An Analysis of a Rising Trend in Dollar Loss in Fire Incidents With and Without Sprinkler Systems in Toronto over a decade (2011-2022)*

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A Fire Incidents dataset was used to assess the general trend in dollar loss in fire incidents and the impact of existence of sprinkler systems installed across the city of Toronto. Based on the analysis, a general rise over the years in the dollar loss in fire incidents as well as a massive amount of loss to property was found wherever sprinkler systems were not installed. This paper suggests that an installation of sprinkler systems will help reduce the impact of fire incidents on loss to property in Toronto.

1 Introduction

The Great Fire of Toronto in 1904 caused mass destruction. The fire demolished around 20 acres of the industrial area in the city of Toronto, demolishing at least 98 buildings, causing a dollar loss of $10 million and leaving numerous thousands unemployed (Bradburn 2020). Since then we have seen an improvement in city codes and policies, better civil planning and extensive training of firefighters (Pandas 2022). Till date, the Toronto Fire Services report approximately 10,000 fires each year which is of immense concern to the city of Toronto and its residents (Ohrn 2019).

The Fire Incidents data of Toronto includes incident reports of fire incidents as defined by the Ontario Fire Marshal from 2011-2022 (Data 2024). This paper delves deeper into the trend of estimated dollar loss in fire incidents in the city of Toronto from 2011-2022 and also analyses the impact of an installation of sprinkler systems on the dollar loss. The aim of the paper is to analyse the impact of better planning, specifically an installation of sprinkler systems, on the extent of loss faced by the residents of Toronto.

*Code and data are available at: https://github.com/Ary4m3n/fire-incidents.git

In this paper, Fire Incidents data (Data 2024) was used to first explore if there is a trend in the estimated dollar loss over the years, and then was used to find any correlation between better civil planning, i.e. the installation of sprinkler systems and a lesser loss of property. It was found that there is a general rising trend in the dollar loss between 2011 and 2022. The paper also found that the dollar loss was drastically higher for fire incidents where there was no sprinkler system installed. This leads us to make an important judgement that better civil planning helps reduce the impact of such unfortunate events.

This paper is structured using the following sections: Data, Results and Discussion In the Data (Section 2) section, the data source of the dataset from Open Data Toronto (Data 2024) is discussed and the data cleaning process is outlined. In the Results (Section 4) section, the paper summarizes the data findings and relevant graphs of the trends observed. The paper ends with the Discussion (Section 5) section, where the findings of the paper have been analysed and delved deeper into, and a further scope for the paper has been discussed.

2 Data

Some of our data is of penguins (Figure 1), from Horst, Hill, and Gorman (2020).

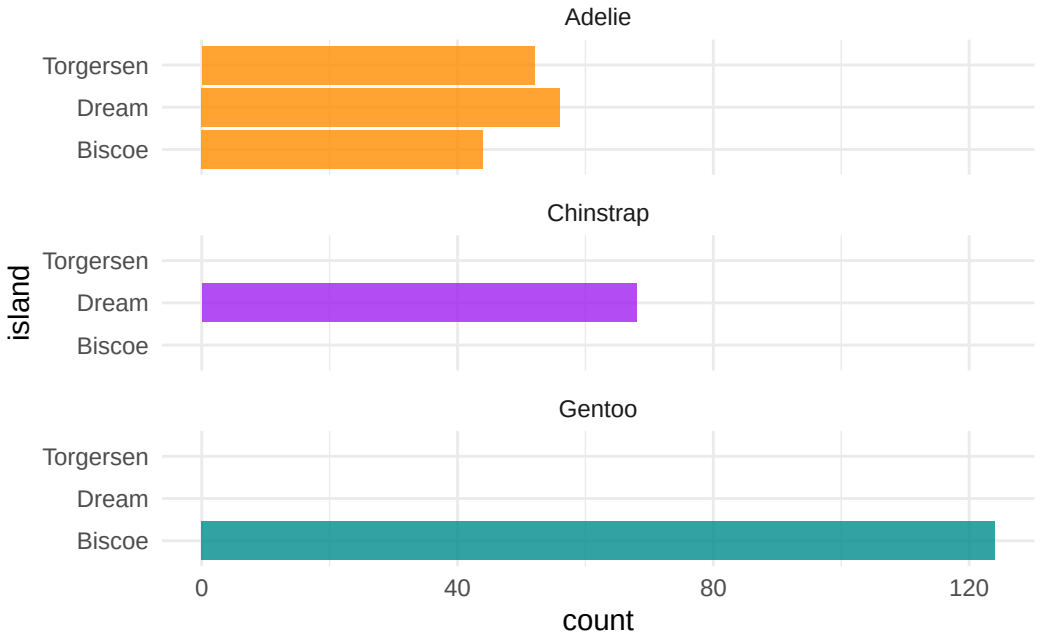


Figure 1: Bills of penguins

Talk more about it.

