# MTFC Scenario Quest 2023-24

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| Team Name | Seetharaman's Snakes |
| Team ID # | 16417 |
| Proposal Topic Title | Mitigating Racial Bias in Judicial Outcomes via Mathematical Risk Assessment |

**MTFC Scenario Quest Template Use Notes:**

- *Refer to the official MTFC Scenario Quest 2023-24 for the prompts for each of the 5 Missions.*
- *The use of this template is NOT required for MTFC Scenario Quest submissions. It is provided as an optional resource for teams to keep their Scenario Quest response organized. Teams who wish to use this template should make a copy in order to edit.*
- *The final version of the MTFC Scenario Quest should be downloaded as a PDF or Word document to submit on the ICS Dashboard. A single file will be submitted.*
- *Additional resources can be found on the Modeling the Future Challenge website:*
    - *The Actuarial Process Guide https://www.mtfchallenge.org/the-actuarial-process/*
    - *Data Sources https://www.mtfchallenge.org/data-sources/*
    - *Sample Project Topics for Proposal Ideas https://www.mtfchallenge.org/example-projects/*
    - *Video Resources https://www.mtfchallenge.org/video-resources/*
- *Please direct any questions to challenge@mtfchallenge.org.*

# Mission 1 Ski Resort Prompts

These prompts can be found on pages 11-12 of the Scenario Quest. Additional information on Data Identification and Analysis can be found on pages 11-22 of the Actuarial Process Guide.

Responses:

- 1.1: Ranging from local businesses to the people frequenting them, there are various parties that will be affected drastically by climate change and the corresponding effects in ski resorts. Given the decrease in the attendees to these ski resorts, two impacts will take place: a decrease in economic output and a customer retention rate. As the quality decreases, customers, a primary party, will begin to attend these locations less and less. Moreover, these communities will struggle in search of different economic models to benefit their corporation.
- 1.2: Some quantifiable risks associated with the climate include changes in temperature by region and the change in snowfall levels. The rate of temperature change may also be a risk since it results in lower-quality, icier snow. Quantifiable risks to the ski resorts would include ticket sales and customer counts, and the economic consequences. In terms of safety, the effects of injuries and temperature changes will spark problems in the community.
- 1.3:
    1) Insurance

        Insurance allows ski resorts to transfer some of the financial risks associated with climate change to the insurance company. Exceptions may apply, however, depending on the type of insurance used; not all financial losses will be covered by the insurance companies.
    2) Behavior Change

        Depending on the impacts of weather on the trails, they can change the amenities they offer to provide excursions separate from skiing for consumers to partake in. They can also close some trails and focus more on trails closer to the central resort area, lowering maintenance costs and snow production costs
    3) Modifying Outcomes

        They can adjust employee shifts accordingly with demand as projected by weather impacts. As the demand and employment decrease consequently, these corporations will be able to decrease the amount of money lost or increase the potential revenue.

## Mission 1 - Team Project Proposal Prompt

- 1 - Project Proposal

Problem statement: Our project aims to analyze the risk derived from racial bias by lawyers. Typically, minorities are at risk of being misprofiled or discriminated against. Some possible risk mitigation strategies are identifying the source of error in the dataset and trying cleaning, or potentially like a counteractive filter or checker for analyzing bias in results. By narrowing the scope and magnitude of the problem, this specific case can be analyzed to a higher degree.

Modeling the risk of profiling in court cases based on external, discriminatory factors such as race, appearance, gender, etc. using Monte Carlo Simulation Analysis. Additionally, one could look at the sensitivity analysis of models to quantify and qualify the impact of said predicament

1.1: The groups at risk of this problem are primarily wrongly convicted people, who were discriminated against based on stereotypes and external factors. The families and closely related people of the convict could be affected by this decision. Lawyers of the convicted parties could suffer in terms of their careers due to a wrongful conviction. Taxpayers could also be affected since they would pay taxes for a public service that is accounting for inflated figures.

1.2: Some quantifiable risks include the expected value of years wrongly served in prison and the rate of wrongful convictions for each race. The money lost by keeping people in jail and out of work in the economy may also be a risk to the state and taxpayers. The costs incurred by reimbursing the wrongful convict and the medical and mental health costs for the victim afterward are also risks.

