Surprise - They're Different!

Comparing Frequentist and Bayesian Approaches in Public Policy

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Statistical Inference in Social Science Classrooms

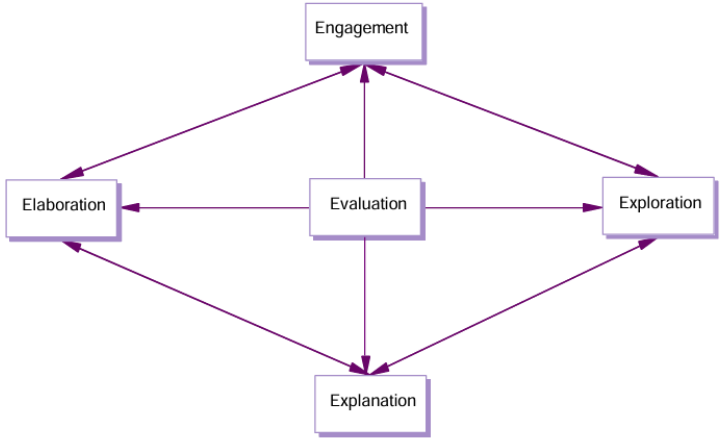
Statistical Inference in Social Science Classrooms

- Traditional Frequentist methods (NHST) are taught in social science classrooms, particularly public policy and political science.
- Two considerations:

1. Teaching quantitative methods alongside substantive theories is hard (Connelly et al. 2021; Gunn 2017; Bates & Jenkins 2007)
2. Different methods produce different outcomes (Luque & Sosa 2023; Gill & Witko 2013)

- Bayesian methods provide an intuitive, and perhaps more appropriate, approach for answering public policy questions (Gill & Witko 2013; Wagner & Gill 2005)

Statistical Inference in Social Science Classrooms



The 5E Instructional Model (Duran & Duran 2004)

Activating epistemological frames:

- *Engage.* Get students interested
- *Explore.* Students do self-directed inquiry
- *Explain.* Give students conceptual tools
- *Elaborate.* Let students work with the tools
- *Evaluate.* Assess the learning outcomes

Statistical Inference in Social Science Classrooms

The Big Idea:

Introduce an applied learning activity for students of public policy that exposes them to Bayesian methods + explores the differences between this statistical paradigm and more commonly used approaches.

Activity Learning Goals:

1. Evaluate hypotheses with inferential statistical models
2. Connect (1) with real-world factors
3. Understand how Frequentists vs. Bayesian assumptions can lead to different conclusions

Overall Goal:

Engineer a “classroom controversy” to motivate students to find their own understanding of (3).

Applied Activity: Comparing Frequentist & Bayesian Approaches

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- Students who participated in the pilot version of the activity are from the University of Denver and Olin College of Engineering.
- **Activity cadence:**

  → Problem Context

  → Activity Introduction

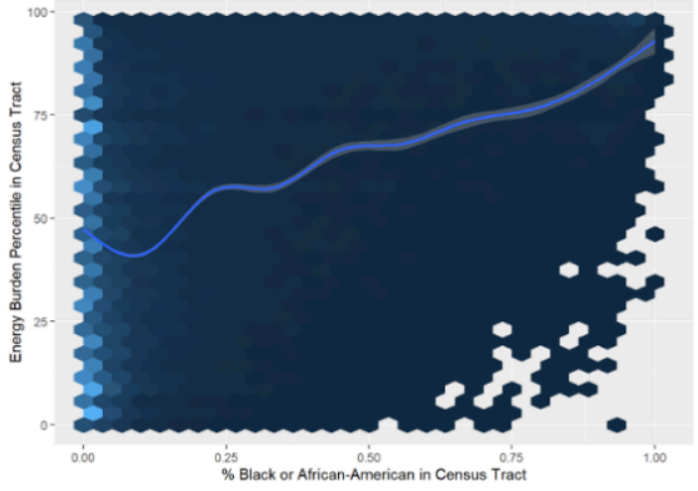
  → Activity Application

  → Activity Closing

Applied Activity: Comparing Frequentist & Bayesian Approaches

Context

- Dataset: Climate and Economic Justice Screening Tool (CEJST)
  - Executive Order issued by President Biden in January 2021
  - U.S. Census tract level data on dozens of indicators
- Exploratory data analysis (EDA)



Applied Activity: Comparing Frequentist & Bayesian Approaches

Introduction

- Students review and discuss ideas around statistical inference
- Research Question: Do Black Americans experience a disproportionate level of energy burden?
- Critical differences one-pager

Table 1: General Inference

Frequentist	Bayesian
Deduction from Pr(data | H0), by setting α in advance	Induction from Pr(θ | data), starting with Pr(θ)
Accept H1 if Pr(data | H0) $< \alpha$	$1-\alpha$% of most likely parameter values fall within a $1-\alpha$ HPD
Accept H0 if Pr(data | H0) α	

