，表示模型正确分类的样本数量占总样本数量的比例。高准确率通常是一个好的迹象，但在不均衡类别分布的情况下，可能会产生误导。
2. 精确度（Precision）：精确度衡量了模型在预测为正类别的样本中实际为正类别的比例。它是在假阳性较为显著时，可以关注的指标。
3. 召回率（Recall）：召回率衡量了模型正确检测为正类别的样本数量占实际正类别样本数量的比例。它是在假阴性较为显著时，可以关注的指标。
4. F1分数（F1-Score）：F1分数是精确度和召回率的调和平均，它可以帮助平衡精确度和召回率之间的权衡。特别是在不平衡类别分布的情况下，F1分数是一个有用的指标。
5. ROC曲线和AUC值：接收者操作特征曲线（ROC曲线）绘制了模型的真阳性率（TPR）与假阳性率（FPR）之间的关系。曲线下面积（AUC）表示模型分类性能的总体质量。AUC值越接近1，模型性能越好。
6. 混淆矩阵（Confusion Matrix）：混淆矩阵显示了模型在每个类别上的真阳性、真阴性、假阳性和假阴性的数量，可以用于更详细地分析模型的性能。
7. ROC曲线和PR曲线：在不同阈值下，ROC曲线用于评估模型的分类性能，而PR（Precision-Recall）曲线则用于评估精确度和召回率之间的权衡。
8. 特征重要性：了解哪些特征对于模型的预测最为重要也是评估模型性能的一部分。

重要的是要根据具体问题的需求和目标来选择适当的评估指标。有些问题可能更关注精确度，而其他问题可能更关注召回率或F1分数。此外，交叉验证也是评估模型性能的重要手段，可以帮助评估模型的稳定性和泛化能力。最终的评估应该综合考虑多个指标以得出综合性的评价。

✅灵敏度分析

对上面三个模型进行灵敏度分析，具体方法为：改变某一个因素的值，分析此改变对其他因素的影响大小。

如何求改变某一因素后的极值变化？可以将这一因素的值设为t，然后对其他因素求偏导，算极值。

将每一个因素都做一次灵敏度分析，分析改变该因素对其他所有因素的影响，然后得出改变哪个因素对其他因素的影响最大。

模型一灵敏度分析代码

```
import numpy as np

R2 = np.array([
    [0.0015,    0.1626, 0.6826, 0.1521, 0.0013],
    [0, 0.0924, 0.5849, 0.2133, 0.1094],
    [0, 0.0098, 0.3592, 0.5832, 0.0478],
    [0.1583,    0.6836, 0.1567, 0.0013, 0],
    [0.0069,    0.3154, 0.6157, 0.0617, 0.0002],
    [0.0369,    0.5473, 0.4024, 0.0135, 0],
])
R1 = np.array([
    [0, 0.5548, 0.0374, 0.5548, 0.4078],
    [0, 0.0008, 0.1213, 0.6776, 0.2004],
    [0.0009,    0.1333, 0.6800, 0.1838, 0.0019],
    [0.0001,    0.0302, 0.5186, 0.4343, 0.0169],
    [0.0016,    0.1693, 0.6821, 0.1459, 0.0011],
    [0.6080,    0.3814, 0.0106, 0,  0]
])
ACC_ALL = np.array([
    [0.0, 0.0, 0.0],
    [0.0, 0.0, 0.0],
    [0.0, 0.0, 0.0],
    [0.0, 0.0, 0.0],
    [0.0, 0.0, 0.0],
    [0.0, 0.0, 0.0]
])
ACC1 = ACC_ALL.copy()
ACC2 = ACC_ALL.copy()

A2 = np.array([0.1079, 0.0987, 0.2127, 0.0766, 0.0699, 0.4342])
A1 = np.array([0.3231, 0.0794, 0.3549, 0.0986, 0.1010, 0.1519])
B_std1 = np.std(np.dot(A1, R1))
B_std2 = np.std(np.dot(A2, R2))
B_s = np.std(0.5*(np.dot(A2, R2)+np.dot(A1, R1)))

for i in range(6):
    for j in range(3):
        R1_modified = R1.copy()
        R1_modified[i] *= 1.05
        B1 = np.dot(A1, R1_modified)
```

```
        B1_std = np.std(B1)
        ACC1[i, j] = 100 * abs(B1_std - B_std1) / B_std1
        R2_modified = R2.copy()
        R2_modified[i] *= 1.05
        B2 = np.dot(A2, R2_modified)
        B2_std = np.std(B2)
        ACC2[i, j] = 100 * abs(B2_std - B_std2) / B_std2
        B = 0.5*(B1+B2)
        B_std = np.std(B)
        ACC_ALL[i, j] = 100 * abs(B_std - B_s) / B_s

print("R1灵敏度分析")
print(ACC1)
print("R2灵敏度分析")
print(ACC2)
print("总灵敏度分析")
print(ACC_ALL)

```

数据计算和结论

✅模型一

需求模型

佛蒙特（结论：可有可无）

1. 利用熵权法求得权重：

[0.3231,0.0734,0.3045,0.0481,0.0991,0.1518]

分别对应：自然灾害发生率，建筑密集程度，经济发展数据，房屋贵重程度，历史索赔数据，地形和土地利用

2. 模糊综合判断矩阵R

U\V	非常需要	需要	可有可无	不太需要	非常不需要
自然灾害发生	0.0015	0.1626	0.6826	0.1521	0.0013
建筑密集程度	0	0.0924	0.5849	0.2133	0.1094
经济发展数据	0	0.0098	0.3592	0.5832	0.0478
房屋贵重程度	0.1583	0.6836	0.1567	0.0013	0

历史索赔数据	0.0069	0.3154	0.6157	0.0617	0.0002
地形和土地利用	0.0369	0.5473	0.4024	0.0135	0

3. 综合评价模型指标B

	非常需要	需要	可有可无	不太需要	非常不需要
佛蒙特	0.02239504	0.24574387	0.53323008	0.28146774	0.02609081

选择上述五个指标中，值最高的作为评价结果

结论：可有可无

新西兰奥克兰（结论：需要）

1. 利用熵权法求得权重：（**和上面一样，没变**）

[0.3231,0.0734,0.3045,0.0481,0.0991,0.1518]

分别对应：自然灾害发生率，建筑密集程度，经济发展数据，房屋贵重程度，历史索赔数据，地形和土地利用

2. 模糊综合判断矩阵R

U\V	非常需要	需要	可有可无	不太需要	非常不需要
自然灾害发生	0.0169	0.4349	0.5181	0.0301	0.0001
建筑密集程度	0.1246	0.6779	0.1953	0.0022	0
经济发展数据	0.0715	0.6329	0.2900	0.0056	0
房屋贵重程度	0.1065	0.6690	0.2217	0.0029	0
历史索赔数据	0.0002	0.0647	0.6213	0.3073	0.0065
地形和土地利用	0.2004	0.6776	0.1213	0.0008	0

3. 综合评价模型指标B

	非常需要	需要	可有可无	不太需要	非常不需要
奥克兰	0.08169084	0.5943832	0.38886232	0.04333219	0.00068881

选择上述五个指标中，值最高的作为评价结果

结论：需要

风险模型

佛蒙特（结论：风险较大）

1. 利用熵权法求得权重：

[0.1079, 0.0987, 0.2127, 0.0766, 0.0699, 0.4342]

分别对应：政策和应对能力，金融市场和投资收益，基础设施强度，环保意识，科技和创新，气候变化和长期趋势

2. 模糊综合判断矩阵R

U\V	风险非常高	风险较高	风险中等	风险较低	风险非常低
政策和应对能力	0.0065	0.3073	0.6213	0.0647	0.0002
金融市场和投资收益	0	0.0025	0.2067	0.6745	0.1163
基础设施强度	0.0026	0.2107	0.6726	0.1135	0.0007
环保意识	0.0147	0.4145	0.5366	0.0342	0.0001
科技和创新	0	0.0045	0.2647	0.6481	0.0828
气候变化和长期趋势	0.1340	0.6807	0.1833	0.0019	0

3. 综合评价模型指标B

	风险非常高	风险较高	风险中等	风险较低	风险非常低
佛蒙特	0.06056319	0.4058455	0.36969653	0.14644262	0.01744466

选择上述五个指标中，值最高的作为评价结果

结论：风险较高

新西兰奥克兰（结论：风险较大）

1. 利用熵权法求得权重：**（和上面一样，没变）**

[0.1079, 0.0987, 0.2127, 0.0766, 0.0699, 0.4342]

分别对应：政策和应对能力，金融市场和投资收益，基础设施强度，环保意识，科技和创新，气候变化和长期趋势

2. 模糊综合判断矩阵R

U\V	风险非常高	风险较高	风险中等	风险较低	风险非常低
政策和应对能力	0	0.5548	0.0374	0.5548	0.4078
金融市场和投资收益	0	0.0008	0.1213	0.6776	0.2004
基础设施强度	0.0009	0.1333	0.6800	0.1838	0.0019
环保意识	0.0001	0.0302	0.5186	0.4343	0.0169
科技和创新	0.0016	0.1693	0.6821	0.1459	0.0011
气候变化和长期趋势	0.6080	0.3814	0.0106	0	0

3. 综合评价模型指标B

	风险非常高	风险较高	风险中等	风险较低	风险非常低
奥克兰	0.26430453	0.26804606	0.25264984	0.20930209	0.06555666

选择上述五个指标中，值最高的作为评价结果

结论：风险较高

结论

佛蒙特：保险需求可有可无，承保风险较高

新西兰奥克兰：保险需要，承保风险较高

结论：佛蒙特保险需求**可有可无**，新西兰奥克兰**需要保险；**两地的承保风险不是非常高，所以保险公司**不太可能会支付过多的索赔。**

✅模型二

层次分析模型

1. 层次分析判断矩阵

i \ j	气候韧性建筑标准	风险缓解策略	风险模型参与	能源可持续发展	社区政府
气候韧性建筑标准	1	3	1/5	4	2
风险缓解策略	1/3	1	1/3	3	2
风险模型参与	5	3	1	7	5
能源可持续发展	1/4	1/3	1/7	1	2
社区政府	1/2	1/2	1/5	1/2	1

2. 层次分析输入矩阵

气候韧性建筑标准	风险缓解策略	风险模型参与	能源可持续发展	社区政府	备注
8	8	0.86242926	3	8	奥克兰
4	7	0.93907558	10	9	佛蒙特

说明：风险模型参与一栏的值为模型1中需求模型和风险模型所得最大值相加

3. 计算结果

CI: 0.10680778346780162

RI: 1.12

CR: 0.09536409238196572

归一化特征向量&权重: [0.20908679 0.13384524 0.51687347 0.07018806 0.07000645]

加权并换算成百分制后的结果：奥克兰：53.6 佛蒙特：46.4

灰色关联分析模型分析因素重要性

1. 灰色关联分析输入矩阵

总得分	气候韧性建筑标准	风险缓解策略	风险模型参与	能源可持续发展	社区政府	备注
53.6	8	8	0.86242926	3	8	奥克兰
46.4	4	7	0.93907558	10	9	佛蒙特

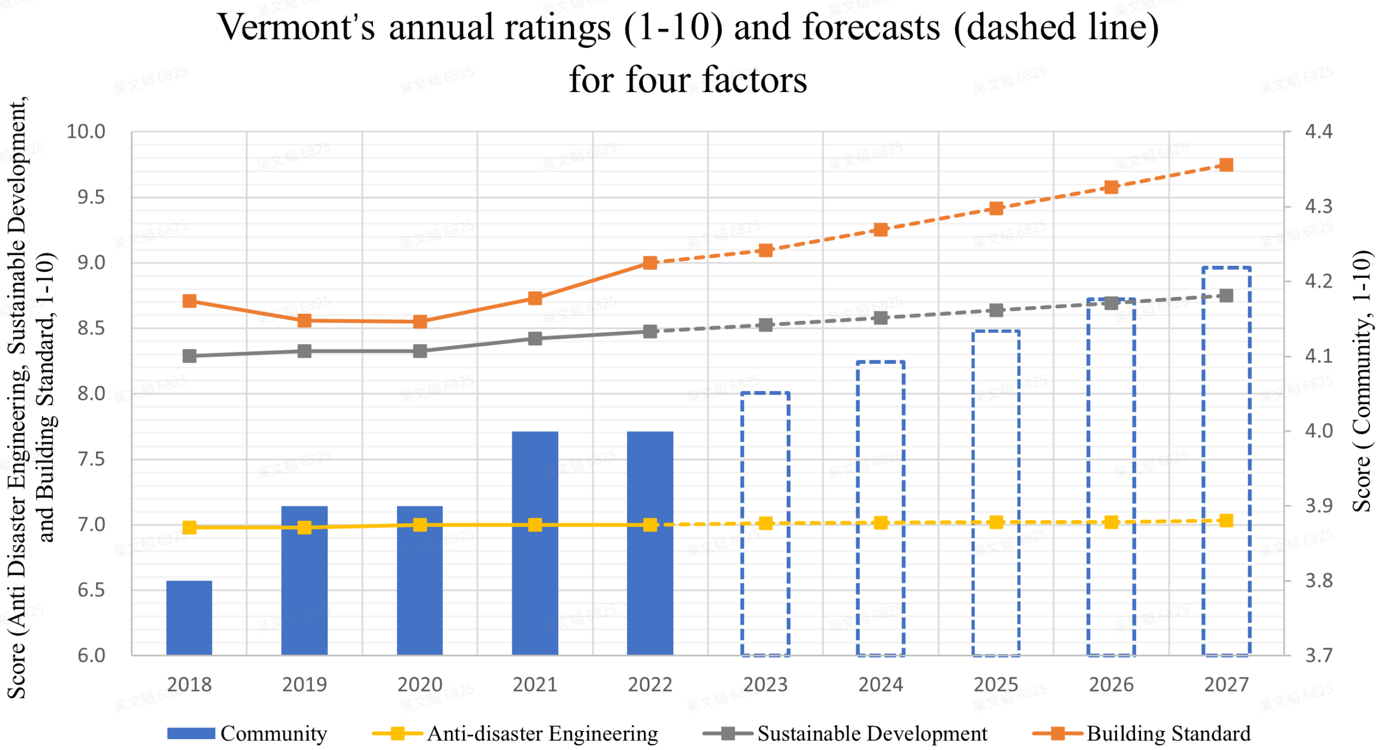
计算得子序列中各个指标的灰色关联度分别为：**[0.54815351 1.   0.73983206 0.33915771 0.71221429]**

因此得出结论：上述五个因素按照重要性排序依次为：**风险缓解策略 > 风险模型参与 > 社区政府 > 气候韧性建筑标准 > 能源可持续发展**

灰色预测模型分析未来

模型二预测数据.xlsx
11.53KB

奥克兰						预测1	预测2	预测3	预测4	预测5	精度	方差
建筑标准	6.9413	7.4144	7.7998	7.9075	8	8.2538	8.4524	8.6558	8.8642	9.0775	96.44%	0.428
防灾工程	7.4	7.4	7.5	8	8	8.315	8.5655	8.8237	9.0896	9.6456	97.54%	0.487
模型的参与	0.8624	0.8624	0.8624	0.8624	0.8624	0.8624	0.8624	0.8624	0.8624	0.8624		
绿色能源	3.6547	3.6349	3.6708	3.999	3.8985	4.0864	4.2076	4.3324	4.4608	4.5931	97.18%	0.638
社区参与	7.9425	7.9234	7.9634	8.0245	8.0273	8.0782	8.116	8.1539	8.192	8.2303	99.59%	0.551
预测后评分	52.07	52.62	53.25	53.69	53.6	54.13	54.47	54.81	55.16	55.7		
佛蒙特						预测1	预测2	预测3	预测4	预测5		
建筑标准	3.8	3.9	3.9	4	4	4.051	4.0922	4.1339	4.1759	4.2184	98.71%	0.37
防灾工程	6.98	6.98	7	7	7	7.01	7.016	7.022	7.022	7.0341	99.90%	0.500
模型的参与	0.9391	0.9391	0.9391	0.9391	0.9391	0.9391	0.9391	0.9391	0.9391	0.9391		
绿色能源	8.2897	8.3243	8.3253	8.4214	8.4745	8.5241	8.5799	8.6361	8.6926	8.7496	99.44%	0.347
社区参与	8.71	8.56	8.55	8.73	9	9.0937	9.2527	9.4145	9.5791	9.7465	98.08%	1.002
预测后评分	47.93	47.38	46.75	46.31	46.4	45.87	45.53	45.19	44.84	44.3		



结论

根据房地产模型，佛蒙德和奥克兰两地建房差异不大，属于可建可不建的状态，但如果要在两地之间选择一个更适合建房的地方，奥克兰最终得分略高于佛蒙特，所以可以选择在奥克兰建房。

预测未来：奥克兰相比于佛蒙特两地建房差异不大，但随着时间发展，奥克兰与佛蒙特两地建房差异逐渐增大，奥克兰相比于佛蒙特越来越适合建房。

✅模型三

使用精细高斯SVM，运用主成分分析将8个数值成分逐渐降维

数据集：

dataset.csv
1.27KB

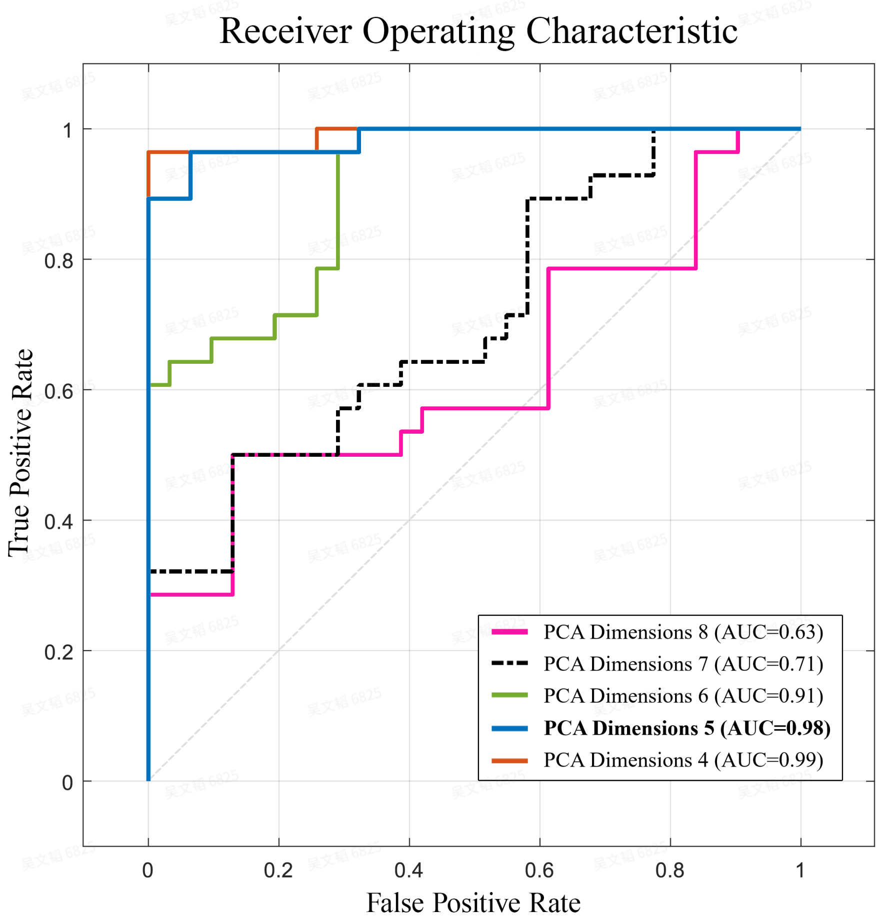
随着数值成分的减少，准确度逐渐上升，如下图

7 ☆ SVM 上次更改：PCA 保留了 4 个数值成分	准确度：89.8% 4/8 特征(PCA 开启)
8 ☆ SVM 上次更改：PCA 保留了 5 个数值成分	准确度：88.1% 5/8 特征(PCA 开启)
9 ☆ SVM 上次更改：PCA 保留了 6 个数值成分	准确度：66.1% 6/8 特征(PCA 开启)
10 ☆ SVM 上次更改：PCA 保留了 8 个数值成分	准确度：61.0% 8/8 特征(PCA 开启)
11 ☆ SVM 上次更改：PCA 保留了 7 个数值成分	准确度：61.0% 7/8 特征(PCA 开启)

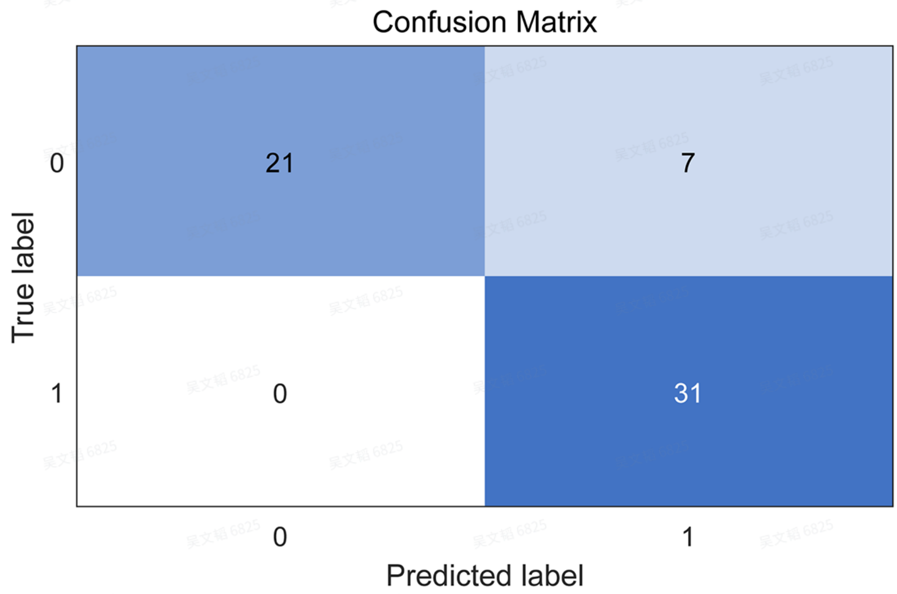
为了平衡数值成分和准确度，我们选取使用PCA保留5个数值成分的SVM模型（此时减小数值成分，准确度提升不大，而增加数值成分，准确度骤降，所以选取5个成分最合理）