1.3:
Insurance:

https://www.lathropgpm.com/services-practices-Civil-Rights-Insurance-Recovery.html

There are organizations such as the one linked above that aid individuals who have been wrongfully convicted by negotiating statements. Health insurance may play a role as well; individuals may suffer from mental and physical issues after wrongful convictions.

Behavior change:

Lawyers must not be racist. Indeed, one potential manner of accomplishing this is by implementing cultural competency lessons within their programs to understand internal biases. By doing so, society will aim to provide victims of these cases, other lawyers, and judges, with the necessary resources to decrease discrimination within the field.

They must look at the court cases without considering the races of the people involved.

Modifying outcomes:

Through more informative educational programs in law, systemic bias and racism can be combatted through more informed decisions. We could potentially incorporate anti-bias AI to transcribe the cases and use our data to combat racism in final rulings.

# Mission 2 Ski Resort Prompts

These prompts can be found on pages 18-19 of the Scenario Quest. Additional information on Data Identification and Analysis can be found on pages 23-29 of the Actuarial Process Guide.

Responses:

- 2.1:
  - 1: What is the change in temperature experienced by the ski resort's region?
  - 2: How long has this establishment been managed for? How well is it managed?
  - 3: What is the climate around the ski resort?
  - 4: What weather conditions do skiers prefer?
- 2.2:
  - Types of data needed:
    - Data that defines historical trends
    - Data that projects future trends
    - Data that separates potential outcomes
    - Data that defines the severity of potential losses
    - Data that defines the frequency of potential outcomes
  - Popularity of the ski resort
  - Average temperatures by year
  - Ski resort revenue by year
  - https://gist.github.com/Ewiseman/b251e5eaf70ca52a4b9b10dce9e635a4
  - https://www.kaggle.com/datasets/agustinpugliese/ski-resort-data
  - MIT Research Dataset
- 2.3:
  - Ski Resort Dataset - 2023_1697463450.xlsx
  - By identifying
  - Sensitivity analysis can be conducted to analyze the variability within the data and the strength of the overall trend.
  - Plotted graphs and histograms can be beneficial in identifying trends in data. Additionally, the deviation and variation of the data may also be analyzed.

## Mission 2 - Team Project Proposal Prompt

- 2 - Project Proposal

2.1: Identify the driving research questions for the topic

- What specific AI application or use case within decision-making processes are we focusing on?
  - Define the context, such as hiring processes, loan approvals, criminal justice sentencing, or any other specific area where decision-making AI is applied.
- How prevalent is the issue of racial bias in the identified AI application?
  - Assess the existing literature and real-world instances to understand the extent of racial bias in the chosen use case.
- What are the key factors contributing to racial bias in the decision-making AI for the selected use case?

    - Investigate potential sources of bias, such as biased training data, algorithmic design, or inherent biases in the decision-making process.
- What methods are currently in place to detect and address racial bias in the AI algorithms used for the selected application?
    - Analyze existing mitigation strategies, whether they involve pre-processing data, adjusting algorithms, or implementing post-processing checks.
- How effective are current methods in mitigating racial bias, and what are their limitations?
    - Evaluate the success rates of existing strategies and identify any shortcomings or challenges faced in mitigating racial bias in decision-making AI.
- What are the ethical implications of implementing counteractive filters or checkers for bias mitigation?
    - Consider the broader ethical considerations, such as the potential for overcorrection, unintended consequences, or the impact on the fairness of the decision-making process.

2.2: Types of Data Needed

- Societal Factors
    - # of individuals who are wrongfully convicted or acquitted, sorted based on race, gender, the political leaning of a judge (look at judges' past sentencings)
    - # of years variation for similar cases that vary based on race, gender, or socioeconomic status.
    - # of disproportionate punishments based on cases that perpetuate the cycle of racism in the law setting.
- Personal factors (for the person on trial and previous cases)
    - Type of crime committed
    - Personal income
    - Ethnicity of inmate
    - Gender of inmate
    - Sentence length
    - Education level
    - Criminal history
- Judge + jury + lawyer factors
    - Race, gender, ethnicity, etc
    - Socioeconomic status
    - Education level
    - Political standing
    - Median income
    - Past case outcomes

2.3:

- https://hls.harvard.edu/wp-content/uploads/2022/08/Massachusetts-Racial-Disparity-Report-FINAL.pdf
    - It provides information that quantifies the data for our topic, specifically within the state of Massachusetts.
- https://www.law.umich.edu/special/exoneration/Documents/Race%20Report%20Preview.pdf
    - It provides in-depth insights into the intersection of racial bias and wrongful convictions within the criminal justice system in the United States.
- https://www.judyrecords.com/
    - Judyrecord provides course records that can be analyzed on a case-by-case basis or fed into an Artificial Intelligence program.

