

# **Two Way ANOVA Based on Customer Satisfaction Between Class and Punctuality of Airline Travels**

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**Word Count: 1486**

# **Two Way ANOVA Based on Customer Satisfaction Between Class and Punctuality of Airline Travels**

## **Introduction**

This report is based on an undertaking of data analysis, performed on data collected from questionnaires completed by customers about airline travel satisfaction<sup>2</sup>. There were 129980 respondents of this survey.

## **Data Description**

The purpose of the original data was to observe people's satisfaction levels of airline travel across 14 different variables – inflight wifi service, departure/arrival time convenience, ease of online booking, gate location, food and drink, online boarding, seat comfort, inflight entertainment, onboard service, leg room service, baggage handling, check in service, inflight service and cleanliness. The data also provided information about departure delay in minutes, arrival delay in minutes, satisfaction, gender, customer type, age, type of travel, customer class and flight distance. Of particular note – customer class had three categories – eco, eco plus and business.

## **Background**

This report refers to a study on that data whereby analysis was conducted, specifically Two Way ANOVA, in order to gain some valuable insights on the overall satisfaction of customers on the basis of class and punctuality of the airline. Specifically, the questions to be answered were whether punctuality had an impact on customer satisfaction, class had an impact on satisfaction, and whether there was a significant interaction effect between the two.

## **Data Alteration**

Initially, the data was loaded into Python, where some data cleaning was undertaken. All of the data to be analysed required alteration. Specifically, two new columns were created – “Mean Satisfaction Level” and “Punctuality”. Customer class remained and was slightly altered to merge economy class and economy plus class. This left two values – Economy and Business.

Punctuality was calculated by summing the departure delay and arrival delay to gain a variable for overall delay in minutes. As the minimum of each variable was 0, it was concluded that there was no data on early flights, or that there were no early flights. The total delay was then processed into four categories – “on time”, which was where the overall delay was less than 30 minutes, “slightly late”, which was between 10 minutes and 1 hour, “late” which was between 1 hour and 2 hours and “very late” which was over 2 hours. These then made the other four values – On Time, Slightly Late, Late and Very Late.

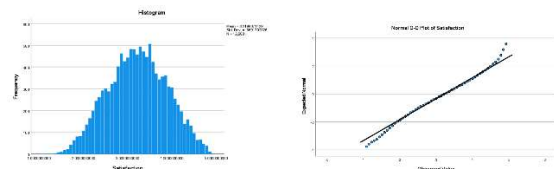
Mean Satisfaction Level was calculated by taking the mean of the 14 variables mentioned above. This resulted in a new variable to be used for the calculation of Two Way ANOVA. This became the dependent variable. All variables were deleted except for the three variables to be analysed. The data was then sampled using simple random sampling, allowing for ease of data loading and manipulation, whilst allowing for an equal sample size. Simple random sampling was necessary as over half of all flights had a total delay of 0, causing issues with stratified random sampling. There were 1500 samples in each group Class-Punctuality, for a total of 12000 samples.

## **Assumptions**

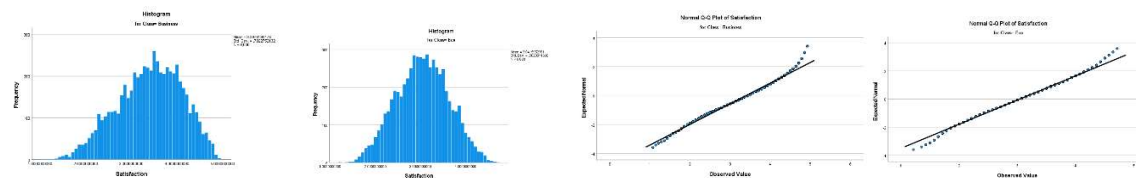
Some tests were run to ensure that the data met the assumptions required. Specifically, there were tests for homogeneity of variance, significant outliers and normality.

There were issues with normality. The histograms were bell shaped and appear normal, there were issues with normality in statistical tests. Particularly, there were issues regarding the Kolmogorov-Smirnov tests, as the data did not pass. However, Two Way ANOVA requires only approximately normal data. Furthermore, the data does all follow a distribution similar to normal distribution, and all QQ plots are roughly straight. In addition, the data had lower levels of skewness, kurtosis being more impactful.

