STEPPING INTO THE ACTUARIAL MODELING WONDERLAND

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Agenda

1 Paradox Overview
2 Simpson’s Paradox
3 Sleeping Beauty Paradox
4 Berkson’s Paradox
Mathematical Paradoxes

“A mathematical paradox is a mathematical conclusion so unexpected that it is difficult to accept even though every step in the reasoning is valid.”

- Britannica
SIMPSON’S PARADOX
Simpson’s Paradox

Simpson’s Paradox is a statistical phenomenon where an **association between two variables in a population emerges, disappears or reverses when the population is divided into subpopulations.**
Simpson’s: Insurance Example

*Springfield Insurance Company is analyzing loss trend on their historical private passenger auto book.*

OVERALL 5-YR TREND: **-1.1%**
Simpson’s: Insurance Example

**5-YR PURE PREMIUM TREND**

OVERALL: **-1.1%**

Massachusetts: **+0.8%**

Oregon: **+0.4%**
Simpson’s: Insurance Example

DISTRIBUTIONAL SHIFT BY STATE

Massachusetts
• Started writing prior to 2019
• Quarterly growth of ≈2%

Oregon
• Low exposure amount
• Exposure ramped up quickly in late 2021
Simpson’s: Insurance Example

5-YR AVG PURE PREMIUM

Massachusetts: $188

Oregon: $125
Simpson’s Takeaways

• Recognize that overall result might not be the total story
• Decompose the effects
• Evaluate data on a normalized basis
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SLEEPING BEAUTY
PARADOX
Sleeping Beauty Paradox

The Sleeping Beauty Paradox is a decision theory puzzle that deals with the logic and uncertainty of experience, or the idea that perspective shapes rational conclusions.
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**Problem:**
Some researchers are going to put you to sleep. During the two days that your sleep will last, they will briefly wake you up either once or twice, depending on the toss of a fair coin (Heads: once; Tails: twice). After each waking, they will put you back to sleep with a drug that makes you forget that waking. When you are first awakened, to what degree ought you believe that the outcome of the coin toss is Heads?
Charming Insurance Company is analyzing conversion experience on their recent quoting data.

OBSERVATIONS
• Conversion rate is better for Source 1
• Conversion rate is better for adults
  – Observed within each source
• Source 2 attracts relatively more youth
Sleeping Beauty: Insurance Example

Conversion ratio = \( \frac{\text{# of policies issued}}{\text{# of quotes}} \)

Insured 1 gets three quotes

Should all three quotes be used in conversion ratio?

Should just one quote be used in conversion ratio?

Which quote should be used?
The bulk of the conversion differences were due to the multi-quoting phenomenon!

The only observation that still holds when considered at unique quote level is that Source 2 attracts relatively more youth.
Sleeping Beauty Takeaways

• Ensure data aligns with the question being asked
• Understand the difference between experiment versus outcome
• Recognize when outcomes are not independent
BERKSON’S PARADOX
Berkson’s Paradox

Berkson’s Paradox is a particular kind of selection bias, caused by systematically observing some events more than others.
How do age and credit score prevalence in insurance data compare to the overall population?

In the general population, credit score increases as age increases.

Source: Experian data from Q3 of 2023; ages as of 2023
Insurance companies tend to avoid writing young drivers or low credit scores.

How does this impact the relationship between age and credit score?
Berkson’s: Insurance Example

How do age and credit score prevalence in insurance data compare to the overall population?

POTENTIAL IMPLICATIONS:
• Unintuitive book profile
• Biased model results
• Market blind spots
• Misinformed new business strategy
Berkson’s: Takeaways

• Be aware of insurance practices and potential influence on data gathered
• Evaluate whether a sample is representative
• Investigate impacts of sampling bias
Thank You

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