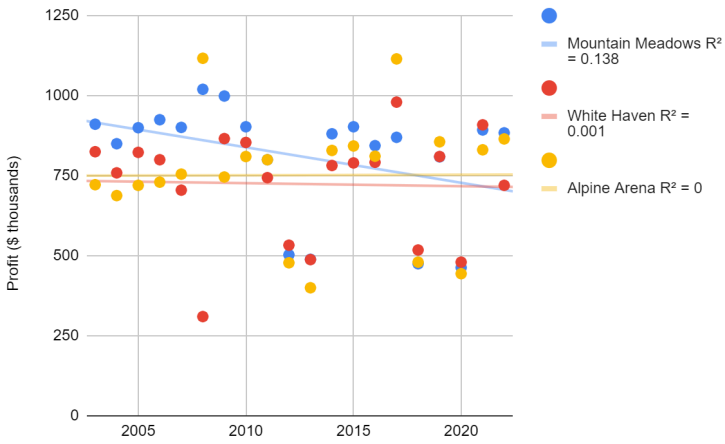
# Mission 3 Ski Resort Prompts

These prompts can be found on pages 24-26 of the Scenario Quest. Additional information on Data Identification and Analysis can be found on pages 30-31 of the Actuarial Process Guide.

Responses:

- 3.1:
    - https://www.mdpi.com/2071-1050/12/24/10617
        - Keywords: climate risk; ski industry; sustainable tourism; adaptive dynamics; tourism demand
        - Kinds of math concepts used in this model: Simulation Modeling (SkiSim2.0), Statistical Analysis (Skier Survey), Agent-Based Modeling (ABM)
    - https://dspace.mit.edu/bitstream/handle/1721.1/42018/226339450-MIT.pdf?sequence=2
        - Keywords: climate change; global warming; greenhouse gasses; carbon dioxide; emissions; temperature; precipitation; snowfall; snowpack; weather; climate models; adaptation; mitigation
        - Kind of math concepts used in this model: Time Series Analysis; VAR Model
    - https://www.sciencedirect.com/science/article/pii/S0048969721021240
        - Keywords: Ski tourism; climate change; internal climate variability; large-ensemble; snow modeling; snow indices.
        - Math concepts: SNOWPACK; spatial analysis; temporal analysis; partial differential equations
    - Summary of findings: Climate change poses significant challenges for the ski industry, as it leads to shorter winters, less snowfall, and reduced snow reliability. These changes threaten the viability of ski resorts, particularly those located at lower altitudes. However, there are also opportunities for the industry, such as the development of new resorts in regions that are less affected by climate change. Additionally, technical snow production can be used as an adaptation strategy to
- 3.2:
    - 3.2.1
        - 70% typical, 10% heavy, 20% light
    - 3.2.2
        - Alpine Arena
            - Typical: $786.14
            - Heavy: $1116.00
            - Light: $450.50
        - Mountain Meadows
            - Typical: $885.93
            - Heavy: $945.00
            - Light: $482.50
        - White Haven
            - Typical: $798.50
            - Heavy: $645.00
            - Light: $504.75
        - Light snowfall years tend to detriment the overall profits. We can see that in all three resorts, light snowfall years are the minimum mean profit.
    - 3.2.3

        - Expected Value:
            - Alpine Arena: $752.00
            - Mountain Meadows: $811.15
            - White Haven: $724.40
- 3.3:
    - 3.3.1




    - Mountain Meadows is a bit in trouble, as it has a downward profit projection. This can be seen with the negative slope of its trendline, although since the $R^2$ is so low, this may not be the most reliable indicator of well-being.
    - We're making the following assumptions about typical vs heavy vs light snowfall years and resort profit
        - There are no other confounding factors affecting profit
        - The degree of heaviness/lightness for heavy and light years respectively are around the same