Table 2: Model Summaries

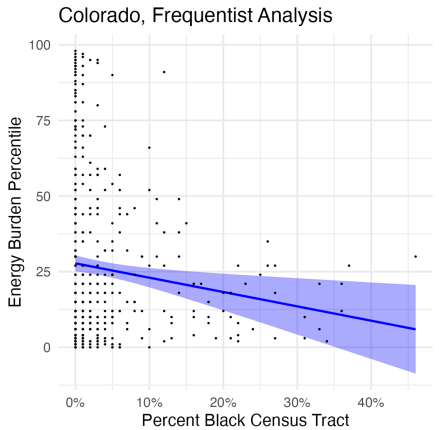
Frequentist	Bayesian
Point estimates and standard errors	Descriptions of the posterior distribution such as means and quantiles
95% confidence intervals indicating that 19/20 times the interval covers the true parameter value	Highest posterior density intervals indicating region of highest posterior probability
	$1-\alpha$% of most likely parameter values fall within a $1-\alpha$ HPD

Applied Activity: Comparing Frequentist & Bayesian Approaches

Activity Application: There's a catch!

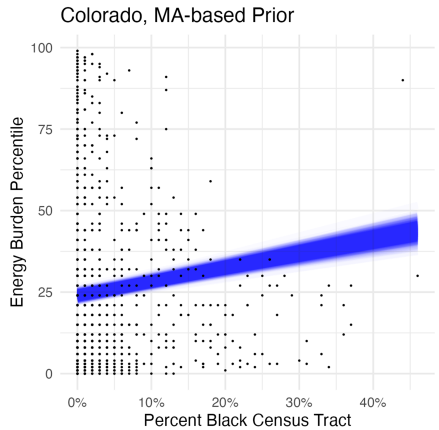
Frequentist version:

1. Overview of a Frequentist statistical model
2. Assessing estimates and confidence
3. Outcomes across different states



Bayesian version:

1. Overview of a Bayesian statistical model
2. Assessing posteriors and confidence
3. Outcomes...pick a state for the prior



Applied Activity: Comparing Frequentist & Bayesian Approaches

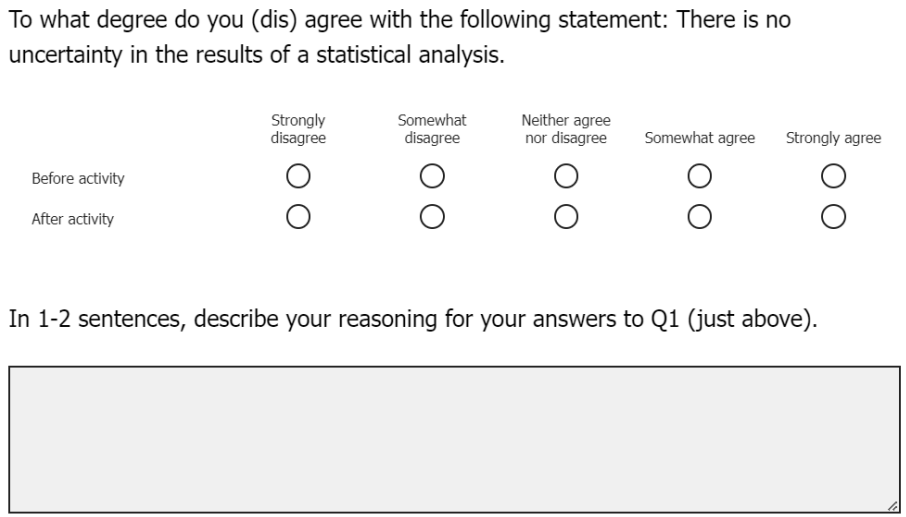
Activity Closing

- Students come together for a full class discussion about the conclusions they draw from their respective analysis.
- There's an apparent controversy here - students from the groups will have come to different conclusions.
- Students finish the activity by "jigsawing" and discussing the differences between general inference and model summaries for Frequentists and Bayesians.

Evaluation

Evaluation

- Pre- and post-pre-survey designs were used to assess students' attitudes and awareness about statistical inference.
- Goal: capture changes in self-perceived attitudes about a topic by asking them to consider where they think their beliefs were *before* the activity, followed by where they think they are *now* (Hiebert & Magnusson 2014).


To what degree do you (dis) agree with the following statement: There is no uncertainty in the results of a statistical analysis.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Before activity	○	○	○	○	○
After activity	○	○	○	○	○

In 1-2 sentences, describe your reasoning for your answers to Q1 (just above).

Evaluation

- Perceived attitudes about inferential statistics, both before and after the activity, were a bit of a mixed bag.
- While the results for the Likert battery were "noisy", the open-ended responses were somewhat illuminating.
- More work to be done here...

Discussion

Discussion

- Bayesian methods are another possibility that non-statistics disciplines should consider both in the classroom and in the wild.
- Using an applied, student-driven approach, this activity moves beyond simple comparisons by using an activity with a real-data application.
- Some evidence that the goal of equipping them with the tools & logical processes necessary to apply either approach as they see fit was met.
- Next steps

Thank you!

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