PROJECT 1.1

Simple Regression Analysis on Fuel Economy Data

Part 1 (R & Excel Analytics)

1. Introduction

You are provided with two datasets, “FE2010.csv” and “FE2011.csv”. You are required to work on “FE2010.csv” only for any kind of experiment. The datasets contain different estimates of fuel economy for passenger cars and trucks. For each vehicle, various characteristics are recorded such as the engine displacement or number of cylinders. Along with these values, laboratory measurements are made for the city and highway fuel economy (FE) of the car.

Analyze the data on the relationship between fuel economy and engine displacement. The training data consists of model year 2010 data and the test set is comprised of cars from 2011 that were not in the 2010 data set.

You are required to build a Regression Model for fuel economy (FE), by choosing a single input variable which is the best suitable for predicting FE. You will use 2010 dataset for this purpose. All your work will be validated on 2011 dataset.

2. Objective

The project aims to perform Simple Regression Analysis on Fuel Economy Data.

3. Prerequisites

N/A

4. Associated Data Files

https://drive.google.com/file/d/0B3nTkXniPMACMUc0RVJXODhlUDA/view?usp=sharing

5. Problem Statement

Below are the points which your final submission should answer:

Use Excel and Functions

1. Find the best input variable for predicting FE using suitable statistical test(s).
2. Fit a Simple Linear Regression Model using the selected input variable. Use the formulas discussed in the class to calculate the coefficients.
3. Observe the relationship between the Input variable and FE and analyse if they maintain a linear relationship using a suitable chart in Excel.
4. Use appropriate transformation of input variable if the relation above is not linear. Build the Regression model after transformation. Please ask the course instructor for help in variable transformation, if you required so.
5. Calculate the MAPE (Mean Absolute percentage Error) and R2 of the model. Implement the model on the test data and find out the test accuracy as well. The formula and small note for the error calculation are given at the end of the document.
6. Use a random sampling method to divide the dataset in to 3 parts. Use rand() function.

a. Take 2 parts for modeling and 1 part for testing at a time randomly.
b. Check the modeling Error statistics (as given in previous point 5) of the model and test on the 3rd part of the data for testing the error.
c. Iterate this process 3 time to cover all possible selection of 2 parts for modeling and the 3rd part for testing. There are 3 possible combination in this way. So you would end up with creating 3 models on three different dataset.
d. Calculate the average model accuracy (Use Error formulas from 5.) and average test accuracy. Judge if they are consistent and provide your comment on what you observe.
e. Compute the Beta coefficients by taking average of the three models.
f. Test the final Accuracy by implementing the model on 2011 dataset.

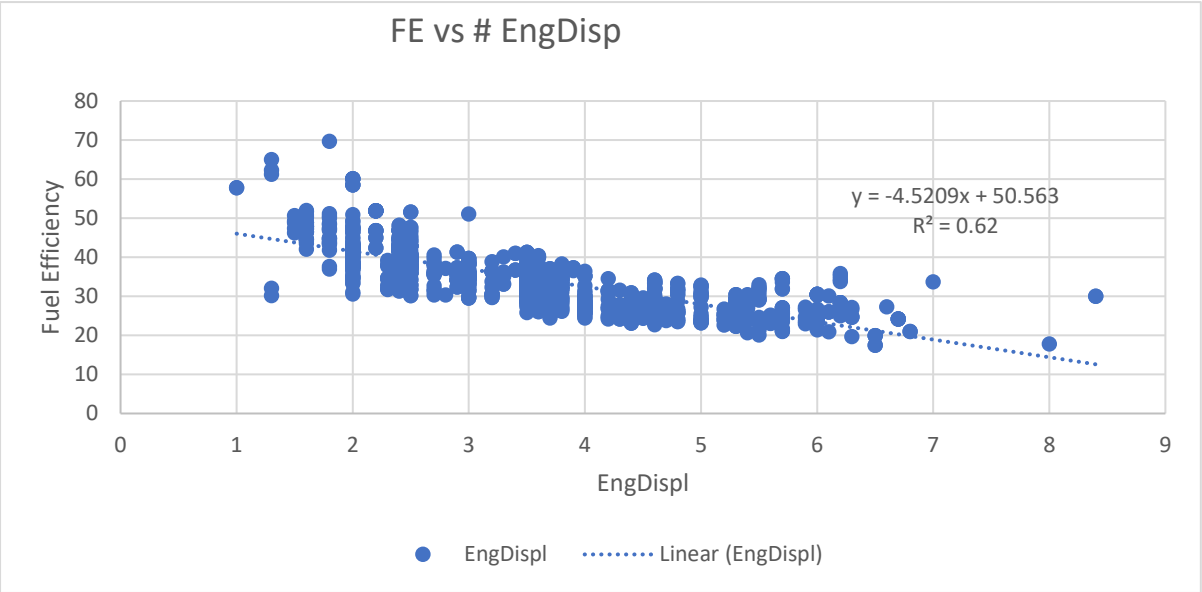
Use Excel Data Analysis tool
7. Use Data Analysis feature of Excel to bypass the co-efficient calculation formulas and compute the Regression Model directly.
8. You should be able to repeat all the points asked under "Use Excel" using Data Analysis tool. You may need to do the random sampling separately here as well.

