

Assignment-based Subjective Questions

1. From your analysis of the categorical variables from the dataset, what could you infer about their effect on the dependent variable? (3 marks)

Answer: Here are some conclusions I drew from looking at the information about bike rentals in the dataset:

- Fall is the best time to rent bikes, followed by summer, because the weather conditions are ideal for biking, and the median number of rentals is highest in fall.
- The median number of bike rentals is increasing each year, with 2019 having a higher median than 2018. This could be because bike rentals are becoming more popular, and people are becoming more environmentally conscious.
- The overall pattern in the monthly plot reflects the seasons, with fall months having a higher median for bike rentals.
- More people rent bikes on non-holidays compared to holidays, possibly because they prefer spending time with family on holidays and use their personal vehicles instead of renting bikes.
- While the overall median rental is the same for all days, the spread is larger on Saturdays and Wednesdays. This might indicate that people with plans for Saturday may not rent bikes since it's a non-working day.
- The median number of rentals is similar for working and non-working days, but the spread is larger for non-working days. This suggests that people on non-working days may have plans and choose not to rent bikes.
- Clear weather is the most favorable condition for bike rentals, as the temperature is optimal, humidity is low, and the temperature is lower..

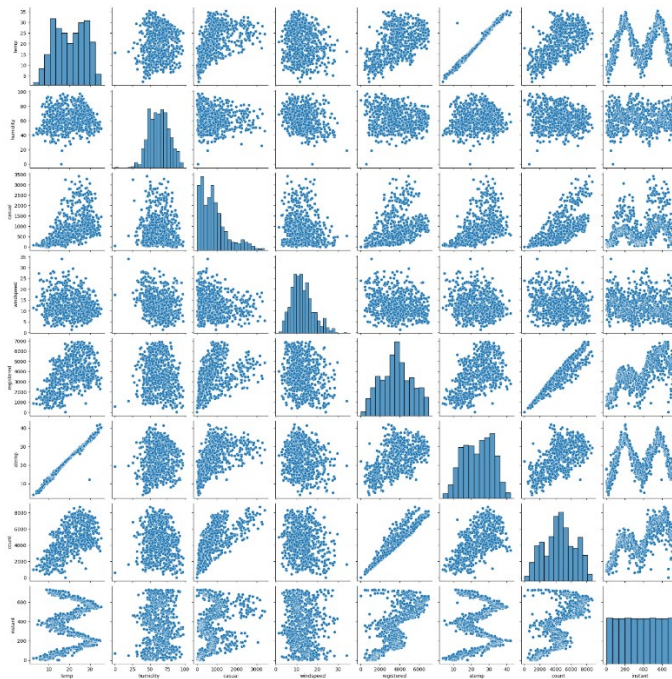
2. Why is it important to use `drop_first=True` during dummy variable creation? (2 mark)

Answer: Not using `drop_first=True` would make the dummy variables correlated to each other and hence, redundant, which is not expected of our analysis.

To explain this further. . A variable with n levels can be represented by $n-1$ dummy variables. So, if we remove the first column then also, we can represent the data. If the value of variable from 2 to n is 0, it means that the value of 1st variable is 1.

3. Looking at the pair-plot among the numerical variables, which one has the highest correlation with the target variable? (1 mark)

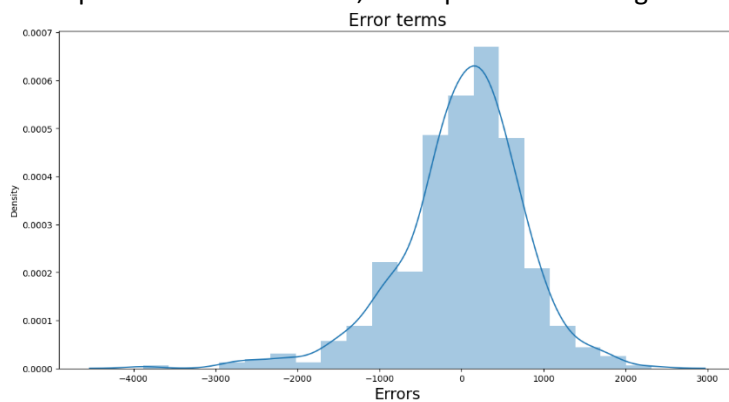
Answer: *atemp* and *temp* has the highest correlation with the target variable, as is evident from the pair plot



4. How did you validate the assumptions of Linear Regression after building the model on the training set? (3 marks)

Answer:

One of the fundamental assumptions of a linear regression model is that the error terms should correspond to a normal curve, when plotted on histogram



5. Based on the final model, which are the top 3 features contributing significantly towards explaining the demand of the shared bikes? (2 marks)

Answer:

The top 3 features directly influencing the count are the features with highest coefficients. These are: Temp, Year (positively influencing) and snowy and rainy weather (negatively influencing).

