Predicting the Popularity of Children's Books Considering Reader's Rating, Physical Attributes and Trend*

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This study formulates a predictive model to estimate the popularity of children's books by the reader's ratings, physical attributes of the books and yearly trend. The study used a dataset of children's books that were published from the year 1905 to 2020. The generalized linear model with a log-liner link has been used, where the predictors are publication year, years from first publication, cover type, number of pages and average rating by readers, and the predicted variable is the total count of ratings received from readers as an indicator of popularity. The study found that apart from the average rating, the number of pages in the book has a significant effect on the potential popularity, whereas the cover type of the book has no effect. The study suggests that republishing older children's books can increase the probability of having higher popularity. The low model fit and lack of availability of data regarding the genre and target audience of the book may limit the reliability of the prediction.

1 Introduction

In this world of digitalization, children are becoming more attached to digital entertainment than reading books(Hadidene (2024)). Developing a critical understanding of the reaction of the consumers towards the product considering the cardinality of different attributes of the product is essential to making beneficial decisions regarding product development in future. By leveraging the preferences of the readers, trends and advanced analytics of the different attributes of the book, the publishers can anticipate the potential popularity of a new book while selecting the best book for maximising engagement. This study aims at predicting

[*] Code and data are available at: https://github.com/PeterFan/Predicting_Popularity_of_Childrens_Books.

the popularity of children's books while examining the effect of ratings by readers, physical attributes and yearly trends.

The study involves predicting the popularity of the children's book by considering the number of ratings received from the users while considering the physical attributes, yearly trend and average user rating as predictors. Along with the development of the predictive model, the study also examined the independent and direct effect of different independent factors on the popularity of the book. The unique relationship between different independent variables or attributes of children's books with the popularity of the books will enable a critical and comparative understanding of the importance of different attributes of the book that contribute to have higher popularity.

This structure of this paper has five sections including Introduction, namely Data which includes the detailed description of the data, Model which includes the quantitative description of the model, Results which includes the quantitative findings of the study and Discussion which discusses the implication of findings. The primary estimand of the study is the average effect of the number of pages, cover type, year of publication, republishing length and average review on the received number of ratings or reviews from the readers of the children's books. The effects have been used to develop a predictive model and formulate predictive outcomes for a simulated dataset of children's books with different physical attributes and ratings.

2 Data

2.1 Overview

2.1.1 Overall Data Handling

Statistical programming language R has been used considering the R packages for data storing, data cleaning and pre-processing (R Core Team (2023)). The library tidyverse (Wickham et al. (2019)) which includes ggplot2, dplyr and other essential packages has been used for data handling and visualization. The library of janitor (Firke (2023)), broom (Robinson, Hayes, and Couch (2024)) have been used for data cleaning and structuring the results. The library here (Müller (2020)) and arrow (Richardson, McKinney, et al. (2024)) have been used to efficiently store and retrieve the data.