此外，我们对上述5个尝试作出了ROC曲线，如下图

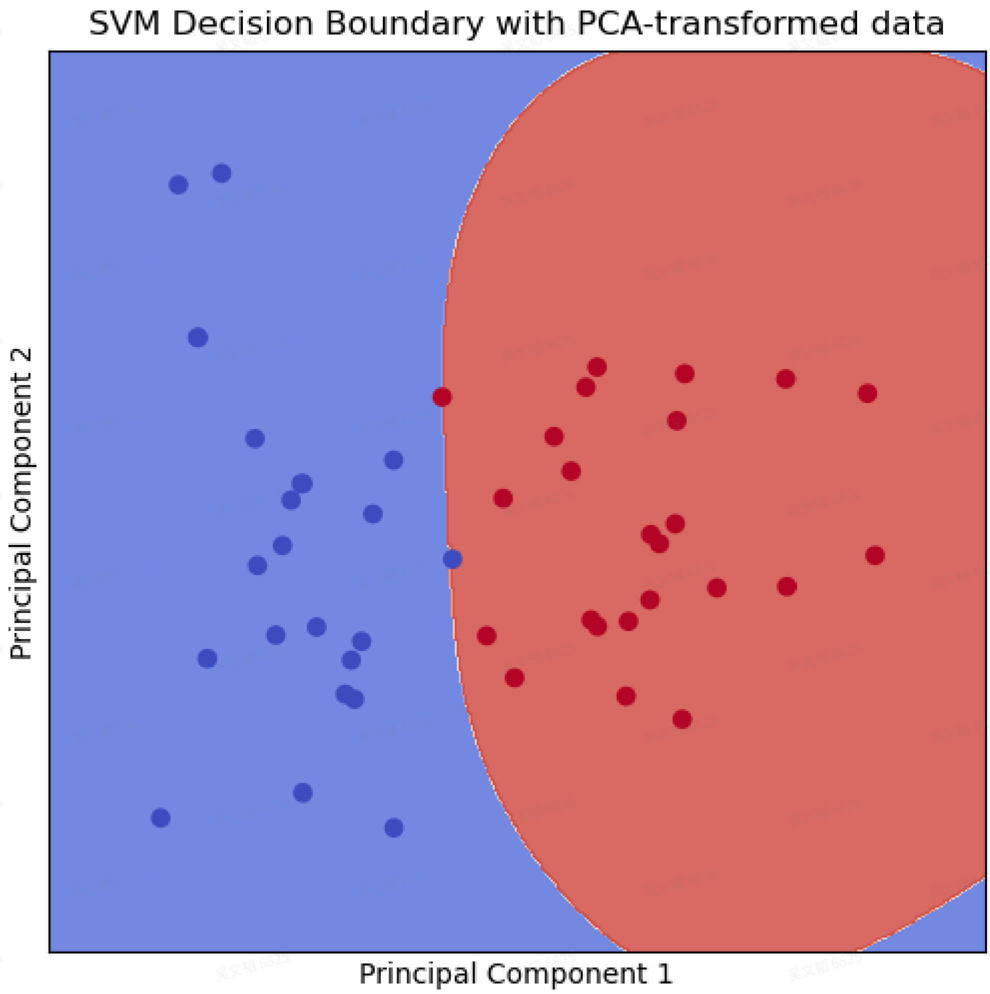
ROC.psd
3.69MB



PCA保留5个值时的混淆矩阵图：



使用PCA降维至2维时，画出的分布图



✅灵敏度分析

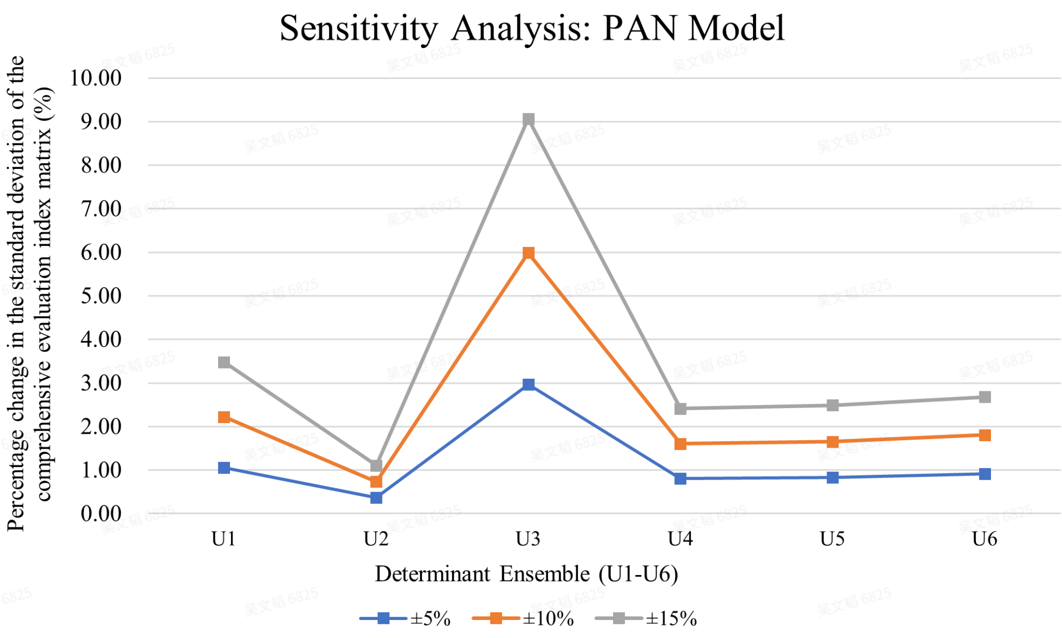
需求模型

说明：灵敏度计算方法，控制其他因素不变时，仅改变某一因素值±5%，±10%，±15%，求解综合评价模型指标B’，分别计算B和B’的标准差，计算两者百分差填入下面的表中

变化越大说明影响越大

注意：下表中数据单位：%

	±5%	±10%	±15%
自然灾害发生	1.05769215	2.21924408	3.48115843
建筑密集程度	0.36284546	0.73174819	1.1066419
经济发展数据	2.96583803	5.98853734	9.06337029
房屋贵重程度	0.80063583	1.60424002	2.41074268
历史索赔数据	0.82452234	1.65421122	2.48894116
地形和土地利用	0.91169518	1.80409335	2.67666366



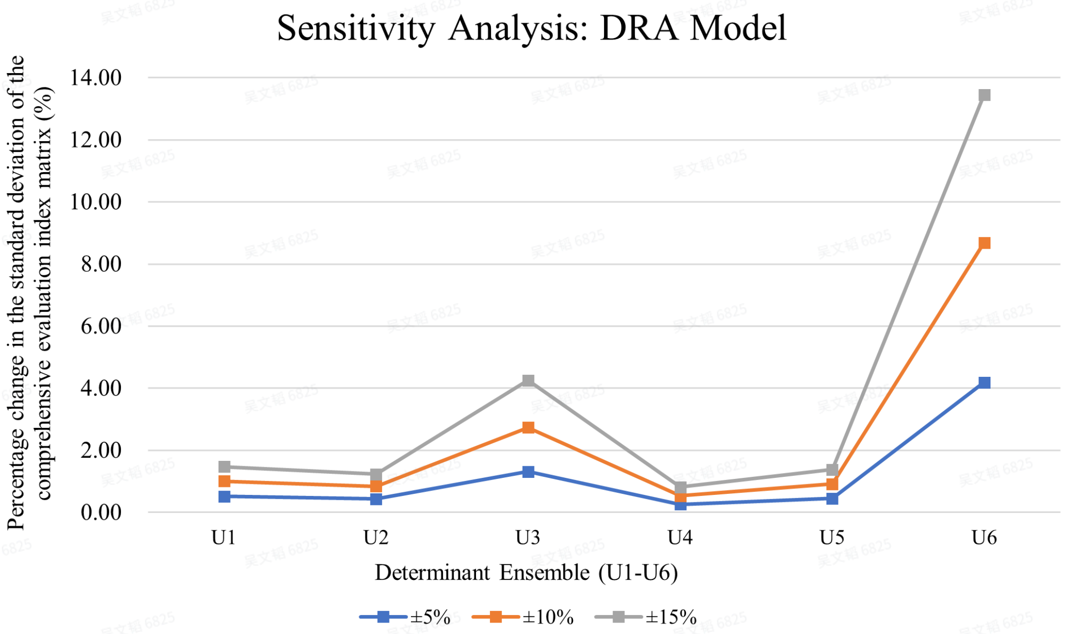
风险模型

说明：灵敏度计算方法，控制其他因素不变时，仅改变某一因素值±5%，±10%，±15%，求解综合评价模型指标B’，分别计算B和B’的标准差，然后计算两者百分差填入下面的表中

变化越大说明影响越大

注意：下表中数据单位：%

	±5%	±10%	±15%
政策和应对能力	0.51788723	1.00806281	1.47011313
金融市场和投资收益	0.43338684	0.84205685	1.22570323
基础设施强度	1.3154316	2.73334764	4.24956649
环保意识	0.25941518	0.53118722	0.81521619
科技和创新	0.44908342	0.90933431	1.38060059
气候变化和长期趋势	4.18647135	8.6838268	13.45510207



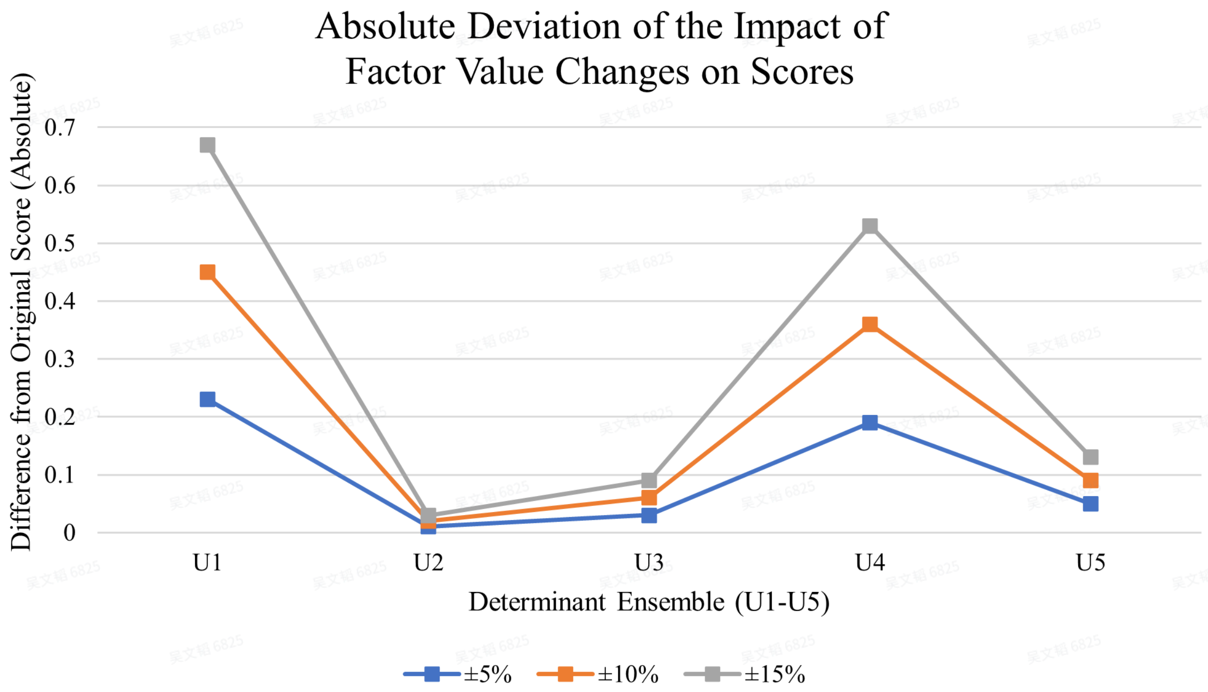
建房模型

模型二灵敏度分析.xlsx
12.77KB

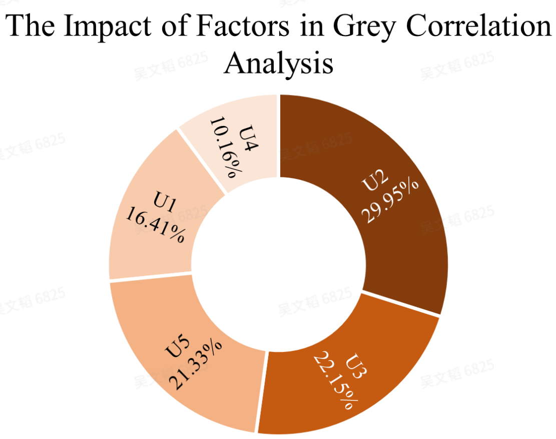
说明：灵敏度计算方法，控制其他因素不变时，仅改变某一因素值±5%，±10%，±15%，求出改变该因素后的新得分，将将新得分减去原本的得分，计算差值，并取绝对值代表偏差，填入下面的表中单位（分数差，满分100分）

	±5%	±10%	±15%
气候韧性建筑标准	0.23	0.45	0.67
风险缓解策略	0.01	0.02	0.03

风险模型参与	0.03	0.06	0.09
能源可持续发展	0.19	0.36	0.53
社区政府	0.05	0.09	0.13



备注：U1-U5分别指：气候韧性建筑标准，风险缓解策略，风险模型参与，能源可持续发展，社区政府



数据统计

美国佛蒙特州

购保相关数据

https://www.sevendaysvt.com/news/flood-insurance-pays-more-than-fema-but⋯

Flood Insurance Pays More Than FEMA — But Few Vermonters Have It

Last week' s flooding left Luke Mulligan and his family stranded when the ragin⋯

重点：

> In Vermont, as in the rest of the country, few people purchase a special insurance policy to protect them from flooding, an event not covered in the typical homeowners' policy. Only about 3,000 Vermont households — or 1 percent of the entire state — have flood policies, according to Kevin Gaffney, the commissioner of the Department of Financial Regulation. Another 800 businesses do, he said.
>
> 在佛蒙特州，与全国其他地区一样，很少有人购买特殊的保险单来保护他们免受洪水侵袭，这是典型房主保单中未涵盖的事件。据金融监管部专员凯文·加夫尼（Kevin Gaffney）称，佛蒙特州只有大约3000户家庭（占全州的1%）制定了洪水政策。他说，另有800家企业这样做。

1%的家庭购买保险。

> For most people, "in 100 years, the place has never flooded, so their bank didn't require them to buy flood insurance," Willett said. "But unfortunately, we got historic floods, and now those poor folks are probably going to have to reach out to FEMA."
>
> 对于大多数人来说，"100年来，这个地方从未被洪水淹没过，所以他们的银行没有要求他们购买洪水保险，"威利特说。"但不幸的是，我们遭遇了历史性的洪水，现在这些穷人可能不得不向联邦紧急事务管理局伸出援手。"

以上体现了为什么 z 值要取样本的极大值

气候

温带大陆性湿润气候（柯本气候分类Dfb）

humid continental type of climate (Köppen climate classification Dfb) https://usafacts.org/issues/climate/state/vermont/

usafacts.org

受灾情况

2019-2023年美国蒙特佛州气象灾害受灾情况.xls
211.50KB

居民经济能力

2000-2022年美国佛蒙特州贫困率.xlsx
9.35KB

1992年至2022年美国佛蒙特州失业率.xlsx
9.25KB

2000-2022年美国佛蒙特州人均个人收入.xlsx
9.34KB

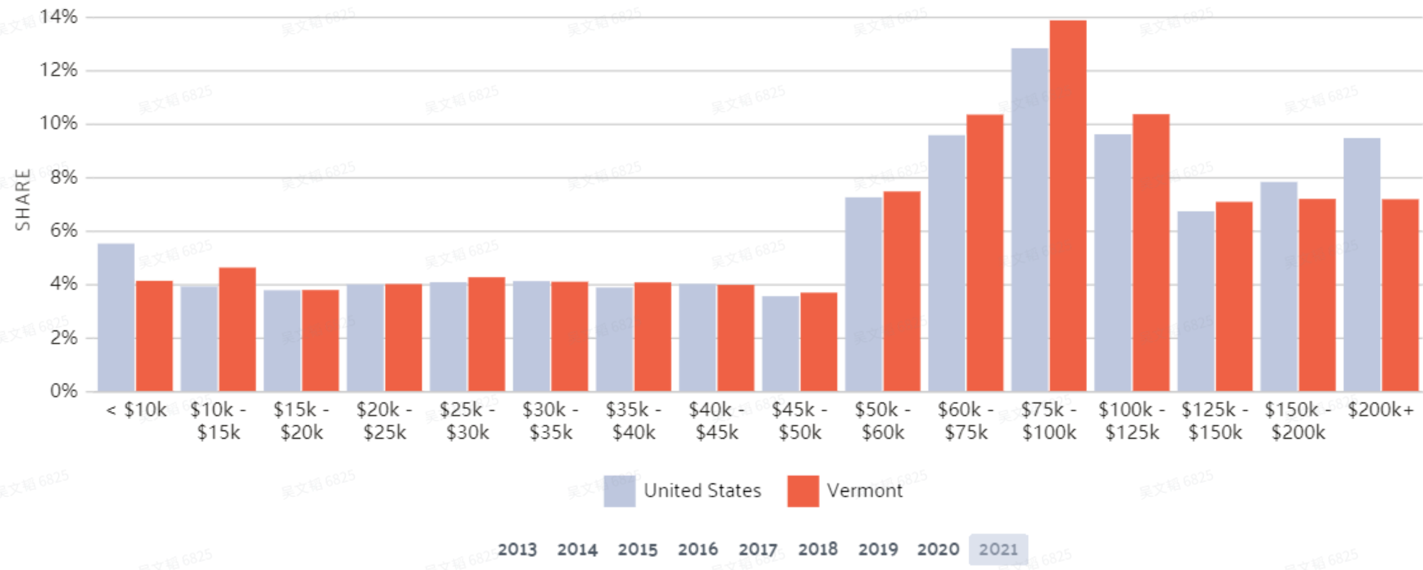
https://www.housingdata.org/profile/income-employment/median-household-income

Median household income | HousingData.org - Directory of affordable rental housing

Skip to main content HousingData.org - Directory of affordable rental housing Vermont directory of affordable rental housing About Contact Managers Main menu Find rental housing Community profiles Hou

家庭收入中位数.xlsx
3.06KB

Household Income.csv
29.06KB



https://datausa.io/profile/geo/vermont/?propertyTaxesValue=propertyValue

datausa.io

建筑

多17世纪殖民时代建筑，超过 30,000 座建筑物、构筑物和考古遗址被列入佛蒙特州史迹名录。超过 11,000 座建筑也被列入美国国家史迹名录。

为了抵御冬季严寒的天气和暴雪，佛蒙特州的房屋墙壁较厚，并采用尖顶设计

Flooding in downtown Montpelier, Vermont, on Tuesday, July 11, 2023. John Tully/The Washington Post via Getty Images

建筑低矮：佛蒙特州是美国唯一一个没有一栋建筑物高度超过 124 英尺（38 米）的州。

https://www.housingdata.org/profile/housing-stock/housing-units

Year-round and seasonal homes | HousingData.org - Directory of affordable rental housing

Skip to main content HousingData.org - Directory of affordable rental housing Vermont directory of affordable rental housing About Contact Managers Main menu Find rental housing Community profiles Hou

佛蒙特州Year-round and seasonal homes.csv

326 B

佛蒙特州的房屋价值中位数低于全国平均水平，但每月住房成本远高于平均水平。佛蒙特州的房屋价值中位数为 223,700 美元，居民平均每月花费 1,594 美元的所有权成本。您可以在佛蒙特州以每平方英尺 148 美元的价格建造房屋，也可以选择以每月 972 美元的价格租一套公寓。