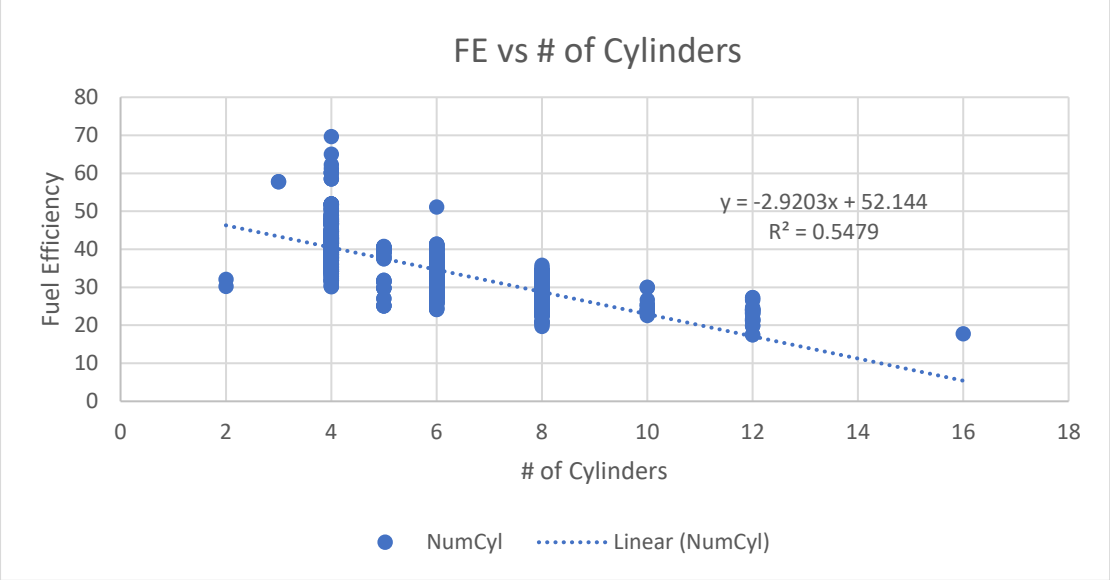
APPROACH

FE 2010 data consists of many input variables and a response variable given as Fuel efficiency collected based on the various vehicle input data. For all these variable correlation coefficient is found in excel and is found as given below

EngDispl	-0.79
Numcyl	-0.74
NumGears	-0.21
TransLockup	-0.27
TransCreeperGear	-0.07
IntakeValvePerCyl	0.28
ExhaustValvesPerCyl	0.34
VarValveTiming	0.12
VarValveLift	0.10

Based on the above findings EngDispl and Numcyl are having very good correlation and as per the problem statement we have plotted these variable with suitable charting in Excel

