2019-20 Example Scenario
Farm Insurance

A program of The Actuarial Foundation

Modeling The Future Challenge

Introduction

Providing healthy, nutritious food for our continuously growing population is critical to our prosperity as a nation and global society. However, environmental stressors and a growing population put ever increasing pressures on our farms to produce the crops and livestock required at affordable prices.

Climate change is expected to significantly alter important environmental factors that could have large effects on agricultural sectors across the country. Changing temperatures, droughts, floods, and other severe weather events will cause major upheavals to many industries across the country, but perhaps none more so than the agricultural industry.

In this scenario, you are given information from three farms in Manitoba, Canada: Abbington Farm, Barton Farm, and Calistoga Farm. Each farm owner has tracked their profits (in thousands of dollars) and the weather over the past 20 years. The farmers organized their annual weather reports into three general categories, noted as *typical, dry, or stormy.*

Typical weather happens most years and had no major weather events causing adverse effects to the farmer's crops. Typical weather generally yields the best results for the farmers. In unusually dry years, farmers saw some crop die-off due to droughts and other related environmental stressors, leading to smaller profits. Occasionally, in what is noted as a "stormy" year, one or more severe storms wiped out a portion of the farmers' crops for that year, severely damaging their production and profits.

The data-set provided includes columns for the year, the farm, the weather category, and the profit reported by the three farmers. The questions on the following pages require you to analyze this data and some additional information provided in the questions to help understand the future profit and risks for these farmers.

The first thing you are tasked with is to conduct some basic mathematical analysis of the reports the farmers gave. This will help us understand what has happened in the past 20 years.

1. Using the data from the past 20 years, calculate the probabilities of each type of weather that the farmers reported.

2. Compare the average profits for each of the three farms across all years and all weather categories. Which farm had the highest average profit?

3. Compare the standard deviations of the profits for each of the three farms across all years and all weather categories. Which farm had the greatest variability?

4. Is the farm with the overall highest average profit that you identified in question #2, the farm with the highest average profit for each type of weather? Identify which farm had the highest profits for each of the three weather types.

5. Construct a 95% confidence interval for the mean profit for Barton Farm during typical weather years. What are the upper and lower bounds on the farm's profit for typical weather?

6. Calculate the probability of exactly two storms in the next ten years.

7. Calculate the probability of at least two storms in the next ten years.

8. Calculate the probability that the second storm from now will happen in the tenth year from now.

9. How quickly is each farm is growing during "typical" weather years? Calculate the least-squares linear regression for each of the three farms' typical weather annual profits. Create a graph plotting the profits and the trend line for each of the three farms. Which farm is growing the fastest in typical weather years?

10. All three farms indicated there were two stormy years over the past two decades (2004, and 2013). Which farm was affected by these storms the most? Using the expected values from your linear regression for typical weather, what was the average profit lost for each farm due to stormy weather?

11. **Use least-squares linear regression on typical weather years only to predict the profit for Calistoga Farm in 2020 (assuming that 2020 also has typical weather).**

12. **If the year 2020 has a 10% chance of being stormy, a 20% chance of dry weather, and a 70% chance of being typical, what is the expected value of each farm's profit for the year 2020? Use the average loss due to stormy and dry weather from the past 20 years to calculate the expected value of each farm's profit for 2020.**

In order to alleviate the risk from severe weather, Abbington Farm is considering an insurance company that offers an annual policy for a $3,000 premium that would pay $20,000 in case of a severe storm.

13. Construct a probability distribution for the expected profit using the average profit for the 20 years of historical data if Abbington Farm buys this insurance policy.

14. Calculate the expected value of Abbington's profit and the standard deviation of the expected profit with insurance.

15. For Abbington Farm, compare your answers to #2 and #14 and interpret the values for the different profits in context.

16. For Abbington Farm, compare your answers to #3 and #14 and interpret the values for the different standard deviation calculations in context.

17. What is the expected profit for the insurance company on its policy for Abbington Farms?

18. Give a mathematical reason why the insurance policy could be considered a good idea by the farmer.

19. Give a mathematical reason why the insurance policy might NOT be considered a good idea for the farmer.

20. **What factors should the farmer consider in making the decision of whether to purchase the insurance policy noted in the previous questions?**

The owner of Abbington Farm decides to consult a climate scientist to analyze what they think the climate will be like in the coming years. The climate scientist tells Abbington's owner that the probability of a stormy year now is actually 0.18%, not the 10% they've seen over the past 20 years. Likewise, the probability of typical weather and dry weather are both 4% less than what the farmer has seen in the past 20 years (66% for Typical and 16% for dry weather).

21. **With this new information, would you recommend that Abbington Farm buy the insurance? Why or why not? Explain with mathematics.**

22. **How much would these changes in climate probabilities affect the insurance company's expected profit on selling a policy to Abbington Farm?**

23. **If you are consulting for the insurance company, how much would you recommend they increase their policy price to maintain the same expected profit as before?**

24. **If the insurance company was considering adding a deductible to the policy it is offering to Abbington Farms instead of increasing the premium, how much should the deductible be to keep the company's expected profit the same as it was? Explain with mathematics.**

National Sponsor

Roy and Georgia Goldman

Executive Sponsor

Event Sponsor

Rick and Beth Jones