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Regression (Multivariate)

SGA07_DATASCI

13th February 2020

Module Overview

- Multiple Regression Model
- Overfitting & Multicollinearity
- Scatterplot & Correlation Matrix
- Metrics: p-value, Standard error, R square, R square (predicted)
- Dummy Variables for Categorical Attributes

Book Keeping

- Resources for API Development
- Upload of module slides along with video & audio
- Morning challenge as regards SQL scripting
- 50% of module covered 💪💪💪

Outcome

After this Module, you will;

- Understand how to extend the linear model for multiple independent variables
- Review some concepts that may cause modelling errors such as overfitting and multicollinearity
- Review how to use visualisation (scatterplot) and statistics (correlation) to build intuition on attribute relationships
- Overview of performance metrics (such as p-value, standard error, r square) for model selection
- Understand how to engineer dummy variables used as features to replace nominal and ordinal attributes in a multiple regression model

Linear Regression (Formula)

$$\hat{y} = \beta_0 + \beta_1 x$$

$\hat{y} =$ Expected value of dependent variable
$x =$ Independent variable
$\beta_1 =$ Slope of line
$\beta_0 =$ y-intercept given by $x = 0$

$$\beta_1 = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sum (x_i - \bar{x})^2}$$

$x_i =$ Observed value of independent variable
$\bar{x} =$ Mean value of independent variable
$y_i =$ Observed value of dependent variable
$\bar{y} =$ Mean value of dependent variable

$$\beta_0 = \bar{y} - \beta_1 \bar{x}$$

Multivariate Regression Model

$$\hat{y} = \beta_0 + \beta_1 x_1 + \ldots + \beta_n x_n$$

$\beta_n =$ Estimated change in y to a one unit change in x_n, when all other x_i are held constant

> This is an extension of the linear regression model that considers more than one independent variable as its input for prediction.

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GoKada Logistics

Let's assume that following Lagos State ban on Okada & Keke, GoKada now starts a logistic delivery business given their existing infrastructure. They want you to build a model that predicts hours a day's delivery operation will take given data on distance covered, fuel price and number of delivery for some past days operations

GoKada Data

Day_ID	Distance Covered	Fuel Price (thousand	No. Of Deliveries	Hours Travelled (Hrs)
1	59	3.84	4	7
2	66	3.19	1	5.4
3	78	3.78	3	6.6
4	111	3.89	6	7.4
5	44	3.57	1	4.8
6	77	3.57	3	6.4
7	80	3.03	3	7
8	66	3.51	2	?
9	109	3.54	5	?
10	76	3.25	3	?

Overfitting

- Contains more parameters than can be justified by the data
- The model has learned the noise instead of the signal
- Always split your data into train and test sets
- Check relationship between each independent and dependent variables

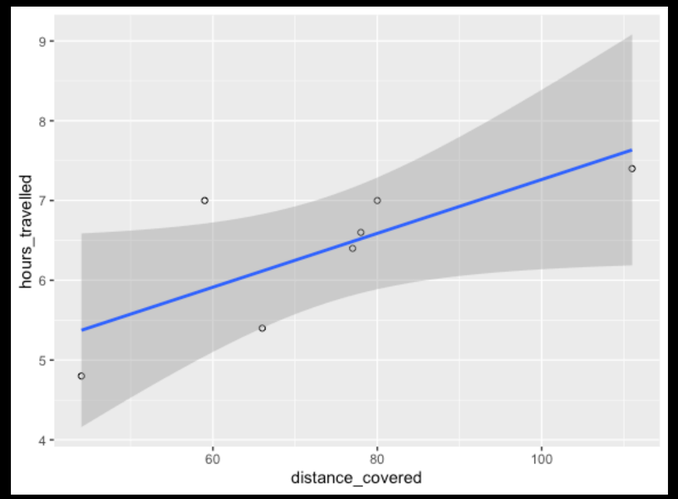
> The production of an analysis that corresponds too closely or exactly to a particular set of data, and may therefore fail to fit additional data or predict future observations reliably