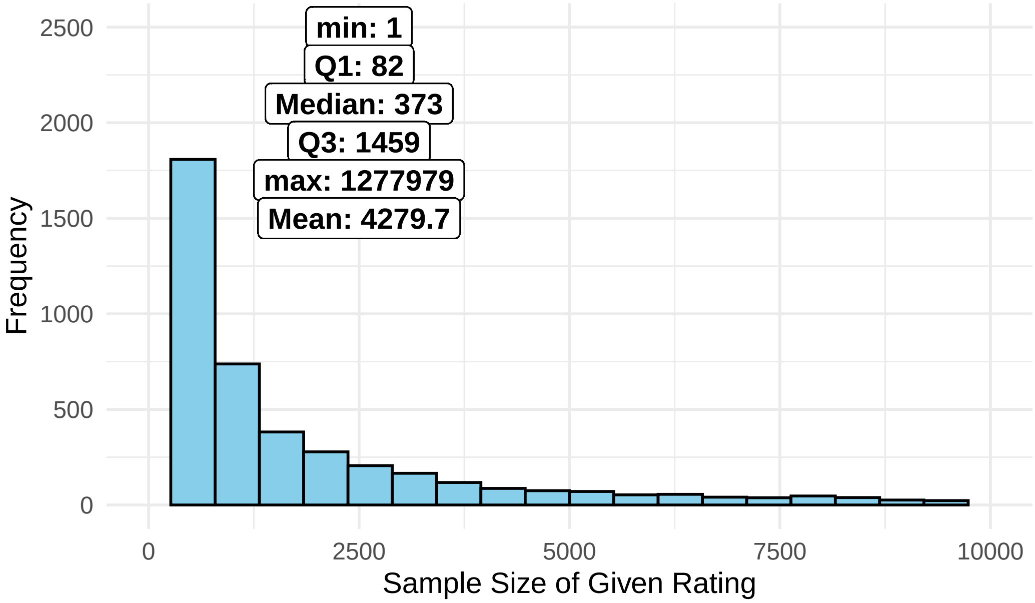
2.1.2 Data Source and Characteristics

The data has been collected from Alex Cookson's database, where the chosen dataset 'children's book' was previously used for empirical Bayes estimation (Cookson (2021)). The raw data of the study was taken without the normalized and estimated ratings. The raw dataset contains 9000 records of individual children's books with ISBN, title, author details, publisher's name, physical attribute of book, publishing years and different user rating-related details.

2.1.3 Data Cleaning Process

The data cleaning process for the chosen raw dataset of this study involves handling missing data, and filtering out the invalid and duplicate records (rows) and attributes (columns) from the dataset. In the selected dataset of children's books, first, the missing data are explored considering each attribute or column of the dataset. The variables of interest in this dataset are rating, cover, publish year, pages and rating count. There are rows only 8% of records that include missing values in any of these columns, and therefore, without using any amputation methods the records have been excluded to develop the filtered dataset. However, the missing values in the column 'original publish year' represent that there is no separate original year from the recorded publish year. Therefore, for this variable, the missing data has been replaced using values from published data and a new variable is created named 'republish length' by subtracting the original year from the published year. The variable signifies the gap between the original publish year and from recent publish year. The 'rating count' includes values from 1 to more than 1 million reviews with an average of 4280 (Q1 = 82, Q2 = 373, Q3 = 1459), whereas the lower number of reviews is not valid enough to represent the overall review rating of any book. Hence, books that have more than 25% quintile reviews (>82) have been selected in the filtered dataset. Then from the filtered dataset, the unwanted columns are excluded while including only ISBN and variables of interest.

Figure 1: Distribution of Sample Sizes up to 10000 Rating Cou



2.2 Measurement

The meta-data of books and films are often used for predicting possible popularity while developing appropriate recommendations for books and film development to have higher potentiality of popularity. In order to examine the popularity of the book while considering the scope and limitation of the chosen dataset, this research considered the number of ratings given by the readers as the measure of the popularity of the book. The average rating of the book is measured by taking the average of the total ratings received by the readers. The readers have given a rating from 1 to 5, where 1 implies the lowest rating or lowest preference and 5 implies the highest rating or highest level of preference.

2.3 Outcome Variable

The outcome variable is the popularity of the book, which is measured by considering the column 'rating count', which indicates the total number of review ratings received by the consumers of the book. The higher number of ratings indicates the higher number of readers and the higher number of readers indicates the popularity of the book. Figure 2, represents that the outcome variable is distributed with an extremely right skewness.

2.4 Predictor Variables

The predictor variables are average ratings given by the reader with a decimal or float variable. The average rating of the book indicates the readers' preference for the book, which is an obvious predictor of the popularity of the book. The physical attributes of a book include physical attribute includes the number of pages in a book and the physical property of the cover. The publishing year represents the publication year of the book. The republication length indicates how old the original publication of this book is from its recent publication.

