**Project Report**

***Comparison of fuel efficiency among all the 2018 model vehicles under the Fuel Economy Guide***

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# Summary

1. **Context of the study**

This project aims to help the buyers to choose the most fuel-efficient vehicle. In this study, most of the data were collected from the handbook *Fuel Economy Guide*, issued by U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy and U.S. Environmental Protection Agency on the date of May 2, 2019. More analysis will be done by comparison of fuel efficiency among all the 2018 model vehicles under this guide, which is integrated with the following variables for each kind of vehicle: MPG in City, MPG in Hwy, combined MPG and annual fuel cost. The scenario indicated above illustrates the context of this study.

1. **Why was the data collected?**

The data were collected and used for the comparison of the fuel economy estimates and annual fuel cost estimates, so the buyer can realize that which kind of car is more fuel economy. This strategy not only can save money for the commuters, but also can reduce our dependence on petroleum. In addition, it can also contribute to reduce the climate change if buying a vehicle with better fuel economy. These reasons mentioned above demonstrates why the data were collected and analyzed.

1. **How was the data collected?**

Part of the data were collected from the Fuel Economy Guide and transferred into the software JMP Pro 10. More analysis of the data will be conducted in this software and generated more useful data. For example, the mean value of the Miles Per Gallon (MPG) and annual fuel cost for each kind of car will be calculated by the software of JMP Pro 10.

1. **High level summary of how the data was analyzed?**

After completing this project, the information will come out to be the answers for the following, but not limited to these questions:

1. Which manufacture’s car, in general, is the most fuel economy?
2. Which kind of transmission, in general, is the most fuel economy?
3. How much total difference of annual fuel cost between the most fuel economy vehicle and the least one?
4. Is there any correlation between the Manufacturer and the combined MPG?
5. Is there any correlation between the Carline and the combined MPG?
6. Is there any correlation between the Transmission and the combined MPG?
7. Can the combined MPG be determined by the Manufacture, Carline and Transmission?

|  |  |
| --- | --- |
| Item | Statistical Methodology |
| a | Distribution; Confidence Interval |
| b | Distribution; Confidence Interval |
| c | Statistical Characteristics |
| d | Oneway Analysis; Quantiles; |
| e | Oneway Analysis; Quantiles; |
| f | Oneway Analysis; Quantiles; |
| g | Oneway Analysis; Quantiles; Statistical Characteristics |

1. Conclusions & Analysis

After analyzing the data, it is easy to come to the following conclusions.

1. Which manufacture’s car, in general, is the most fuel economy?

According to the Oneway Analysis of Annual Fuel Cost by Manufacturer Name, the most fuel economy is Kia, which means the lowest median of the annual fuel cost is only 2050 USD. In addition, this also means the people buy Kia can get more possibility to lower the annual fuel cost. In contrast, the least fuel economy Manufacturer is Bugatti, which the median of the annual fuel cost is 5700 USD.

1. Which kind of transmission, in general, is the most fuel economy?

According to the Oneway Analysis of Annual Fuel Cost by different types of transmission, the most fuel economy transmission is Auto(AV-S7), which means the lowest median of the annual fuel cost is only 1475 USD. In addition, this also means the people buy this kind of transmission can get more possibility to lower the annual fuel cost. In contrast, the least fuel economy transmission is Auto (AM7), which the median of the annual fuel cost is 3800 USD.

1. How much total difference of annual fuel cost between the most fuel economy vehicle and the least one?

According to the different manufacture’s car, the total difference of annual fuel cost between the most fuel economy vehicle and the least one is 3650 USD, which is a huge amount of money.

According to the different types of transmission’s car, the total difference of annual fuel cost between the most fuel economy vehicle and the least one is 2325 USD, which is also a huge amount of money.

1. Is there any correlation between the Manufacturer and the combined MPG?

Yes, there is correlation between the Manufacturer and the combined MPG after Fit Model analysis, which is to check the Effect Tests by the source of different Manufacturer Name. The p-value is less than .0001, which indicates the Null Hypothesis that Manufacturer name does not affect to the Combined MPG is rejected. So it demonstrates that the Manufacturer name does affect to the Combined MPG.