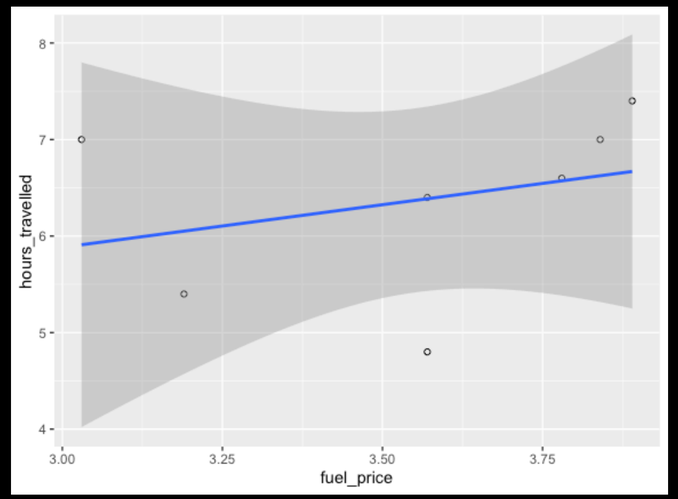
Multicollinearity

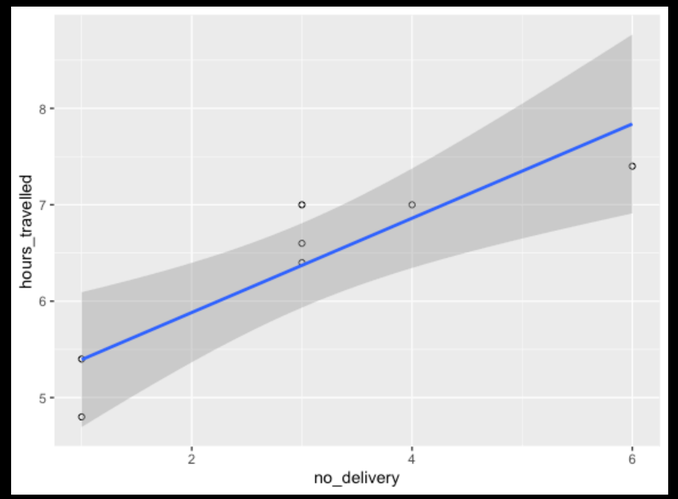
- Independent variables should be independent.
- Reduces the precision of the estimate coefficients, which weakens the statistical power of your regression model
- Check relationship between each independent variables

> A phenomenon in which one predictor variable in a multiple regression model can be linearly predicted from the others with a substantial degree of accuracy

Scatterplot Visualisation







Test for Overfitting

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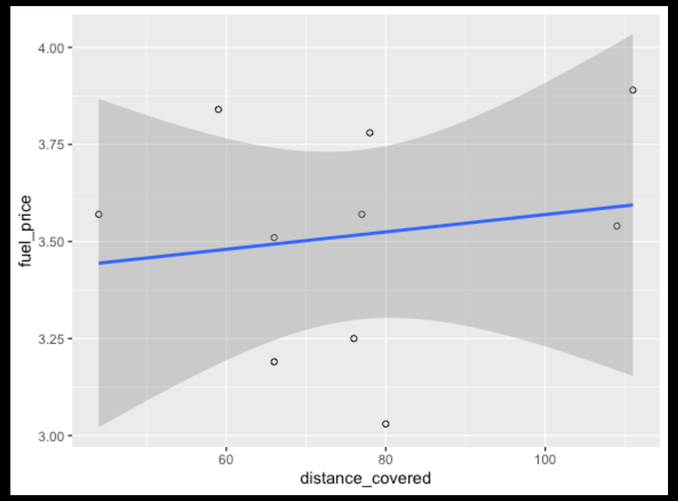
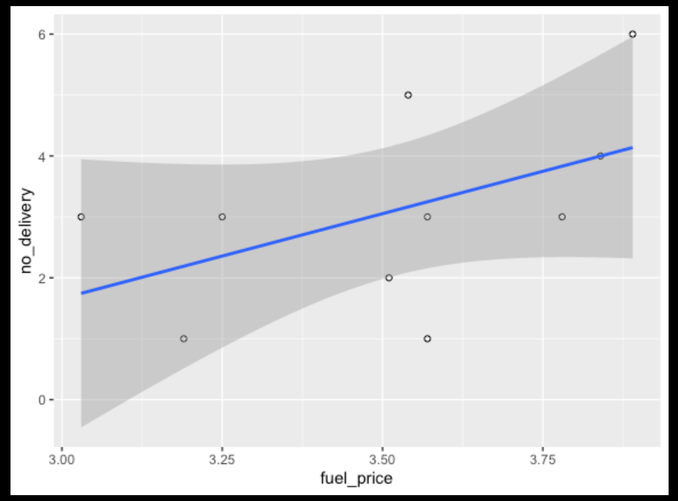
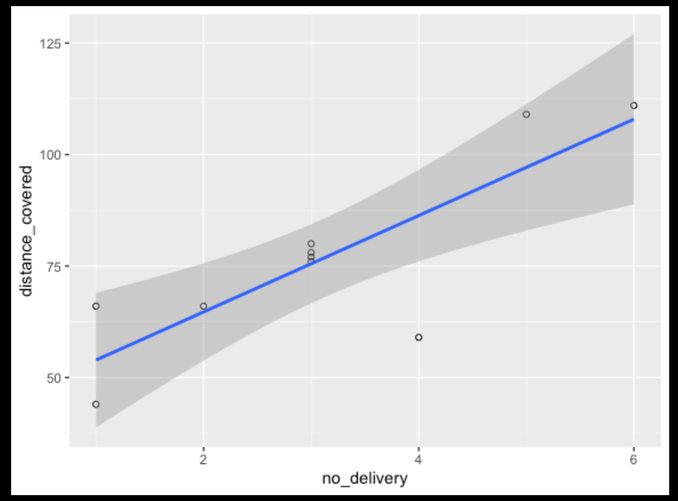
Scatterplot Visualisation