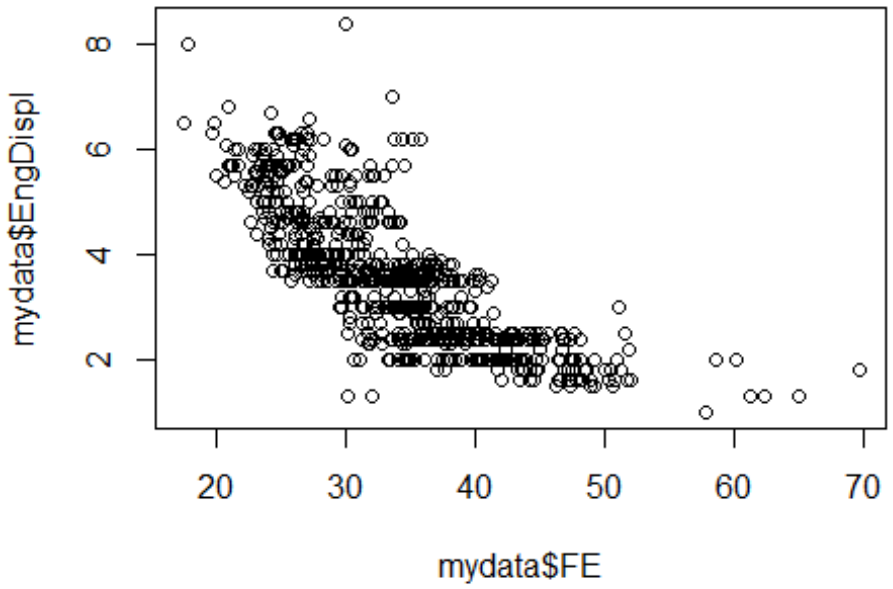




Based on this graph these two input variables appear to be linear. Further the whole data is analysed in R to find the Linear relationship

Use appropriate transformation of input variable if the relation above is not linear. Build the Regression model after transformation.

Please ask the course instructor for help in variable transformation, if you required so.




```
cor(mydata$FE,mydata$EngDispl)
## [1] -0.7873938
cor(mydata$FE,mydata$VarValveLift)
## [1] 0.09621127
cor(mydata$FE,mydata$VarValveTiming)
## [1] 0.1249528
cor(mydata$FE,mydata$ExhaustValvesPerCyl)
## [1] 0.3356529
cor(mydata$FE,mydata$IntakeValvePerCyl)
## [1] 0.280344
cor(mydata$FE,mydata$TransCreeperGear)
## [1] -0.06962168
cor(mydata$FE,mydata$TransLockup)
## [1] -0.2719389
cor(mydata$FE,mydata$NumGears)
## [1] -0.2112849
cor(mydata$FE,mydata$NumCyl)
## [1] -0.740218
```