佛蒙特州的房屋拥有率高于全国平均水平，但房产税相当高。典型的佛蒙特州居民每年在房产税上花费 4,040 美元，房产税率平均为 1.83%。

地标与古迹

超过 30,000 座建筑物、构筑物和考古遗址被列入佛蒙特州史迹名录。超过 11,000 座建筑也被列入美国国家史迹名录。

https://historicsites.vermont.gov/

historicsites.vermont.gov

旧宪法大厦 Old Constitution House

https://www.wikiwand.com/en/Old_Constitution_House

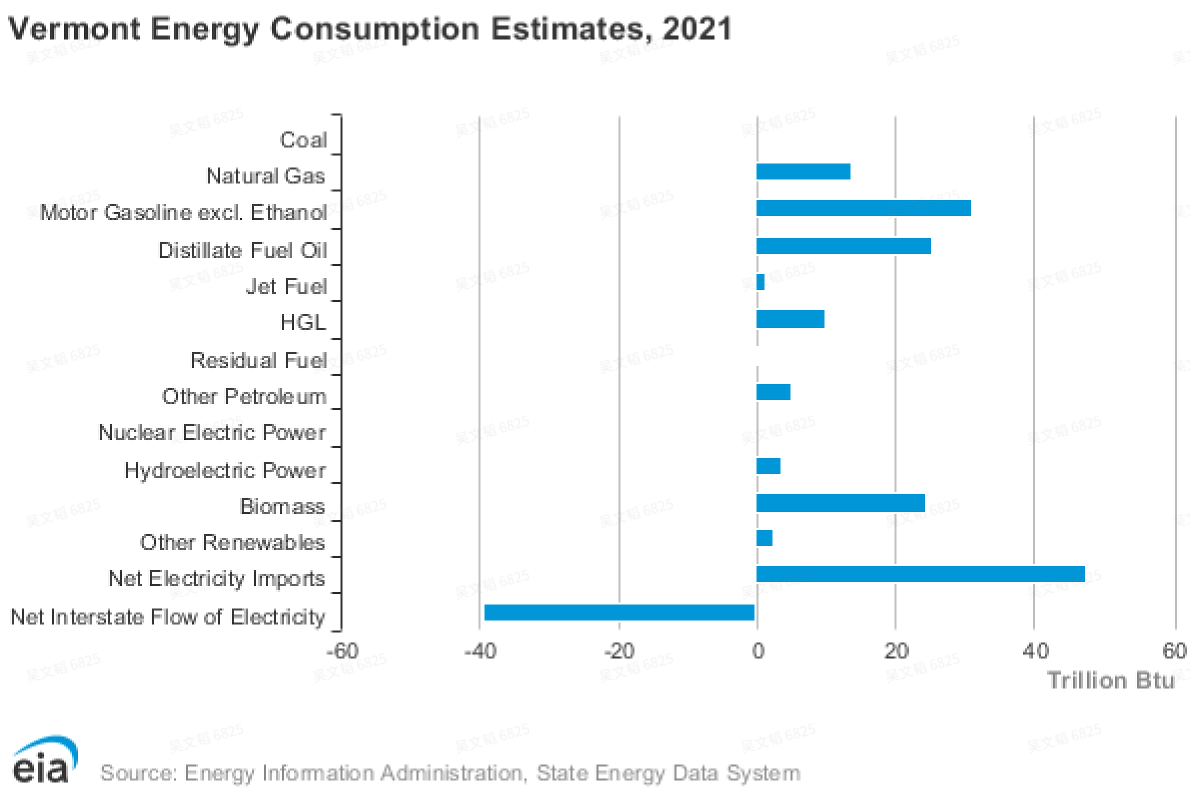
www.wikiwand.com

https://historicsites.vermont.gov/constitution-house

historicsites.vermont.gov

可持续发展

Vermont_Energy_Consumption_Estimates_2021.csv
542 B



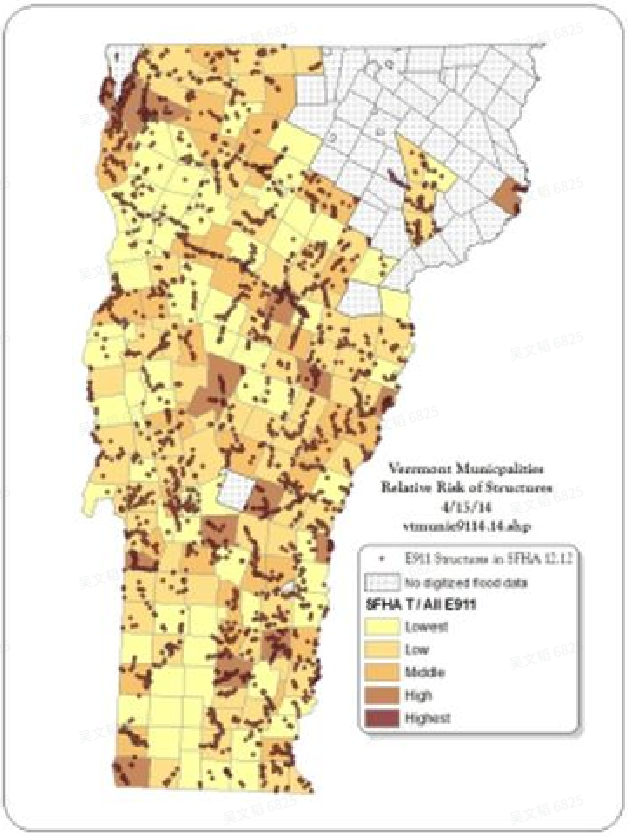
易受灾区域

https://floodready.vermont.gov/update_plans/municipal_plan/flood_resilience
floodready.vermont.gov

今天，佛蒙特州有一万多座建筑物目前处于特殊洪水危险区。

Many communities cherish their historic villages and features and are concerned about how to prepare for the future. What options are available? What works best?

许多社区珍惜他们历史悠久的村庄和特色，并关心如何为未来做准备。有哪些选项可用？什么最有效？



洪水危险区：legislature.vermont.gov

人口

人口面积：每平方英里平均有 67.9 人

人口素质：人口的宗教偏好而言，54%的人隶属于基督教信仰，8%的人隶属于非基督教信仰，高达37%的人不隶属于任何宗教。同样有趣的是，佛蒙特州被认为是该国宗教信仰最少的州，只有 23% 的居民认为自己“非常虔诚”，离婚人数比例在全国排名第五。

老龄化程度：佛蒙特州人口的中位年龄约为 42.6 岁。

性别比例：女性占50.7%，男性占49.3%。

历年人口数据：

https://worldpopulationreview.com/states/vermont-population
worldpopulationreview.com

历史保护

https://accd.vermont.gov/historic-preservation/planning
accd.vermont.gov

State of Vermont Historic Preservation Plan 2023-2029
(approved NPS version 12.23.2022)

Table of Contents

FINAL Vermont Historic Preservation Plan 2023-2029.pdf

Housing Projects Advance with Vermont Housing & Conservation Board Support

https://www.vhcb.org/our-programs/conservation
Conservation | Vermont Housing & Conservation Board
Working with a statewide network of partners, VHCB funds the conservation of agricultural land, natural areas, forestland, recreational land, and the preservat…

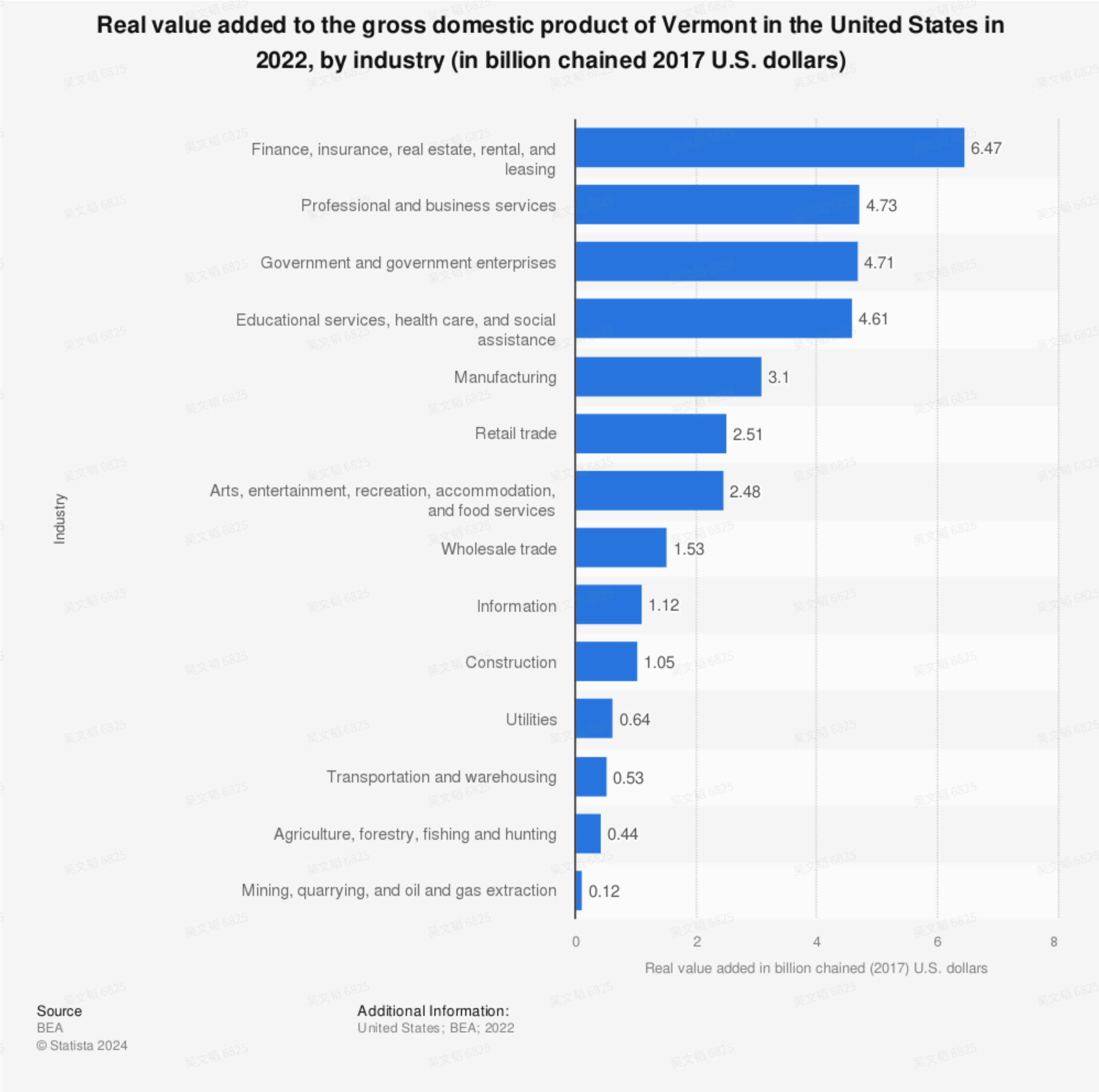
旧房修缮计划

佛蒙特州拥有全美最古老的住房存量之一。根据人口普查局 2021 年的数据，佛蒙特州的平均房屋建于 1975 年，而全国平均水平为 1979 年。当涉及到该州最古老的房屋时，鸿沟甚至更大。该州四分之一的住房单元建于 1939 年或更早，而全国其他地区仅为 12%。

https://vtdigger.org/2023/04/09/vermonts-aging-homes-put-extra-strain-on-states-housing-crisis/

产业结构

statistic_id1065238_us-real-value-added-to-gdp-in-vermont-2022-…
9.23KB



新西兰 New Zealand

购保相关数据

From October 01, 2022, the EQC first loss cover will double to $300,000 ex GST. All residential property owners, regardless of location, risk or value, will pay up to $552 including GST a year, an increase of $207.

从 2022 年 10 月 1 日起，EQC 的首次损失保险将翻倍至 300,000 美元（不含消费税）。所有住宅业主，无论位置、风险或价值如何，每年将支付高达 552 澳元（包括商品及服务税），增加了 207 澳元。

https://www.insurancebusinessmag.com/nz/news/columns/new-zealands-natural-disaster-scheme-314622.aspx
www.insurancebusinessmag.com

Climate change is having a significant impact on insured losses. Last year, insured losses from extreme weather events hit a high of $274 million and at this stage this year they will be well in excess of $200 million. These losses are significantly higher than what was experienced less than a decade ago and the next few years will almost certainly see an increase in losses and impact premiums.

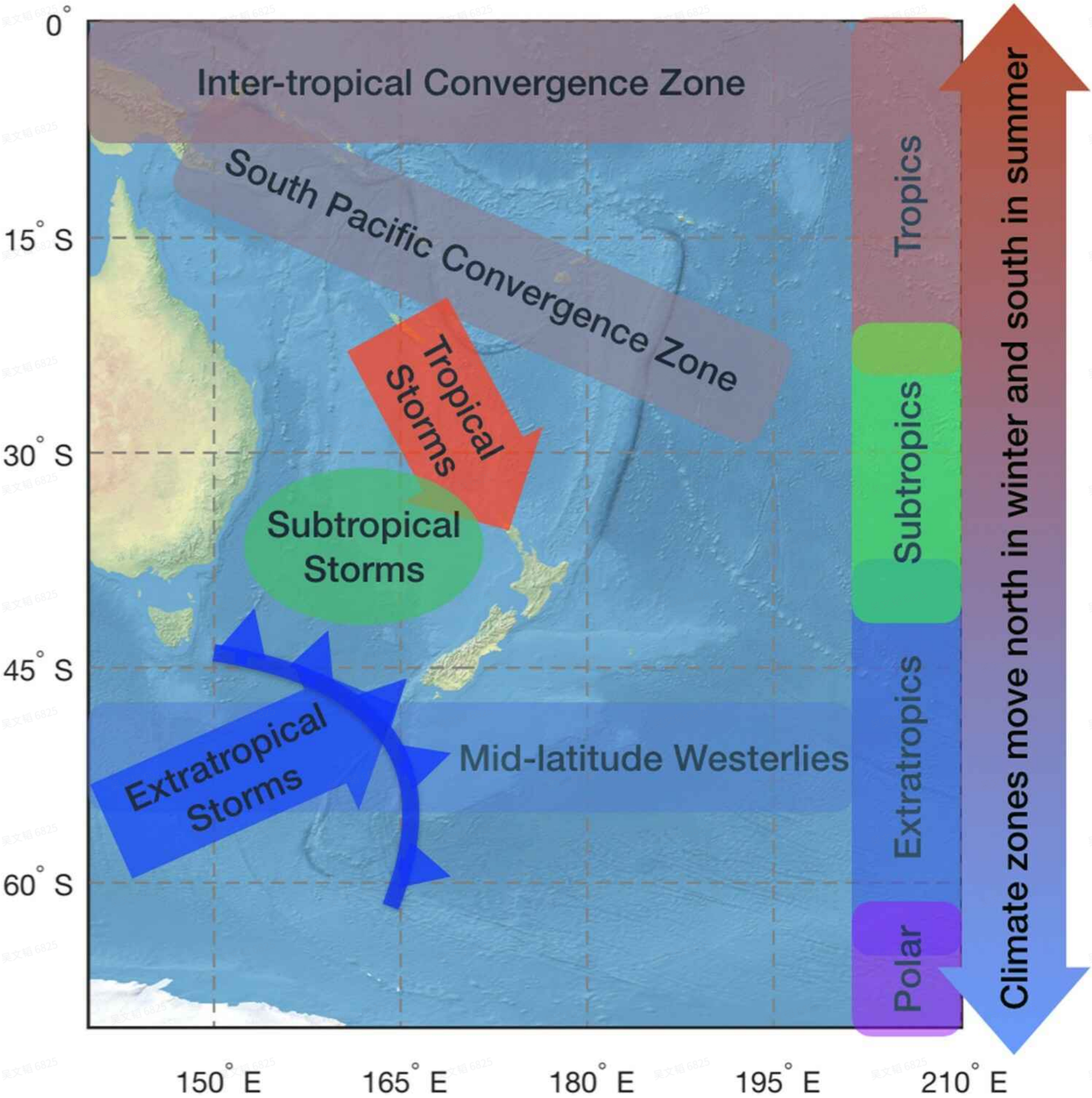
气候变化对保险损失产生了重大影响。去年，极端天气事件造成的保险损失达到2.74亿美元的高位，今年现阶段将远远超过2亿美元。这些损失明显高于不到十年前所经历的损失，未来几年几乎肯定会看到损失和影响溢价的增加。

气候

由于其纬度范围为南纬35°至南纬47°，新西兰暴露在热带、亚热带和温带的风暴中，有时还会爆发严重的极地冷空气。显示这些气候带：热带（0°至~24°S）;亚热带（南纬24°至南纬40°）;温带（南纬40°至南纬65°）和极地地区（南纬65°至90°）。虽然广义上由纬度定义，但这些区域实际上随着季节向北和向南移动。在夏季，当太阳直接在南纬24°C时，北岛可以经历热带条件，相反，在冬季，南岛可以经历极地条件。南太平洋辐合带（SPZC）位于新西兰北部，该地区的热带气候条件和风暴产生比大多数其他海洋经度更向极地延伸。

下图：

Figure 2. Illustration of New Zealand climate influencers and origin of storm systems.



论文链接：

https://www.tandfonline.com/doi/full/10.1080/17477891.2021.1905595
www.tandfonline.com

论文名字：**Normalised New Zealand natural Disaster insurance losses: 1968–2019**

期刊名：**Environmental Hazards**

论文位置：Pages 58 - 76

点这个链接引用该文：

www.tandfonline.com

大多数影响新西兰的风暴（低压系统）都是在热带或温带地区产生的（）。在热带地区，风通常从东向西吹。热带风暴，包括热带气旋，在温暖的海水上形成，并可能在新西兰上空向极地移动。在温带地区，风通常从西向东吹，温带气旋是中纬度西风的一部分。(1) 这些风暴是由于冷空气和暖空气的碰撞而形成的，其特点是冷锋可以向赤道推进并影响整个新西兰

虽然亚热带地区通常以高压系统和稳定的天气为特征，但塔斯曼海是亚热带风暴的全球热点地区。这些被认为是具有热带和温带气旋特征的混合风暴——它们从温暖的海洋和凉爽的大气之间的对比中汲取能量。新西兰是全球为数不多的风暴经常在热带和热带地区之间过渡的地方之一（例如Sinclair（2002））。

如上所述，这些风暴事件在全年的时间很大程度上取决于南半球气候区的季节性南北变化。在年际时间尺度上，风暴事件的频率（以及最有可能的聚类）受到大规模气候变率的影响，例如厄尔尼诺南方涛动（ENSO），年代际太平洋涛动（IPO）和南方环形模式（SAM）（江等人，2013）

受灾信息

新西兰保险委员会（ICNZ）自然灾害数据库提供的灾害清单

the Insurance Council of New Zealand’s (ICNZ) Natural Disaster Database

https://www.icnz.org.nz/natural-disasters/cost-of-natural-disasters/

居民经济能力

国内生产总值：New Zealand - Gross domestic product (GDP) 2028 | Statista

Statistic as Excel data file
New Zealand: Gross domestic product (GDP) in current prices from 1988 to 2028 (in billion U.S. dollars)
Access data

Source

Source	IMF
Conducted by	IMF
Survey period	1988 to 2028
Region	New Zealand
Type of survey	*n.a.*
Number of respondents	*n.a.*
Age group	*n.a.*
Special characteristics	*n.a.*
Note	* Estimate. Figures have been rounded.

Publication

Published by	IMF

新西兰国内生产总值.xlsx

人均国民总收入：www.macrotrends.net

建筑

Table: Number, value and floor area by building type, nature & region (Disc April 2015) (Monthly)

按建筑类型、性质和地区划分的数量、价值和建筑面积（2015年4月光盘）（每月）

https://infoshare.stats.govt.nz/infoshare/SelectVariables.aspx?pxID=dc5cf45a-3e94-49cd-9670-707353ecc5a7

Browse - Infoshare - Statistics New Zealand

Infoshare: Connecting you to a wealth of information. A free service provided by Statistics New Zealand to allow viewing our survey data.

https://infoshare.stats.govt.nz/infoshare/SelectVariables.aspx?pxID=5aa9dab3-edf0-4bd4-af4b-b111f91393d3

Browse - Infoshare - Statistics New Zealand

Infoshare: Connecting you to a wealth of information. A free service provided by Statistics New Zealand to allow viewing our survey data.

https://infoshare.stats.govt.nz/infoshare/SelectVariables.aspx?pxID=2e5819f5-7e12-4e65-921d-f39d9ab30bfd

Browse - Infoshare - Statistics New Zealand

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奥克兰的平均房价：

约 18,100,000 个结果

Opes 奥普斯

https://www.opespartners.co.nz/property-markets/auckland

Auckland House Prices [2024] | Auckland Property

奥克兰房价 [2024] |奥克兰房产

网页 2024年1月14日 · As at December 2023, the median house **price** in **Auckland** is $1,050,000. This is up from $610,000 10 years earlier. That means that the median **Auckland** property increased in value by 5.58% each year, or $44,000 on **average**.

