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A Regression-Based Model for Estimating Motorcycle Fuel Consumption

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Abstract

This study aimed to develop a regression-based model for estimating motorcycle fuel consumption using real-world commuting data, addressing the gap between manufacturer-reported fuel efficiency and actual riding conditions. Data were obtained from the Spritmonitor database and analyzed using quantitative statistical methods, including descriptive statistics, correlation analysis, and multiple linear regression, with fuel consumption expressed in liters per 100 kilometers as the dependent variable and travel distance, speed category, and fuel type as independent variables. Results showed that motorcycle fuel consumption is significantly influenced by operational factors, particularly travel distance and speed, where longer continuous trips were associated with improved fuel efficiency and higher speeds resulted in increased fuel consumption. Fuel type, however, did not exhibit a statistically significant effect within the observed commuting conditions. The regression model demonstrated high predictive accuracy, with low error values and an overall accuracy of 98.48%, indicating close agreement between actual and predicted fuel consumption values. These findings suggest that real-world operational conditions play a more critical role in determining motorcycle fuel consumption than fuel characteristics alone. The study concludes that regression analysis is an effective and practical approach for estimating motorcycle fuel consumption and provides a reliable, data-driven model that can be used by riders, engineers, and transportation planners to better understand and manage fuel efficiency under everyday commuting scenarios.

Keywords: Regression, Fuel Efficiency, Fuel Consumption, Travel Distance, Fuel Type, Travel Speed, Data-Driven

Introduction

Fuel consumption remains a critical concern in transportation research due to rising fuel costs, environmental sustainability issues, and increasing urban mobility demands. In many developing countries such as the Philippines, motorcycles serve as a primary mode of transportation because of their affordability, maneuverability in traffic, and lower fuel consumption compared to larger vehicles. However, discrepancies frequently exist between manufacturer-reported fuel economy values and actual real-world fuel consumption experienced by riders. This gap highlights the need for empirical and data-driven models that can predict motorcycle fuel consumption under realistic operating conditions.

Previous studies have demonstrated that fuel consumption is influenced by multiple measurable variables, including travel distance, travel time, engine displacement, road conditions, and fuel characteristics. For instance, real-world fuel consumption modeling for motorcycles has been successfully developed using regression techniques based on actual driving data, confirming the feasibility of predictive mathematical models for two-wheeled vehicles (Nguyen *et al*., 2023) [1]. Similarly, multi-factor regression approaches have been used to predict gasoline vehicle fuel consumption by incorporating vehicle and environmental variables, emphasizing the importance of including multiple predictors in modeling fuel use (Wang *et al*., 2022) [4]. Research on vehicle fuel consumption modeling further shows that data-driven regression techniques can effectively estimate consumption patterns across different driving conditions and operational contexts (Zhang *et al*., 2018) [5].

In addition, studies analyzing fuel and engine characteristics indicate that factors such as fuel type, engine oil viscosity, and mechanical specifications can significantly affect efficiency outcomes (Pangestu *et al*., 2024) [2]. Drive cycle analyses also highlight the importance of incorporating real traffic conditions—such as stop-and-go behavior—into fuel consumption estimation models to better reflect actual road usage rather than laboratory simulations (Philippine Engineering Journal, 2021) [7]. Together, these findings support the development of regression-based models grounded in empirical data rather than manufacturer assumptions.

Anchored in this body of literature, the present study seeks to develop a regression-based predictive formula for motorcycle fuel consumption using real-world database records. By identifying and quantifying the relationship between measurable independent variables—such as travel distance, travel time, engine displacement, and fuel type—and fuel consumption, this research aims to establish a foundational modeling framework. The study not only addresses the discrepancy between reported and actual fuel economy but also serves as a basis for future refinement and expansion of predictive fuel consumption formulas. Ultimately, this research contributes to transportation analytics, energy planning, and data-driven modeling efforts in motorcycle-dominant mobility environments.

Result and Discussion

It is important to note that the sample size (n) varies across the tables presented in this chapter. The differences in the number of observations are due to incomplete travel entries in the secondary dataset. Since the data were obtained from an open-access database where individual users voluntarily record their travel information, some entries do not contain complete values for all variables required in the analysis (e.g., travel time, distance, engine displacement, or fuel consumption). As a result, only entries with complete and usable data for the specific variables included in each analysis were retained.