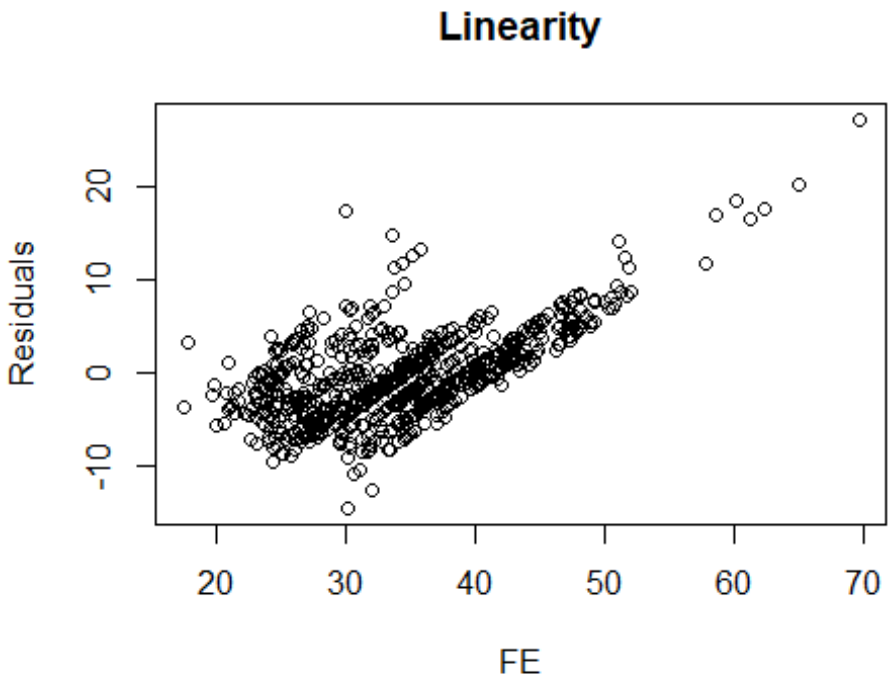
```r
mod=lm(mydata$FE~mydata$EngDispl)
mod
```

```
##
## Call:
## lm(formula = mydata$FE ~ mydata$EngDispl)
##
## Coefficients:
##     (Intercept)  mydata$EngDispl
##          50.563           -4.521
```

```r
summary(mod)
```

```
##
## Call:
## lm(formula = mydata$FE ~ mydata$EngDispl)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -14.486  -3.192  -0.365   2.671  27.215
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)      50.5632     0.3985  126.89   <2e-16 ***
## mydata$EngDispl  -4.5209     0.1065  -42.46   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.624 on 1105 degrees of freedom
## Multiple R-squared:   0.62,  Adjusted R-squared:  0.6196
## F-statistic:  1803 on 1 and 1105 DF,  p-value: < 2.2e-16
```

```r
#Assumption1 Linearity
plot(mydata$FE,mydata$error,xlab="FE",ylab="Residuals",main="Linearity")
```




```
fit<-lm(FE~EngDispl+NumCyl+NumGears+TransLockup+TransCreeperGear+IntakeVal
vePerCyl+ExhaustValvesPerCyl+VarValveTiming+VarValveLift,data=FE2010)
fit
```

```
##
## Call:
## lm(formula = FE ~ EngDispl + NumCyl + NumGears + TransLockup +
##     TransCreeperGear + IntakeValvePerCyl + ExhaustValvesPerCyl +
##     VarValveTiming + VarValveLift, data = FE2010)
##
## Coefficients:
##         (Intercept)             EngDispl               NumCyl
##             54.3472              -3.8610              -0.4888
##            NumGears          TransLockup     TransCreeperGear
##             -0.1725              -1.4450              -0.9138
##   IntakeValvePerCyl  ExhaustValvesPerCyl       VarValveTiming
##             -0.3737              -1.1105               1.6870
##        VarValveLift
##              0.6235
```

```
summary(fit)
```

```
##
## Call:
## lm(formula = FE ~ EngDispl + NumCyl + NumGears + TransLockup +
##     TransCreeperGear + IntakeValvePerCyl + ExhaustValvesPerCyl +
##     VarValveTiming + VarValveLift, data = FE2010)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -17.1153  -2.7142  -0.3535   2.4191  25.6521
##
```

```
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)          54.3472     1.0973  49.530  < 2e-16 ***
## EngDispl             -3.8610     0.2805 -13.765  < 2e-16 ***
## NumCyl               -0.4888     0.1845  -2.649  0.00819 **
## NumGears             -0.1725     0.1065  -1.620  0.10555
## TransLockup          -1.4450     0.3000  -4.817 1.66e-06 ***
## TransCreeperGear     -0.9138     0.6681  -1.368  0.17167
## IntakeValvePerCyl    -0.3737     0.9892  -0.378  0.70566
## ExhaustValvesPerCyl  -1.1105     0.9598  -1.157  0.24752
## VarValveTiming        1.6870     0.3796   4.444 9.71e-06 ***
## VarValveLift          0.6235     0.3719   1.676  0.09393 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.489 on 1097 degrees of freedom
## Multiple R-squared:  0.6445, Adjusted R-squared:  0.6415
## F-statistic: 220.9 on 9 and 1097 DF,  p-value: < 2.2e-16
```

```
vif(fit)
```

```
##            EngDispl              NumCyl            NumGears
##            7.363137            6.750388            1.214238
##         TransLockup    TransCreeperGear   IntakeValvePerCyl
##            1.075253            1.137623            6.693985
## ExhaustValvesPerCyl      VarValveTiming        VarValveLift
##            7.073284            1.153276            1.057688
```

```
vif(fit)>5
```

```
##            EngDispl              NumCyl            NumGears
##                TRUE                TRUE               FALSE
##         TransLockup    TransCreeperGear   IntakeValvePerCyl
##               FALSE               FALSE                TRUE
## ExhaustValvesPerCyl      VarValveTiming        VarValveLift
##                TRUE               FALSE               FALSE
```