## Mission 3 - Team Project Proposal Prompt

- 3 - Project Proposal

Modeling Research on Your Topic

- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9388269/
    - Keywords: Racism, corruption, infectious diseases, control strategies, stakeholders, basic reproduction numbers, qualitative analysis, mathematical methods, deterministic compartmental model, transmission rates, sensitivity analysis, endemic equilibrium point, disease-free equilibrium point
    - Helpful info: The article uses a deterministic compartmental model to analyze the dynamics of racism and corruption coexistence in communities. The article computes basic reproduction numbers by applying the next-generation matrix method. The developed model has a disease-free equilibrium point that is locally asymptotically stable whenever the reproduction number is less than one. Additionally, the article does sensitivity analysis to observe the effect of the parameters on the incidence and transmission of mind infections that deduce the transmission rates of both racism and corruption are highly

sensitive. The article also discusses the effects of parameters on the basic reproduction numbers and the effect of parameters on the infectious groups.

- https://www.innovatingjustice.org/sites/default/files/media/document/2019/Beyond_The_Algorithm.pdf
    - Keywords: Pretrial reform, risk assessment, racial fairness, criminal history, demographic factors, pretrial detention
    - Helpful info: The study involves the use of a risk assessment tool developed for research purposes. The tool draws exclusively on criminal history and demographic factors known to be predictive of future arrests. The risk algorithm relies on nine risk factors to estimate the probability of a new arrest over a two-year tracking period. These factors include criminal history and demographic information but do not explicitly use race or ethnicity in calculating risk scores. The assessment uses a two-year tracking period to estimate the probability of new arrests. Longer tracking periods are justified to improve the stability of algorithms for predicting outcomes, covering both pretrial and post-disposition periods for the majority of defendants. An analysis is conducted on how the risk assessment tool classifies defendants in racially disparate ways.
- https://psycnet.apa.org/fulltext/2023-54964-015.html
    - Keywords: Implicit bias, community supervision, recidivism, racial disparities, and criminal justice as the main keywords
    - Helpful info: The authors use data from Black and White clients entering probation and post-release supervision in North Carolina from 2012 through 2016 to estimate the difference in racial disparities in discretionary versus non-discretionary decisions across five levels of supervision. They evaluate the robustness of their main fixed-effects model using an alternative regression discontinuity design. The results show that racial disparities in discretionary decisions grew as supervision intensity decreased, and the bias was larger for women than men. There was no similar pattern of increased disparity for non-discretionary decisions. The authors conclude that criminal justice system actors have a great deal of discretion, particularly in how they deal with less serious criminal behavior. Although decentralized decisions are foundational to the function of the criminal justice system, they provide an opportunity for implicit bias to seep in. Shortcuts and mental heuristics are more influential when the decision-maker's mental resources are already strained—for instance, if someone is tired, distracted, or overworked.

Identify Mathematical Modeling Methods to Consider in the Project Phase

- Markov Chain Monte Carlo, or **MCMC**, would be considered one of the most fitting mathematical analysis methods in our project, where MCMC could be used to estimate the posterior distribution—the mixture of the likelihood of decision-making upon initial thoughts (biases) and updated evidence (genuine arguments)— of the risk of bias given the biodata and crime severity. Further advantages of MCMC include its impressive flexibility in handling a wide range of probability distributions, its computational efficiency, its ability to provide a comprehensive representation of the uncertainty in the risk estimates, and its ability to perform sensitivity analysis. All of these elements stand crucial to our understanding of the datasets used and allow us to specify intricate values that reflect the multitude of otherwise perplexing factors which exist within the real world.
    - https://www.collimator.ai/reference-guides/what-is-a-markov-chain-monte-carlo
    - https://www.editage.com/insights/exploring-the-magic-of-markov-chain-monte-carlo-a-biomedical-researchers-guide

    - https://resources.pcb.cadence.com/blog/2020-the-use-of-the-monte-carlo-method-in-sensitivity-analysis-and-its-advantages

Goals of a Mathematical Model in the Project Phase

- Ideally, we hope the mathematical model can provide a numerical value for the risk of false conviction of an individual, based on various characteristics from the biodata of the individual to the severity of the alleged crime. This mathematical model would not only provide crucial information to acknowledge potential biases in court decisions, but would also serve as a window into the shifts of bias over an extended period of time. As risk is a dynamic value, it is imperative to implement effort regarding its projected behavior by being mindful of any patterns it exhibits.