And also planes (Figure 2). (You can change the height and width, but don't worry about doing that until you have finished every other aspect of the paper - Quarto will try to make it look nice and the defaults usually work well once you have enough text.)

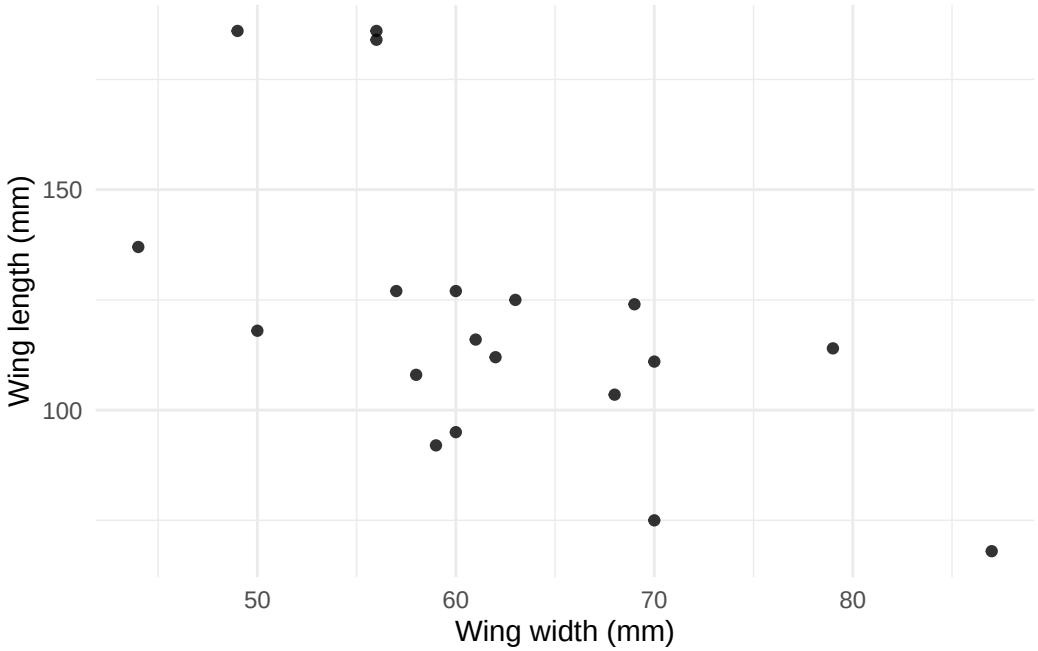


Figure 2: Relationship between wing length and width

Talk way more about it.

3 Model

The goal of our modelling strategy is twofold. Firstly,...

Here we briefly describe the Bayesian analysis model used to investigate... Background details and diagnostics are included in Appendix B.

3.1 Model set-up

Define y_i as the number of seconds that the plane remained aloft. Then β_i is the wing width and γ_i is the wing length, both measured in millimeters.

$$y_i|\mu_i, \sigma \sim \text{Normal}(\mu_i, \sigma) \tag{1}$$
$$\mu_i = \alpha + \beta_i + \gamma_i \tag{2}$$
$$\alpha \sim \text{Normal}(0, 2.5) \tag{3}$$
$$\beta \sim \text{Normal}(0, 2.5) \tag{4}$$
$$\gamma \sim \text{Normal}(0, 2.5) \tag{5}$$
$$\sigma \sim \text{Exponential}(1) \tag{6}$$

We run the model in R (R Core Team 2022) using the `rstanarm` package of Goodrich et al. (2022). We use the default priors from `rstanarm`.

3.1.1 Model justification

We expect a positive relationship between the size of the wings and time spent aloft. In particular...

We can use maths by including latex between dollar signs, for instance θ.

4 Results

Our results are summarized in Table 1.

