Paper Clip Fatigue

Katelyn Miller and Matthew Wilson

Research Questions

- How does the temperature (colder, cold, room temperature) affect the number of times a paper clip can be bent before it breaks?
- How does the wire gauge (1mm vs. 0.8mm) influence paper clip fatigue?
- Does the person bending the paper clip have a different affect on paper clip fatigue?

Data Collection

(a) Original form.

(b) Opened paper clip.

(c) Broken paper clip.

Figure: These three images depict different stages in the data collection process.

Model

Let y_i be the number of bends required to break the i^{th} paper clip. Then,

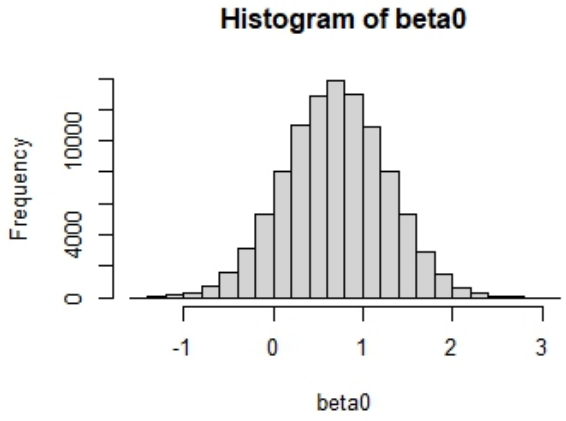
$$y_i \sim \text{Poisson}(\lambda_i) \tag{1}$$

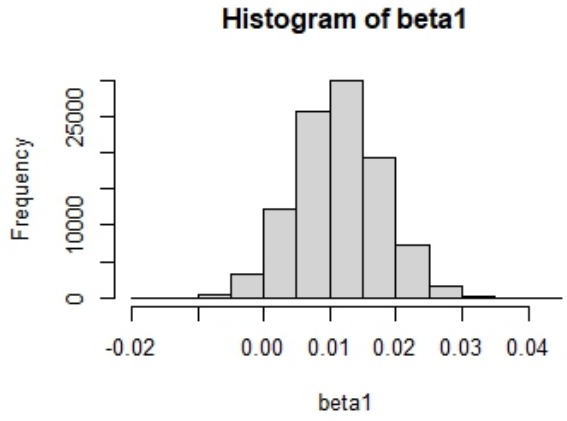
$$log(\lambda_i) = \beta_0 + \beta_1 \text{temp}_i + \beta_2 \text{gauge}_i + \beta_3 \text{tester}_i \tag{2}$$

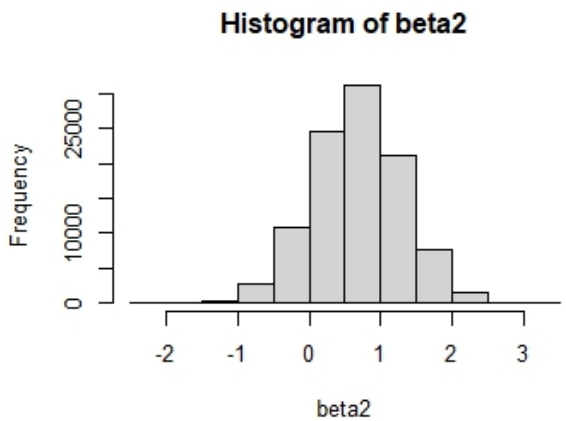
$$\beta_j \sim \text{Normal}(0, 100) \tag{3}$$

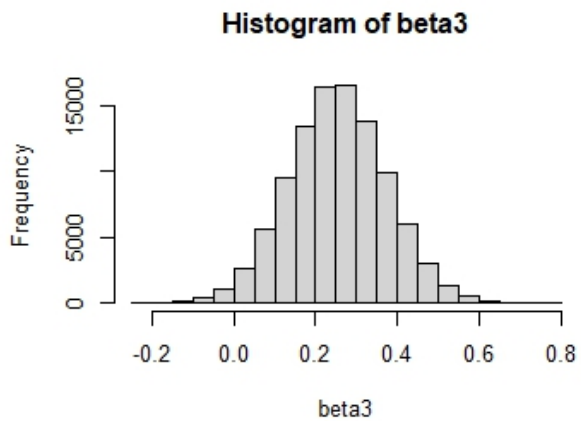
where $i = 1, 2, \ldots, 60$
where $j = 0, 1, 2, 3$