Test for Mulitcollinearity

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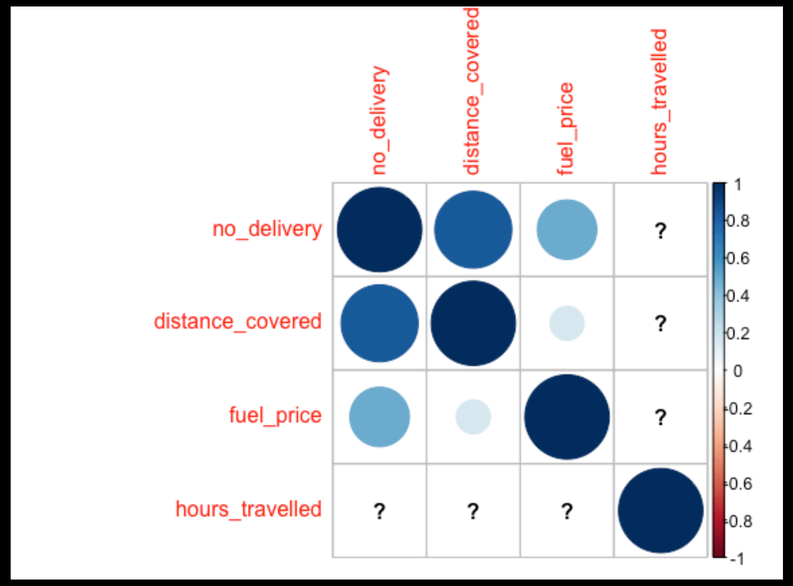
Correlation Analysis

	no_delivery	distance_covered	fuel_price	hours_travelled
no_delivery	1.0000000	0.8338111	0.4982422	NA
distance_covered	0.8338111	1.0000000	0.1618352	NA
fuel_price	0.4982422	0.1618352	1.0000000	NA
hours_travelled	NA	NA	NA	1



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Multiple Regression Performance

Predictor	R squared	R squared (Adj)	p-value	SE	F-stat	R square (diff)
Distance	0.56	0.47	0.052	0.68	6.381	0.09
Delivery	0.81	0.77	0.005	0.45	21.25	0.04
Fuel	0.10	-0.09	0.500	0.98	0.53	0.19
Dist + Del	0.81	0.72	0.035	0.49	8.70	0.09
Dist + Fuel	0.58	0.37	0.171	0.74	2.83	0.21
Del + Fuel	0.88	0.82	0.015	0.40	14.36	0.06
Dist + Del + Fuel	0.89	0.77	0.063	0.45	7.75	0.12

Multiple Regression (Qualitative)

- Feature engineering of dummy variables
- Works like a coding system to transform qualitative variables into a series of variables which can then be entered into the regression model
- Avoid dummy variable trap by encoding into just k-1 variables for qualitative attribute with k-levels

> A dummy variable (aka, an indicator variable) is a numeric variable that represents categorical data, such as gender, race, political affiliation, etc.

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Dummy Variable (Nominal)

North = 0
West = 1
South = 2
East = 3

Day_ID	Distance Covered (KM)	Fuel Price (thousand Naira)	No. Of Deliveries	Hours Travelled (Hrs)	Region
1	59	3.84	4	7	East
2	66	3.19	1	5.4	West
3	78	3.78	3	6.6	East
4	111	3.89	6	7.4	North
5	44	3.57	1	4.8	South
6	77	3.57	3	6.4	North
7	80	3.03	3	7	East
8	66	3.51	2	?	North
9	109	3.54	5	?	West
10	76	3.25	3	?	South