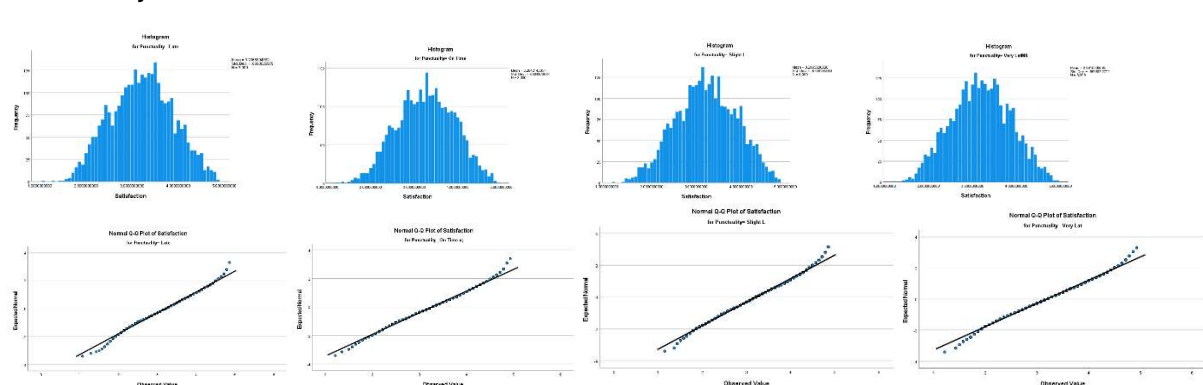
## All Data



## Class



## Punctuality



Specifically, the data had:

- Skewness = (-0.036), and kurtosis = (-0.504) for All Data.
- Skewness = (-0.285, -0.028), and kurtosis = (-0.482, -0.434) for Class.
- Skewness = (-0.007, -0.063, -0.062, -0.006), and kurtosis = (-0.530, -0.498, -0.485, -0.497) for Punctuality.

Hence, it was proceeded on the basis that the data was approximately normal.

From the histograms, the data also had no significant outliers. Hence it was proceeded on the basis that the assumption of having no significant outliers was accepted.

Then, the assumption of homogeneity of variance was tested. There were also issues with the statistical test for homogeneity of variance. In particular, Levene's spread test did not pass. However, the descriptive statistics show that all of the data has a similar level of variance:

- Variances = (0.448) for All Data.
- Variances = (0.493, 0.399) for Class.

- Variances = (0.499, 0.431, 0.461, 0.488) for Punctualities.

Hence, it was proceeded on the basis that the data had homogeneity of variance.

However, as a caveat to having some issues regarding normality and homogeneity of variance in the statistical tests, the significance level for the test was set at 0.025, to mitigate the risks of non-normality and non-homogeneity of variance from the statistical tests.

## Results

The Two-Way ANOVA test was conducted. The hypotheses were set out as follows:

- Class
  - o  $H_{a0}$ : there is no difference between the means of different classes.
  - o  $H_{a1}$ : there is a difference between the means of different classes.
- Punctuality
  - o  $H_{b0}$ : there is no difference between the means of different punctualities.
  - o  $H_{b1}$ : there is no difference between the means of different punctualities.
- Interaction
  - o  $H_{c0}$ : there is no interaction effect on the means of different classes and punctualities.
  - o  $H_{c1}$ : there is a interaction effect on the means of different classes and punctualities.
- $\alpha = 0.025$ .

The Two Way Anova test concluded that there was a significant difference between classes and punctualities, but that there was no significant interaction effect. Therefore,  $H_{a0}$  and  $H_{b0}$  were rejected, and  $H_{c0}$  failed to be rejected.

There was a significant difference between classes ( $F_{\text{stat}} = 915.496$ ,  $p < 0.001$ ). From the means, the Business class had a significantly higher satisfaction level than the Economy class. This was calculated at 100 % power.