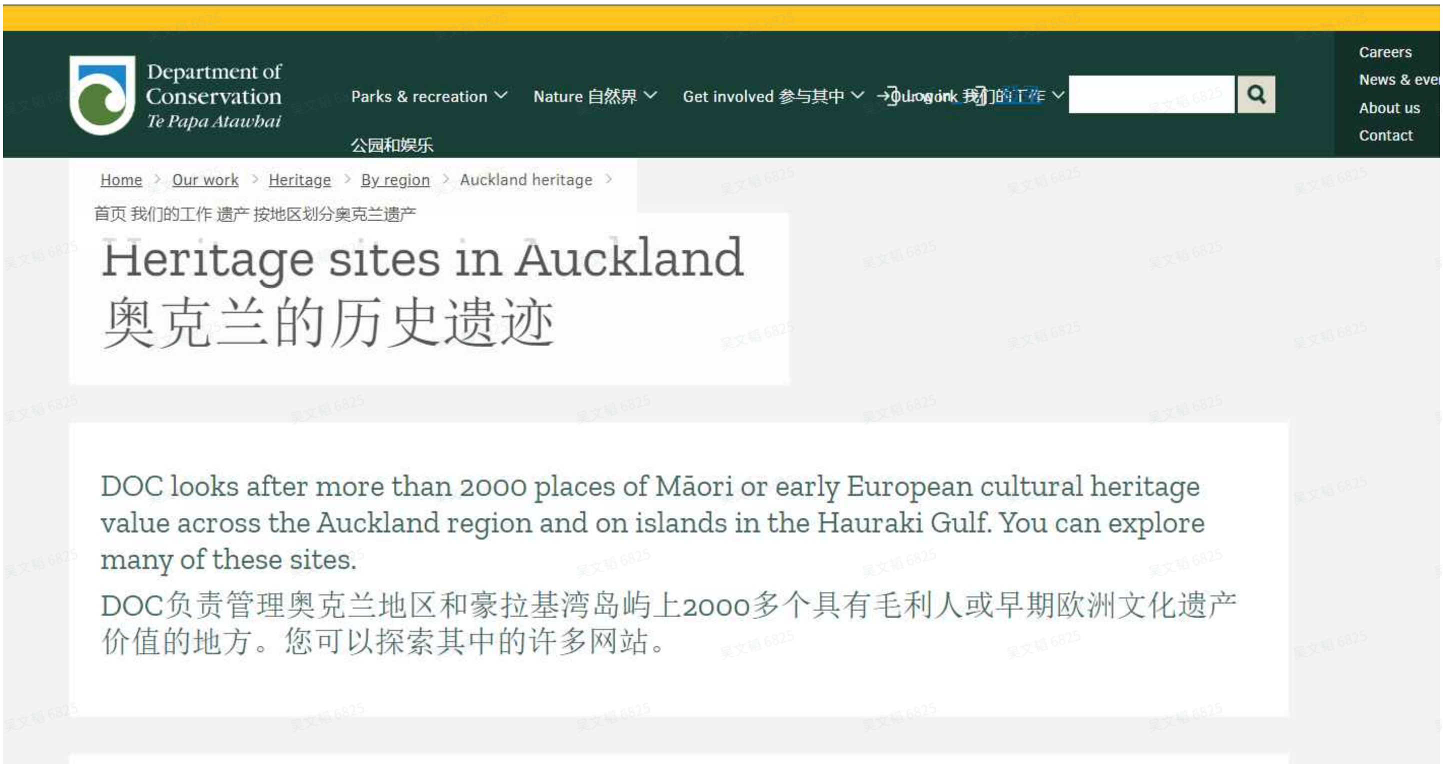
网页2024年1月14日 ·截至 2023 年 12 月，奥克兰的房价中位数为 $1,050,000。这比 10 年前的 610,000 美元有所增加。这意味着奥克兰房产的中位数每年增长 5.58%，平均为44,000澳元。

地标和古迹

The Sky Tower

位于 Auckland 『奥克兰』，高328米，是南半球第二高的独立式建筑。

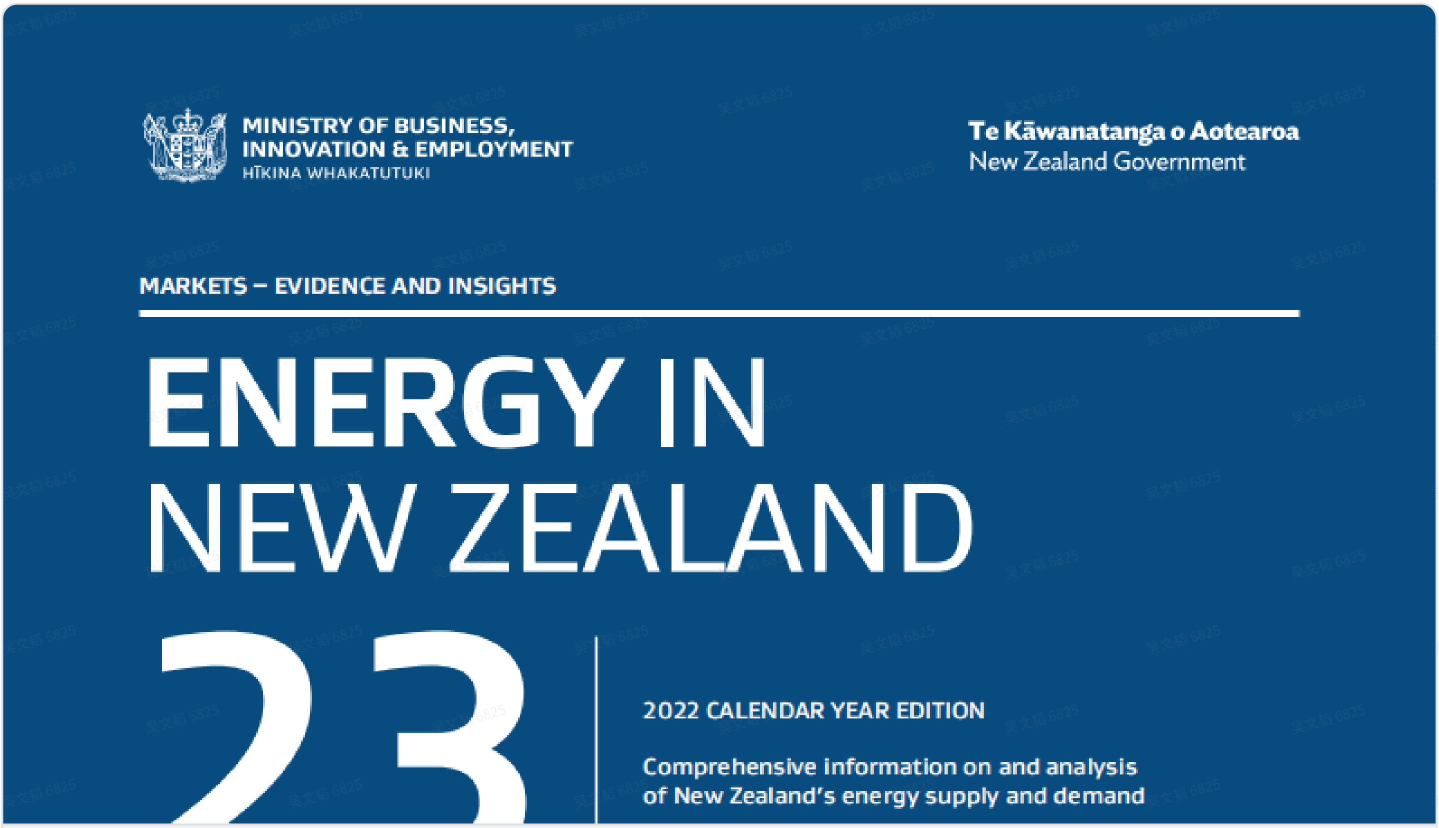
自 1997 年完工以来，天空塔因其高度和设计而成为奥克兰天际线的标志性地标。



https://www.doc.govt.nz/our-work/heritage/by-region/auckland/
www.doc.govt.nz

可持续发展

energy-overview.xlsx
315.83KB



energy-in-new-zealand-2023.pdf

https://environment.govt.nz/publications/aotearoa-new-zealands-first-emissio…

Energy and industry

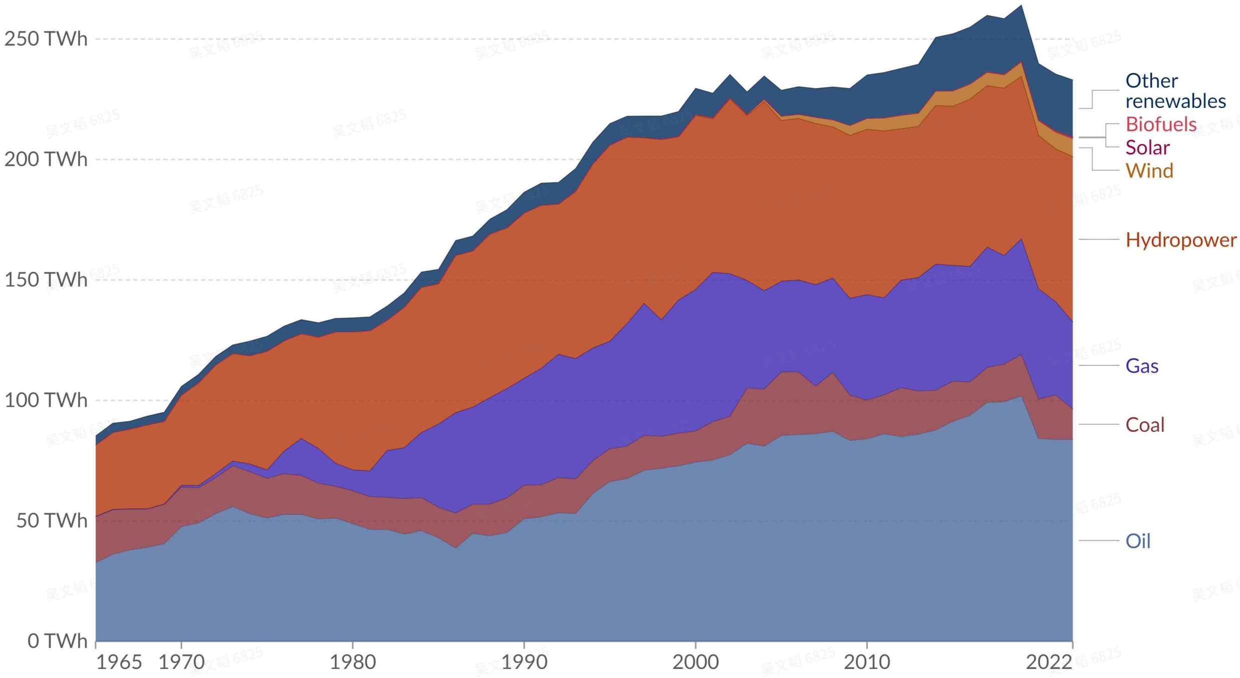
Site search Main navigation Publications OIA releases Consultations Pūtaiao Facts & Science Show submenu for "Facts & Science " He mahi ka taea e koe What yo…

energy-consumption-by-source-and-country.csv

494.75KB

Energy consumption by source, New Zealand

Measured in terms of primary energy[1] using the substitution method[2].

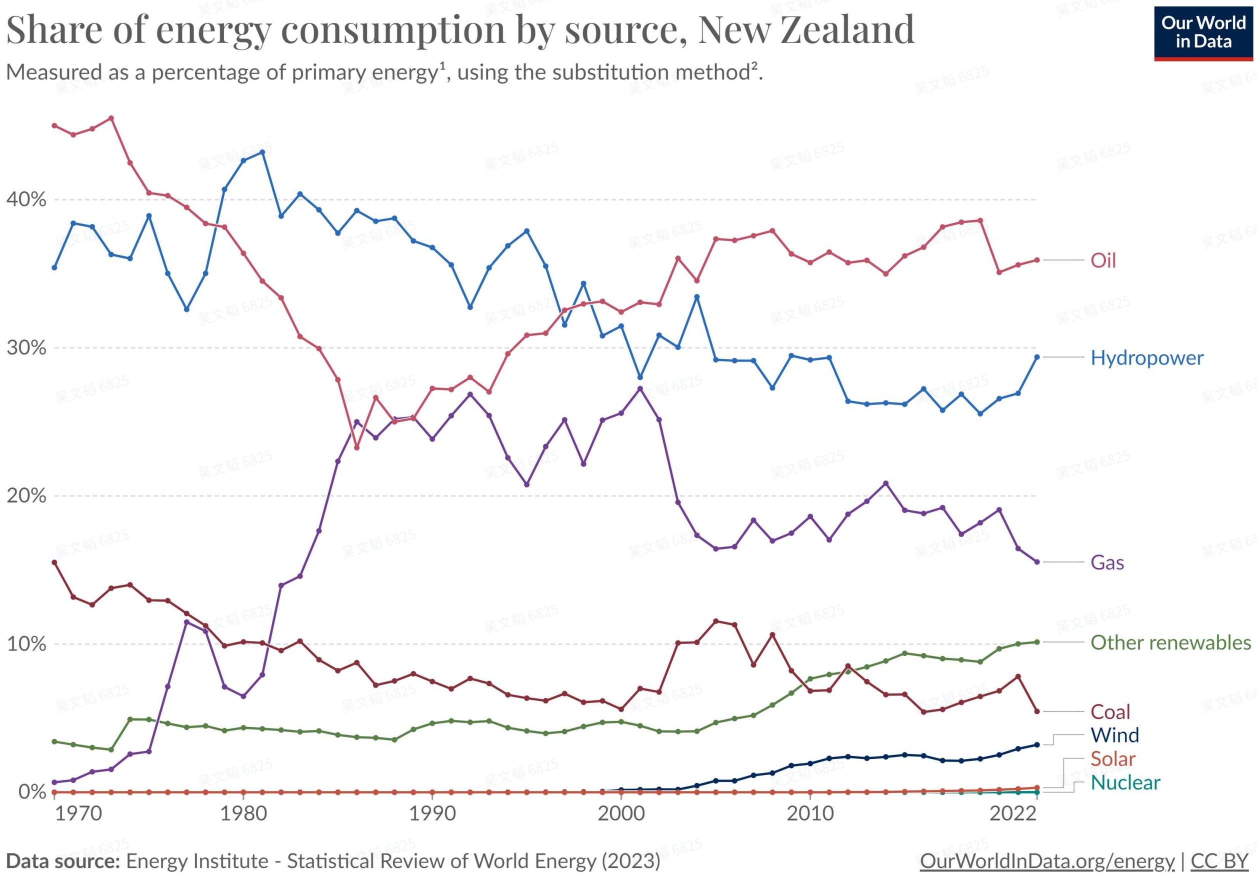


Data source: Energy Institute - Statistical Review of World Energy (2023)
OurWorldInData.org/energy | CC BY
Note: Other renewables include geothermal, biomass and waste energy.

1. Primary energy: Primary energy is the energy available as resources – such as the fuels burnt in power plants – before it has been transformed. This relates to the coal before it has been burned, the uranium, or the barrels of oil. Primary energy includes energy that the end user needs, in the form of electricity, transport and heating, plus inefficiencies and energy that is lost when raw resources are transformed into a usable form. You can read more on the different ways of measuring energy in our article.

2. Substitution method: The 'substitution method' is used by researchers to correct primary energy consumption for efficiency losses experienced by fossil fuels. It tries to adjust non-fossil energy sources to the inputs that would be needed if it was generated from fossil fuels. It assumes that wind and solar electricity is as inefficient as coal or gas. To do this, energy generation from non-fossil sources are divided by a standard 'thermal efficiency factor' – typically around 0.4 Nuclear power is also adjusted despite it also experiencing thermal losses in a power plant. Since it's reported in terms of electricity output, we need to do this adjustment to calculate its equivalent input value. You can read more about this adjustment in our article.

share-energy-source-sub.csv
394.22KB



1. **Primary energy**: Primary energy is the energy available as resources – such as the fuels burnt in power plants – before it has been transformed. This relates to the coal before it has been burned, the uranium, or the barrels of oil. Primary energy includes energy that the end user needs, in the form of electricity, transport and heating, plus inefficiencies and energy that is lost when raw resources are transformed into a usable form. You can read more on the different ways of measuring energy in our article.

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energy-consumption-by-source-and-country.svg
34.58KB

share-energy-source-sub.svg
60.93KB

https://ourworldindata.org/energy/country/new-zealand#what-sources-does-the-country-get-its-energy-from

易受灾区域

https://www.aucklandcouncil.govt.nz/building-and-consents/natural-hazards-e…

Building on land at risk of a natural hazard

Find out how a possible natural hazard on your property affects your ability to build on it or alter an existing building.

人口

https://worldpopulationreview.com/world-cities/auckland-population

worldpopulationreview.com

奥克兰2016年人口为1,415,550人，占全国人口的33.4%。奥克兰市议会地区的人口估计较多，为 157万，是更大的奥克兰地区的一部分，奥克兰地区包括南部的许多农村城镇和地区，以及豪拉基湾的岛屿。城市人口密度为每平方公里1,210人。

https://www.macrotrends.net/countries/NZL/new-zealand/population

历史保护

https://www.heritage.org.nz/

www.heritage.org.nz

https://www.doc.govt.nz/our-work/heritage/by-region/auckland/

Heritage sites in Auckland

DOC looks after more than 2000 places of Māori or early European cultural heritage value across the Auckland region and on islands in the Hauraki Gulf. Yo…

政府支持历史遗产社区共建：

https://www.aucklandcouncil.govt.nz/arts-culture-heritage/heritage/protecting…

Protecting our heritage

A full list of heritages schedule, how to nominate for heritage protection, how we identify and evaluate mana whenua cultural sites, and heritage controls on you…

历史遗产保护政策

https://www.environmentguide.org.nz/issues/heritage/threats-to-historic-heritage/

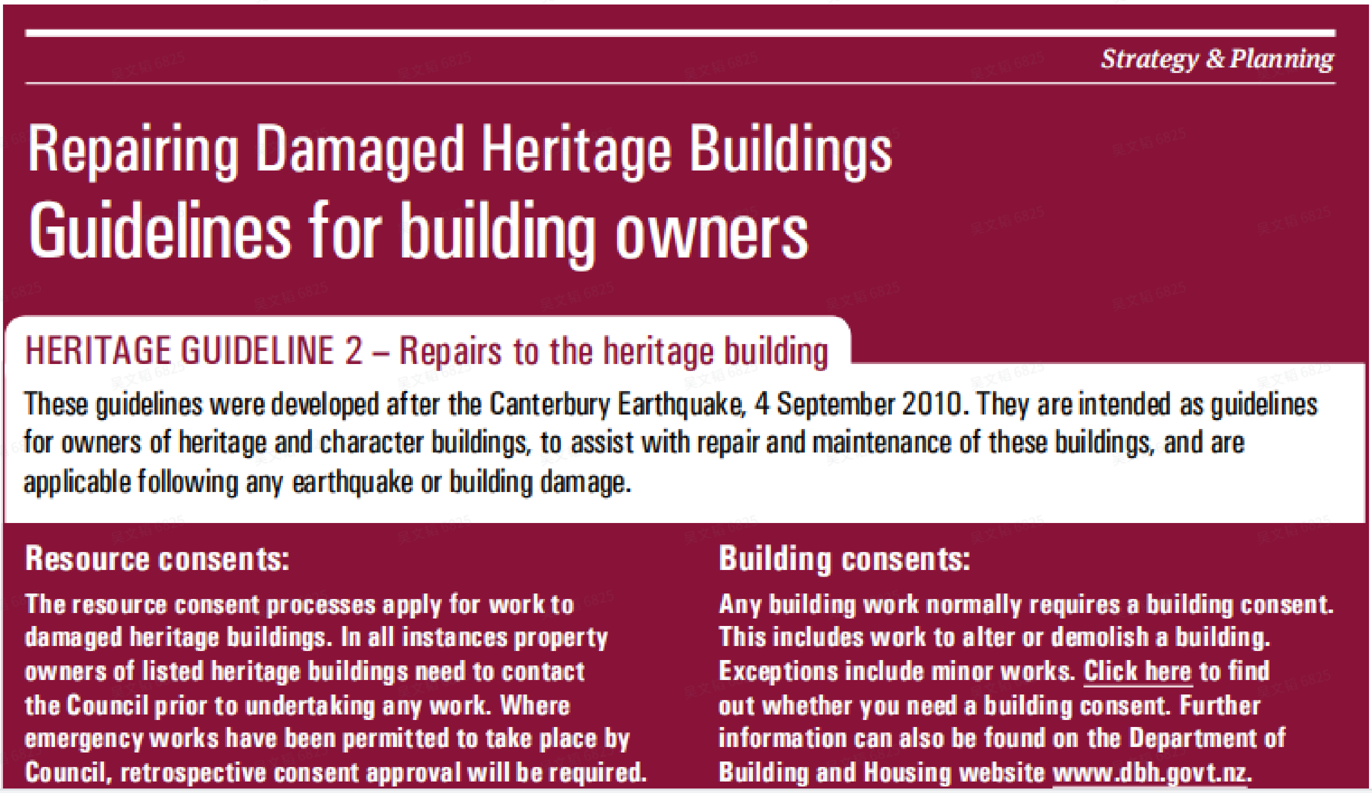
www.environmentguide.org.nz

旧房修缮计划

https://www.tandfonline.com/doi/figure/10.1080/17567505.2020.1715597?scroll=top&needAccess=true

www.tandfonline.com

详细的修复方式：



Strategy & Planning

Repairing Damaged Heritage Buildings
Guidelines for building owners

HERITAGE GUIDELINE 2 – Repairs to the heritage building

These guidelines were developed after the Canterbury Earthquake, 4 September 2010. They are intended as guidelines for owners of heritage and character buildings, to assist with repair and maintenance of these buildings, and are applicable following any earthquake or building damage.

Resource consents:

The resource consent processes apply for work to damaged heritage buildings. In all instances property owners of listed heritage buildings need to contact the Council prior to undertaking any work. Where emergency works have been permitted to take place by Council, retrospective consent approval will be required.

Building consents:

Any building work normally requires a building consent. This includes work to alter or demolish a building. Exceptions include minor works. Click here to find out whether you need a building consent. Further information can also be found on the Department of Building and Housing website www.dbh.govt.nz.

HeritageGuideline2.pdf

灾后房屋的紧急修缮工程：

https://www.building.govt.nz/managing-buildings/managing-buildings-in-···

Remediation, repair and, urgent Works

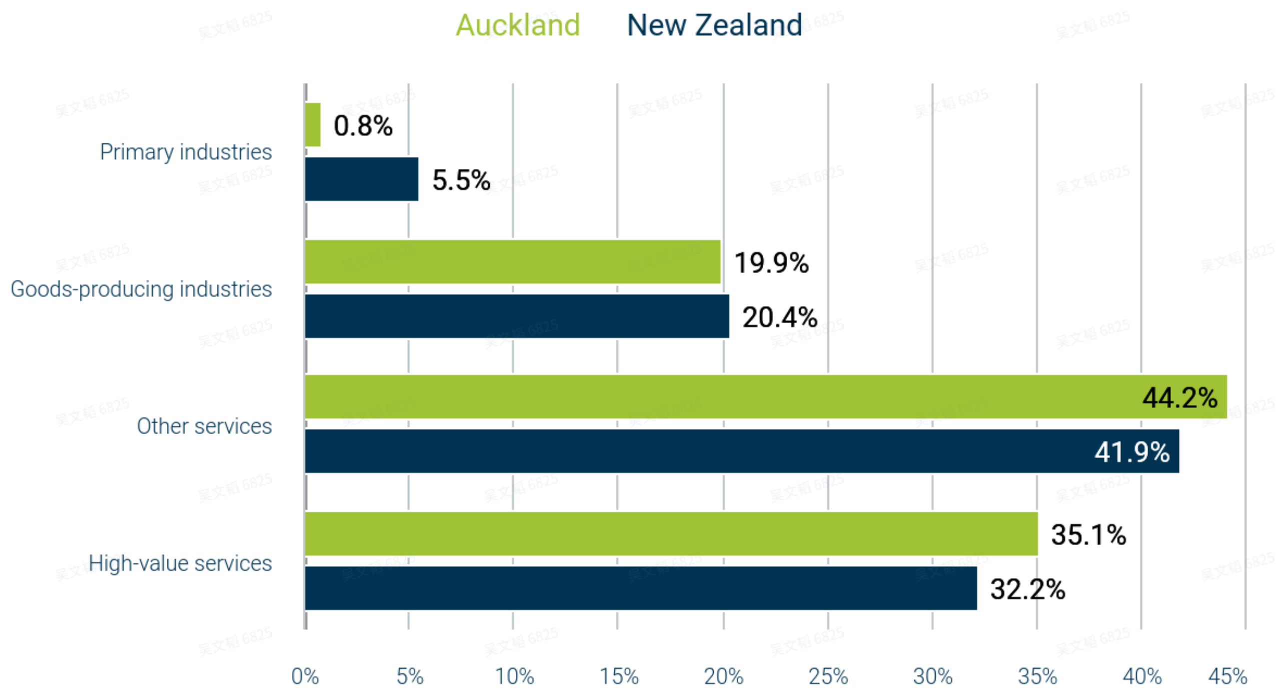
Remediation and repair works are often required following an emergency event to make buildings safe to use.