Draws from β



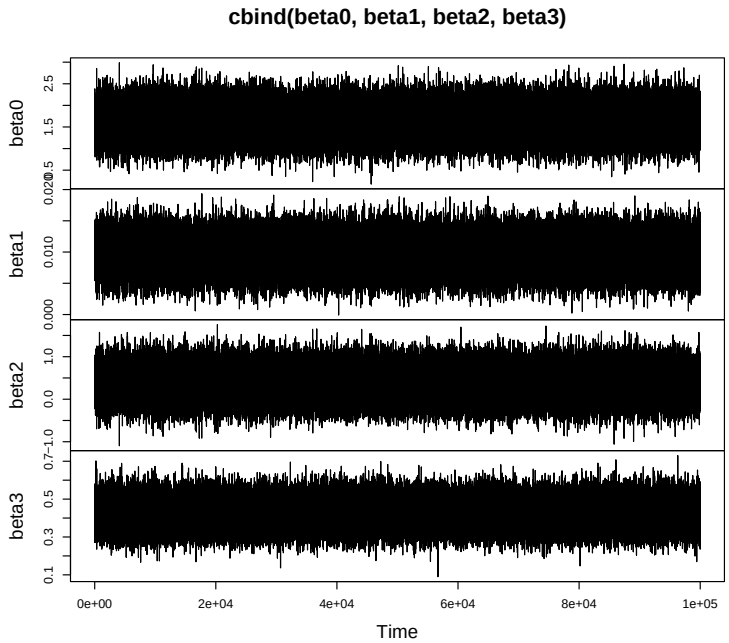




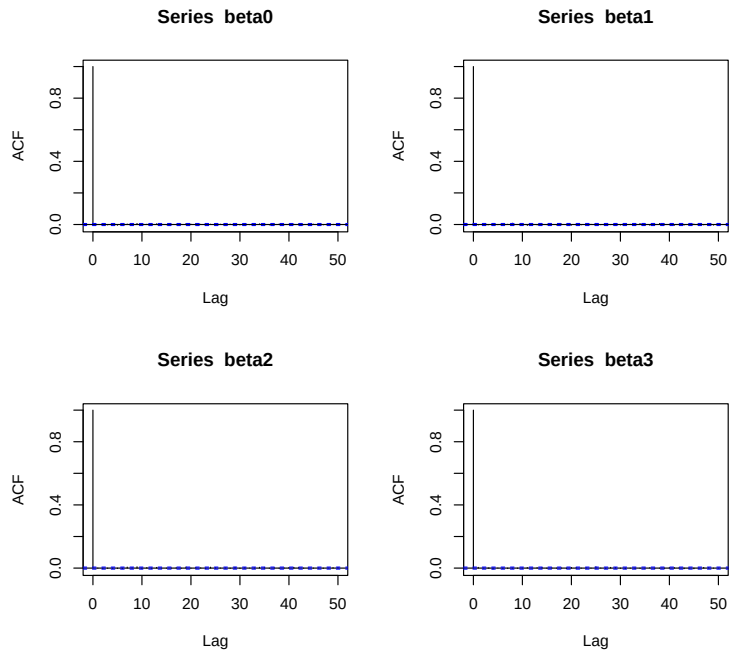


β_1: (0.001 0.022) β_2: (-0.346, 1.702) β_3: (0.060, 0.448)

Check Convergence



(a) Beta Trace plots



(b) Beta ACF

Figure: We conclude that our β have converged. They also all had a Gelman Diag. of 1