General Subjective Questions

1. Explain the linear regression algorithm in detail. (4 marks)

Answer: Linear Regression is a machine learning algorithm which is based on **supervised learning** category. It finds a best linear-fit relationship on any given data, between independent (Target) and dependent (Predictor) variables. In other words, it creates the best straight-line fitting to the provided data to find the best linear relationship between the independent and dependent variables. Mostly it uses **Sum of Squared Residuals Method**.

Linear regression is of the 2 types:

i. **Simple Linear Regression:** It explains the relationship between a dependent variable and only one independent variable using a straight line. The straight line is plotted on the scatter plot of these two points.

Formula for the Simple Linear Regression:

$$Y = \beta_0 + \beta_1 X_1 + \epsilon$$

ii. **Multiple Linear Regression:** It shows the relationship between one dependent variable and several independent variables. The objective of multiple regression is to find a linear equation that can best determine the value of dependent variable Y for different values independent variables in X. It fits a 'hyperplane' instead of a straight line.

Formula for the Multiple Linear Regression:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_p X_p + \epsilon$$

The equation of the best fit regression line $Y = \beta_0 + \beta_1 X$ can be found by the following two methods:

- Differentiation
- Gradient descent

We can use statsmodels or SKLearn libraries in python for the linear regression.

2. Explain the Anscombe's quartet in detail. (3 marks)

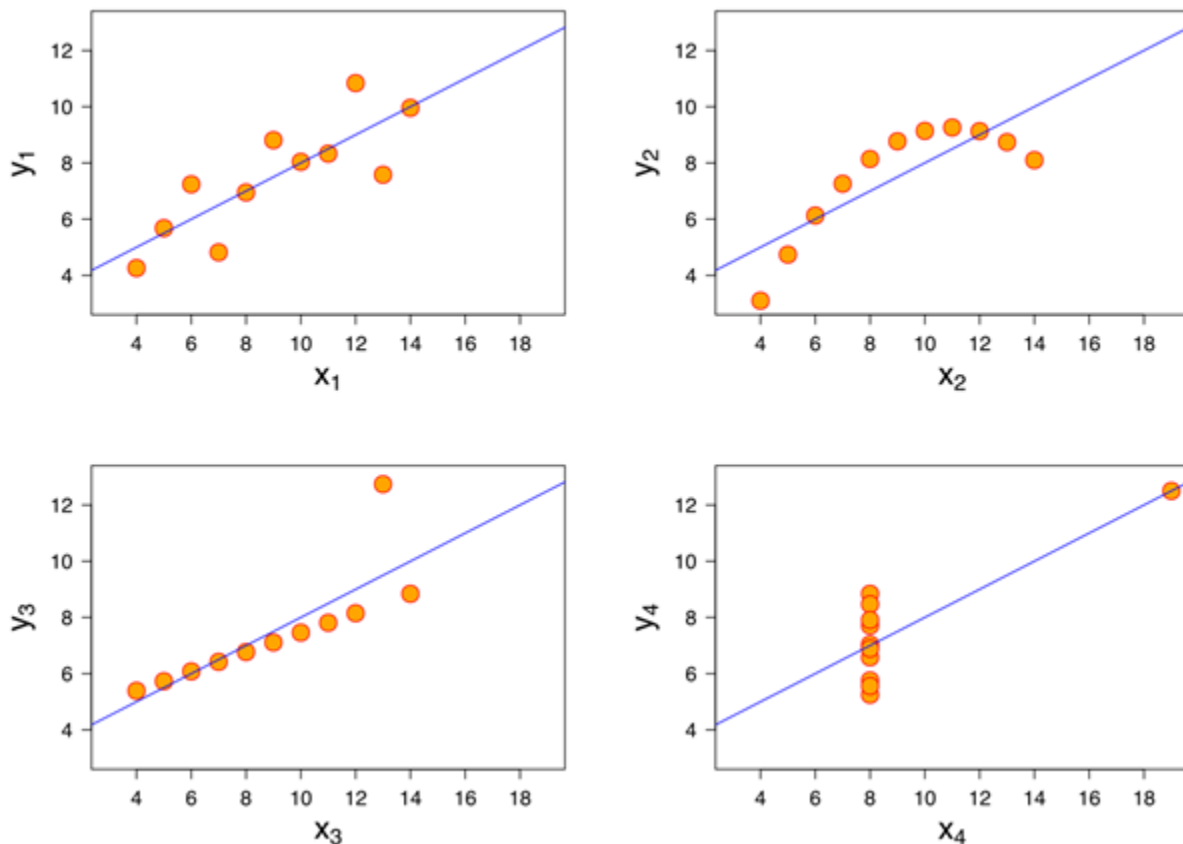
Answer: Anscombe's Quartet was developed by statistician **Francis Anscombe**. This is a method which keeps four datasets, each containing eleven (x, y) pairs. The important thing to note about these datasets is that they share the same descriptive statistics. Each graph tells a different story irrespective of their similar summary statistics. Below is the glimpse of the statistics of the 4 datasets:

	I		II		III		IV	
	x	y	x	y	x	y	x	y
	10	8,04	10	9,14	10	7,46	8	6,58
	8	6,95	8	8,14	8	6,77	8	5,76
	13	7,58	13	8,74	13	12,74	8	7,71
	9	8,81	9	8,77	9	7,11	8	8,84
	11	8,33	11	9,26	11	7,81	8	8,47
	14	9,96	14	8,1	14	8,84	8	7,04
	6	7,24	6	6,13	6	6,08	8	5,25
	4	4,26	4	3,1	4	5,39	19	12,5
	12	10,84	12	9,13	12	8,15	8	5,56
	7	4,82	7	7,26	7	6,42	8	7,91
	5	5,68	5	4,74	5	5,73	8	6,89
SUM	99,00	82,51	99,00	82,51	99,00	82,50	99,00	82,51
AVG	9,00	7,50	9,00	7,50	9,00	7,50	9,00	7,50
STDEV	3,32	2,03	3,32	2,03	3,32	2,03	3,32	2,03

The summary statistics show that the means and the variances were identical for x and y across the groups:

- Mean of x is 9 and mean of y is 7.50 for each dataset.
- Similarly, the variance of x is 11 and variance of y is 4.13 for each dataset
- The correlation coefficient (how strong a relationship is between two variables) between x and y is 0.816 for each dataset

When we plot these four datasets on an x/y coordinate plane, we can observe that they show the same regression lines as well but each dataset is telling a different story:



- Dataset I appears to have clean and well-fitting linear models.
- Dataset II is not distributed normally.
- In Dataset III the distribution is linear, but the calculated regression is thrown off by an outlier.
- Dataset IV shows that one outlier is enough to produce a high correlation coefficient.

This quartet emphasizes the importance of visualization in Data Analysis. Looking at the data reveals a lot of the structure and a clear picture of the dataset.

Additionally, Anscombe's Quartet warns of the dangers of outliers in data sets.

3. What is Pearson's R? (3 marks)

Answer: Pearson's R was developed by **Karl Pearson** and it is a correlation coefficient which is a measure of the strength of a linear association between two variables and it is denoted by 'r'. It has a value between +1 and -1, where 1 is total positive linear correlation, 0 is no linear correlation, and -1 is total negative linear correlation.

Mathematically, Pearson's correlation coefficient is denoted as the [covariance](#) of the two variables divided by the product of their [standard deviations](#). The form of the definition involves a "product moment", that is, the mean (the first [moment](#) about the origin) of the product of the mean-adjusted random variables; hence the modifier product-moment in the name.

