



Introduction

- We **aim** to find factors related to passengers' satisfaction with public transport to help operator to improve its service.
- The **data** are from [Scotland's official statistics](#). The theme of Transport contains seven datasets, [Road Transport Expenditure](#), [Public Transport](#), [Road Vehicles](#), [Concessionary Travel Cards](#), [Road Network and Traffic](#), [Travel to Work and Other Purposes](#). There are 460 observations of 24 variables in this research.

Methods

- Summarize table and density plots are illustrated to detect data patterns. The scatter and correlation plots are proposed to explore the relationship among variables. Potential factors are identified through **EDA**.
- The *Satisfaction* is the response variable, the *DateCode* is the control variable and others are independent variables. A **linear regression** model is applied as [Eq.\(1\)](#):

$$y = \beta_0 + \beta_1 x_1 + \dots + \beta_p x_p + \varepsilon \quad (1)$$

- Model diagnosis** are carried out to check model assumptions. **Stepwise regression** is applied to select variables with **AIC** as the criterion. Compare the selected model with full model on *adj R²*, AIC and BIC.
- The uncertainty of the parameters is determined via **bootstrap** method. The significant variables are verified and their 95% CI are estimated.

Results

Model diagnosis

[Fig.1](#) shows the regression diagnosis results of model1 with all variables.

- Residuals vs Fitted plot** (left top) shows that there is no systematic correlation between the residual value and the fitting value.
- Normal Q-Q plot** (right top) shows the points on the graph fall on a straight line with an angle of 45 degrees, which indicates the assumption of normality is not violated.
- Scale-location plot** (left bottom) displays the points around the horizontal line are randomly distributed. The invariant variance assumption is satisfied.
- Residuals vs leverage** (right bottom) figures out special observations.
- According to the correlation plot and VIF, there is obvious **multicollinearity** among variables.