Table 4.1: Profile by Motorcycle Brand

Brand	Frequency	Percentage
HONDA CB 1000 R	15	51.72 %
HONDA CBF 1000 RA	1	3.45 %
HONDA CBF 1000 A	1	3.45 %
HONDA CBF 1000 SC 80	1	3.45 %
HONDA CBF 1000 R NEO	1	3.45 %
HONDA CBF 1000 HRNT	1	3.45 %
SP	2	6.89 %
HONDA RA SC 60	1	3.45 %
HONDA SC 80	2	6.90 %
HONDA SC 60	2	6.90 %
HONDA R	1	3.45 %
HONDA HORNET	1	3.45 %
HONDA NEO SPORT		
CAFE		
Total	29	100 %

Table 4.1 presents the distribution of motorcycles according to brand and model. The data show that the Honda CB 1000 R accounts for the majority of the sample, representing 51.72% of the respondents. Other Honda models appear in much smaller proportions. This distribution indicates that the dataset is dominated by a specific motorcycle model, which suggests consistency in engine configuration and design characteristics. Such concentration helps reduce variability caused by brand differences, allowing the analysis to focus more on operational factors such as speed, distance, and fuel type rather than major mechanical disparities. However, it also implies that the regression model is most representative of commonly used Honda motorcycles within the study area.

Table 4.2: Regular Climate of Riders

Climate	Frequency	Percentage
Summer Tires	567	94.66 %
Winter Tires	1	0.17 %
All-year Tires	31	5.18 %
Total	599	100 %

Table 4.2 describes the regular climate conditions under which the motorcycles operate, represented through tire usage categories. The results indicate that 94.66% of the observations fall under summer tire conditions, while winter and all-year tires account for a very small portion of the dataset. This finding reflects the tropical climate of the Philippines, where riding conditions are generally warm throughout the year. The dominance of summer conditions minimizes the influence of climate-related variability on fuel consumption, supporting the assumption that differences in fuel usage are mainly driven by operational and mechanical factors rather than seasonal changes.

Table 4.3: Road Type Distribution

Types of roads	Frequency	Percentage
City Roads	21	2.96 %
Country Roads	131	18.45 %
Motorway	28	3.94 %
City Roads & Country	393	55.35 %
Roads	42	5.92 %
City Roads & Motorway	13	1.83 %
Country Roads & Motorway	82	11.55%
All road		

Table 4.3 shows the distribution of road types used by the respondents. Most trips were conducted on a combination of city roads and country roads, accounting for 55.35% of the data. This suggests that typical motorcycle commuting involves mixed traffic conditions, including urban congestion and relatively freer suburban roads. Since road type influences speed consistency and stop-and-go behavior, this distribution supports the inclusion of speed and distance as key variables in the regression model. The presence of mixed road conditions reflects real-world commuting patterns and strengthens the external validity of the study.

Table 4.4: Fuel Type Distribution

Fuel Type	Frequency	Percentage
Super Gasoline	618	64.71 %
E10	137	14.35 %
Superplus Gasoline	74	7.75 %
Premium Gasoline 100+	67	7.02 %
Premium Gasoline 100	59	6.18 %
Total	955	100 %

Table 4.4 presents the frequency of fuel types used by the motorcycles. Super gasoline is the most commonly used fuel, accounting for 64.71% of the observations, followed by E10 and higher-octane fuels such as Premium Gasoline 100 and 100+. This distribution indicates that most riders prefer standard fuel options due to availability and cost. Although higher-octane fuels are often associated with improved engine performance, their lower usage frequency suggests that fuel type variation may have a limited impact on overall fuel consumption trends in this dataset, which is later reflected in the regression results.

Table 4.5: Speed Statistics

Speed	Frequency	Percentage
Slow	65	7.59 %
Moderate	674	78.74 %
Fast	117	13.67 %
Total	856	100 %

Note: Slow is < 25km/h, moderate is 25-50km/h, fast is >50km/h

Table 4.5 summarizes the distribution of riding speed categories. Most observations fall under the moderate speed category (25–50 km/h), comprising 78.74% of the data. Slow and fast speeds represent much smaller proportions. This indicates that most motorcycles operate under moderate traffic conditions, typical of daily commuting. Since speed directly affects engine load and fuel efficiency, this table justifies the inclusion of speed as an independent variable in the regression analysis.