Formula:

$$r = \frac{N\sum xy - (\sum x)(\sum y)}{\sqrt{[N\sum x^2 - (\sum x)^2][N\sum y^2 - (\sum y)^2]}}$$

Where:

N	=	number of pairs of scores
$\sum xy$	=	sum of the products of paired scores
$\sum x$	=	sum of x scores
$\sum y$	=	sum of y scores
$\sum x^2$	=	sum of squared x scores
$\sum y^2$	=	sum of squared y scores

Example:

- Statistically significant relationship between age and height.
- Relationship between temperature and ice cream sales.
- Relationship among job satisfaction, productivity, and income.
- Which two variables have the strongest co-relation between age, height, weight, size of family and family income.

4. What is scaling? Why is scaling performed? What is the difference between normalized scaling and standardized scaling? (3 marks)

Answer: Scaling is the process to normalize the data within a particular range. Many times, in our dataset we see that multiple variables are in different ranges. So, scaling is required to bring them all in a single range.

The two most discussed scaling methods are Normalization and Standardization. Normalization typically scales the values into a range of [0,1]. Standardization typically scales data to have a mean of 0 and a standard deviation of 1 (unit variance).

Formula of Normalized scaling:

$$x = \frac{x - \min(x)}{\max(x) - \min(x)}$$

Formula of Standardized scaling:

$$x = \frac{x - \text{mean}(x)}{\text{sd}(x)}$$

5. You might have observed that sometimes the value of VIF is infinite. Why does this happen? (3 marks)

Question 7: You might have observed that sometimes the value of VIF is infinite. Why does this happen?

Answer: The value of VIF is calculated by the below formula:

$$VIF_i = \frac{1}{1 - R_i^2}$$

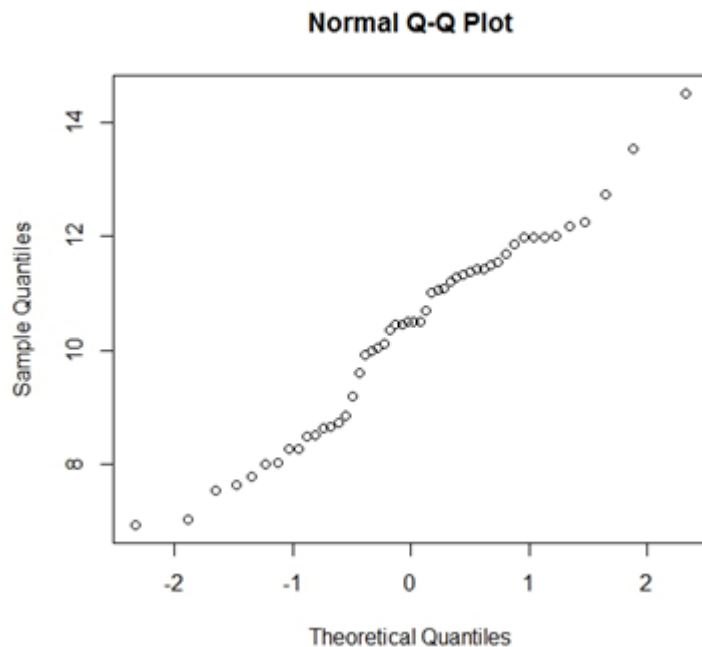
Where, 'i' refers to the ith variable.

If R-squared value is equal to 1 then the denominator of the above formula become 0 and the overall value become infinite. It denotes perfect correlation in variables.

6. What is a Q-Q plot? Explain the use and importance of a Q-Q plot in linear regression. (3 marks)

Answer: The Q-Q plot or quantile-quantile plot is a graphical technique for determining if two data sets come from populations with a common distribution.

A Q-Q plot is a scatterplot created by plotting two sets of quantiles against one another. If both sets of quantiles came from the same distribution, we should see the points forming a line that's roughly straight. Here's an example of a Normal Q-Q plot when both sets of quantiles truly come from Normal distributions.



Use of Q-Q plot in Linear Regression: The Q-Q plot is used to see if the points lie approximately on the line. If they don't, it means, our residuals aren't Gaussian (Normal) and thus, our errors are also not Gaussian.

Importance of Q-Q plot: Below are the points:

- I. The sample sizes do not need to be equal.
- II. Many distributional aspects can be simultaneously tested. For example, shifts in location, shifts in scale, changes in symmetry, and the presence of outliers.
- III. The q-q plot can provide more insight into the nature of the difference than analytical methods.