Based on the above Vif(fit)>5 the yellow highlighter like EngDispl, Numcyl etc are better linearity and fit for further analysis in Excel

Excel Analysis

Calculate the MAPE (Mean Absolute percentage Error) and R2 of the model. Implement the model on the test data and find out the test accuracy as well.
The formula and small note for the error calculation are given at the end of the document.
One example (small part of excel data)for the data Numcyl is given below to show how we calculate MAPE values

For the entire 2010 data we have calculated Beta coefficient and the intercept from the scatter plot to predict the Fuel efficiency as given below in predicted Y

Beta coefficient calculation for 2010

	FE	Engdisp	Numcyl	**NumGears**	**TransLockup**	**TransCreeperGe**
std dev	7.498033	1.305905	1.900575	1.396624	0.466603	0.215506
Variance (VARA(B3:B1109))	56.22049	1.705388	3.60892	1.948796	0.217522	0.046401
Covariance (COVAR(A3:A1109,B3:B1109)		-7.70297	-10.539	-2.21056	-0.95055	-0.1124
Beta coeff by cal Formula=(covariance/variance)		-4.51685	-2.92026	-1.13432	-4.36989	-2.42232
Beta coeff by graph		(-)4.5209	(-)2.9203			

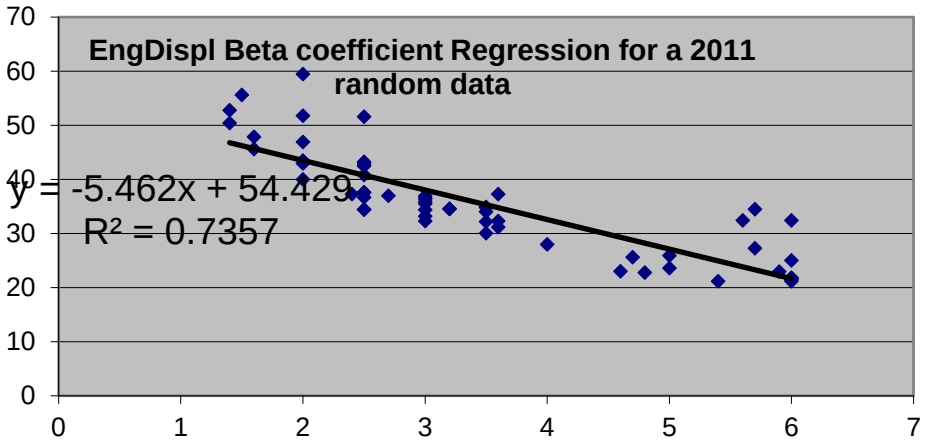
Excel Instructions:

There are four ways that you can calculate a Beta using Excel. The first is to use the "=slope" formula. In this formula, the X variable series is the return on the market and the Y variable series if the return on FE.
This gives:
-5.0180

A second alternative is to calculate the Beta directly as the covariance between the two return series, divided by the variance of market returns. Using the summary statistics at the bottom of the page, this gives:
-5.4164

A third method is to use the full regression procedure in Excel. Go to "Tools" - "Data Analysis" - "Regression" and click OK. Again, enter the market return series as the X variable and the HD return series as the Y variable. When you click OK, you should get full regression output similar to that shown in the worksheet labelled " FERegr Output".

Finally, you can create a regression Beta in Excel using the chart functions. Remember that Beta is just the slope in a regression where EngDispl are on the X axis and FUEL EFICENCY (FE are on the Y axis.
To create this type of graph, highlight the two columns of data, with market returns on the left. After highlighting the return series, click on the chart wizard icon (or choose "Insert" - "Chart"). Under chart types, select "X-Y scatterplot" and click Next. Click Next twice more to get to step 4 of 4. In step 4, select "as new sheet" and click finish. When the new chart comes up, select the "Chart" tab at the top of the page, and then select "Add Trendline". Select the "Options" tab, and click the buttons for "display equation" and "display R square", then click OK. This should add both a regression line and a regression equation to your chart. The results should look similar to those shown in the worksheet labelled "FE Chart".