产业结构

employment-structure-by.xlsx
5.58KB

Employment structure by broad sector, 2023

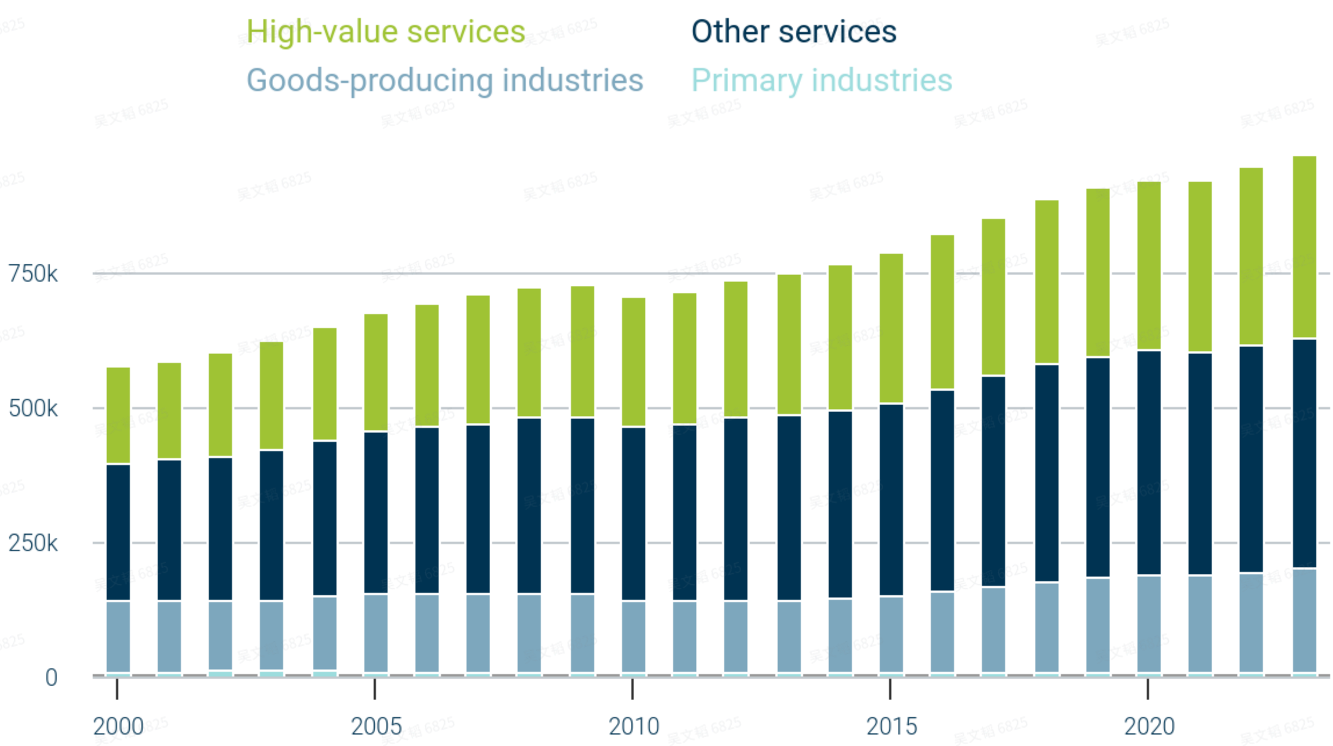
% of total, year to March 2023



employment-structure-by.csv
848 B

Employment structure by broad sector

Filled jobs, March years



https://rep.infometrics.co.nz/auckland/employment/structure

rep.infometrics.co.nz

宏观灾害数据

https://www.iii.org/fact-statistic/facts-statistics-global-catastrophes

www.iii.org

https://www.ncdc.noaa.gov/stormevents/

Storm Events Database | National Centers for Environmental Information

The Storm Events Database contains records on various types of severe weather, as collected by NOAA's National Weather Service (NWS).

https://www1.ncdc.noaa.gov/pub/data/swdi/stormevents/csvfiles/

Index of /pub/data/swdi/stormevents/csvfiles

Index of /pub/data/swdi/stormevents/csvfiles Name Last modified Size Description Parent Directory - Storm-Data-Bulk-csv-Format.pdf 2020-07-17 13:10 161K Storm-Data-Export-Format.pdf 2020-07-17 09:17 1

TR_231115_Uninsurable_Future.pdf

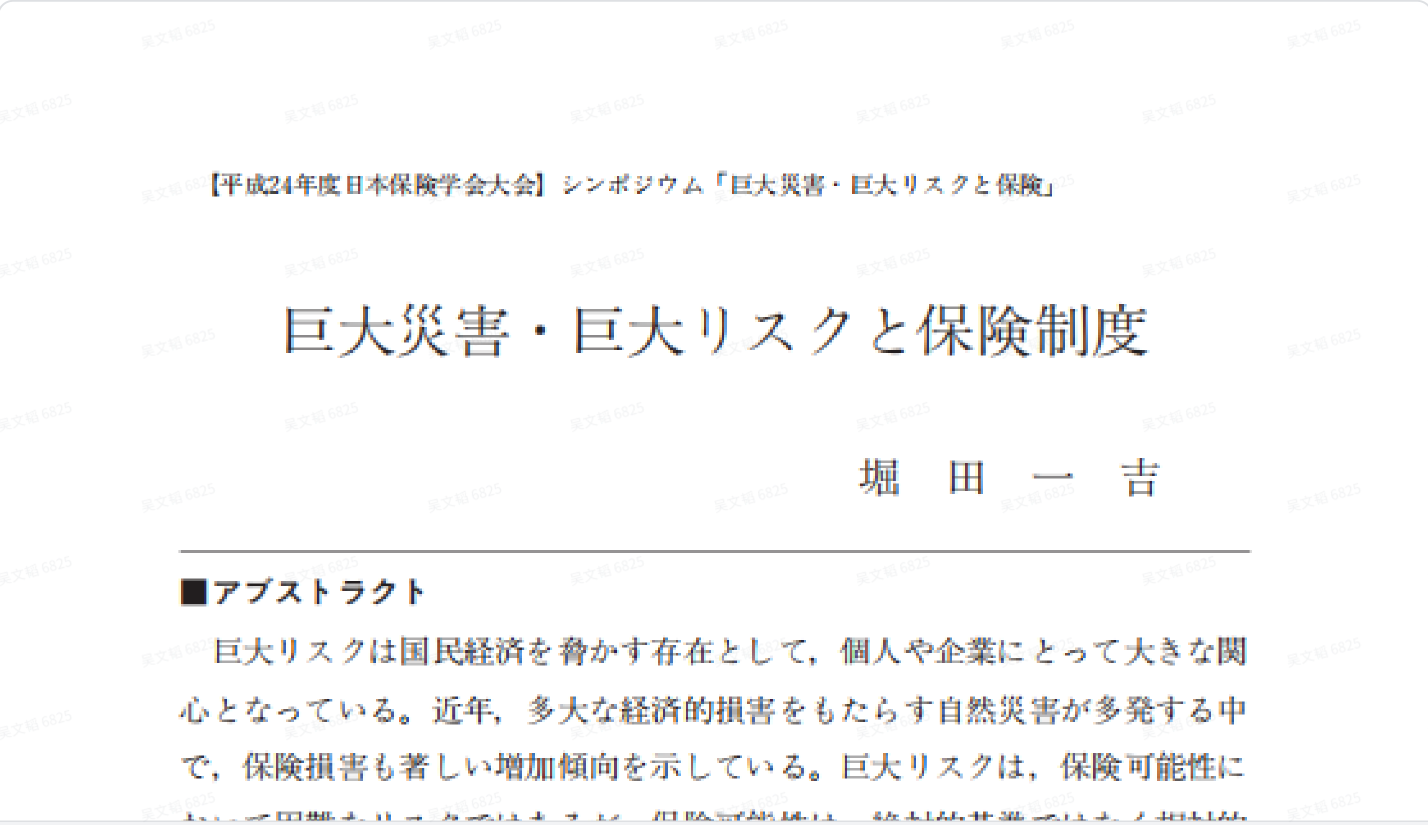
Meteo disasters Excel dwnld.xls
72.50KB

2000-2022年美国佛蒙特州贫困率.xlsx
9.35KB

1992年至2022年美国佛蒙特州失业率.xlsx
9.25KB

2000-2022年美国佛蒙特州人均个人收入.xlsx
9.34KB

保险相关


【平成24年度日本保険学会大会】シンポジウム「巨大災害・巨大リスクと保険」

巨大災害・巨大リスクと保険制度

堀　田　一　吉

■アブストラクト

巨大リスクは国民経済を脅かす存在として，個人や企業にとって大きな関心となっている。近年，多大な経済的損害をもたらす自然災害が多発する中で，保険損害も著しい増加傾向を示している。巨大リスクは，保険可能性に

2013_620_23.pdf

https://smartfinancial.com/catastrophe-insurance
smartfinancial.com

https://www.icnz.org.nz/industry/cost-of-natural-disasters/

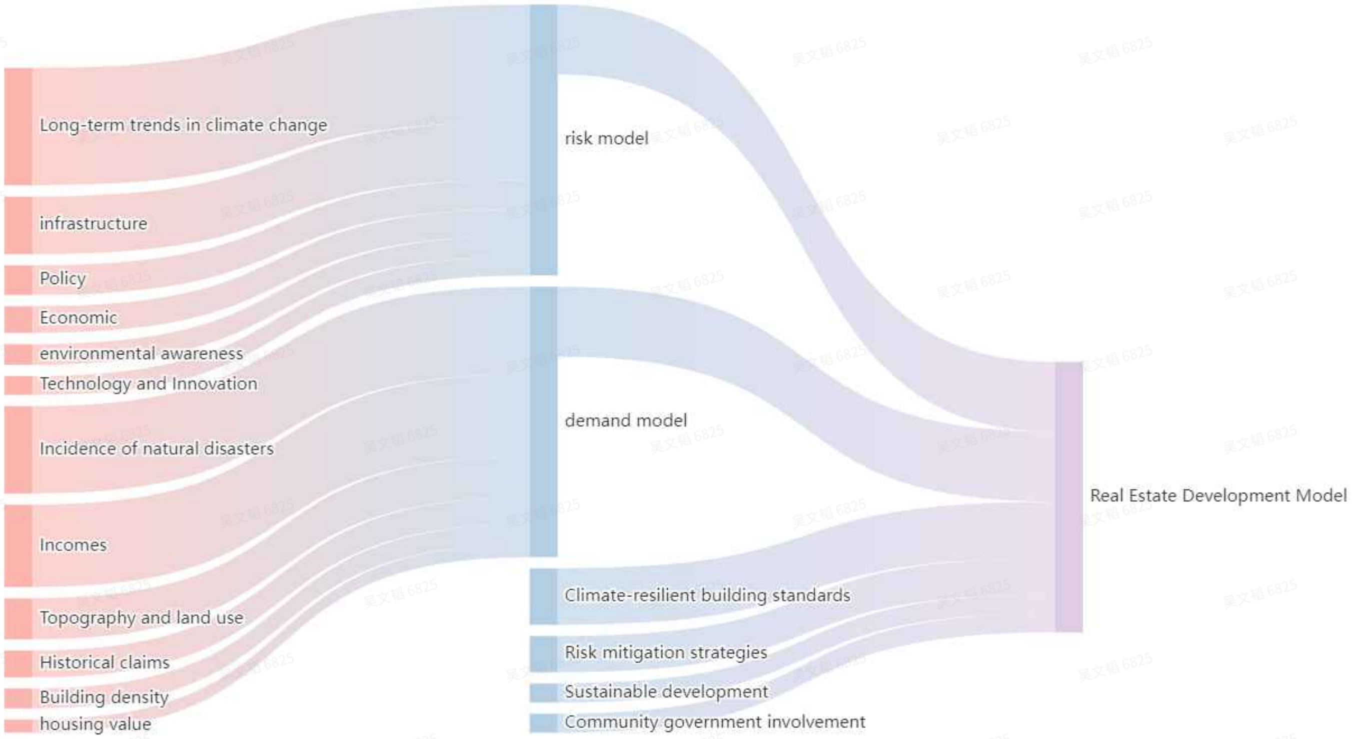
www.icnz.org.nz

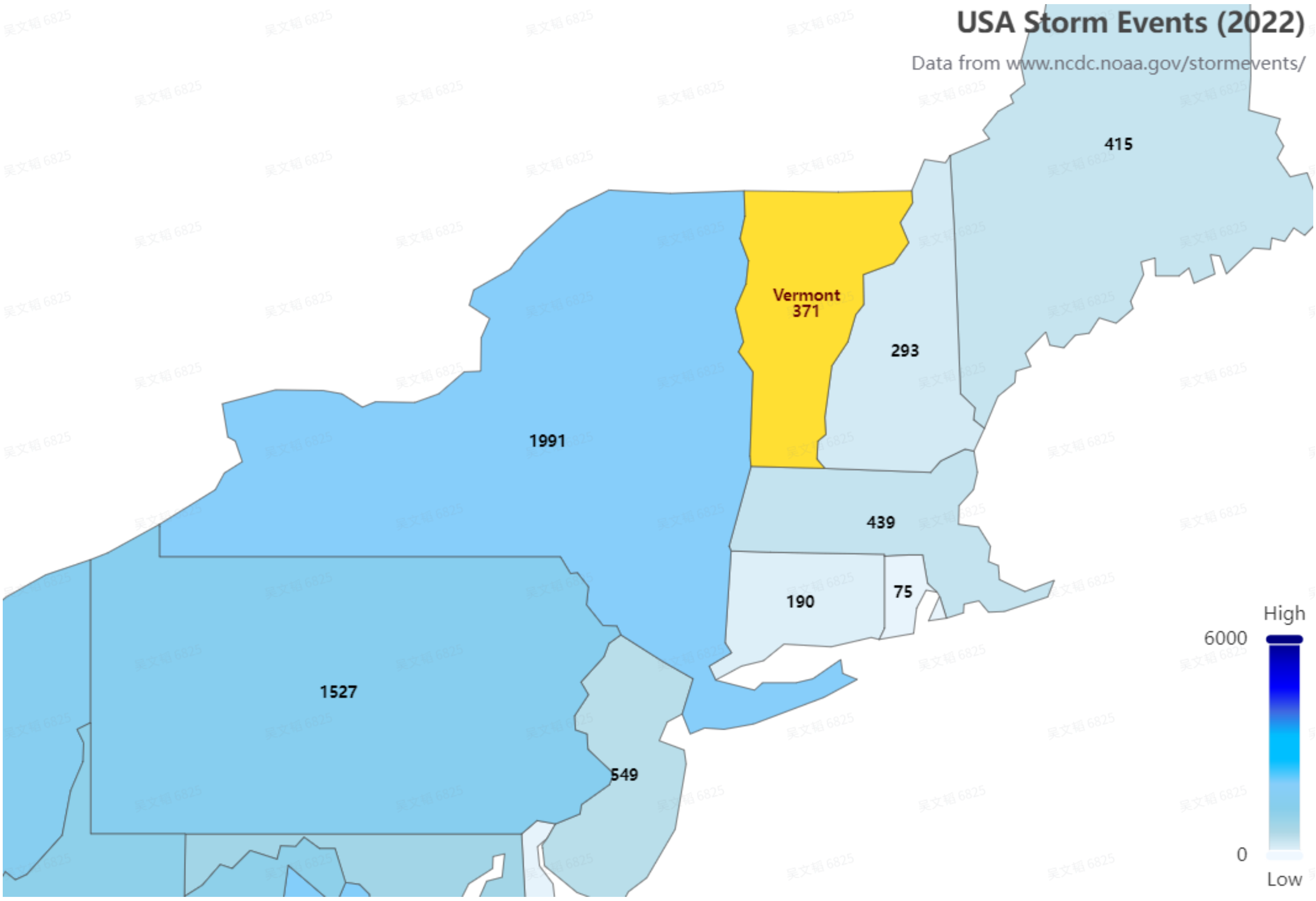
https://www.swissre.com/media/press-release/nr-20211214-sigma-full-year-2021-preliminary-natcat-loss-estimates.…

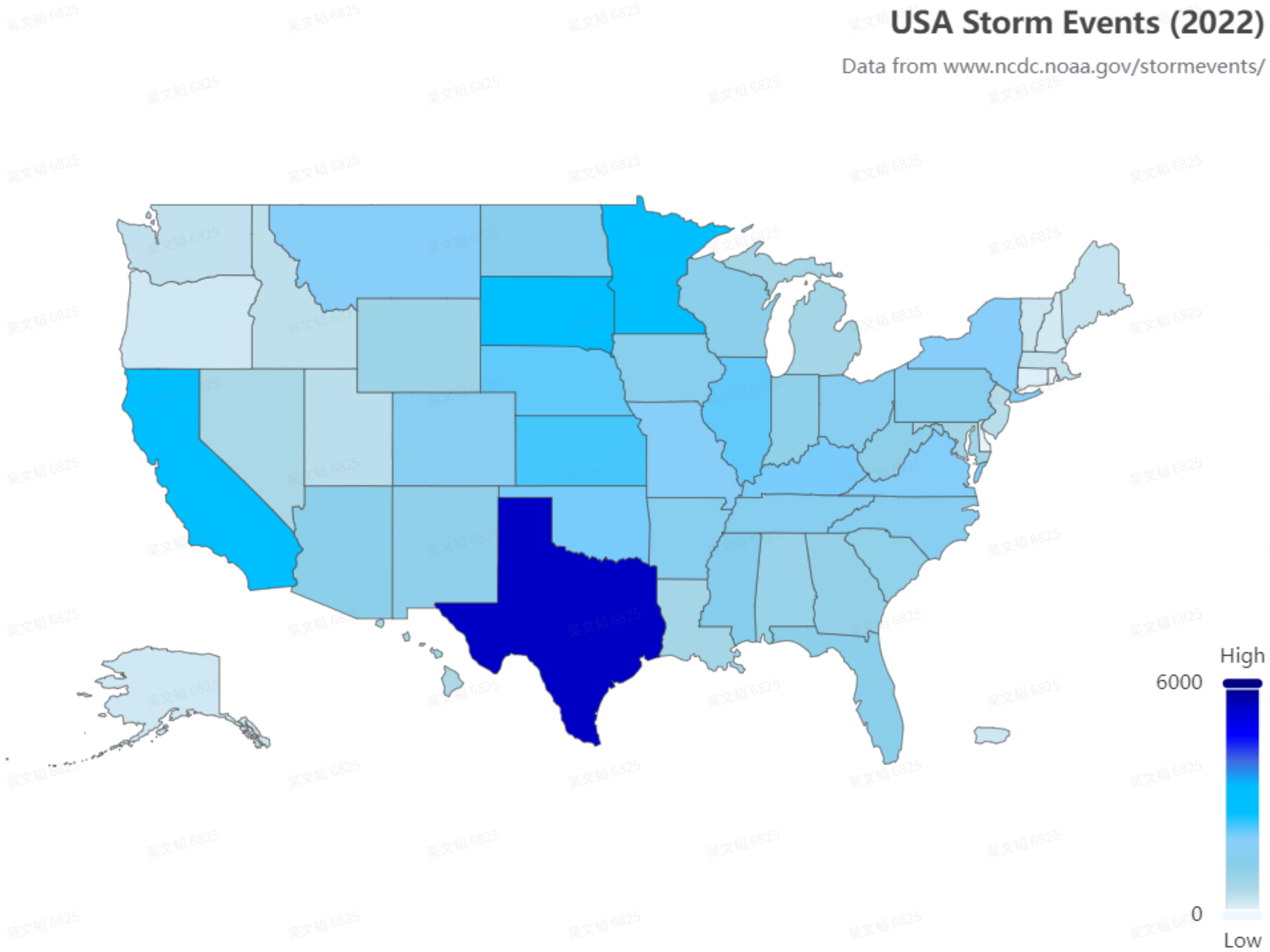
Global insured catastrophe losses rise to USD 112 billion in 2021, the fourth highest on record, Swi

Swiss Re Institute estimates USD 83 billion global insured catastrophe losses in 2020, the fifth-costliest on record.

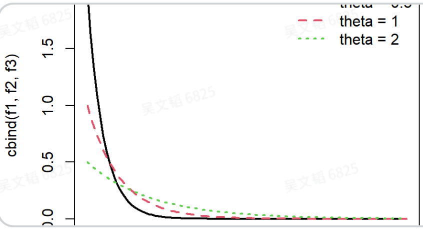
各种图图：




USA Storm Events (2022)
Data from www.ncdc.noaa.gov/stormevents/
415
Vermont
371
293
1991
439
190
75
1527
549
High
6000
0
Low


USA Storm Events (2022)
Data from www.ncdc.noaa.gov/stormevents/
High
6000
0
Low

参考资料：风险函数



https://lizhengxiao.github.io/Non-life-Insurance-Actuarial-Science/riskmod.html

Chapter 3 基本的损失分布 | 非寿险精算与风险模型

This is a minimal example of using the bookdown package to write a book. The output format for this example is bookdown::gitbook.