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# Mission 4 Ski Resort Prompts

These prompts can be found on pages 31-32 of the Scenario Quest. Additional information on Data Identification and Analysis can be found on pages 32-33 of the Actuarial Process Guide.

Responses:

- 4.1:
    - There are significant outliers in atypical snowfall years. The most noticeable is White Haven's 2008 profit of $310 during heavy snowfall. An explanation for this profit outlier would be unusually heavy levels of snow, which would result in damage to the resort; the damage would take some part out of the profit. Transportation to the resort may be affected as well if the level of snow is deemed unsafe (i.e. blizzards, other anomalies in weather). Another more likely explanation could be that other factors may have caused damage of some sort to White Haven, in which the skiing population went to the other resorts: in 2008, Alpine Arena had a profit of $1117.00, above its heavy average of $1116.00, and Mountain Meadows had a profit of $1020.00, above its heavy average of $945.00.
- 4.2
    - 4.2.1
        - These probabilities provide insight into the frequency of each level of snowfall, which corresponds with the frequency of loss. This tells us that the distribution of risk is 20% high risk, 70% normal risk, and 10% low risk.
    - 4.2.2
        - The mean profits of Mountain Meadows provide insight into the severity of loss, not frequency since they represent the quantitative differences in profit based on year type. This tells us how much the resort stands to lose or gain in atypical snowfall years.
    - 4.2.3
        - We can calculate loss for a given year of Mountain Meadows by comparing how much they earned with how much they were supposed to earn, or the expected value of their profits. This is because failing to earn as much as one should've is essentially the same as losing money, even if the profit itself is still positive.

## Mission 4 - Team Project Proposal Prompt

- 4 - Project Proposal

Audiences & Mitigation Strategy Viability:

Out of the three risk mitigation strategies, behavior change seems like the most viable as the expected output of the model is a risk factor that captures the likelihood of misrepresentation given certain factors and sources of bias in the case. The risk factor outputted by the model is intended to be used as an informative figure that could affect how court authorities and audiences approach a case. As a result, the most prominent risk mitigation strategy to minimize the presence of biases is to inform behavior change, contributing to a more cognizant courtroom overall. Targeting behavior change doesn't change the approach or audience since it aligns with the overarching goal of fostering awareness and promoting a more equitable and informed judicial process.

Goals for Mitigation Strategy:

Without interventions, the current trajectory of racial bias in courtrooms suggests an ongoing pattern of wrongful convictions based on stereotypes, adversely affecting individuals, their families, and legal professionals. Wrongly convicted individuals face unwarranted imprisonment, and families experience emotional and financial strain, perpetuating generational impact. Legal professionals risk damage to their careers, potentially leading to a decline in the quality of legal defense. Taxpayers fund a justice system that accounts for inflation figures due to wrongful convictions, straining public finances, and eroding trust. Quantifiable risks include an increase in the expected value of years wrongly served in prison, persistent racial disparities, and economic costs from keeping individuals out of work. The goal of a risk mitigation strategy is to establish a fair and just system, reduce wrongful convictions, provide support to affected families, protect legal professionals, optimize resource allocation, and enhance public trust. The hope is to create a more equitable criminal justice system, minimizing the emotional, financial, and societal impact of racial bias in courtrooms.

# Mission 5 Ski Resort Prompts

These prompts can be found on pages 36-38 of the Scenario Quest. Additional information on Data Identification and Analysis can be found on pages 34-35 of the Actuarial Process Guide.