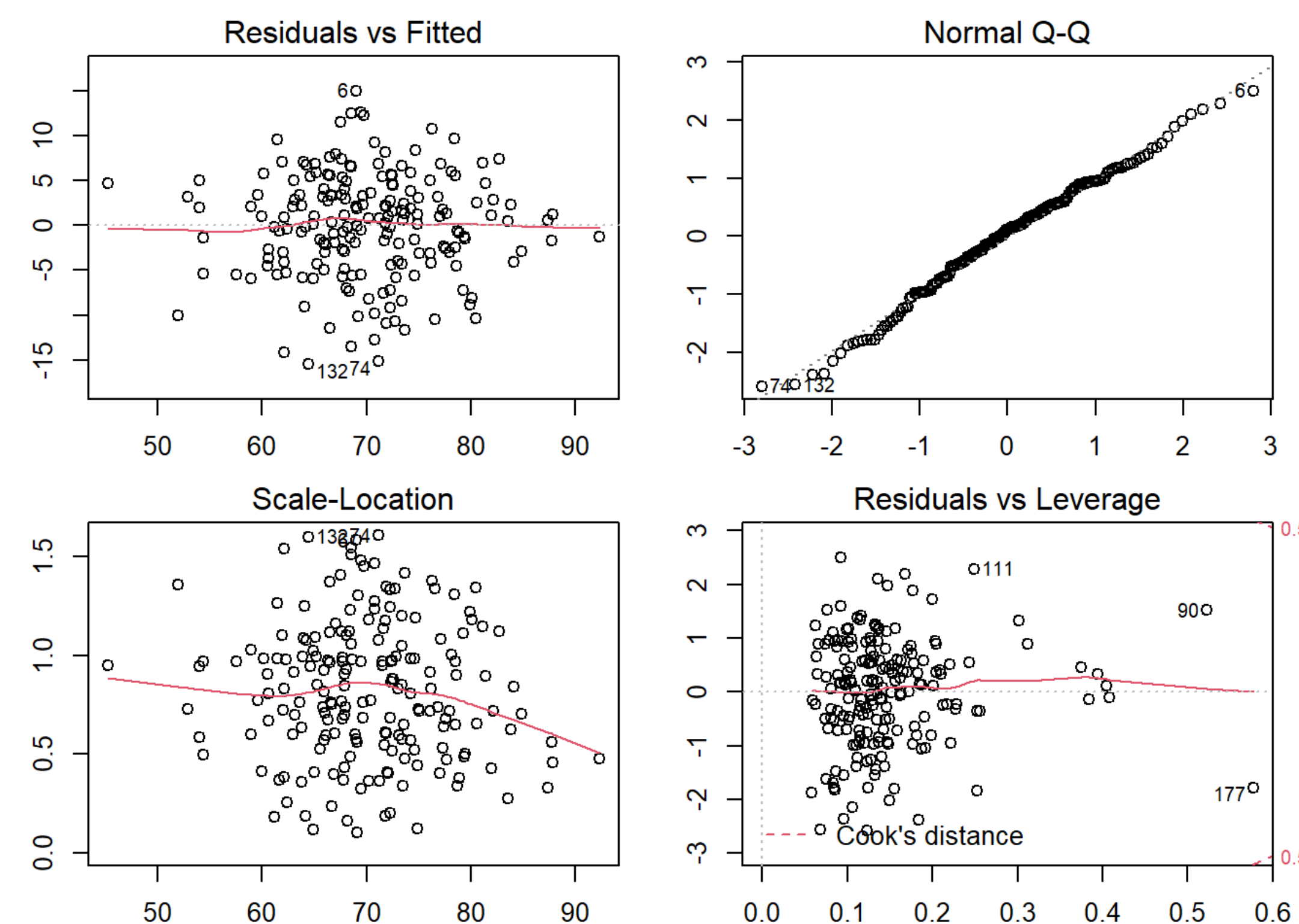


Figure 1: Regression diagnosis results

Stepwise regression

Stepwise regression technique is applied to model selection. The selected model is as [Table. 1](#).

Table 1: Model2, selected by Stepwise regression

term	estimate	std.error	statistic	p.value
(Intercept)	49.14	4.04	12.2	0.00
Cards	0.00	0.00	3.3	0.00
Repair	0.24	0.06	3.8	0.00
Work_Bus	0.86	0.10	8.3	0.00
School	-0.12	0.05	-2.6	0.01
Health	0.77	0.51	1.5	0.13
Work_Train	0.81	0.13	6.4	0.00
Train_Stations	-0.14	0.04	-3.3	0.00
Without_Car	0.10	0.07	1.4	0.15
Petrol_Diesel	-0.03	0.01	-2.2	0.03

The variables with high correlation are removed by stepwise regression.

Model comparison

Model2 has higher *adj R²* and smaller AIC and BIC compared with the model1 as [Table. 2](#).

Table 2: Comparison of model1 with model2 on adj R², AIC and BIC

model	adj.r.squared	AIC	BIC
model 1	0.55	1271	1366
model 2	0.56	1255	1310

Therefore the **model2** is better.

Bootstrap

To obtain robust results, a bootstrap is developed for the estimation of parameters. This process is repeated **1000** times.