GoF

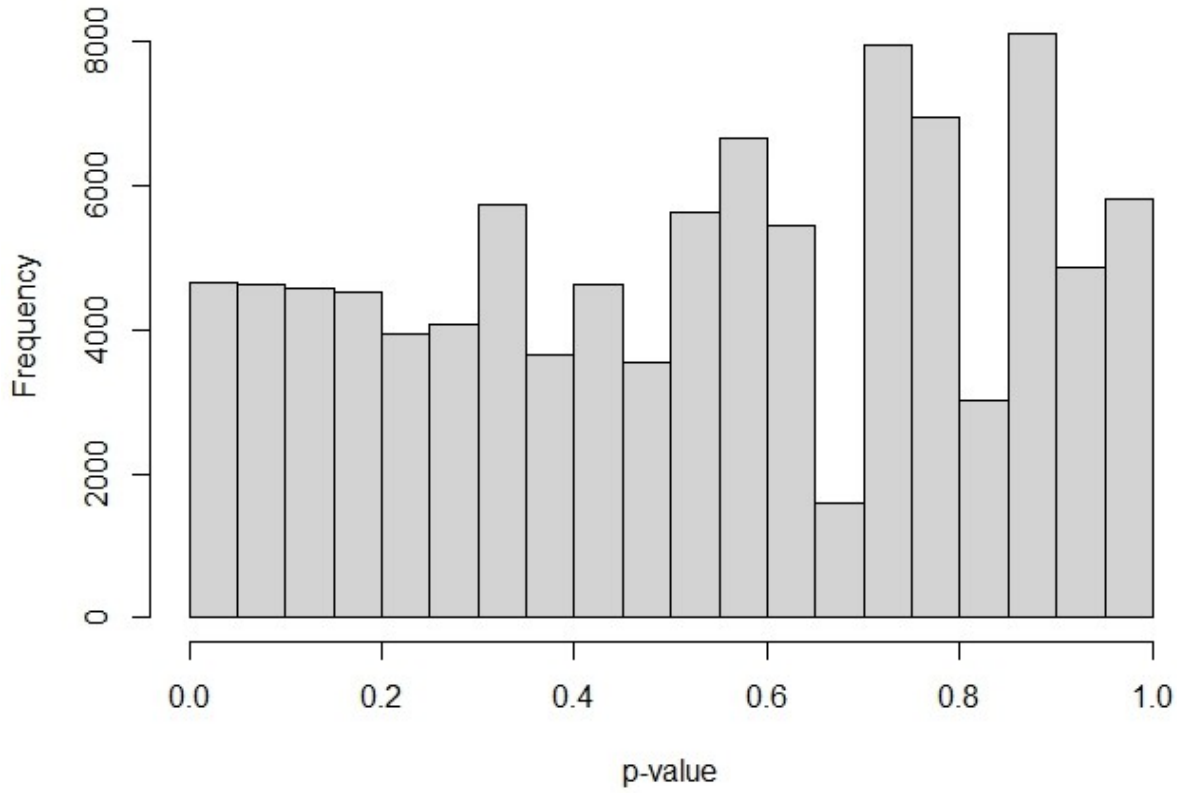


Figure: The distribution of goodness-of-fit p-values is good. Proportion below 0.05 is 0.04.