Based on the calculation of Beta coefficient as given above and with the intercept from the graph,
One example (small part of FE 2011 excel data)for the data Numcyl is given below to show how we calculate MAPE values

X	Y	Predicted Y				
NumCyl	FE	Predicted FE	Error		Dis Y and their mean	Square F
12	22.9258	17.1004	5.8254	33.93529	-11.80486408	139.3548
8	26.7678	28.7816	-2.0138	4.05539	-7.962864082	63.4072
8	24.301	28.7816	-4.4806	20.07578	-10.42966408	108.7779
10	24.3325	22.941	1.3915	1.936272	-10.39816408	108.1218
10	23.0667	22.941	0.1257	0.0158	-11.66396408	136.0481
6	32.8579	34.6222	-1.7643	3.112754	-1.872764082	3.507245
4	52.2	40.4628	11.7372	137.7619	17.46933592	305.1777
4	55.6446	40.4628	15.1818	230.4871	20.91393592	437.3927
8	26	28.7816	-2.7816	7.737299	-8.730664082	76.2245
12	25	17.1004	7.8996	62.40368	-9.730664082	94.68582
8	26.8	28.7816	-1.9816	3.926739	-7.930664082	62.89543

Abs v of error	Error 2	ABS values of error/Actual value
5.8254	33.93529	0.254098
2.0138	4.05539	0.075232
4.4806	20.07578	0.184379
1.3915	1.936272	0.057187
0.1257	0.0158	0.005449
1.7643	3.112754	0.053695

11.7372	137.7619	0.224851
15.1818	230.4871	0.272835
2.7816	7.737299	0.106985
7.8996	62.40368	0.315984
1.9816	3.926739	0.073940

No of rows is calculate in n = COUNT(D3:D247) MSE is calculated (L248/C250)(Error square/n)
RMSE is the square root of MSE (SQRT(C253)
MAPE is calculated ((M248/C250)*100) M248 = sum of (ABS values of error/Actual value) and C 250 is the no row count ie 245
Given below is calculated from the prediction of FE using the input variable Numcyl beta coefficient and intercept. Similarly we have calculated the same with EngDispl variable

n 245

MAD		4.470793061	
MSE		34.67015725	
RMSE		5.888136993	
MAPE		13.37649118	Mean absolute percentage error

1 - (SUM(E3:E247)) sum of all values of Error square) /sum of Square of Dis Y and their mean would provide the R square by calculation.

0.589277463 R 2 by calculation 1-(E248/G248) by graph 0.5479

Use a random sampling method to divide the dataset in to 3 parts. Use rand() function.
FE 2011 data is divided into 3 sets using random function in Excel like Rand() , Rand1,Rand2 and Rand3 is used for testing based on these two data,

Hence Fe2011 data is divided into 3 equal parts approximately 82 values in each

Dataset 2011 rand testing - Excel — Varatharajan Seshan

File Home Insert Draw Page Layout Formulas Data Review View Add-ins Help Tell me what you want to do

O15

	A	B	C	D	E	F	G	H	I	J	K	L
1	EngDispl	NumCyl	FE	NumGear	TransLock	TransCree	IntakeVal	ExhaustVa	VarValveT	VarValveL	Predicted	Rand
2	3.6	6	29.5	5	1	0	2	2	1	0		0.000532
3	5	8	24.7928	6	1	0	2	2	1	1		0.006908
4	4.4	8	33.6032	8	1	0	2	2	1	0		0.007212
5	2.3	4	34.7	6	0	0	2	2	1	0		0.007591
6	1.8	4	50.8	6	0	0	2	2	1	0		0.01187
7	3.8	6	36.7669	7	1	0	2	2	1	1		0.019214
8	4.7	8	24.6	5	1	0	1	1	0	0		0.021569
9	3.4	6	41.347	7	1	0	2	2	1	1		0.024303
10	1.5	4	49.6	5	0	0	2	2	1	0		0.03002
11	3.7	6	28.1	4	1	0	1	1	0	0		0.040897
12	4.6	8	24.3	4	1	0	1	1	0	0		0.04208
13	5	8	30.8503	6	1	0	2	2	1	1		0.048234
14	6	8	21.6515	6	1	0	1	1	1	0		0.050549
15	6.2	8	19.5139	6	0	1	1	1	1	0		0.051692
16	5.3	8	29	6	1	0	1	1	1	0		0.060294
17	5.4	8	20.6	4	1	1	1	1	0	0		0.062983
18	2	4	46.2	5	0	0	1	1	0	0		0.067213
19	2.5	4	31.3669	6	0	0	2	2	1	0		0.073016
20	2.5	4	36.6557	4	1	0	2	2	0	1		0.074834
21	3	6	37.9997	8	1	0	2	2	1	1		0.077579
22	2.5	4	40.1077	1	1	0	2	2	0	1		0.079931
23	4.6	8	33.9	6	1	0	2	2	1	0		0.084856
24	3.5	6	35.8	6	1	0	2	2	1	0		0.088245
25	5	8	27.4375	7	1	0	2	2	1	1		0.090225
26	2.4	4	38.7	4	1	0	2	2	1	0		0.091763
27	6	8	32.4	1	0	0	1	1	1	0		0.095059