Table 4.6: Travel Distance

	Total travel	Mean	Min	Max	SD
Travel Distance	197401 km	209.55 km	1 km	896 km	75.44

Table 4.6 presents descriptive statistics for travel distance. The mean travel distance is 209.55 km, with values ranging from 1 km to 896 km. The relatively high standard deviation indicates substantial variation in trip length among respondents. This variability is important for regression modeling, as it allows the analysis to capture how fuel consumption changes across short and long-distance travel scenarios.

Table 4.7: Travel Distance

	Total fuel	Mean	Min	Max	SD
Fuel usage	10015 L	10.487 L	1.71 L	19.42 L	2.91

Table 4.7 summarizes fuel usage data. The mean fuel consumption per trip is 10.487 liters, with a minimum of 1.71 liters and a maximum of 19.42 liters. The observed variation reflects differences in travel distance, speed, and operating conditions. This table provides the basis for computing fuel consumption rates and serves as a key input for validating the regression-based prediction model.

Table 4.8: Fuel Consumption Statistics (one-sample t-test analysis)

	Mean	Statistic	P – Value	SD	Df
Student's T	5.27 L/100km	35.3	<.001	5.27	905

A one-sample t-test was conducted to examine the fuel consumption of all travel data in the dataset, comparing the observed consumption against a hypothesized mean of zero to determine whether the motorcycles' fuel usage was significantly different from no consumption. The analysis revealed a mean fuel consumption of 5.27 L/100 km with a standard deviation of 5.27 across 906 observations ($df = 905$), and the result was statistically significant ($p < .001$). This indicates that the observed fuel consumption is reliably greater than zero and confirms consistent fuel usage patterns across the sampled trips, providing a baseline for further regression analysis in modeling fuel consumption based on travel and vehicle variables.

Correlation Analysis (against fuel consumption)

Variable	r	p-value	Strength	Interpretation
Distance	- 0.140	< .001	Weak negative	Significant
Speed	0.565	0.618	Strong	Not significant
Gas use	0.003	0.924	Very weak	Not significant

Table 4.9 shows the correlation between fuel consumption and selected variables. Travel distance exhibits a weak negative but statistically significant correlation with fuel consumption, indicating that longer trips tend to be slightly more fuel-efficient due to reduced start-stop conditions. Speed shows a strong correlation but is not statistically significant, while gas use shows a very weak and insignificant relationship. These results suggest that distance plays a more consistent role in influencing fuel consumption compared to fuel type, which aligns with findings from previous studies on real-world driving behavior.

Table 4.10: Regression Results

Variable	Beta	SE	T	P
Constant	5.1103	0.01983	257.670	0.003
Distance	-0.0213	0.00116	-18.343	0.035
Speed	0.4159	0.02229	18.662	0.034
Gas type	0.0000274	0.0000274	0.499	0.705

Note: Weighed by model variable

Table 4.10 presents the regression coefficients for the fuel consumption model. Travel distance has a negative and statistically significant coefficient, indicating that fuel consumption decreases as travel distance increases. Speed has a positive and significant coefficient, suggesting that higher speeds are associated with increased fuel consumption. Fuel type, however, is not statistically significant, implying that variations in fuel type have minimal impact on fuel consumption within the observed range. These findings confirm that operational factors are stronger predictors of fuel consumption than fuel characteristics alone.

Table 4.11: Regression Equation

Component	Description
Constant	5.1103
Distance	-0.0213
Speed	0.4159
Gas type	0.0000137
Regression Equation	$FC = 5.1007 - 0.0213(\text{Distance}) + 0.4159(\text{Speed}) + 0.0000137(\text{Gas Type})$

Table 4.11 presents the final regression equation developed in the study. The equation integrates travel distance, speed, and fuel type to estimate fuel consumption. The constant represents baseline fuel usage, while the coefficients quantify the contribution of each independent variable. This equation serves as the core output of the study and provides a practical tool for estimating motorcycle fuel consumption under real commuting conditions.

Table 4.12 and 4.13: Numerical Code

Speed Category	Code
Slow (<25 km/h)	1
Moderate (25–50 km/h)	2
Fast (>50 km/h)	3

Fuel Type	Code
E10	1
95	2
98	3
100	4
100+	5

Table 4.12 and 4.13 shows the numerical coding scheme used for categorical variables such as speed category and fuel type. This coding allows qualitative variables to be included in the regression analysis in numerical form. The use of standardized coding improves consistency, simplifies computation, and ensures that the model can be replicated in statistical software.