Figure 2: Distribution of Rating Count by Cover Type Without

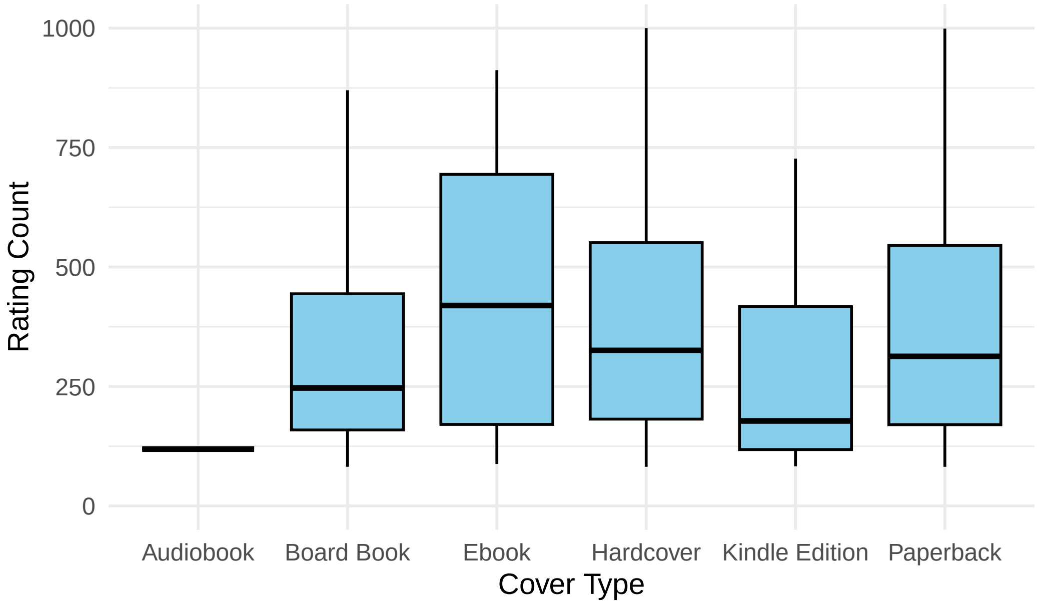


Figure 3: Scatter Plot of Rating vs. Rating Count up to 10000

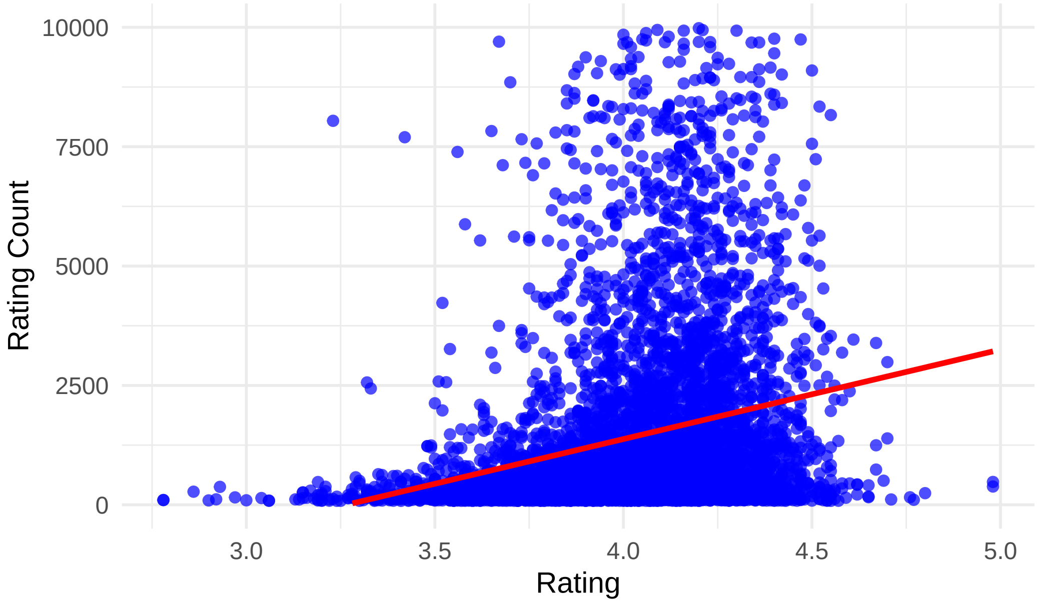