Results

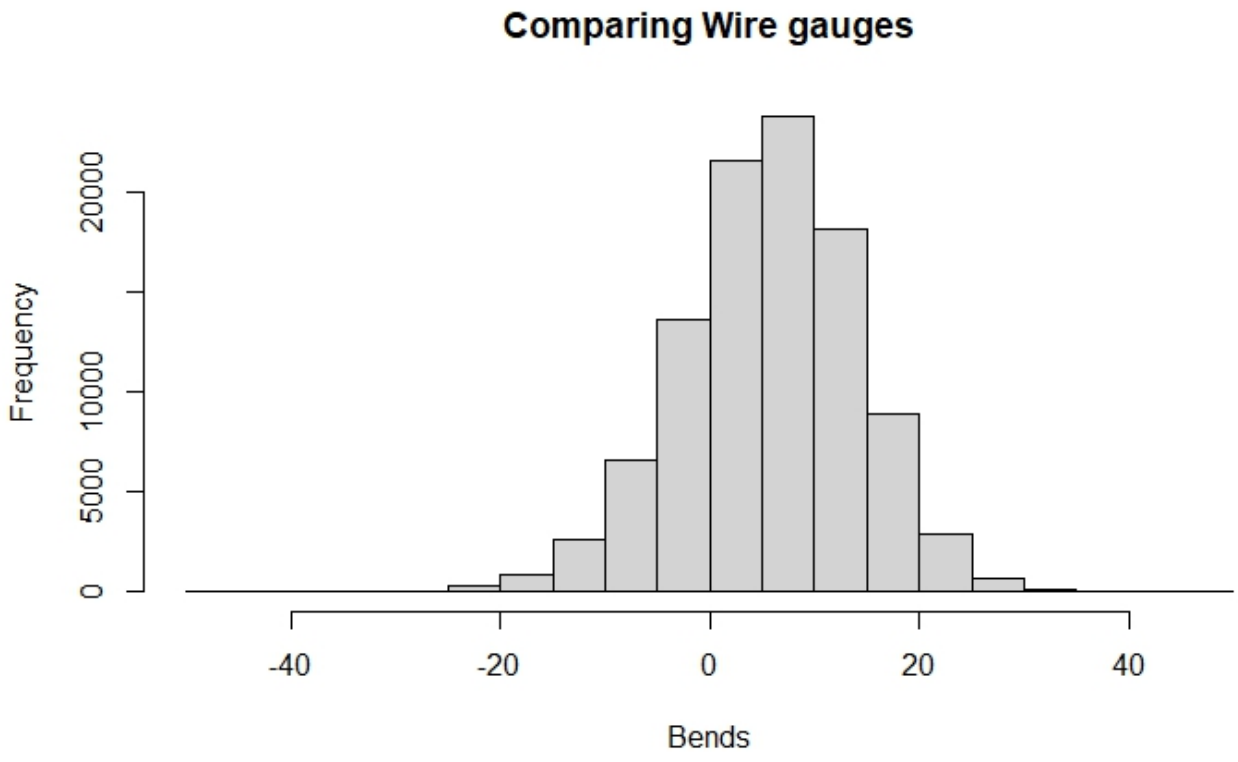


Figure: PPD depicting how many more bends it takes to break a 1mm paper clip versus 0.8mm.