论文完整latex代码

```
%%
%% This is file `mcmthesis-demo.tex',
%% generated with the docstrip utility.
%%
%% The original source files were:
%%
%% mcmthesis.dtx  (with options: `demo')
%%
%% -----------------------------------
%%
%% This is a generated file.
%%
%% Copyright (C)
%%       2010 -- 2015 by Zhaoli Wang
%%       2014 -- 2019 by Liam Huang
%%       2019 -- present by latexstudio.net
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%%   http://www.latex-project.org/lppl.txt
%% and version 1.3 or later is part of all distributions of LaTeX
%% version 2005/12/01 or later.
%%
%% This work has the LPPL maintenance status `maintained'.
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%% The Current Maintainer of this work is Liam Huang.
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%%
%% This is file `mcmthesis-demo.tex',
%% generated with the docstrip utility.
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%% mcmthesis.dtx  (with options: `demo')
%%
```

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%% ----------------------------------
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%% This is a generated file.
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%% conditions of the LaTeX Project Public License, either version 1.3
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%% The latest version of this license is in
%%   http://www.latex-project.org/lppl.txt
%% and version 1.3 or later is part of all distributions of LaTeX
%% version 2005/12/01 or later.
%%
%% This work has the LPPL maintenance status `maintained'.
%%
%% The Current Maintainer of this work is Liam Huang.
%%
\documentclass{mcmthesis}
\mcmsetup{CTeX = false,    % 使用 CTeX 套装时，设置为 true
          tcn = \textcolor{black}{2409529}, problem = \textcolor{black}{E},
          sheet = true, titleinsheet = true, keywordsinsheet = true,
          titlepage = false, abstract = false}

\usepackage{newtxtext}     % \usepackage{palatino}
\usepackage[backend=bibtex]{biblatex}   % for RStudio Complie
\usepackage{tocloft}
\setlength{\cftbeforesecskip}{6pt}
\renewcommand{\contentsname}{\hspace*{\fill}\Large\bfseries Contents \hspace*{\fill}}
\usepackage{enumitem}

% Reduce spacing in itemize environment
\setlist[itemize]{itemsep=0pt, parsep=0pt}

\setlength{\parskip}{0.5em} % Adjust the 0.5em to the desired space
\setlist[enumerate]{itemsep=0pt}
\usepackage{subcaption}
\title{Navigating the Turbulent Waters}
% \author{\small \href{http://www.latexstudio.net/}
%   {\includegraphics[width=7cm]{mcmthesis-logo}}}
\date{\today}

\begin{document}
```

```latex

\begin{abstract}
    \paragraph{ }In response to the increasing frequency of global extreme weather events, property owners and insurers are confronting crises unprecedented in scale. This has prompted a fundamental reassessment and redevelopment of traditional risk assessment models and underwriting strategies, leading to our creation of three innovative models: PANDRA, the Real Estate Development Insurance Model, and E-SVM-HCP. Each model offers a detailed risk evaluation and decision-making framework.

    For Model 1, this \textbf{PANDRA} model decomposes into a demand model and a risk model, identifying six critical \textbf{fuzzy comprehensive evaluation} factors—such as the rate of natural disasters and urban density—and uses the \textbf{entropy weight method} to determine weight sets Through refinement of \textbf{membership functions} and \textbf{comprehensive evaluation models}, PANDRA yields the following needs assessment for Vermont: \textit{[Highly Needed: 0.022, Needed: 0.246, Optional: 0.533, Less Necessary: 0.281, Not Needed: 0.026]}.The \textbf{risk degree} for Vermont is represented by this matrix:\textit{[Very High Risk: 0.061, High Risk: 0.406, Moderate Risk: 0.370, Low Risk: 0.146, Very Low Risk: 0.017]}.The analysis assists insurance companies in making informed policy underwriting choices by evaluating these indices to balance demand and risk.

    For Model 2, the \textbf{Real Estate Development Insurance Model} employs \textbf{Analytic Hierarchy Process (AHP)} to systematically evaluate factors influencing real estate development within the insurance framework. Through a \textbf{calculated Consistency Ratio (CR)}, it offers nuanced insights into the suitability of real estate projects, with \textbf{grey forecasting} and \textbf{relational analysis to analyzing data correlation}, thereby forecasting development trajectories and assessing the interplay of different factors.

    For Model 3, \textbf{E-SVM-HCP}, equips community leaders with a \textbf{robust SVM-based tool} for historic preservation decisions. It evaluates cultural significance and potential economic benefits to prioritize preservation, optimizing \textbf{feature engineering} and \textbf{kernel functions} to address the unique challenges of cultural heritage decision-making, blending precision and reverence for history.

    Our integrative approach through PANDRA, the Real Estate Development Insurance Model, and E-SVM-HCP, provides a robust framework for risk assessment and cultural preservation. We've crafted a meticulous strategy involving \textbf{sensitivity analyses} to reinforce model resilience and policy dynamism. Our synthesized efforts culminate in a strategic plan communicated through a \textbf{community letter}, outlining a cost-effective and timeline-conscious approach to preserving culturally significant landmarks while embracing future development and maintaining community heritage. This
```

```latex
multifaceted plan sets a precedent for future work that requires adaptability, proactive engagement, and a thorough understanding of the intricate balance between heritage conservation and modernization demands.

    \begin{keywords}
        Climate Change, Property Insurance, Analytic Hierarchy Process, Grey Forecasting, E-SVM-HCP
    \end{keywords}

\end{abstract}

\maketitle

%% Generate the Table of Contents, if it's needed.
% \renewcommand{\contentsname}{\centering Contents}
\tableofcontents        % 若不想要目录，注释掉该句
\thispagestyle{empty}

\newpage

\section{Introduction}

\subsection{Problem Background}

Climate change is not a specter on the horizon but a storm we are living through. The property insurance sector, long predicated on stability and predictability, now grapples with the capricious nature of a warming planet. As extreme weather events become more frequent and severe, insurers and property owners alike face a dual crisis: soaring premiums and a burgeoning insurance protection gap that threatens to leave vast swathes of our cultural and economic heritage uninsured and unprotected. This complex landscape requires a radical rethinking of traditional risk assessment models and underwriting strategies, as well as a proactive approach to the preservation of properties that embody significant cultural, historical, and economic value.

Scholars such as Williamson and Hudson (2021) have highlighted the increasing volatility in insurance claim patterns related to climate-induced disasters, emphasizing the need for a paradigm shift in risk modeling and financial planning within the industry \cite{1}. Furthermore, the work of Fisher and Kumar (2022) has brought attention to the growing insurance protection gap, particularly in regions highly susceptible to climate change, underscoring the urgency of developing more inclusive and resilient insurance frameworks \cite{2}.


\begin{figure}[h]
    \centering
```

```latex
    \includegraphics[width=12cm]{fig_int.jpg}
    \caption{Extreme Weather} \label{fig_int}
\end{figure}

\subsection{Restatement of the Problem}

Given the increasing severity of extreme weather events and their consequential impact on the property insurance sector, our team is dedicated to addressing this multifaceted challenge by:

\begin{enumerate}
    \item \textbf{Modeling for Insurance Decision-Making:} Developing a robust model to guide insurance companies in making informed decisions about underwriting policies in areas prone to extreme weather. The model aims to define the conditions under which companies should underwrite policies, identify the appropriate times to accept risks, and explore ways property owners can influence these decisions.

    \item \textbf{Adapting the Insurance Model for Real Estate Decisions:} Tailoring the insurance model to assess key considerations in real estate development, such as determining suitable locations, construction methodologies, and the feasibility of building projects in the context of changing insurance landscapes.

    \item \textbf{Creating a Preservation Model for Community Leaders:} Developing a comprehensive preservation model that aids community leaders in recognizing and safeguarding structures of cultural, historical, economic, or community importance. This model will serve as a tool for determining the necessary measures to protect and preserve the integral buildings within their communities.

    \item \textbf{Communicating with the Community:} Crafting a detailed one-page letter to the community, outlining a strategic plan, timeline, and financial proposal for the future preservation of treasured landmarks. This communication will reflect the insights garnered from the insurance and preservation models, ensuring a well-informed and community-centered approach.
\end{enumerate}

\subsection{Our Work: Analyzing Risk and Informing Decision-Making}
This paper introduces a tripartite model framework that is engineered to redefine the paradigm of property insurance underwriting and cultural heritage preservation amidst the evolving challenges posed by climate change. Our approach systematically amalgamates advanced statistical techniques with forward-looking climate projection data, thereby transcending traditional actuarial methodologies to furnish a granular risk assessment.

\begin{figure}[h]
```

```latex
    \centering
    \includegraphics[width=12cm]{Design.png}
    \caption{Flowchart of our study}
    \label{fig:SystemDesign}
\end{figure}

\subsection{Assumptions and Justifications}

Considering the complex nature of modeling insurance needs in the face of climate change, we present our assumptions followed by their justifications to bolster the model's validity:

\begin{itemize}
    \item[$\blacktriangleright$] \textbf{Assumption 1: Uniformity in Catastrophe Definition.}
        \begin{itemize}
            \item[$\vartriangleright$] \textit{Justification:} Standardizing the definition of extreme-weather events ensures data comparability and model coherence, providing a consistent framework for analysis.
        \end{itemize}

    \item[$\blacktriangleright$] \textbf{Assumption 2: Stability of Economic Parameters.}
        \begin{itemize}
            \item[$\vartriangleright$] \textit{Justification:} Economic factors such as inflation rates and property values are considered stable in the short term, sharpening the model's focus on weather-related variables.
        \end{itemize}

    \item[$\blacktriangleright$] \textbf{Assumption 3: Homogeneity in Risk Perception.}
        \begin{itemize}
            \item[$\vartriangleright$] \textit{Justification:} Assuming a uniform risk perception among stakeholders allows the model to provide universally applicable guidelines, free from individual biases.
        \end{itemize}

    \item[$\blacktriangleright$] \textbf{Assumption 4: Consistency in Policy Application.}
        \begin{itemize}
            \item[$\vartriangleright$] \textit{Justification:} This assumption is crucial for deriving actionable insights across regions, facilitating insurance companies to implement uniform underwriting policies.
        \end{itemize}
\end{itemize}

\section{Notations}
```

```latex
\begin{table}[h]
    \centering
    \caption{List of Notations}
    \begin{tabular}{|c|c|}
    \hline
    \textbf{Notation} & \textbf{Description} \\
    \hline
    $U$ & Determinant Ensemble \\
    $V$ & Appraisal Lexicon \\
    $A$ & Significance Aggregator \\
    $X_{ij}$ & Original value of the $j$-th indicator for the $i$-th object \\
    $X'_{ij}$ & Normalized value of the $j$-th indicator for the $i$-th object \\
    $Z_{ij}$ & Standardized value of the $j$-th indicator for the $i$-th object \\
    $P_{ij}$ & Probability of the $j$-th indicator for the $i$-th object \\
    $E_j$ & Entropy of the $j$-th indicator \\
    $W_j$ & Entropic weight of the $j$-th indicator \\
    $V_{\text{maximal}}$ & Transformed maximal-type value \\
    $V_{\text{minimal}}$ & Original minimal-type value \\
    $\Phi(z)$ & Cumulative distribution function for a normal distribution \\
    $f(x; \mu, \sigma)$ & Probability density function of the normal distribution \\
    \hline
    \end{tabular}
    \label{table:notations}
    \end{table}

\noindent where we define the main parameters while specific value of those parameters will be given later.

\section{Model Overview}

\subsection{Panoramic Insurance Needs and Risk Assessment Model (PANDRA)}
The PANDRA model is designed to address the insurance industry's challenges in underwriting policies in areas prone to extreme weather events. As climate change escalates the severity and frequency of such events, PANDRA aims to provide a robust framework to assess the risks and potential claims costs in different geographic regions. The model integrates risk assessment, sustainability considerations, and the influence of property owners into a holistic view, ensuring long-term viability for insurance companies while serving the needs of property owners. By incorporating ample factorsmics, PANDRA offers a comprehensive tool for insurers to balance risk, profitability, and sustainability in their policy underwriting decisions.

\subsection{Analytic Hierarchy Process for Real Estate Development Insurance Model}
```

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As the insurance landscape evolves, real estate decisions must be made with deliberation, ensuring properties are resilient and strategically placed. This model employs the Analytic Hierarchy Process (AHP) to guide developers in identifying optimal sites for construction, taking into account the changing dynamics of property insurance. The model evaluates factors such as climate resilience, risk mitigation strategies, community involvement, and sustainable development practices. By providing a structured decision-making framework, the model aids developers and community leaders in making informed choices about where, how, and whether to build, ensuring future properties are aligned with the principles of resilience and sustainability in the face of extreme weather events.

\subsection{Historical Cultural Preservation Model using Enhanced SVM (E-SVM-HCP)}
In regions where extreme weather events are prevalent, community leaders face the challenge of preserving buildings with cultural, historical, economic, or community significance. The E-SVM-HCP model is an optimized SVM framework tailored for this purpose. It classifies significant buildings for preservation based on a multifaceted evaluation of factors like historical value, cultural significance, economic impact, and legal protection. The model's customized kernel function and non-linear penalty for classification errors ensure sensitivity to the unique aspects of cultural preservation. E-SVM-HCP provides community leaders with a data-driven tool to make decisions on preserving their cultural heritage, considering the intricate interplay between preservation value and the threats posed by extreme weather conditions.

\section{Model Application Sites Analysis}
\textbf{Rationale for Location Selection:} Our models are applied to regions distinctly impacted by climate phenomena, as depicted in the provided climatic map Figure\ref{fig:climatic_zones}. These areas are prone to extreme weather events, influencing our decision to assess the viability of insurance underwriting and the necessity for preservation efforts.

\textbf{Analysis of Climatic Zones:}
\begin{itemize}
    \item \textbf{Inter-tropical Convergence Zone (ITCZ):} Characterized by heavy precipitation, the ITCZ's dynamic weather patterns necessitate an adaptable insurance framework to manage the heightened risk of flooding.
    \item \textbf{Subtropical and Extratropical Storms:} These regions experience a high frequency of cyclonic activity, underscoring the importance of robust insurance models to mitigate the financial impact on property and heritage sites.
\end{itemize}

\textbf{Justification for Model Deployment:}
\begin{enumerate}
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    \item In the \textit{Subtropics}, our models capitalize on the patterns of subtropical storms to predict potential damages, aiding insurers in calculating premiums accurately.
    \item \textit{Mid-latitude Westerlies} region's exposure to extratropical storms informs our preservation model, emphasizing structural resilience in historic landmarks.
\end{enumerate}

\textbf{Incorporating Geographic Specificity:}
The models' parameters are fine-tuned to reflect the unique climatic conditions of each zone, ensuring precise assessments tailored to the local meteorological realities.

Based on the above analysis, we selected Auckland, New Zealand, and Vermont, USA. Our selection of these two sites, as model application sites is underpinned by a robust rationale driven by their distinct vulnerability to extreme weather events in different climatic zones. Auckland, representing the Inter-tropical Convergence Zone (ITCZ) with its heavy precipitation and dynamic weather patterns, highlights the critical need for adaptable insurance frameworks to manage heightened flood risks effectively. Conversely, Vermont's exposure to subtropical and extratropical storms underscores the importance of deploying robust insurance models and promoting structural resilience in historic landmarks within the Mid-latitude Westerlies region.

\textbf{Figure Reference:}
\begin{figure}[h]
    \centering
    \includegraphics[width=8cm]{NewZealand.png}
    \caption{Climatic zones and storm paths influencing model application sites.}
    \label{fig:climatic_zones}
\end{figure}

\section{Panoramic Insurance Needs and Risk Assessment Model (PANDRA)}

This section introduces the Panoramic Insurance Needs and Risk Assessment Model (PANDRA), a comprehensive framework developed to assist insurance companies in navigating the complexities of underwriting policies in regions prone to extreme weather events. PANDRA synergistically integrates two distinct but interconnected components: the Panoramic Insurance Needs (PAN) model and the Disaster Risk Assessment (DRA) model. This integration facilitates a holistic approach to insurance needs and risk assessment, taking into account a wide spectrum of factors from natural disaster frequency and severity to socioeconomic dynamics, geographic characteristics, and the influence of property owners' actions.

\begin{figure}[h]
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    \centering
    \includegraphics[width=12cm]{PANDRA.png}
    \caption{PANDRA Model} \label{PANDRA}
\end{figure}

\subsection{Panoramic Insurance Needs (PAN)}
\subsubsection{Constituent Elements Articulation}
The formulation of the Panoramic Insurance Needs (PAN) model revolves around a meticulously engineered framework, encompassing a spectrum of determinants conceptualized to delineate the multifaceted nature of insurance necessities and associated risks.

\textbf{1. Determinant Ensemble (U)}
The Determinant Ensemble, representing a curated compendium of influential factors, is the linchpin of the PAN model. It encapsulates:
\begin{enumerate}
    \item The \textbf{Natural Disaster Incidence Rate (U1)}, serving as a barometer for gauging the vulnerability of regions to catastrophic events.
    \item The \textbf{Urban Density Index (U2)}, which mirrors the potential compound risk in densely populated areas.
    \item The \textbf{Economic Vitality Indicator (U3)}, reflecting the financial robustness and insurance-affordability of demographics.
    \item The \textbf{Asset Valuation Parameter (U4)}, indicative of the monetary stakes involved and the consequent insurance stakes.
    \item The \textbf{Historical Claims Chronicle (U5)}, offering empirical insights into the claim patterns and risk proneness of sectors.
    \item The \textbf{Topographic and Land Utilization Synopsis (U6)}, painting a vivid picture of how geographical contours and anthropogenic land use sculpt the insurance landscape.
\end{enumerate}

\textbf{2. Appraisal Lexicon (V)}
The Appraisal Lexicon constitutes a graded spectrum of evaluative terms, stratifying the insurance necessity from 'Highly Needed' to 'Not Needed', thereby instilling a nuanced granularity into the assessment, as demonstrated in Figure~\ref{fig::Appraisal-Level}.

\begin{figure}[h]
    \centering
    \includegraphics[width=12cm]{Needed.png}
    \caption{Appraisal Level} \label{fig::Appraisal-Level}
\end{figure}

\textbf{3. Significance Aggregator (A)}
The Significance Aggregator is emblematic of the relative prominence of each determinant within the ensemble. Rooted in the entropy-weighting method, it is
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a testament to an empirical approach to ascertaining the weighted significance, ensuring an unbiased and data-driven synthesis of determinants.

\subsubsection{Entropic Weight Ascertainment for Significance Aggregator (A)}
The construction of the Significance Aggregator (A) within the PAN framework incorporates an advanced entropic weighting methodology, designed to objectively quantify the influence of each determinant. This rigorous approach ensures that the composite assessment reflects the inherent importance of each constituent factor, thereby enhancing the precision of the model. The procedure unfolds through several systematic phases:

1. Normalization of the Primitive Matrix

Our original matrix consists of Determinant Ensemble(U) from U1 to U6.To harmonize the diverse nature of the indicators and convert them into a unified format conducive for further analysis, the primitive matrix is normalized, ensuring that each indicator is transformed into a \textit{maximal-type} indicator, representing a paradigm where higher values connote more favorable outcomes.
\begin{equation}
X'_{ij} = \frac{X_{ij} - \min(X_j)}{\max(X_j) - \min(X_j)}
\end{equation}
where $X_{ij}$ denotes the original value of the $j$-th indicator for the $i$-th object, and $X'_{ij}$ represents the normalized value.

2. Standardization of the Normalized Matrix

The normalized matrix undergoes a standardization process, ensuring comparability across different indicators and establishing a groundwork for subsequent probabilistic assessments.
\begin{equation}
Z_{ij} = \frac{X'_{ij}}{\sum_{i=1}^n X'_{ij}}
\end{equation}
where $Z_{ij}$ signifies the standardized value.

3. Probability Matrix Computation (P)

The standardized matrix is then utilized to construct a probability matrix (P), offering a refined structure for encapsulating the distribution characteristics of each indicator.
\begin{equation}
P_{ij} = \frac{Z_{ij}}{\sum_{j=1}^m Z_{ij}}
\end{equation}
where $P_{ij}$ symbolizes the probability of the $j$-th indicator for the $i$-th object.

4. Entropic Weight Calculation
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The entropic weight for each indicator is calculated to quantitatively express its informational entropy, which intrinsically reflects the degree of disorder or randomness associated with the indicator's distribution. The entropic weight is a testament to the significance of each indicator within the overall assessment framework.
\begin{align}
E_j &= -k \sum_{i=1}^n P_{ij} \ln(P_{ij}) \\
W_j &= \frac{1 - E_j}{m - \sum_{j=1}^m E_j}
\end{align}
where $E_j$ is the entropy of the $j$-th indicator, $k = \frac{1}{\ln(n)}$ is a constant, and $W_j$ is the entropic weight of the $j$-th indicator.

\subsection{Enhanced Probabilistic Calibration of Membership Functions}
Our model adopts a sophisticated probabilistic approach to calibrate membership functions that categorize risk levels and insurance necessity. This calibration is particularly critical in the context of extreme weather events and their impact on property insurance.

\textbf{Empirical Data Analysis}
We initiate the process by calculating the mean, $\mu$, and standard deviation, $\sigma$, for each risk determinant such as the rate of occurrence of natural disasters. These statistics are essential for constructing the membership functions based on the cumulative distribution function (CDF) of the normal distribution:

\begin{equation}
\Phi(z) = \frac{1}{2}\left[1 + \text{erf}\left(\frac{z - \mu}{\sigma\sqrt{2}}\right)\right],
\end{equation}
where $\Phi(z)$ represents the CDF for a value $z$ in the normal distribution, and $\text{erf}$ is the error function which integrates Gaussian distributions.

\textbf{Normal Distribution and Membership Functions}
To derive the membership values, we consider the normal distribution probability density function (PDF):

\begin{equation}
    f(x; \mu^\prime, \sigma^\prime) = \frac{1}{\sigma^\prime\sqrt{2\pi}}e^{(-\frac{(x - \mu^\prime)^2}{2\sigma^\prime2})}, \mu' = \Phi(z),
\end{equation}
and integrate this function over the intervals corresponding to the fuzzy sets of insurance necessity, from 'Highly Needed' to 'Not Needed'. This integration is visualized in Figure \ref{fig:math_rel}, where the area under the curve represents the probability associated with each category of necessity.

\textbf{Rationale Behind $\sigma^\prime$ Selection:}
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The selection of $\sigma^\prime = 0.1$ is informed by the empirical rule which indicates that, for a normal distribution, approximately 95.45\% of the data falls within two standard deviations ($2\sigma^\prime$) from the mean ($\mu^\prime$). This statistical insight is applied to ensure that the 'optional' insurance necessity range, defined from 0.4 to 0.6, corresponds to the central portion of the distribution where most data points are concentrated.


\textbf{Derivation of Membership Values}
Integrating the PDF over the necessary intervals, we obtain the membership values for each category:

\begin{equation}
\int_{a}^{b} f(x; \mu, \sigma) dx,
\end{equation}
where $[a, b]$ defines the interval for each category ([0, 0.2], [0.2, 0.4], [0.4, 0.6], [0.6, 0.8], [0.8, 1]) correspond to categories that seem to represent different levels of necessity for insurance, ranging from "Not Needed" to "Highly Needed.". These values are then normalized to sum up to unity across all categories.

\begin{figure}[h]
\centering
\includegraphics[width=0.75\textwidth]{F_Model1.png}
\caption{Mathematical relationship between input values and insurance needs.}
\label{fig:math_rel}
\end{figure}

\subsubsection{Establishment of the Fuzzy Comprehensive Evaluation Matrix (R)}
In the Synoptic Appraisal of Insurance Imperatives and Risk Stratification (PAN) model, the establishment of the Fuzzy Comprehensive Evaluation Matrix (R) is pivotal for elucidating the intricate interdependencies among the determinant factors and the graded insurance necessity spectrum. The construction of this matrix involves the transformation of raw values into a maximal-type configuration to resonate with the model's assessment philosophy where higher values signify augmented necessity or risk.

The synthesis of this matrix with the probabilistic calibration of membership functions ensures a robust, data-driven approach to insurance risk assessment within diverse climatic contexts. To construct the matrix \( R \), values are determined based on a combination of empirical data retrieval and expert assessment. The matrix reflects the influence and interplay of various factors, quantified as follows:

\begin{itemize}
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    \item \textbf{Natural Disaster Frequency}: Represented by the number of meteorological disasters occurring per month.
    \item \textbf{Building Density}: Defined as the ratio of the urban population to the urban area, reflecting the concentration of buildings in a given area.
    \item \textbf{Economic Development Indicators}: Comprised of per capita national income, median family income, and the unemployment rate among residents.
    \item \textbf{Value of Housing}: Indicated by the average local house price, offering a measure of the financial stakes involved.
    \item \textbf{Historical Claim Data}: Derived from data provided by the New Zealand Insurance Commission, reflecting past claim patterns and frequencies.
    \item \textbf{Terrain and Land Use}: Factors such as the length of rivers multiplied by the area of both banks to represent flood plains, coastline length, tidal flat area, and low-lying areas prone to flooding are considered to assess the risk associated with topography and land use.
\end{itemize}

Each factor is assigned a value based on the aforementioned criteria, and these values are then populated into the matrix \( R \). The unit of measurement for each factor is tailored to its nature and the most common metrics used in its assessment, ensuring that the matrix offers a nuanced and comprehensive view of the risk landscape.

\textbf{Transformation into Maximal-Type Values}
Special attention is paid to ensure that all values are represented in a maximal-type format. For determinants where lower values traditionally represent a more favorable scenario (minimal-type) after normalization, a transformation is employed to invert the scale, thus aligning with the maximal-type paradigm. This is achieved through the equation:
\begin{equation}
V_{maximal} = 1 - V_{minimal}
\end{equation}
where $V_{maximal}$ represents the transformed maximal-type value, and $V_{minimal}$ is the original minimal-type value.

\subsubsection{Synthesis of the Comprehensive Evaluation Model}
The synthesis of the Comprehensive Evaluation Model within PANDRA (Panoramic Insurance Needs and Risk Assessment Model) is executed via an advanced fuzzy synthetic evaluation method. This technique employs the fusion of a fuzzy relation matrix \( R \) and a weight vector \( A \), materializing into a fuzzy result vector \( B \), which encapsulates the graded necessity of insurance across various predefined categories.

Executing this synthesis necessitates a meticulous matrix operation, symbolized by \( \circ \), which is defined as:
```