Figure 4: Scatter Plot of Publish year vs. Rating Count up to

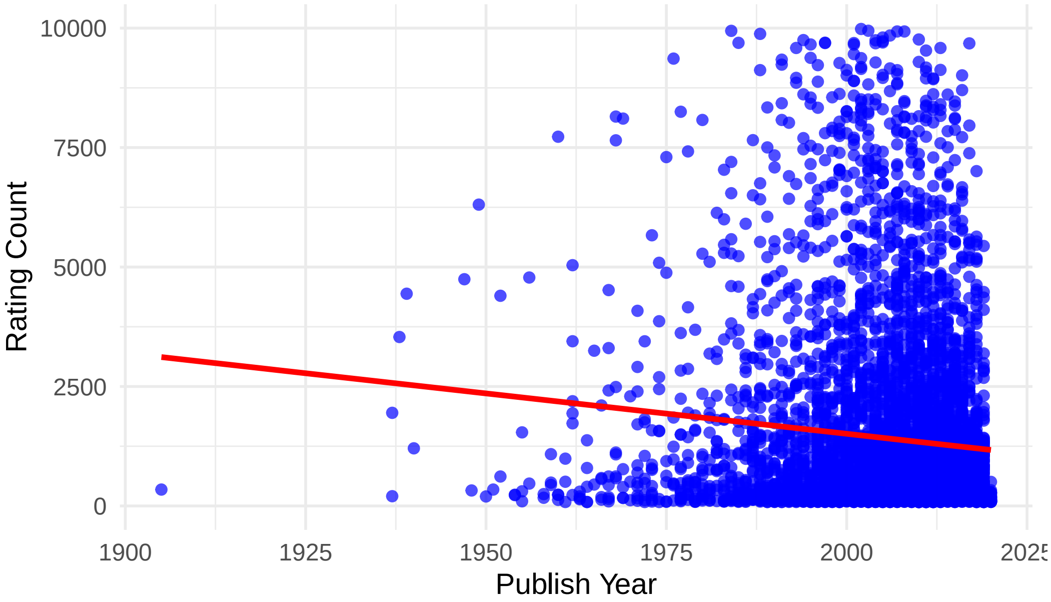


Figure 5: Scatter Plot of Pages vs. Rating Count up to 10000

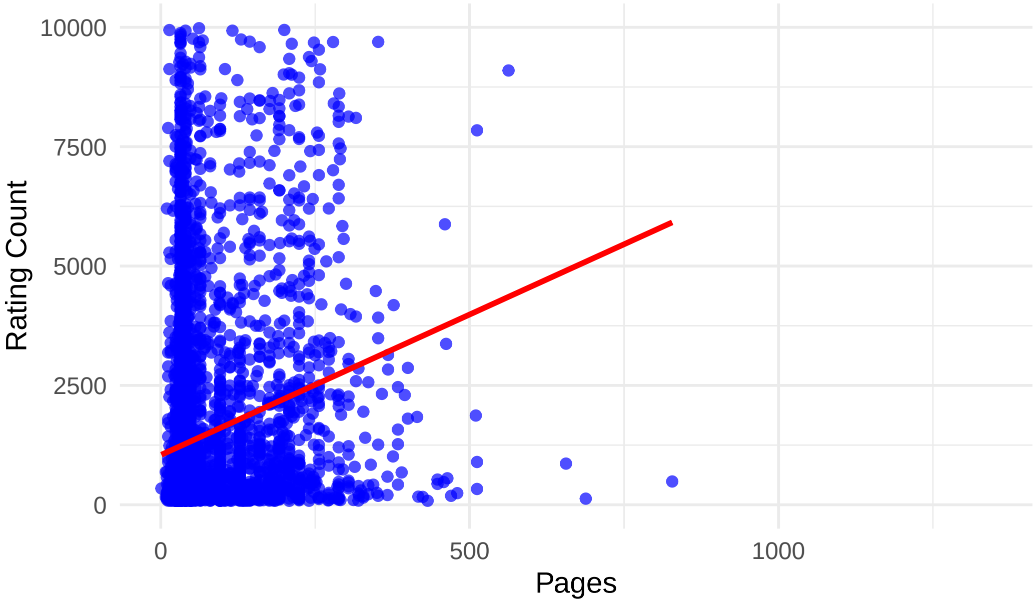
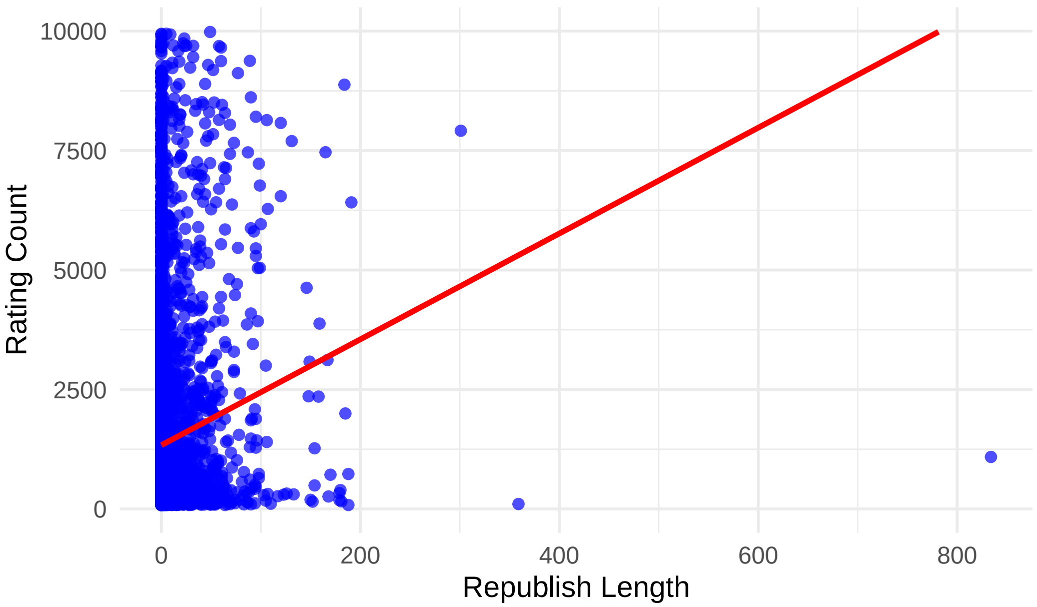