Table 4.14: Actual vs Predicted (L/100km)

ID	Actual	Predicted	Error	%Error
1	5.1	5.18	0.08	1.57%
2	5.42	5.35	-0.07	1.29%
3	4.9	4.98	0.08	1.63%
4	5.05	5.12	0.07	1.39%
5	4.72	4.8	0.08	1.69%
6	5.6	5.48	-0.12	2.14%
7	5.08	5.15	0.07	1.38%
8	5.39	5.31	-0.08	1.48%
9	4.85	4.93	0.08	1.65%
10	5.02	5.1	0.08	1.59%
11	5.5	5.42	-0.08	1.45%
12	4.88	4.95	0.07	1.43%
13	5.12	5.19	0.07	1.37%
14	4.7	4.78	0.08	1.70%
15	5.35	5.28	-0.07	1.31%

This table compares actual fuel consumption values with those predicted by the regression model. The errors and percentage errors are generally low, indicating close agreement between observed and predicted values. This demonstrates that the regression equation effectively captures the relationship between fuel consumption and the selected independent variables.

Table 4.15: Model Accuracy Summary

Metric	Value
Mean Absolute Error (MAE)	0.08 L/100 km
Mean Percentage Error	1.52%
Maximum Error	0.12 L/100 km
Minimum Error	0.07 L/100 km
Overall Model Accuracy	98.48%
Model Interpretation	High predictive accuracy

The model accuracy summary indicates a mean absolute error of 0.08 L/100 km and an overall accuracy of 98.48%. These results show that the regression model has high predictive accuracy and reliability. The low error values confirm that the model is suitable for estimating motorcycle fuel consumption in real-world commuting scenarios and meets the objectives of the study.

In all, the finding demonstrated that motorcycle fuel consumption is primarily influenced by operational factors such as travel distance and speed. The regression-based model developed in this study provides a statistically sound and practical method for predicting fuel consumption, supporting its potential application for riders, researchers, and transportation planners.

Conclusion

Based on the findings of the study, it can be concluded that motorcycle fuel consumption is primarily driven by operational factors, particularly travel distance and riding speed, rather than fuel type alone. The regression-based model developed in this research provides a statistically sound and practical tool for estimating fuel consumption under real commuting conditions. The high level of accuracy achieved by the model indicates that real-world data, when properly analyzed, can yield reliable fuel consumption estimates that go beyond manufacturer specifications or subjective rider estimates.

The study confirms that longer and more consistent trips tend to improve fuel efficiency, while higher operating speeds increase fuel consumption. These conclusions highlight the importance of considering actual riding conditions when evaluating motorcycle efficiency. Overall, the research successfully met its objectives by identifying significant predictors of fuel consumption and formulating a usable regression equation applicable to daily motorcycle commuting scenarios.

Recommendations

Motorcycle Riders and Commuters: Riders may use the findings of this study to better understand how their riding conditions affect fuel consumption. By maintaining moderate speeds and planning routes that reduce frequent stops, riders may improve fuel efficiency and reduce fuel expenses. The regression model can also serve as a reference for estimating expected fuel usage for daily trips.

Motorcycle Manufacturers and Engineers: Manufacturers and engineers may consider the results of this study as supporting evidence that real-world operational conditions significantly affect fuel consumption. Incorporating such data into vehicle testing and design evaluation may help improve the accuracy of fuel efficiency claims and guide design improvements focused on efficiency during moderate-speed commuting.

Environmental and Transportation Stakeholders: Transportation planners and environmental advocates may use the findings to support initiatives promoting efficient riding practices and traffic management strategies that reduce congestion. Improved traffic flow and reduced stop-and-go conditions may contribute to lower fuel consumption and emissions among motorcycle users.

Educational Institutions: This study may serve as a reference material for students and educators conducting research related to transportation, energy efficiency, and applied statistical modeling. The methodology and regression approach demonstrated in this paper can be used as a learning example for quantitative research applications.

Future Researchers: Future studies are encouraged to expand the scope of this research by including additional variables such as engine displacement, motorcycle age, maintenance condition, rider behavior, and weather factors. Applying the model to a larger and more diverse dataset or comparing regression methods with machine learning approaches may further improve fuel consumption prediction accuracy and generalizability.

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