1. Is there any correlation between the Carline and the combined MPG?

Yes, there is correlation between the Carline and the combined MPG after Fit Model analysis, which is to check the Effect Tests by the source of different Carline. The p-value is less than .0001, which indicates the Null Hypothesis that Carline does not affect to the Combined MPG is rejected. So it demonstrates that the Carline does affect to the Combined MPG.

1. Is there any correlation between the Transmission and the combined MPG?

Yes, there is correlation between the Transmission and the combined MPG after Fit Model analysis, which is to check the Effect Tests by the source of different types of Transmission. The p-value is less than .0001, which indicates the Null Hypothesis that different types of Transmission does not affect to the Combined MPG is rejected. So it demonstrates that the different types of Transmission does affect to the Combined MPG.

1. Can the combined MPG be determined by the Manufacture, Carline and Transmission?

Yes, the combined MPG can be affected by the Manufacture, Carline and Transmission after Fit Model analysis. The p-value is less than 0.0001, which indicates the Null Hypothesis that different Manufacture, Carline and Transmission does not affect to the Combined MPG is rejected. So this illustrates that the combined MPG can be affected by the Manufacturer, Carline and Transmission.

Generally speaking, it is quite complicated to do the comparison of the efficiency of Vehicles’ Fuel with different autos before conducting this project. In this study, the data was analyzed systematically and statistically, which presents the comparison of the Combined MPG and annual total cost determined by different Manufacture, Carline and Transmission, clearly and rigorously. It is quite useful for the customers to consider about this report before deciding to buy a car.

# Detailed statistical analysis

1. Which manufacture’s car, in general, is the most fuel economy? The following plot shows how the data analysis run and come out in order for solving the above problem.

**Oneway Analysis of Annual Fuel Cost By Manufacturer Name**



1. Which kind of transmission, in general, is the most fuel economy? The following plot shows how the data analysis run and come out in order for solving the above problem.

**Oneway Analysis of Annual Fuel Cost By Transmission**



1. Is there any correlation between the Manufacturer and the combined MPG? The following tables show how the data analysis run and come out in order for solving the above problem.

**Response Combined MPG**

| **Summary of Fit** | |
| --- | --- |
| RSquare | 0.228847 |
| RSquare Adj | 0.208446 |
| Root Mean Square Error | 5.132991 |
| Mean of Response | 22.30472 |
| Observations (or Sum Wgts) | 1165 |

**Analysis of Variance**

| **Source** | **DF** | **Sum of Squares** | **Mean Square** | **F Ratio** |
| --- | --- | --- | --- | --- |
| Model | 30 | 8866.647 | 295.555 | 11.2175 |
| Error | 1134 | 29878.177 | 26.348 | **Prob > F** |
| C. Total | 1164 | 38744.824 |  | <.0001\* |

**Effect Tests**

| **Source** | **Nparm** | **DF** | **Sum of Squares** | **F Ratio** | **Prob > F** |  |
| --- | --- | --- | --- | --- | --- | --- |
| Manufacturer Name | 30 | 30 | 8866.6474 | 11.2175 | <.0001\* |  |

1. Is there any correlation between the Carline and the combined MPG? The following tables show how the data analysis run and come out in order for solving the above problem.

**Response Combined MPG**

| **Summary of Fit** | |
| --- | --- |
| RSquare | 0.946177 |
| RSquare Adj | 0.87029 |
| Root Mean Square Error | 2.077865 |
| Mean of Response | 22.30472 |
| Observations (or Sum Wgts) | 1165 |

**Analysis of Variance**

| **Source** | **DF** | **Sum of Squares** | **Mean Square** | **F Ratio** |
| --- | --- | --- | --- | --- |
| Model | 681 | 36659.461 | 53.8318 | 12.4682 |
| Error | 483 | 2085.363 | 4.3175 | **Prob > F** |
| C. Total | 1164 | 38744.824 |  | <.0001\* |

**Effect Tests**

| **Source** | **Nparm** | **DF** | **Sum of Squares** | **F Ratio** | **Prob > F** |  |
| --- | --- | --- | --- | --- | --- | --- |
| Carline | 681 | 681 | 36659.461 | 12.4682 | <.0001\* |  |

1. Is there any correlation between the Transmission and the combined MPG? The following tables show how the data analysis and come out run in order for solving the above problem.