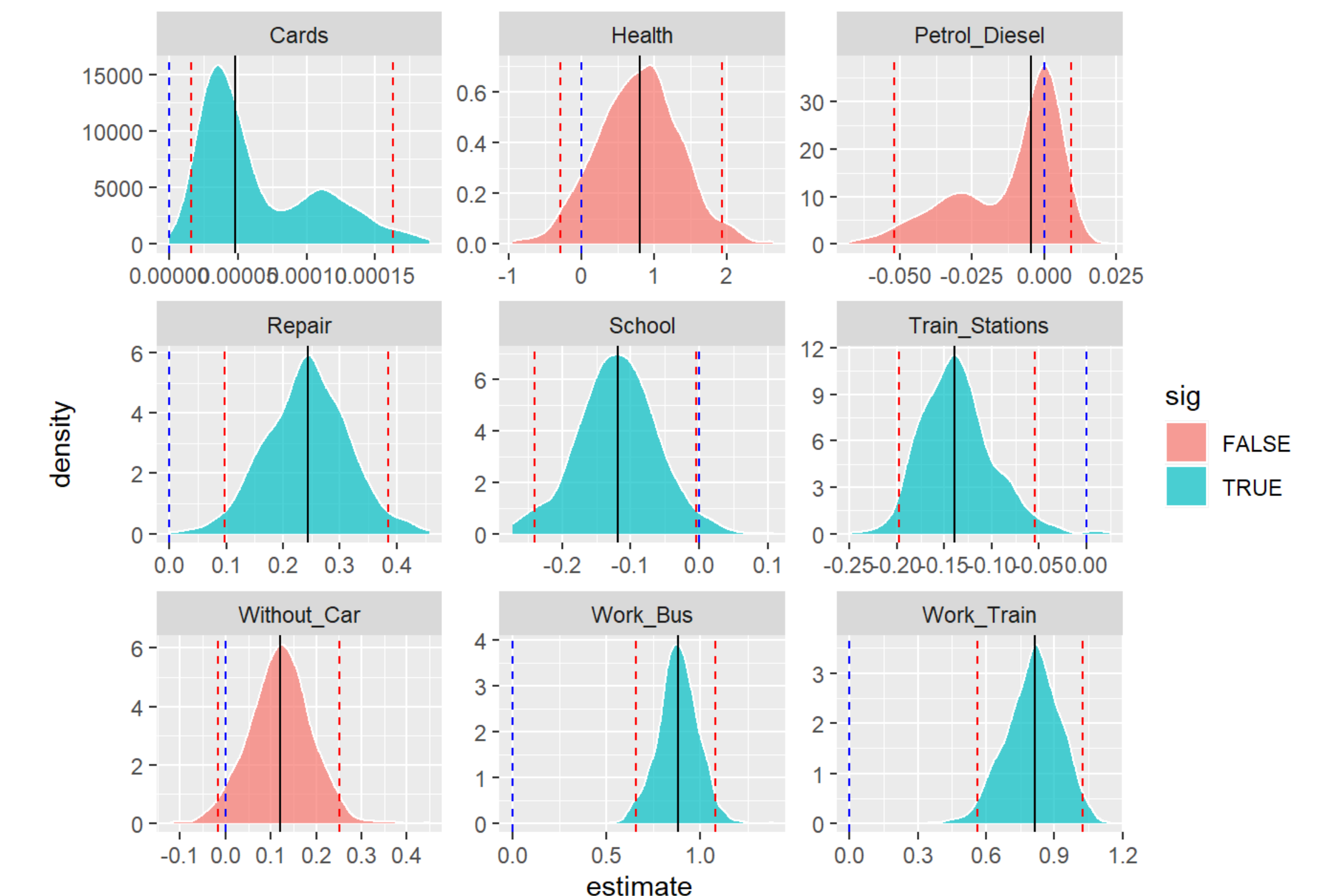


Figure 2: Density plots of parameters via bootstrap

The density plots of parameters are displayed in [Fig.3](#). The variables with orange are not significant while the variables with blue are significant at the $\alpha = 0.05$. The blue dashed lines are zero and the orange dashed lines are 95% CI of parameters.

Conclusion

- The variables **Cards** (*Number of concessionary cards issued to all adults*), **Repair** (*The Percentage of Roads Needing Repairs*), **Work_Bus** (*Bus Journeys To Work*) and **Work_Train** (*Train Journeys To Work*) have **positive** influence on satisfaction with public transport. The **School** (*Child Journeys To School By Walking/Cycling*) and **Train_Stations** (*Number of Train Stations*) have **negative** relationship with satisfaction with public transport.
- The reason that more roads needing repairs and less train stations come with higher satisfaction needs to be further explored.

References

- Jim Hester and Hadley Wickham, (2020). *fs: Cross-Platform File System Operations Based on 'libuv.'* R package version 1.5.0
- Kuhn et al., (2020). *Tidymodels: a collection of packages for modeling and machine learning using tidyverse principles.*
- Wickham et al., (2019). *Welcome to the tidyverse. Journal of Open Source Software*, e, 4(43), 1686