Figure 6: Scatter Plot of Republish Length vs. Rating Count



As per Figure 2, it can be seen that the average rating count and the distribution notably differ based on different cover types of the book, which indicates that the cover type could be a predictor of the received number of ratings. As per Figure 3, a positive correlation has been found from the trend line or linear regression line between Average Rating and Rating Count. There is a plausible association between the audience preference and the popularity of the book, which is also reflected in this scatter plot. A negative regression line or potentially negative association has been found in Figure 4, between the published year and rating count (popularity), which indicates the published year can be a predictor of popularity. As per Figure 5, a positive association has been found from the trend line or linear regression line between the number of pages in a book and the Rating Count, which makes the 'pages' a possible predictor of popularity. Figure 6: Indicates that Republish Length and Rating Count could have a positive association and linear relationship. Therefore, the Republish Length could be a potential predictor of popularity.

3 Model

3.1 Monte Carlo Simulation

The study used Monte Carlo Simulation to create a distribution of published children's books based on the distribution found in the chosen dataset to develop the productive model. The purpose of the simulated dataset is to explain the uncertainty of the popularity estimation by developing realistic children's book records with the predictor variables. For each book the estimated popularity or number of ratings have been developed denoted as $\widehat{yi}, j$, by adding a random error term $\epsilon i, j$ to the model's predicted popularity $\widehat{yi}$. The error term, $\epsilon i, j$, indicates the sampling variability which is drawn from a normal distribution $N(0, \sigma^2)$:

$$\hat{y}_{i,j} = \hat{y}_i + \epsilon_{i,j}$$

In each simulation, j, the simulated model calculated the count of ratings for a specific book, $\bar{y}_j$, by aggregating the simulated number of ratings:

$$\bar{y}_j = \frac{1}{n} \sum_{i=1}^{n} \hat{y}_{i,j}$$

The process was repeated 1000 times to develop the distribution of $\widehat{yi}, j$ which can forecast the possible popularity or received number of ratings for each simulated children's book.

3.2 Generalized Linear Model

GLM or generalized linear model has been used considering log-normal distribution. The Gaussian distribution with log-link has been used for GLM modelling. The multiple predictors have been described in the predictor section while the variable 'publish year' has been considered to control the yearly trend.