Responses:

- 5.1:
    - Mountain Meadows
        - Typical: $885.93
        - Heavy: $945.00
        - Light: $482.50
    - The data above shows the means of Mountain Meadow's profits in each of the snowfall categories. By simply comparing the means, it becomes apparent that years with light snowfall were close to half of the means during typical and heavy snowfall. It's important to note that the mean profit is significantly lower in the years with light to no snowfall. For this reason, the years with light snowfall contribute to the overall risk of loss the most. The aspiration should be to increase profits in the years with light snowfall to mitigate the risk of decreased profits.
- 5.2
    - Risk Mitigation Strategy: Behavior Change (2-3 concepts)
        - Instead of depending purely on snowfall, invest inversely to the amount of fake snow in a given year to ensure that their business may still operate effectively.
        - Increase prices of entries during these times, since it would not affect revenue. Contrary to popular belief, the existing demand would be met because individuals have limited areas and limited time to have this opportunity.
        - Decrease the shift times for employees per the projections in the model since decreasing expenses will increase revenue.
    - Risk Mitigation Strategy: Modifying Outcomes (2-3 concepts)
        - Create a virtual reality skiing simulation where skiers can experience the joy of skiing without actually needing white, fluffy snow that covers an endless mountain range in the resorts.
        - Renting out spaces in the facility that are not being used during the light snowfall years can decrease rent costs and generate more revenue to replace the profits lost due to the lack of snowfall.
        - During times when there is limited demand for the ski resorts, reallocate the hotel rooms for their intended purpose independent of the ski resort. This would also generate more revenue to replace the profits lost due to the lack of snowfall.
    - Risk Mitigation Strategy: Insurance (2-3 sentences)
        - Insurance policies will have a tremendous benefit to the ski resort since they can help subsidize the losses for 2 out of 10 years. These policies are extremely beneficial, especially as it is nearly impossible to interpret the behavior of the target audience, weather conditions, and other problems.
- 5.3
    -

| With Insurance | Mean Profit | Probability |
|---|---|---|
| Light | $552.5k | 0.20 |

| | | |
|---|---|---|
| Typical | $855.93k | 0.70 |
| Heavy | $915.00k | 0.10 |

Expected value of profit: 0.20(552.5) + 0.70(855.93) + 0.10(915.00) = $805.15k
Standard deviation of profit:

$$\sqrt{0.20(552.5 - 805.15)^2 + 0.70(855.93 - 805.15)^2 + 0.10(915 - 805.15)^2} = \$125.61k$$

Without the insurance policy:

Expected value of profit: $811.15k
Standard deviation of profit: $176.32k

The expected value of profit without insurance is higher, meaning they are technically losing money with the insurance policy. However, the standard deviation with insurance is much lower, meaning there is less profit variability and less risk for each individual year. Ultimately, this risk mitigation strategy addresses the risks for Mountain Meadows because it decreases the severity of loss, even if the resort goes through a bad year, and because it addresses the concern of light snowfall years becoming more frequent in the future.

## Mission 5 - Team Project Proposal Prompt

- 5 - Project Proposal

Recommendation Differences Between Mitigation Strategies:

- For the risk mitigation strategy identified in Mission 4, behavior change of the jury and judges, one possible recommendation is mandatory implicit bias training to allow participation in the courtroom. Implicit bias programs are designed to teach people about their unconscious biases, such as predispositions against certain races, and how to identify and mitigate the effect of those biases, creating a more cognizant and fair courtroom. We can produce recommendations such as that for each of the strategies, quantify the potential losses and gains in terms of the rate of false conviction and monetary costs, and use the results to prioritize which risk mitigation strategies to take.

Considering New Problems Introduced by the Risk Mitigation Strategies:

- The recommended risk mitigation strategies could potentially lead to overcompensation by the jury and judges to try to avoid their implicit biases, reversing the trend of discrimination. For example, white people may become more likely to be falsely convicted. Another potential pitfall is failing to take into account the defendant's background due to attempting to avoid stereotyping, which removes a critical aspect of the defendant's individual circumstances and contextual nuances.

Goals for Situation Improvement:

- In summary, our project seeks to revolutionize the courtroom landscape by targeting behavior change as a key strategy to mitigate racial bias. The ultimate improvement we hope to achieve is a more aware and equitable judicial process, reducing the risk of wrongful convictions. Through the use of a validated model as an informative tool to bring awareness to the systemic discrimination present in our judicial system, we aim to encourage adaptability among judges and juries and foster a nuanced understanding of individual cases. Our vision is a justice system that prioritizes fairness, diminishes resistance, and ensures that the risk factor output serves as a catalyst for positive transformation, contributing to a more trustworthy and impartial legal system.