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\begin{equation}
B = A \circ R = \left( \max_{i} \min(a_{i}, r_{ij}) \right)_{j=1}^{m}
\end{equation}
Here, \( A = (a_1, a_2, \ldots, a_n) \) is the weight vector representing the importance of each criterion, and \( R \) is the fuzzy relation matrix composed of membership grades assigned to each criterion across different insurance necessity levels. The vector \( B \) is thus a composite fuzzy assessment, reflecting the confluence of each determinant's weighted influence.

The mathematical operation \( \max_{i} \min(a_{i}, r_{ij}) \) underpins the decision-making rule within PANDRA, selecting the maximal element from the minimal pairs formed by the corresponding weights and relation grades. This max-min operator is a hallmark of fuzzy logic, offering a means to accommodate the inherent imprecision within the decision-making context.

The resultant vector \( B \), with components \( b_j \), signifies the aggregate degree to which the ensemble of determinants correlates with each evaluative term within the insurance necessity lexicon. The highest value within \( B \) dictates the ultimate appraisal, denoting the most fitting category of insurance necessity given the prevailing conditions.

\subsection{DRA Module: Disaster Risk Assessment}
The DRA (Disaster Risk Assessment) module, following the structured approach of the PAN model in PANDRA, focuses on analyzing and quantifying the multifaceted dimensions of disaster-related risks impacting insurance. This module integrates the assessment of policy and response capacity, financial markets and investment returns, infrastructure robustness, environmental consciousness, technological and innovation indices, as well as the implications of climate change and long-term trends.

  \begin{figure}[h]
    \centering
    \begin{minipage}{.5\textwidth}
        \centering
        \includegraphics[width=.9\linewidth]{US1.png} % Example image
        \label{fig:vermont}
    \end{minipage}%
    \begin{minipage}{.5\textwidth}
        \centering
        \includegraphics[width=.9\linewidth]{US2.png} % Example image
        \label{fig:texas}
    \end{minipage}
    \label{fig::USA-storm}
    \caption{USA Storm Events}
\end{figure}
```

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%   The DRA module's implementation within the PANDRA framework incorporates data analysis of storm events in the United States, as represented in Figure above. These visualizations underscore the disparate impact of storm events across different states, which is a crucial factor in risk assessment for insurance underwriting.

\subsubsection{Modification and Integration of Determinants in DRA}
DRA modifies and integrates the determinant ensemble to encompass the specificities of disaster risk in the context of insurance:
\begin{enumerate}
    \item \textbf{Policy and Response Capacity (D1)}: Quantifies the effectiveness of local policies and disaster response strategies.
    \item \textbf{Financial Market Stability and Investment Returns (D2)}: Assesses the stability of local financial markets and potential impacts on insurance.
    \item \textbf{Infrastructure Robustness (D3)}: Evaluates the resilience of physical infrastructure against disasters.
    \item \textbf{Environmental Consciousness (D4)}: Measures the level of environmental awareness and its impact on disaster risk mitigation.
    \item \textbf{Technological and Innovation Index (D5)}: Gauges the contribution of technology and innovation to disaster risk reduction.
    \item \textbf{Climate Change and Long-term Trends (D6)}: Analyzes the effects of climate change and long-term environmental trends on disaster risks, incorporating a climate classification matrix.
\end{enumerate}

\subsubsection{Climate Classification Matrix in DRA}
The Climate Classification Matrix is crucial in DRA for reflecting the variability and complexity of climate impact on disaster risks, The following table shows the structure of our Climate Classification Matrix based on the PAN model:
% Table for Climate Classification Matrix
\begin{table}[h]
\centering
\caption{Climate Classification Matrix and Corresponding Membership Values}
\begin{tabular}{|c|c|}
\hline
\textbf{Climate Type} & \textbf{Membership Matrix} \\
\hline
Tropical Rainforest Climate & [0.7, 0.2, 0.1, 0, 0] \\
\hline
Temperate Oceanic Climate & [0.1, 0.1, 0.5, 0.2, 0.1] \\
\hline
Tropical Savanna Climate & [0.2, 0.4, 0.35, 0.05, 0] \\
\hline
Temperate Continental Climate & [0.2, 0.25, 0.5, 0.05, 0] \\
\hline
```

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Tropical Desert Climate & [0.5, 0.3, 0.2, 0, 0] \\
\hline
Temperate Monsoon Climate & [0.3, 0.25, 0.25, 0.15, 0.05] \\
\hline
Tropical Monsoon Climate & [0.6, 0.3, 0.1, 0, 0] \\
\hline
Subarctic Coniferous Forest Climate & [0.4, 0.15, 0.25, 0.15, 0.05] \\
\hline
Mediterranean Climate & [0.1, 0.1, 0.4, 0.3, 0.1] \\
\hline
Polar Climate & [0.8, 0.2, 0, 0, 0] \\
\hline
Subtropical Monsoon and Humid Climate & [0.4, 0.2, 0.25, 0.1, 0.05] \\
\hline
Highland Climate & [0.5, 0.3, 0.2, 0, 0] \\
\hline
\end{tabular}
\label{table:ClimateClassificationMatrix}

\end{table}

\subsection{Application of the PANDRA Model}
The PANDRA model's application to Vermont and Auckland, New Zealand, leads to the following insights regarding insurance needs and underwriting risks.

\textbf{Vermont:} The insurance necessity in Vermont is categorized as 'optional', and the underwriting risk is identified as higher. The entropy method calculated the following weights for the determinants: [0.3231, 0.0794, 0.3549, 0.0986, 0.1010, 0.1519].

\textbf{Auckland, New Zealand:} In contrast, Auckland exhibits a clear need for insurance with a similar risk profile in underwriting. The same weights were calculated, suggesting that the determinants are consistent across the two regions.

Here are the Fuzzy Comprehensive Evaluation Matrices (R) for Vermont and Auckland:

% Table for Vermont


\begin{table}[h]
    \centering
    \caption{Fuzzy Comprehensive Evaluation Matrix (R) for Vermont}
    \resizebox{\linewidth}{!}{
        \begin{tabular}{|l|c|c|c|c|c|}
            \hline
```

```latex
            \textbf{Determinants} & \textbf{Highly Needed} & \textbf{Needed} & \textbf{Optional} & \textbf{Less Needed} & \textbf{Not Needed} \\
            \hline
            Natural Disaster Incidence & 0.0015 & 0.1626 & 0.6826 & 0.1521 & 0 \\
            Urban Density & 0 & 0.0924 & 0.5849 & 0.2133 & 0.1094 \\
            Economic Development & 0 & 0.0098 & 0.3592 & 0.5832 & 0.0478 \\
            Property Valuation & 0.1583 & 0.6836 & 0.1567 & 0.0013 & 0 \\
            Historical Claims Data & 0.0069 & 0.3154 & 0.6157 & 0.0617 & 0.0002 \\
            Topography and Land Use & 0.0369 & 0.5473 & 0.4024 & 0.0135 & 0 \\
            \hline
        \end{tabular}
    }
    \end{table}

% Table for Auckland, New Zealand
\begin{table}[h]
\centering
\caption{Fuzzy Comprehensive Evaluation Matrix (R) for Auckland, New Zealand}
\resizebox{\linewidth}{!}{
\begin{tabular}{|l|c|c|c|c|c|}
\hline
\textbf{Determinants} & \textbf{Highly Needed} & \textbf{Needed} & \textbf{Optional} & \textbf{Less Needed} & \textbf{Not Needed} \\
\hline
Natural Disaster Incidence & 0.0169 & 0.4349 & 0.5181 & 0.0301 & 0 \\
Urban Density & 0.1246 & 0.6779 & 0.1953 & 0.0022 & 0 \\
Economic Development & 0.0715 & 0.6329 & 0.2900 & 0.0056 & 0 \\
Property Valuation & 0.1065 & 0.6690 & 0.2217 & 0.0029 & 0 \\
Historical Claims Data & 0.0002 & 0.0647 & 0.6213 & 0.3073 & 0.0065 \\
Topography and Land Use & 0.2004 & 0.6776 & 0.1213 & 0.0008 & 0 \\
\hline
\end{tabular}
}
\end{table}

\begin{table}[h]
    \centering
    \caption{Necessity of Insurance}
    \begin{tabular}{@{}lccccc@{}}
    \toprule
                 & Highly Needed & Needed & Optiona & Less Needed & Not Needed \\ \midrule
    Vermont & 0.02239504 & 0.24574387 & 0.53323008 & 0.28146774 & 0.02609081 \\
    Auckland & 0.08169084 & 0.5943832 & 0.38886232 & 0.04333219 & 0.00068881 \\
 \bottomrule
```

```latex
    \end{tabular}
    \end{table}

    \begin{table}[h]
    \centering
    \caption{Risk Levels}
    \begin{tabular}{@{}lccccc@{}}
    \toprule
                     & Highly Risk & Higher Risk & Medium Risk & Lower Risk & Very Low Risk\\ \midrule
    Vermont & 0.06056319 & 0.4058455 & 0.36969653 & 0.14644262 & 0.01744466 \\
    Auckland & 0.26430453 & 0.26804606 & 0.25264984 & 0.20930209 & 0.06555666 \\ \bottomrule
    \end{tabular}
    \end{table}

The final result drawn from these matrices indicates that while Vermont's insurance necessity is optional, Auckland requires insurance. Both regions show a considerable underwriting risk, but not at a level that would discourage insurers from offering coverage.

\subsection{Strategic Implications for Property Owners}

Given the PANDRA model's findings, property owners in regions like Vermont and Auckland are confronted with the strategic imperative to influence the underwriting decisions of insurance companies. The model's insights into the nuanced interplay of risk factors provide a roadmap for property owners to take proactive measures that could sway insurance companies to offer favorable policy terms.

\textbf{Mitigation Efforts to Influence Underwriting}
Property owners can undertake various mitigation strategies to reduce the perceived risk and therefore encourage insurance companies to underwrite policies. These strategies include:

\begin{itemize}
    \item \textbf{Infrastructure Upgrades:} Enhancing the resilience of property structures against extreme weather events, such as improving drainage systems to prevent flood damage or reinforcing structures to withstand high winds.
    \item \textbf{Adoption of Smart Technologies:} Implementing smart home technologies that can detect and prevent potential damages early, such as water sensors for leak detection and automated shut-off systems.
    \item \textbf{Community-Level Initiatives:} Participating in community-wide disaster preparedness programs and advocating for public infrastructure that mitigates the impact of natural disasters.
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    \item \textbf{Environmental Stewardship:} Engaging in environmental conservation efforts that help mitigate climate change and thus reduce the frequency and severity of extreme weather events.
\end{itemize}

\textbf{Economic Incentives and Negotiation}
Economic incentives can be a potent tool for property owners to negotiate better insurance terms:

\begin{itemize}
    \item \textbf{Premium Discounts:} Seeking premium discounts for properties that have implemented recognized risk mitigation measures.
    \item \textbf{Policy Customization:} Working with insurers to customize policies that reflect the unique risk profile of the property, possibly resulting in lower premiums.
\end{itemize}


% \textbf{Model Application to Policy Determination}
% Applying the PANDRA model to the context of Vermont and Auckland, it becomes evident that insurance companies should underwrite policies under conditions where the risk is manageable and mitigated by proactive actions taken by property owners. The decision to take the risk hinges on a comprehensive analysis provided by models that consider the multifaceted nature of climate change and its impact on property insurance. The PANDRA model is instrumental in providing such analysis and helping insurers make informed decisions on policy underwriting.

% Table for PANDRA Model Application Conclusions
% \begin{table}[h]
% \centering
% \caption{PANDRA Model Application Conclusions}
% \begin{tabular}{lcc}
% \toprule
% \textbf{Location} & \textbf{Insurance Need} & \textbf{Underwriting Risk} \\
% \midrule
% Vermont & Optional & Higher \\
% Auckland, New Zealand & Needed & Higher \\
% \bottomrule
% \end{tabular}
% \end{table}


\section{Analytic Hierarchy Process for Real Estate Development Insurance Model}


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    In the landscape of modern real estate development, accurately assessing risk and forecasting developmental trajectories is paramount. Our model harnesses the Analytic Hierarchy Process (AHP) and Grey Systems Theory to dissect and prioritize the insurance risk factors. AHP meticulously structures multifaceted criteria into a judgment matrix, facilitating a consistent evaluation of risk components as depicted in Figure \ref{fig:ahp_flow}. Grey Forecasting and Relational Analysis further our model's prowess by capturing the subtleties within incomplete data, enabling robust predictions in uncertain environments. These methods, synergistically applied, empower stakeholders to navigate the real estate sector's volatility effectively, with a particular emphasis on climate resilience and sustainable development.

    \begin{figure}[h]
    \centering
    \includegraphics[width=0.8\linewidth]{Model2.png}
    \caption{Analytic Hierarchy Process integrated with Grey System components.}
    \label{fig:ahp_flow}
    \end{figure}

\subsection{Judgment Matrix Construction and Consistency Evaluation}
The Analytic Hierarchy Process (AHP) is utilized to systematically analyze and prioritize the multifaceted criteria influencing real estate development decisions in the context of insurance risk management. These methodologies, when cohesively integrated, equip stakeholders to adeptly manage the complexities of the real estate sector. They particularly enhance decision-making by quantitatively assessing the robustness of climate-resilient construction standards, the efficacy of risk mitigation strategies, the involvement in risk models, the commitment to energy sustainability, and community government collaboration, as delineated in our comprehensive judgment matrix.
% Abbreviated Judgment Matrix Table
\begin{table}[h]
\centering
\caption{Abbreviated Judgment Matrix for Criteria Comparison}
\resizebox{\textwidth}{!}{%
\begin{tabular}{|c|c|c|c|c|c|}
\hline
\textbf{Criteria} & \textbf{CRB} & \textbf{RMS} & \textbf{MP} & \textbf{SED} & \textbf{CGE} \\
\hline
Climate-Resilient Building (CRB) & 1 & 3 & 1/5 & 4 & 1/2 \\
\hline
Risk Mitigation Strategies (RMS) & 1/3 & 1 & 1/3 & 3 & 2 \\
\hline
Model Participation (MP) & 5 & 3 & 1 & 5 & 5 \\
\hline
```

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Sustainable Energy Development (SED) & 1/4 & 1/3 & 1/5 & 1 & 2 \\
\hline
Community and Gov. Engagement (CGE) & 2 & 1/2 & 1/5 & 1/2 & 1 \\
\hline
\end{tabular}}
\label{table:AbbreviatedJudgmentMatrix}
\end{table}

\begin{table}[h]
    \centering
    \resizebox{\textwidth}{!}{%
    \begin{tabular}{|c|c|p{10cm}|}
    \hline
    \rowcolor[HTML]{C0C0C0}
    \multicolumn{2}{|c|}{\cellcolor[HTML]{C0C0C0}Scale} & Meaning \\
    \hline
    \multirow{5}{*}{\rotatebox[origin=c]{90}{Judgment}} & 1 & Both factors are of equal importance \\
    & 3 & Moderate importance of one over another \\
    & 5 & Strong importance of one over another \\
    & 7 & Very strong importance of one over another \\
    & 9 & Extreme importance of one over another \\
    \hline
    \multicolumn{2}{|c|}{2, 4, 6, 8} & Intermediate values between the two adjacent judgments \\
    \hline
    \multicolumn{3}{|c|}{When subjective judgment is uncertain, methods such as expert scoring and historical data analysis can assist} \\
    \hline
    \end{tabular}%
    }
    \end{table}

The consistency of the judgment matrix is verified through the calculation of the Consistency Index (CI) and the Consistency Ratio (CR), ensuring the judgments' reliability. The CR is computed as:
\begin{equation}
CR = \frac{CI}{RI},
\end{equation}
where $CI = \frac{\lambda_{\text{max}} - n}{n - 1}$, $\lambda_{\text{max}}$ is the largest eigenvalue of the judgment matrix, $n$ is the number of criteria, and $RI$ is the Random Index value, which is determined based on the matrix size. The CR values are interpreted as follows:
\begin{equation*}
\text{CR} =
\begin{cases}
0, & \text{if the judgment matrix is consistent,} \\
```

```latex
< 0.1, & \text{if the judgment matrix is acceptably consistent,} \\
\geq 0.1, & \text{if the judgment matrix is inconsistent and needs adjustment.}
\end{cases}
\end{equation*}

\subsubsection{Priority Vector Derivation and Final Score Calculation}

To determine the priority vector, we perform an eigenvector analysis on the judgment matrix. The eigenvector corresponding to the largest eigenvalue of this matrix represents the relative weights of the criteria. These weights signify the relative importance of each criterion in the context of real estate development suitability.

The computation of these weights through eigenvector analysis involves the following steps:

\begin{enumerate}
    \item Normalize the judgment matrix by dividing each element by its column sum.
    \item Estimate the priority vector by averaging over the rows of the normalized matrix.
    \item Verify the consistency of the judgment matrix to ensure reliable weights by calculating the Consistency Ratio (CR). This is a measure of how much the judgments have deviated from consistency.
    \item If the CR is within acceptable limits, the normalized principal eigenvector is used as the weights for the criteria.
\end{enumerate}

The final score for real estate development suitability is then obtained by aggregating these weighted scores, calculated as follows:

\[
\text{Final Score} = \sum_{i=1}^{n} w_i \cdot s_i
\]

where \( w_i \) is the weight of the \( i^{th} \) criterion, and \( s_i \) is the score of the \( i^{th} \) criterion. This final score integrates the multi-dimensional aspects essential for assessing the resilience and strategic development of real estate under the shadow of climate-induced risks.

\subsection{Integration of Grey Forecasting and Grey Relational Analysis for Real Estate Development}

In the realm of real estate development, the integration of Grey Forecasting and Grey Relational Analysis (GRA) is pivotal for enhancing predictive accuracy and depth of analysis, particularly when handling incomplete or uncertain data sets.
```

```
The Grey Forecasting Model, specifically the GM(1,1) that we choosed, is designed for predicting the trajectory of key developmental factors. The model's formulation is as follows:
\begin{equation}
\hat{X}^{(1)}(k+1) = (X^{(0)} - \frac{b}{a})e^{-an} + \frac{b}{a},
\end{equation}
where $X^{(0)}$ represents the original data sequence, $a$ denotes the development coefficient, $b$ is the grey action, and $\hat{X}^{(1)}(k+1)$ predicts the value at the $(k+1)$-th instance.

Expanding the Grey Forecasting Model, we refine the data preprocessing phase by accumulating the original data to obtain a new sequence that exposes the inherent data pattern more clearly. This accumulation is defined by:
\begin{equation}
X^{(1)}(k) = \sum_{i=1}^{k}X^{(0)}(i), \quad k = 1, 2, ..., n,
\end{equation}
which then undergoes modeling to predict future values.

In Grey Relational Analysis, we compute the Grey Relational Coefficient (GRC) to assess the relationship strength between variables. This computation is detailed as:
\begin{equation}
\zeta_i(k) = \frac{\min_{i}\min_{k} |x_0(k) - x_i(k)| + \rho \cdot \max_{i}\max_{k} |x_0(k) - x_i(k)|}{|x_0(k) - x_i(k)| + \rho \cdot \max_{i}\max_{k} |x_0(k) - x_i(k)|},
\end{equation}
with $x_0(k)$ as the reference sequence, $x_i(k)$ the comparative sequence, and $\rho$ the distinguishing coefficient, set to $0.5$ for balanced differentiation.

The Grey Relational Grade (GRG), which provides an aggregated measure of association, is then determined by averaging the GRCs:
\begin{equation}
r_i = \frac{1}{n} \sum_{k=1}^{n} \zeta_i(k),
\end{equation}
thereby quantifying the overall correlation for each influencing factor.

\subsection{Application and Conclusion of Model}

The application of the Analytic Hierarchy Process (AHP) and Grey System models to the data collected for Vermont and Auckland, New Zealand, has led to insightful conclusions about real estate development and insurance underwriting in these regions.

% AHP Weighted Scores Table
\begin{table}[h]
```

```latex
\centering
\caption{Normalized Eigenvector and Weighted Scores}
\label{table:weighted_scores}
\begin{tabular}{|c|c|c|}
\hline
\textbf{Region} & \textbf{Weighted Score (\%)} \\
\hline
Auckland & 53.6 \\
\hline
Vermont & 46.4 \\
\hline
\end{tabular}
\end{table}

The Consistency Index (CI), Random Index (RI), and Consistency Ratio (CR) for the judgment matrix validate the reliability of these judgments. With a CR of 0.0953, the matrix falls within an acceptable consistency range.

\textit{Grey System Model Application}
The Grey System model analysis, particularly the Grey Relational Analysis (GRA), was instrumental in determining the importance of various factors affecting real estate development. The results suggest that Risk Mitigation Strategies and Model Participation are the most critical factors, followed by Community Government, Climate-Resilient Building Standards, and Sustainable Energy Development.

% Grey Relational Analysis Table
\begin{table}[h]
\centering
\caption{Grey Relational Analysis of Factors}
\label{table:gra_factors}
\begin{tabular}{|c|c|}
\hline
\textbf{Factor} & \textbf{Grey Relational Degree} \\
\hline
Risk Mitigation Strategies & 1.00 \\
\hline
Model Participation & 0.7398 \\
\hline
Community Government & 0.7122\\
\hline
Climate-Resilient Building Standards & 0.5482 \\
\hline
Sustainable Energy Development & 0.3392 \\
\hline
\end{tabular}
\end{table}
```