$\text{rating count} = \exp(\beta_0 + \beta_1 \cdot \text{publis year} + \beta_2 \cdot \text{republish length} + \beta_3 \cdot \text{pages} + \beta_4 \cdot \text{cover} + \beta_5 \cdot \text{rating})$

## GLM Model Assumptions

The assumptions for the GLM model of this research are: • The outcome variable 'reading count' has a distribution that falls under the exponential family • The relationship between each predictor and log-transformed outcome variable 'reading count' is linear • The observations are independent of each other • There is no high multi-collinearity within the predictors

4 Results

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=====================================================
                                 Model 1
-----------------------------------------------------
(Intercept)                                 29.77
                                          (316.09)
publish_year                                -0.02 ***
                                            (0.00)
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```
republish_length                            0.00 ***
                                           (0.00)
pages                                       0.00 ***
                                           (0.00)
as.factor(cover)Board Book                  4.29
                                         (316.01)
as.factor(cover)Ebook                       3.44
                                         (316.02)
as.factor(cover)Hardcover                   3.99
                                         (316.01)
as.factor(cover)Kindle Edition              3.36
                                         (316.01)
as.factor(cover)Paperback                   3.93
                                         (316.01)
rating                                      1.94 ***
                                           (0.30)
----------------------------------------------------
AIC                                    149481.19
BIC                                    149555.34
Log Likelihood                         -74729.60
Deviance                        8824916001884.52
Num. obs.                                6252
====================================================
*** p < 0.001; ** p < 0.01; * p < 0.05
```

From the GLM output, it has been found that the publishing year is a significant predictor with a negative effect size. It indicates that with the progression of the year the popularity of books reduced. The strongest predictor of rating count with significant positive effect size is rating. It shows, that having a higher average rating increases the popularity of children's books. Republish length is a significant predictor of the popularity of a book with a positive effect size. It indicates when a publisher republishes older books it increases the probability of having high popularity. The variable 'pages' is also a significant predictor of rating count or popularity with a positive effect size. It indicates that containing a higher number of pages in children's books increases popularity. However, the different types of cover do not have any significant effect on the rating count. It implies there is no direct relationship between the type of cover and the popularity of a children's book.

5 Discussion

5.1 Overview of Research and Results

In this study, the underlying factors that could have effects on the popularity of children's books have been examined using a generalized linear model. The study considered an already existing dataset on children's book ratings that also includes the physical attribute of the book, the publication details and readers' ratings with unique ISBNs published from the year 1905 to 2020. Through developing a predictive model for estimating the popularity of children's books, the study examined whether there are other attributes apart from the obvious factor such as user preference can contribute to higher popularity. The results indicate that the average rating of the books, the number of pages in the book, the publishing year and the length of republishing or the duration of republishing of the book from the original year have significant predictability to estimate the popularity of a children's books.

5.2 Implication and Significance