	EngDispl	FE
std dev	1.515269	8.985048
variance	2.29604	80.73108
covariance	-11.2347	
B coefficient	-4.89309	

	Numcyl	FE
std dev	1.79952	9.069173
variance	2.29604	82.24989
covariance	-12.5022	
B coefficient	-5.44514	

Data4R2 EngD | Accuracy | Rand() | Rand3 test | Rand2 | Rand1 | Numcyl data | EngDis data

Ready — Average: 12.91120711 — Count: 12 — Sum: 77.46724265

Type here to search

Dataset 2011 rand testing - Excel — Varatharajan Seshan

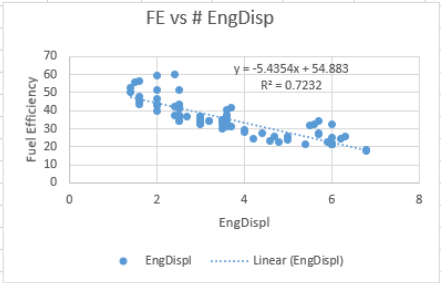
File Home Insert Draw Page Layout Formulas Data Review View Add-ins Help Tell me what you want to do

S6

	C	D	E	F	G	H	I	J	K	L
1	FE	NumGear	TransLock	TransCree	IntakeVal	ExhaustVa	VarValveT	VarValveL	Predicted	Rand
2	40	4	1	0	2	2	1	0		0.321774
3	36.9202	6	1	0	2	2	1	1		0.332473
4	34.5424	6	1	0	2	2	1	0		0.337248
5	45.5991	1	1	0	2	2	1	0		0.343075
6	42.9733	1	0	0	2	2	1	0		0.348118
7	42.4888	6	1	0	2	2	1	0		0.349488
8	36.4738	6	0	0	2	2	1	0		0.350633
9	25.6	5	0	0	1	1	0	0		0.350983
10	22.9258	6	0	0	2	2	0	0		0.355907
11	22.8	6	1	0	1	1	1	0		0.357966
12	47.8478	6	1	0	2	2	1	1		0.364244
13	30.0493	6	1	0	2	2	1	0		0.364841
14	32.286	8	1	0	2	2	1	1		0.365239
15	34.7675	6	1	1	2	2	1	0		0.377609
16	21.4734	6	1	0	1	1	1	0		0.378726
17	43.2617	6	1	0	2	2	1	0		0.37909
18	34.5424	6	1	0	2	2	1	0		0.384462
19	21.2	6	1	0	1	1	1	0		0.393809
20	37.2998	7	1	0	2	2	1	1		0.401323
21	36.4738	6	0	0	2	2	1	0		0.402023
22	55.6446	1	1	0	2	2	1	1		0.402061
23	23.6028	6	1	0	2	2	1	0		0.403762
24	32.4	1	0	0	1	1	1	0		0.40597
25	32.2993	6	0	0	2	2	1	1		0.4086
26	34.4	7	1	0	2	2	1	0		0.412255
27	37.6	5	0	0	2	2	1	0		0.412605

