SHOULD WASHINGTON DC’S BIKESHARE REDUCE OPERATIONS IN WINTER?

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MOTIVATION

Bike-sharing systems contribute to reducing carbon dioxide emissions and improving health but must adapt to local demand patterns. Winter operations see significantly lower trip generation due to environmental factors, as noted in studies like Agency (2005) and Gotschi & Mills (2008). Understanding the impact of winter on bike usage can optimize resources while maintaining sustainability.

Our analysis focuses on Capital Bikeshare in 2011 during peak hours (5-6 PM and 8 AM), seeking to determine **whether reducing operations to reflect seasonal demand changes is reasonable for Bikeshare**, as supported by the broader evidence on climate impacts and bikeshare.

DATA COLLECTION

Biikeshare data: from the UCI Machine Learning Repository and originally compiled by Fanaee-T and Gama (2013); contains hourly bikeshare usage data from Washington DC’s Capital Bikeshare system for 2011.

Hourly weather data & holidays: from Freemeteo (2013); contains normalized temperature, humidity, and wind speed. Missing weather data was filled using the nearest available reports. Additionally, information on official holidays in Washington, D.C., provided by the Department of Human Resources (2013), was used to classify days as working or non-working.

The combined dataset captures key predictors such as weather, holiday, and seasonal variables, all of which are crucial for analyzing the impact of winter on bike usage during peak hours. Variables were normalized for consistency and are supported as reliable by multiple peer-reviewed studies (Beigi et al., 2022; Godavarthy & Taleqani, 2017; Fournier, Christofa, and Knodler, 2017). This makes the dataset suitable for investigating our research question.

METHODS OF ANALYSIS

We undertook the following steps in R to develop our final model:

1. Initial Model Specification
The initial model included hourly bike share usage during peak hours as the response variable and predictors such as winter dummy, working day dummy, normalized temperature, squared humidity, and wind speed.

2. Diagnostics & Assumptions Testing

- Linearity: Scatterplots of residuals vs. predictors found non-linearity in humidity, which we squared
- Constant Variance: Residual vs. fitted values plot [Figure 1] detected hetero-scedasticity in wind speed, which we log transformed
- Normality: Q-Q plot [Figure 2] revealed a peculiar deviation from normality, but the Box-Cox method prescribed no transformation (optimal lambda (~0.93) was close to 1)
- Multicollinearity: Variance Inflation Factors (VIFs) found no strong multicollinearity (all VIFs < 5).

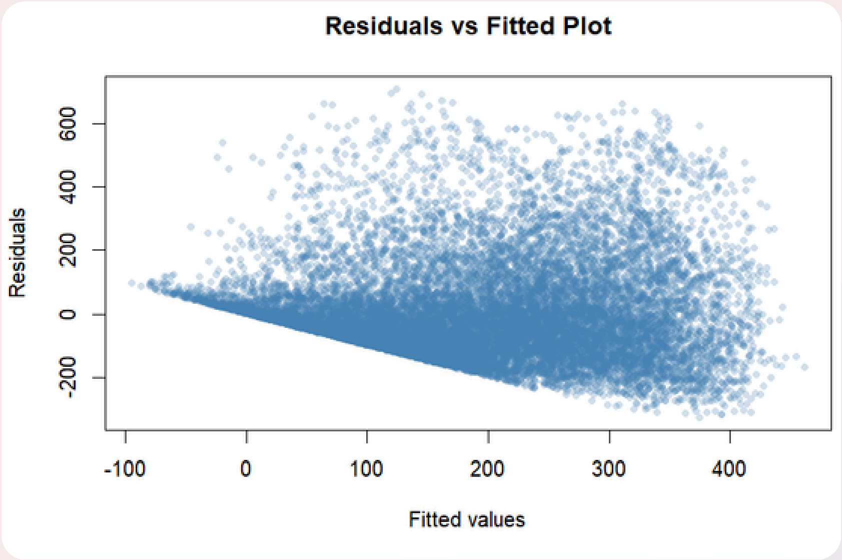

Figure 1: Residuals vs. Fitted Scatter Plot

3. Outlier Analysis
Cook’s Distance identified potential outliers, but further evaluation using hat values, DFBETAs, and DFFITS showed no observations with significant influence. Thus, we removed no data points.

4. Model Selection
Backward selection using the Bayesian Information Criterion (BIC) identified and removed non-significant predictors. For instance, the log-transformed wind speed variable was excluded.

5. Validation
We assessed the model’s performance with the F-test and adjusted R^2; the predictors were significant and explained about 70% of the variance in the response variable.

Thus, our final is:

$$\hat{cnt} = \beta_0 + \beta_1 is\_winter + \beta_2 workingday$$
$$+ \beta_3 temp + \beta_4 hum^2 + \epsilon$$

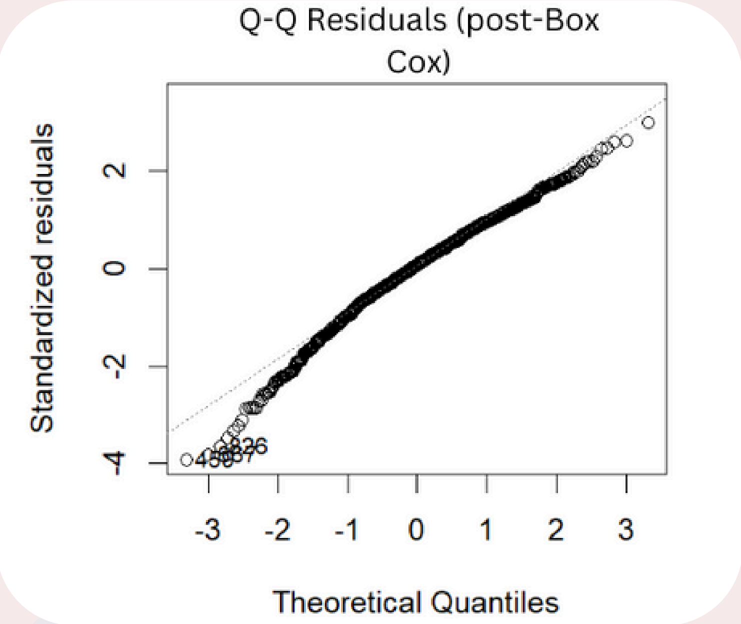

Figure 2: Q-Q Plot of Residuals

RESULTS AND CONCLUSION

Linear Model Summary: Coefficients Table

	Coefficients			
	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	204.4614	19.32459	10.58037	0
temp	391.1143	25.86640	15.12055	0
I(hum^2)	-212.5503	18.18510	-11.68815	0
is_winter	-140.5533	11.35115	-12.38231	0
I(workingday == 1)TRUE	322.3852	8.68873	37.10384	0

Table 1: Summary of Final Linear Regression Model Coefficients and Diagnostics

The two most impactful variables in peak hourly bike usage are is_winter and working day.

- **winter**: highlights how wintertime factors, like snow or ice blocking bike lanes, can discourage biking
- **working day**: emphasizes the role of cycling as a commuting option for Washington DC’s residents

Reducing bikeshare services during the wintertime is a reasonable response, but focusing on holiday services could be more effective.

LIMITATIONS

Single-year data from one city limits generalizability.

Residuals exhibited deviations from normality, and potential interaction terms (e.g., temperature × winter) were not included.

Expanding data scope across multiple years and cities and **including logical interaction terms** could improve the model.

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