As per the conventional understanding of the print media, the audience review or audience likability of the product is the major predictor of the potentiality (Loh and Sun (2019)). This research highlights that not only the liability or average rating of the audience, the physical attributes such as the number of pages also major contributors to the popularity of the book. These findings will enable the publishers to consider the number of pages in a book to estimate its potential popularity. Besides, the study also highlights that older books which were originally published many years ago, can also have larger popularity than comparatively newly published books. The findings will enable publishers to focus on republishing older books to gain more popularity within the market of children's books.

5.3 Research Limitation

The major limitation of this research is associated with the limitation of the dataset of this study. The regression model that has been developed using the GLM method has low fitness and low predictability, which indicates that there are a considerable number of potential predictors and confounders which has not been considered in this study. The dataset of this study does not include information about the genre of the book and the target audiences, which could increase the accuracy of the predictability with a more critical understanding of the underlying factors of popularity. Besides, each continuous variable of this dataset consists of a large number of outliers, which has not been addressed in this dataset in order to avoid any predictive anomaly due to a lower sample size.

5.4 Conclusive Statement and Future Research

As per the findings of this study, it can be concluded that apart from the reader's preference or average of received ratings, the physical attribute namely the number of pages of a book can have a significant incremental effect on the popularity of the book. It can be also concluded that republishing older children's books could lead to higher popularity among readers. However, the predictability of popularity using the publishing details and physical attributes is not adequate, which requires more information regarding the book such as the genre of the book and target audience. In future research, the information regarding the genre of the book and target audience should be included as predicted. Besides, the outliers should be handled by future research while considering the cross-validation method and advanced machine learning methods such as neural networking for predicting the popularity of the book.

Appendix

.1 Alternative Model

In this research, the linear regression model using ordinary least squares was initially chosen for developing the prediction model. However, from an exploratory analysis of variables it was found that a large number of variables including outcome variables have a non-normal distribution that belongs to the exponential family. Therefore, a generalized linear model with log-normal link has been selected for this study.

.2 Observational Data

The author of the dataset Alex Cookson created the dataset of children's books with given ratings by the readers for empirical Bayes estimation of reader's ratings. The data collection process of the author of the dataset is not mentioned. However, this study collected the data from the GitHub data repository. The dataset includes all details as per the specific ISBN of the books. The dataset represents ratings of the readers of children's books, whereas each instance or record represents a single book with a specific ISBN. Each record contains character and numerical type data to represent the book title, publisher name, ratings, published year, page number and book cover type. The raw data consists of 9240 books with unique ISBN where the children's books that were published from 1905 to 2020 have been included.

.3 Sampling

All records within the children's book dataset of Alex Cookson have been included in this study using no selection criteria. Convenient sampling has been used for selecting all the available records within the selected dataset.

.4 Model Diagnosis

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GLM Model MSE: 1411534869
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GLM Model RMSE: 37570.4
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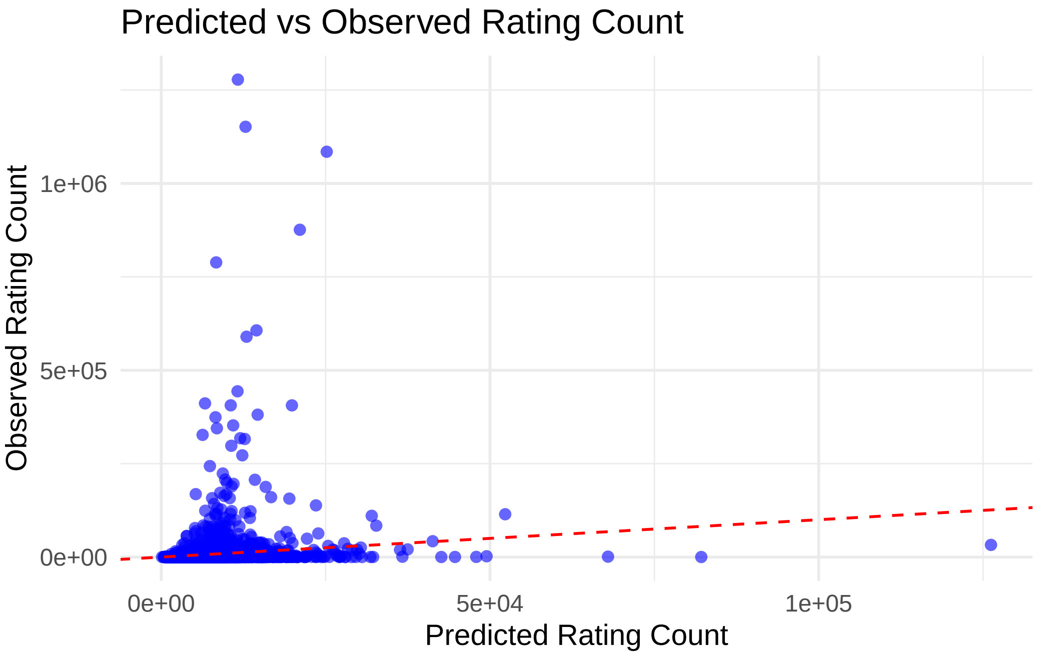
Predicted vs Observed Rating Count
Observed Rating Count
1e+06
5e+05
0e+00
0e+00
5e+04
1e+05
Predicted Rating Count

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