Day_ID	Distance Covered (KM)	Fuel Price (thousand Naira)	No. Of Deliveries	Hours Travelled (Hrs)	Region
1	59	3.84	4	7	3
2	66	3.19	1	5.4	1
3	78	3.78	3	6.6	3
4	111	3.89	6	7.4	0
5	44	3.57	1	4.8	2
6	77	3.57	3	6.4	0
7	80	3.03	3	7	3
8	66	3.51	2	?	0
9	109	3.54	5	?	1
10	76	3.25	3	?	2

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Dummy Variable (Nominal)

Day_ID	Distance Covered (KM)	Fuel Price (thousand Naira)	No. Of Deliveries	Hours Travelled (Hrs)	Region
1	59	3.84	4	7	3
2	66	3.19	1	5.4	1
3	78	3.78	3	6.6	3
4	111	3.89	6	7.4	0
5	44	3.57	1	4.8	2
6	77	3.57	3	6.4	0
7	80	3.03	3	7	3
8	66	3.51	2	?	0
9	109	3.54	5	?	1
10	76	3.25	3	?	2

Day_ID	Distance Covered (KM)	Fuel Price (thousand Naira)	No. Of Deliveries	Hours Travelled (Hrs)	Region (North)	Region (West)	Region (South)	Region (East)
1	59	3.84	4	7	0	0	0	1
2	66	3.19	1	5.4	0	1	0	0
3	78	3.78	3	6.6	0	0	0	1
4	111	3.89	6	7.4	1	0	0	0
5	44	3.57	1	4.8	0	0	1	0
6	77	3.57	3	6.4	1	0	0	0
7	80	3.03	3	7	0	0	0	1
8	66	3.51	2	?	1	0	0	0
9	109	3.54	5	?	0	1	0	0
10	76	3.25	3	?	0	0	1	0

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Dummy Variable (Ordinal)

Small = 0
Medium = 1
Large = 2

Day_ID	Distance Covered (KM)	Fuel Price (thousand Naira)	No. Of Deliveries	Hours Travelled (Hrs)	Package Size
1	59	3.84	4	7	Small
2	66	3.19	1	5.4	Medium
3	78	3.78	3	6.6	Medium
4	111	3.89	6	7.4	Large
5	44	3.57	1	4.8	Large
6	77	3.57	3	6.4	Small
7	80	3.03	3	7	Medium
8	66	3.51	2	?	Small
9	109	3.54	5	?	Large
10	76	3.25	3	?	Small

Day_ID	Distance Covered (KM)	Fuel Price (thousand Naira)	No. Of Deliveries	Hours Travelled (Hrs)	Package Size
1	59	3.84	4	7	0
2	66	3.19	1	5.4	1
3	78	3.78	3	6.6	1
4	111	3.89	6	7.4	2
5	44	3.57	1	4.8	2
6	77	3.57	3	6.4	0
7	80	3.03	3	7	1
8	66	3.51	2	?	0
9	109	3.54	5	?	2
10	76	3.25	3	?	1

Practice Lab

Build a predictive multiple regression model using R

Use the following Instructions:

- Use the mtcar data in r with ***mpg*** as the dependent variable
- Divide into train (70%) and test (30%)
- Explore the data (Univariate & Bivariate)
- Build a multiple regression model
- Apply linear model to test data to validate model

Recap/Summary

At the end of this Module, you should understand;

- Understand how to extend the linear model for multiple independent variables
- Review some concepts that may cause modelling errors such as overfitting and multicollinearity
- Review how to use visualisation (scatterplot) and statistics (correlation) to build intuition on attribute relationships
- Overview of performance metrics (such as p-value, standard error, r square) for model selection
- Understand how to engineer dummy variables used as features to replace nominal and ordinal attributes in a multiple regression model

Suggested Material

- O'Reilly Doing Data Science by Carthy O'Neil and Rachel Schutt Pages 55 - 71
- https://www.youtube.com/playlist?list=PLleGtxpvyG-lqjoU8liF0Yu1WtxNq_4z-
- https://elitedatascience.com/overfitting-in-machine-learning
- https://en.wikipedia.org/wiki/Overfitting
- https://statisticsbyjim.com/regression/multicollinearity-in-regression-analysis/
- https://en.wikipedia.org/wiki/Multicollinearity
- https://rpubs.com/davoodastaraky/mtRegression

Suggested Material (Logistic Regression)

- O'Reilly Doing Data Science by Carthy O'Neil and Rachel Schutt Pages Chapter 5 (113 - 129)

Suggested Material (API Development)

- https://www.analyticsvidhya.com/blog/2016/11/an-introduction-to-apis-application-programming-interfaces-5-apis-a-data-scientist-must-know/
- https://medium.com/better-practices/api-driven-analytics-d980b28cb15e
- https://towardsdatascience.com/deploying-a-machine-learning-model-as-a-rest-api-4a03b865c166