**Response Combined MPG**

| **Summary of Fit** | |
| --- | --- |
| RSquare | 0.293175 |
| RSquare Adj | 0.280188 |
| Root Mean Square Error | 4.894854 |
| Mean of Response | 22.30472 |
| Observations (or Sum Wgts) | 1165 |

**Analysis of Variance**

| **Source** | **DF** | **Sum of Squares** | **Mean Square** | **F Ratio** |
| --- | --- | --- | --- | --- |
| Model | 21 | 11359.001 | 540.905 | 22.5757 |
| Error | 1143 | 27385.823 | 23.960 | **Prob > F** |
| C. Total | 1164 | 38744.824 |  | <.0001\* |

**Effect Tests**

| **Source** | **Nparm** | **DF** | **Sum of Squares** | **F Ratio** | **Prob > F** |  |
| --- | --- | --- | --- | --- | --- | --- |
| Transmission | 21 | 21 | 11359.001 | 22.5757 | <.0001\* |  |

1. Can these data determine the best combined MPG according to the Manufacture, Carline and Transmission? The following table shows how the data analysis run in order for solving the above problem.

| **Summary of Fit** | |
| --- | --- |
| RSquare | 0.953648 |
| RSquare Adj | 0.883218 |
| Root Mean Square Error | 1.971595 |
| Mean of Response | 22.30472 |
| Observations (or Sum Wgts) | 1165 |

**Analysis of Variance**

| **Source** | **DF** | **Sum of Squares** | **Mean Square** | **F Ratio** |
| --- | --- | --- | --- | --- |
| Model | 702 | 36948.943 | 52.6338 | 13.5403 |
| Error | 462 | 1795.881 | 3.8872 | **Prob > F** |
| C. Total | 1164 | 38744.824 |  | <.0001\* |

**Lack Of Fit**

| **Source** | **DF** | **Sum of Squares** | **Mean Square** | **F Ratio** |
| --- | --- | --- | --- | --- |
| Lack Of Fit | 239 | 783.7145 | 3.27914 | 0.7225 |
| Pure Error | 223 | 1012.1667 | 4.53886 | **Prob > F** |
| Total Error | 462 | 1795.8811 |  | 0.9932 |
|  |  |  |  | **Max RSq** |

**Effect Tests**

| **Source** | **Nparm** | **DF** | **Sum of Squares** | **F Ratio** | **Prob > F** |  |
| --- | --- | --- | --- | --- | --- | --- |
| Manufacturer Name | 30 | 0 | 0.000 | . | . | LostDFs |
| Carline | 681 | 650 | 19636.332 | 7.7716 | <.0001\* | LostDFs |
| Transmission | 21 | 20 | 289.481 | 3.7235 | <.0001\* | LostDFs |

# APPENDIX

**Variables**

|  |  |
| --- | --- |
| **Variable Name** | **What the variable represents** |
| MPG in City | Miles Per Gallon(MPG) for the vehicle driving in city roads |
| MPG in Hwy | Miles Per Gallon(MPG) for the vehicle driving in highway |
| Combined MPG | The overall Miles Per Gallon (MPG) for the vehicle driving in both of local roads (55%) and highway(45%) |
| Annual Fuel Cost | Annual total fuel cost for a vehicle (Assumption of travelling 15,000 miles per year and that fuel costs 2.58USD/gallon for regular unleaded gasoline) |

**Reference**

1. *Fuel Economy Guide, Published by U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy and U.S. Environmental Protection Agency, May 2,2019.*