5 Discussion

5.1 First discussion point

If my paper were 10 pages, then should be be at least 2.5 pages. The discussion is a chance to show off what you know and what you learnt from all this.

5.2 Second discussion point

5.3 Third discussion point

5.4 Weaknesses and next steps

Weaknesses and next steps should also be included.

Table 1: Explanatory models of flight time based on wing width and wing length

	First model
(Intercept)	1.12
	(1.70)
length	0.01
	(0.01)
width	−0.01
	(0.02)
Num.Obs.	19
R2	0.320
R2 Adj.	0.019
Log.Lik.	−18.128
ELPD	−21.6
ELPD s.e.	2.1
LOOIC	43.2
LOOIC s.e.	4.3
WAIC	42.7
RMSE	0.60

Appendix

A Additional data details

B Model details

B.1 Posterior predictive check

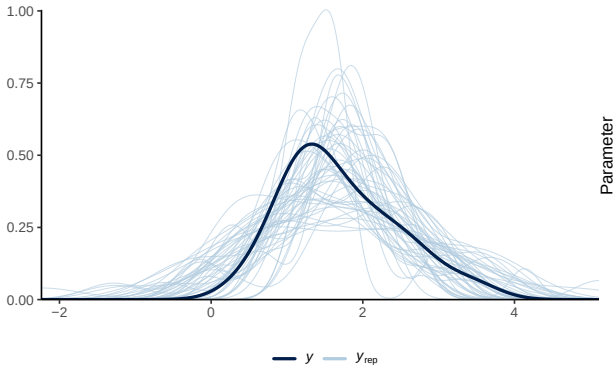
In Figure 3a we implement a posterior predictive check. This shows...

In Figure 3b we compare the posterior with the prior. This shows...

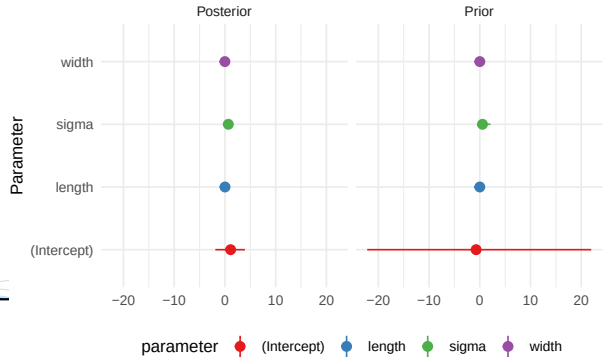
B.2 Diagnostics

Figure 4a is a trace plot. It shows... This suggests...

Figure 4b is a Rhat plot. It shows... This suggests...

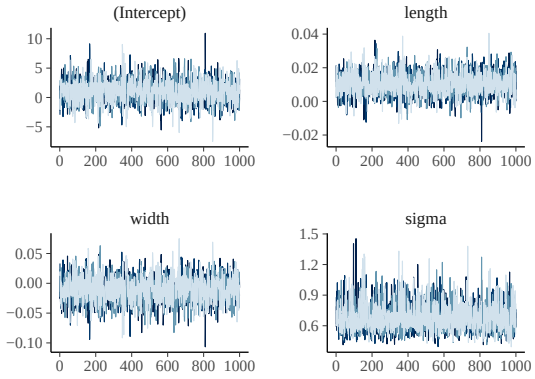


(a) Posterior prediction check

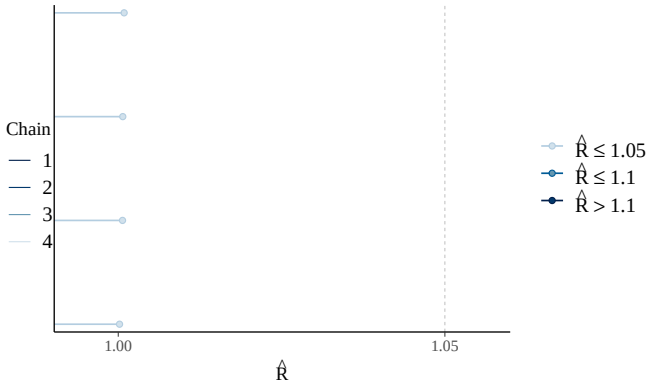


(b) Comparing the posterior with the prior

Figure 3: Examining how the model fits, and is affected by, the data



(a) Trace plot



(b) Rhat plot

Figure 4: Checking the convergence of the MCMC algorithm

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