Results

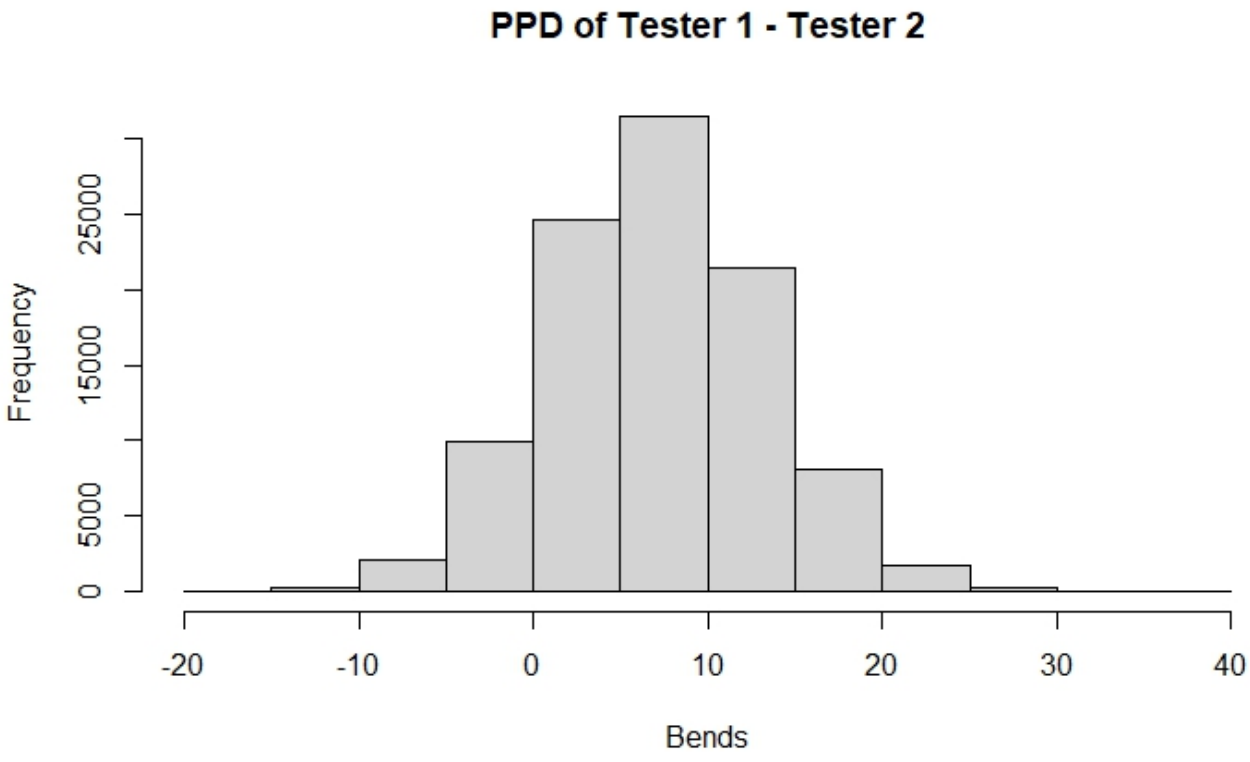
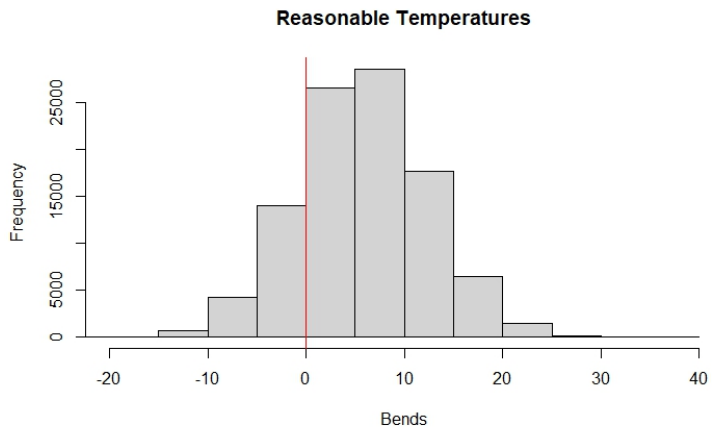
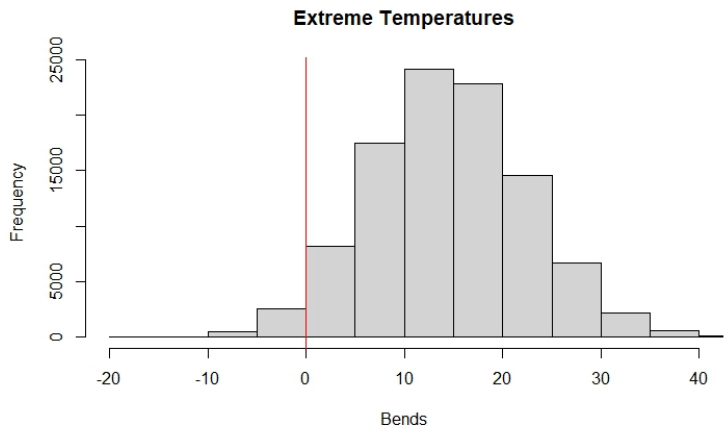


Figure: Posterior predictive distribution of the difference in the number of bends until breaks for Testers 1 and 2.

Results



(a) PPD 74°F compared to 42°F.



(b) PPD 100°F compared to 30°F.

Figure: Comparing the impact of cold versus hot temperatures in reasonable and extreme situations.

Conclusion

- **Temperature:** Colder temperatures cause paper clips to break after fewer bends, suggesting increased brittleness.
- **Wire Gauge:** No significant impact was found between the 1mm and 0.8mm wire gauges on paper clip fatigue.
- **Tester Variability:** While the tester had some effect on results, it was not statistically significant.

Summary:

- Temperature and tester identity influence paper clip fatigue.
- Wire gauge does not significantly affect performance.