There was a significant difference between Punctuality ( $F_{\text{stat}} = 7.182$ ,  $p < 0.001$ ), calculated at 96.8% power. A Tukey Post Hoc test was subsequently carried out to evaluate specific differences between Punctualities. On Time flights had a significantly higher level than other late flights:

- On Time ( $\mu = 3.264$ )
- Slightly Late ( $\mu = 3.217$ )
- Late ( $\mu = 3.207$ )
- Very Late ( $\mu = 3.191$ )

Individually, there were significant differences between:

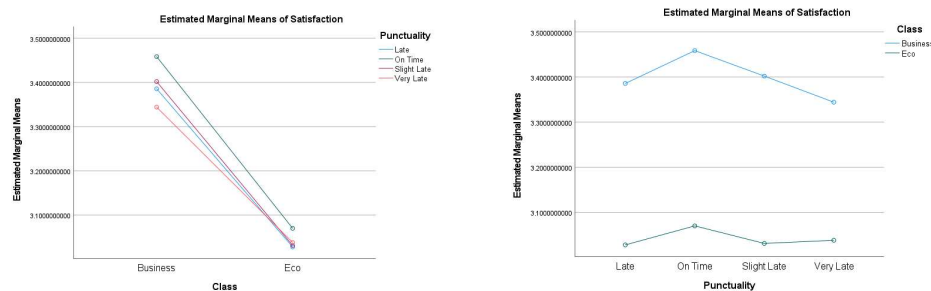
- On Time-Slightly Late ( $\mu_1 - \mu_2 = 0.0477$ ,  $p = 0.022$ ).
- On Time-Late ( $\mu_1 - \mu_2 = 0.0575$ ,  $p = 0.003$ ).
- On Time-Very Late ( $\mu_1 - \mu_2 = -0.0732$ ,  $p < 0.001$ ).

It was found that there was no significant differences between:

- Slightly Late-Late ( $\mu_1 - \mu_2 = 0.0098$ ,  $p = 0.935$ ).

- Slightly Late-Very Late ( $\mu_1 - \mu_2 = 0.0255$ ,  $p = 0.419$ ).
- Late-Very Late ( $\mu_1 - \mu_2 = -0.0157$ ,  $p = 0.782$ ).

There was no significant interaction effect between Class and Punctuality ( $F_{\text{stat}}=2.274$ ,  $p = 0.078$ ), calculated at 46.6% power. The estimated marginal means plot showed that there was some intersection between the mean plots, however this is mitigated by the slope of these lines, which is near parallel, and the extent to which these lines are close to each other. The second plot shows that the lines are very close to parallel.



In summary, a Two Way ANOVA test was carried out to test for the differences between satisfaction levels amongst different classes of airline travel, different punctualities of the airlines, and the interaction effect between class and punctuality. It was found that passengers in business class had a significantly higher satisfaction level than those of economy class. It was found that planes that arrived on time had passengers with a significantly higher satisfaction level than passengers with planes that were late. However, the extent to which those planes were late did not have a significant impact on customer satisfaction. This test was calculated with 96.6% statistical power. Furthermore, there was no significant interaction effect between classes and economy on passenger satisfaction, however this should be caveated with there being some intersection between the plots, and that the test had only 46.6% statistical power. Thus, it showed that the impact that class had on satisfaction level was independent of the punctuality of the plane, and similarly punctuality was independent of class.

As a brief aside, some flaws in this test should be noted:

- Taking the mean of 14 variables is a bit clunky, as this may not give a necessarily true representation of the overall satisfaction of a customer, as certain variables may matter more than others. For example, an elderly person may care much more about cleanliness than wifi service. This was something that just needed to be accepted within the data.
- Simple random sampling is imperfect, and did not allow for an accurate representation of the group sizes. From the population pool, there were 100000 entries with that were on time. There were 1000 planes that were slightly late, late, and very late, with all of these entries being roughly evenly split into business and economy tickets. This disparity was smoothed by simple random sampling, but didn't give a perfect reflection.

## Bibliography

<https://www.kaggle.com/datasets/binaryjoker/airline-passenger-satisfaction>