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The Grey Forecasting Model (GM) predictions indicate that the difference in suitability for real estate development between Vermont and Auckland is not significant at present. However, as time progresses, the disparity is expected to widen, with Auckland becoming increasingly suitable for development compared to Vermont.

\textbf{Conclusion:}
Based on the real estate model assessment, it appears that the differences in housing development between Vermont and Auckland are marginal, categorizing them in a state of equilibrium where development could be equally considered or deferred. However, when faced with a decision to choose between the two locations for a more suitable housing development site, Auckland scores marginally higher than Vermont, tipping the scale in its favor for development.

\subsection{Predictive Trends and Implications}
The application of forecasting within our models provides a forward-looking perspective on the potential trends in real estate development and insurance necessity. The predictive analysis leverages historical data to forecast future scores for critical factors, offering a nuanced understanding of regional development trajectories.

\begin{figure}[h]
    \centering
    \begin{minipage}{.5\textwidth}
        \centering
        \includegraphics[width=\linewidth]{Model2P1.png} % Example image
        %\caption{Vermont's annual ratings and forecasts}
        \label{fig:vermont_forecast}
    \end{minipage}%
    \begin{minipage}{.5\textwidth}
        \centering
        \includegraphics[width=\linewidth]{Model2P.png} % Example image
        %\caption{Predictive model for Auckland}
        \label{fig:auckland_forecast}
    \end{minipage}
    \caption{Forecasting Trends for Vermont and Auckland}
    \label{fig:forecasts}
\end{figure}

For Vermont, the forecast model suggests a stable trend in Sustainable Development and Building Standards, with the scores expected to increase moderately over the next decade. Specifically, Sustainable Development is projected to grow from a rating of 8.2 in 2023 to 8.6 by 2027, indicating a gradual enhancement in sustainability practices. Conversely, Anti-disaster Engineering shows a more variable pattern, underscoring the need for improved risk mitigation strategies.
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In contrast, Auckland's forecast exhibits a steady upward trajectory in Community and Anti-disaster Engineering scores, reflecting a strong emphasis on community resilience and disaster preparedness. This aligns with the observed scores for Community, which are anticipated to rise from 4.0 in 2023 to approximately 4.3 by 2027, suggesting an increasing focus on community-centric development policies.

\textbf{Conclusion:} Forecasting the future, the gap between the suitability for housing development in Auckland and Vermont is not significant at present. However, as time progresses, this disparity is expected to widen, with Auckland becoming increasingly favorable for housing development compared to Vermont.

\section{Enhanced SVM for Historical Cultural Preservation (E-SVM-HCP)}

\subsection{Model Overview}
The Enhanced SVM for Historical Cultural Preservation (E-SVM-HCP) is designed to provide community leaders with a robust decision-support tool. This model incorporates an optimized Support Vector Machine (SVM) framework to evaluate and classify significant buildings for preservation based on cultural, historical, and socio-economic importance.

\subsection{Input Factor Selection}
Factors incorporated into E-SVM-HCP are selected based on their relevance to cultural and historical significance, community impact, and preservation cost-benefit analysis. These factors include:

\begin{itemize}
  \item Historical significance, quantified by the building's age and relevance to pivotal historical events or figures.
  \item Cultural significance and impact, including the building's role in local traditions and community identity.
  \item Economic benefits, such as tourism potential and job creation opportunities.
  \item Physical condition and sustainability prospects, taking into account the feasibility and cost-effectiveness of restoration.
  \item Legal protection status, based on existing heritage conservation regulations.
  \item Community consultation and engagement in the decision-making process.
\end{itemize}

\subsection{Model Optimization for Historical Cultural Preservation}

The Enhanced Support Vector Machine for Historical Cultural Preservation (E-SVM-HCP) is tailored to manage the complex, categorical, and non-linear
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relationships inherent in the cultural preservation decision-making process. The optimization formulation is as follows:

% Optimization Problem
\begin{equation}
\begin{aligned}
& \underset{\mathbf{w}, b, \boldsymbol{\xi}}{\text{minimize}}
& & \frac{1}{2} \|\mathbf{w}\|^2 + C \sum_{i=1}^{n} \xi_i^\gamma \\
& \text{subject to}
& & y_i(\mathbf{w}^\intercal \phi(\mathbf{x}_i) + b) \geq 1 - \xi_i, \; \forall i \in \{1, \ldots, n\}, \\
&&& \xi_i \geq 0.
\end{aligned}
\end{equation}

Here, the standard SVM formulation is modified by:
\begin{enumerate}
    \item Introducing a non-linear penalty factor $\gamma > 1$ to the slack variables $\xi_i$, intensifying the penalty for misclassified points, thus focusing on the accurate classification of culturally significant buildings.

    \item Customizing the kernel function to reflect the non-numeric nature of cultural and historical data. The kernel function incorporates feature-specific scaling factors $\eta_k$:

    \begin{equation}
    K(\mathbf{x}_i, \mathbf{x}_j) = \exp\left(-\gamma \sum_{k=1}^{m} \eta_k |x_{ik} - x_{jk}|^2\right),
    \end{equation}

    where each $\eta_k$ corresponds to the relative importance of the $k$-th feature in the preservation decision-making context. This allows the kernel to effectively measure the similarity between data points in a way that respects the ordinal and categorical nature of the input factors.
\end{enumerate}

% Feature Engineering
Feature engineering plays a crucial role in enhancing the model's predictive capability. Through careful consideration and transformation of input factors, the model captures complex dependencies between variables. For example, the historical value (HV) can be engineered to reflect not only the age of a building but also its relevance to significant historical events.

The E-SVM-HCP model's adaptability to the intricate domain of cultural preservation showcases the power of machine learning techniques in supporting critical decisions that balance cultural heritage against the forces of modernization.
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\textbf{Model Validation and Interpretability}
To ensure the model's validity and interpretability, E-SVM-HCP undergoes extensive cross-validation using historical data on preserved and non-preserved buildings. The interpretability is enhanced by mapping the high-dimensional SVM decision function back to the original input space, allowing for a clear understanding of the model's decisions in the context of cultural preservation.

\textbf{Strategic Outcomes}
The strategic insights offered by the E-SVM-HCP model are twofold: it delineates a clear path for the preservation of culturally significant buildings and presents a data-driven justification for such actions in the face of economic and insurance pressures. This dual utility ensures that preservation efforts are both strategic and sustainable.

\begin{figure}[h]
    \centering
    \begin{minipage}{.5\textwidth}
        \centering
        \includegraphics[width=.7\linewidth]{SVM1.png} % Example image
        \caption{Receiver Operating Characteristic}
        \label{fig:roc}
    \end{minipage}%
    \begin{minipage}{.5\textwidth}
        \centering
        \includegraphics[width=\linewidth]{SVM2.png} % Example image
        \caption{SVM Decision Boundary with PCA-transformed data}
        \label{fig:svm_boundary}
    \end{minipage}
\end{figure}

The integration of Receiver Operating Characteristic (ROC) curves and SVM decision boundaries, as visualized in Figures \ref{fig:roc} and \ref{fig:svm_boundary}, enhances the analytical capabilities of the E-SVM-HCP model. These visual tools allow community leaders to better understand the model's classification accuracy and the effects of dimensionality reduction through PCA on the decision-making process.

% Example Implementation of E-SVM-HCP for a Historic Building
\begin{table}[h]
\centering
\caption{E-SVM-HCP Application for Historic Building Preservation}
\begin{tabular}{lcc}
\toprule
\textbf{Building} & \textbf{Preservation Priority} & \textbf{Recommended Measures} \\
```

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\midrule
Cape Hatteras Lighthouse Analog & High & Relocation and Fortification \\
\bottomrule
\end{tabular}
\label{table:preservation}
\end{table}

\subsection{E-SVM-HCP in Community Decision-Making}

The Enhanced Support Vector Machine for Historical Cultural Preservation (E-SVM-HCP) serves as an advanced analytical tool for community leaders tasked with the critical decisions of preserving buildings of cultural, historical, economic, or community significance. By applying this model, leaders can systematically evaluate buildings and prioritize preservation efforts that align with community values and resource allocation.

\textit{Identifying Buildings for Preservation}
The E-SVM-HCP model enables community leaders to input various data points concerning the building's historical significance, cultural impact, economic contribution, current physical condition, and legal protections. The model analyzes these inputs and classifies the buildings on a preservation priority scale, thus aiding leaders in identifying structures that are integral to the community's heritage and identity.

\textit{Determining the Extent of Preservation Measures}
Upon identifying significant buildings, the E-SVM-HCP model can simulate various preservation scenarios to determine the most appropriate measures. Input adjustments regarding cost and impact facilitate exploration of different outcomes, such as potential tourism revenue or the impact on community cohesion.

\textit{Balancing Modernization with Preservation}
When insurance models indicate high risk for certain properties, the E-SVM-HCP model offers a nuanced perspective by accounting for the intangible cultural values these properties bring to the community. This holistic approach enables a well-rounded decision-making process, factoring in both measurable risks and qualitative benefits of preservation.


\section{Sensitivity Analysis}


An exhaustive sensitivity analysis was conducted on the Panoramic Insurance Needs and Risk Assessment Model (PANDRA), the Disaster Risk Assessment (DRA) model, and the Grey Correlation Analysis to gauge the robustness and adaptability of these models. This analysis focused on the reaction of the models' outputs to nuanced changes in the input parameters, underpinning the
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overall reliability and resilience against unpredictable data fluctuations and external factors.

The \textbf{Grey Correlation Analysis} revealed that the parameters U2 and U3 are crucial, with their variations accounting for 29.95\% and 22.15\% impact on the model output, respectively. Conversely, U5, fluctuating slightly around a value of 66.67, indicated a lower sensitivity, with an impact of 21.33\%.

In the \textbf{PANDRA model}, parameter U3 exhibited a pronounced peak in sensitivity at approximately 9\%, when a \(\pm10\%\) variation was applied. This suggests a critical inflection point beyond which the model's output stabilizes, indicating an area of less sensitivity and greater reliability.

Similarly, the \textbf{DRA model's} response to a \(\pm15\%\) change in parameter U6 highlighted a stark increase to over 12\% in model output sensitivity, underlining the parameter's significance in the model's predictive accuracy.

To ensure the models' stability and mitigate risks associated with highly sensitive parameters, robustness checks against outliers and data inconsistencies have been implemented. This measure guarantees that the models maintain their accuracy and reliability even when faced with irregular data patterns or unexpected external shocks.

% Inserting the images in a two-by-two configuration
\begin{figure}[h]
    \centering
    \begin{subfigure}{.4\textwidth}
        \centering
        \includegraphics[width=\linewidth]{S1.png}
        %\caption{Sensitivity Analysis: PAN Model}
        \label{fig:panmodel}
    \end{subfigure}%
    \begin{subfigure}{.4\textwidth}
        \centering
        \includegraphics[width=\linewidth]{S2.png}
        %\caption{Sensitivity Analysis: DRA Model}
        \label{fig:dramodel}
    \end{subfigure}
    \begin{subfigure}{.4\textwidth}
        \centering
        \includegraphics[width=\linewidth]{S3.png}
       % \caption{Absolute Deviation of the Impact}
        \label{fig:absdeviation}
    \end{subfigure}
    \begin{subfigure}{.4\textwidth}
        \centering
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        \includegraphics[width=\linewidth]{S4.png}
        %\caption{The Impact of Factors in Grey Correlation Analysis}
        \label{fig:greyanalysis}
    \end{subfigure}
    \caption{sensitivity analyses}
    \label{fig:composite}
\end{figure}

\section{Strength and Weakness}

\subsection{Strength}
\textbf{1. Precision and Accuracy:} The models are meticulously designed to provide accurate predictions, utilizing advanced statistical methods and climate projection data for precise risk assessments.

\textbf{2. Comprehensive Data Integration:} The models integrate various data sources, encompassing factors like natural disaster frequency, socio-economic dynamics, and geographic characteristics, offering a multi-dimensional view of the problem.

\textbf{3. Robustness to Variations:} The models exhibit strong resilience against data variations and uncertainties, ensuring reliable outcomes even in the face of changing conditions.

\subsection{Weakness}

\textbf{1. Computational Complexity:} The advanced nature of the models translates to substantial computational demands, which might limit their accessibility or increase operational costs.

\textbf{2. Data Dependency:} The models' performance heavily relies on the quality and comprehensiveness of the input data, making them potentially less effective in data-scarce environments.

\textbf{3. Overfitting Risk:} The complexity of the models and their high parametrization can lead to overfitting, especially when dealing with a limited or highly specific dataset.

These strengths and weaknesses outline the capabilities and limitations of the developed models, providing a balanced view of their potential impact and areas for improvement.
\section{Further Discussion}
The continuous evolution of the Panoramic Insurance Needs and Risk Assessment Model (PANDRA), Analytic Hierarchy Process for Real Estate Development Insurance Model, and Historical Cultural Preservation Model relies on the following strategic enhancements:

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\textbf{Model Refinement:} Future work should focus on integrating more dynamic data sources, enhancing the robustness of the predictive algorithms, and refining the models to adapt to the rapidly changing environmental and socio-economic conditions.

\textbf{Stakeholder Engagement:} Strengthening the involvement of local communities, policymakers, and industry experts in the model development process can ensure the models are more aligned with practical needs and can effectively influence decision-making.

\textbf{Technological Integration:} Leveraging emerging technologies such as AI, IoT, and Big Data analytics can provide deeper insights, improve real-time responsiveness, and increase the overall accuracy and efficiency of the models.

\begin{thebibliography}{99}
    \addcontentsline{toc}{section}{Reference}

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    \end{thebibliography}
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\begin{letter}{}

    \textbf{To the Esteemed Members of the Auckland Community,}

    \textit{Subject: Preservation Plan for Our Beloved Landmark}

    We are an ICM team from COMAP. It is our great honor to present to you the results of the Preservation Plan. With a deep understanding of your shared heritage and in light of the recent analyses conducted through our insurance and preservation models, we present a cohesive plan for the future of our treasured landmark. Our models have meticulously evaluated the risks and necessities associated with the landmark, considering the escalating frequency of extreme weather events and their impact on our cultural beacons.

    \textbf{Recommendation:}

    After extensive analysis using the PANDRA and E-SVM-HCP models, we recommend a strategic preservation plan that not only fortifies the landmark against natural calamities but also enhances its role in our cultural and social fabric. Our proposal balances the financial implications with the intrinsic value that the landmark holds for our community.

    \textbf{Plan and Timeline:}

    \begin{itemize}
      \item Immediate commencement of structural assessment to evaluate the current resilience of the landmark.
      \item By the end of the current fiscal quarter, you can finalize the cost-effective measures for preservation and enhancement.
      \item Over the next six months, you will execute the necessary fortification and restoration works, ensuring minimal disruption to the community's daily life.
      \item Parallel to the physical works, we will initiate community engagement programs to reinforce the landmark’s significance and galvanize public support.
    \end{itemize}

    \textbf{Cost Proposal:}

    \begin{itemize}
      \item The total projected cost for the preservation plan is estimated at \$250,000. This includes structural reinforcements, restoration, and community engagement activities.
      \item We propose a funding mix of government grants, community fundraisers, and potential sponsorships, reducing the financial load on any single entity.
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        \item A detailed financial plan is available upon request and will be discussed in the upcoming community meeting.
    \end{itemize}

    We understand the weight of this decision and its implications for our future generations. The proposed plan is not merely a response to climatic threats but a testament to our commitment to safeguarding our legacy. We invite each one of you to be a part of this vital endeavor.

    \vspace{\parskip}

    Sincerely yours,

    [Team \# 2409529]

    \end{letter}

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% \section*{Report on Use of AI}

% \section*{Introduction}
% This report documents the use of OpenAI's ChatGPT (April, 2023 version, ChatGPT-4) in our analytical approach during the MCM/ICM competition. We describe how AI contributed to the development of our models, the insights we gained, and its impact on our problem-solving strategies.

% \section*{Problem A: Model Construction for Climate Impact}
% \subsection*{Query to AI}
% \textbf{Query A1:} "Considering the increasing impacts of climate change, what key factors should be included in a model to assess its effects on coastal property valuation?"

% \textbf{Output A1:}
% ChatGPT-4 advised us to incorporate a multi-dimensional analysis, considering factors such as sea-level rise, storm frequency and severity, economic valuation of coastal properties, infrastructure resilience, community adaptation strategies, and local environmental policies.

% \subsection*{Data Retrieval and Analysis}
% \textbf{Query A2:} "Identify authoritative sources for sea-level rise projections over the next 50 years for the Atlantic coastal region."
```

```
% \textbf{Output A2:}
% ChatGPT-4 summarized findings from the latest IPCC report and directed us to NOAA's Sea Level Rise Viewer for granular, region-specific projection data.

% \section*{Problem B: Preservation of Cultural Heritage}
% \subsection*{Query to AI}
% \textbf{Query B1:} "What methodologies can be employed to factor in community preferences for cultural heritage preservation into a quantitative model?"

% \textbf{Output B1:}
% ChatGPT-4 suggested a blend of quantitative and qualitative methods, highlighting the Analytic Hierarchy Process (AHP) for prioritization based on community feedback, and the Delphi method for expert consensus building.

% \section*{Conclusion}
% OpenAI's ChatGPT-4 has played a crucial role in our MCM/ICM endeavors. Its ability to provide rapid, comprehensive insights allowed us to deepen our understanding of complex problems, validate data sources, and explore a range of solution strategies. The tool's versatility was particularly beneficial in adapting our models to the nuanced challenges posed by climate change and cultural heritage preservation, enabling a more informed and nuanced approach to decision-making.

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% \clearpage
% \setcounter{page}{\value{lastpage}}

\end{document}
%%
%% This work consists of these files mcmthesis.dtx,
%%                                   figures/ and
%%                                   code/,
%% and the derived files             mcmthesis.cls,
%%                                   mcmthesis-demo.tex,
%%                                   README,
%%                                   LICENSE,
%%                                   mcmthesis.pdf and
%%                                   mcmthesis-demo.pdf.
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论文（Realese）

Problem Chosen	2024 MCM/ICM Summary Sheet	Team Control Number
E		**2409529**

Navigating the Turbulent Waters

Summary

In response to the increasing frequency of global extreme weather events, property owners and insurers are confronting crises unprecedented in scale. This has prompted a fundamental reassessment and redevelopment of traditional risk assessment models and underwriting strategies, leading to our creation of three innovative models: PANDRA, the Real Estate Development Insurance Model, and E-SVM-HCP. Each model offers a detailed risk evaluation and decision-making framework.

For Model 1, this **PANDRA** model decomposes into a demand model and a risk model, identifying six critical **fuzzy comprehensive evaluation** factors—such as the rate of natural disasters and urban density—and uses the **entropy weight method** to determine weight sets Through refinement of **membership functions** and **comprehensive evaluation models**, PAN-