	EngDispl	FE
std dev	1.526909	9.759394
variance	2.33145	95.24578
covariance	-12.5178	
B coefficient	-5.36912	

	Numcyl	FE
std dev	1.921095	1.954436
variance	3.690605	3.81982
covariance	-15.1677	
B coefficient	-4.1098	



Data4R2 EngD | Accuracy | Rand() | Rand3 test | Rand2 | Rand1 | Numcyl data | EngDis data

Ready

Type here to search

Dataset 2011 rand testing - Excel — Varatharajan Seshan

File Home Insert Draw Page Layout Formulas Data Review View Add-ins Help Tell me what you want to do

S1

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	EngDispl	NumCyl	FE	NumGear	TransLock	TransCree	IntakeVal	ExhaustVa	VarValveT	VarValveL	Predicted	Rand							
2	2.8	6	30.3	6	1	0	2	2	1	0		0.692438							
3	3.7	6	28.5674	6	0	1	2	2	1	0		0.699183							
4	4.6	8	21.9	4	1	1	1	1	0	0		0.716823							
5	2.4	4	38.7	5	0	0	2	2	1	0		0.717307			EngDispl	FE			
6	6	8	21.4734	6	1	0	1	1	1	0		0.72223		std dev	1.370863	8.942652			
7	3.5	6	34.763	6	1	1	2	2	1	0		0.723868		variance	1.879265	79.97103			
8	2.4	4	37.4	6	1	0	2	2	1	0		0.725082		covariance	-10.0548				
9	3.6	6	35.5	6	1	0	2	2	1	0		0.727246		B coefficient	-5.35038				
10	5.3	8	29	6	1	0	1	1	1	0		0.73027							
11	5.7	8	25.6	5	1	0	1	1	1	0		0.732559							
12	2.4	4	42	6	1	0	2	2	1	0		0.733229			Numcyl	FE			
13	5	8	28.7009	6	0	1	2	2	1	0		0.739334		std dev	1.71049	1.720568			
14	3.4	6	37.055	6	0	0	2	2	1	1		0.73939		variance	2.925775	2.960355			
15	3.6	6	32.3	5	1	0	2	2	1	0		0.744939		covariance	-12.1794				
16	5.4	8	21.8	4	1	1	1	1	0	0		0.745723		B coefficient	-4.16279				
17	2	4	41.2	1	0	0	2	2	1	0		0.751602							
18	5.2	10	24.3325	6	0	0	2	2	1	0		0.756237							
19	3.5	6	34.9	6	1	0	2	2	1	0		0.758343							
20	3	6	35.8	6	1	0	2	2	1	0		0.763618							
21	6	8	21.4734	6	1	0	1	1	1	0		0.763631							
22	2	4	41.5	4	1	0	2	2	1	0		0.763819							
23	3.7	6	28.5668	6	1	1	2	2	1	0		0.773601							
24	1.4	4	59.7	6	0	0	2	2	1	0		0.774523							
25	5.3	8	29	6	1	0	1	1	1	0		0.779221							
26	3.6	6	40.5	6	1	0	2	2	1	0		0.784926							
27	1.5	4	52.2	6	0	0	2	2	1	1		0.78767							

Data4R2 EngD | Accuracy | Rand() | **Rand3 test** | Rand2 | Rand1 | Numcyl data | EngDis data

Ready

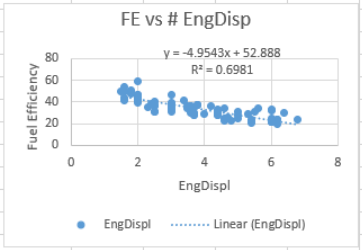
Type here to search

Dataset 2011 rand testing - Excel — Varatharajan Seshan

File Home Insert Draw Page Layout Formulas Data Review View Add-ins Help Tell me what you want to do

R9

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	y	predicted y	Error	Err square	Dis Y and their mean	Square of F		correlation B&C				Abs v of error	Error 2	ABS values of error/Actual value	% Error			
2	FE	Predicted FE																
3	30.3	39.01596	-8.71596	75.96796	-4.689	21.9867324		0.830312				8.71596	75.96796	0.287655	28.8			
4	28.5674	34.55709	-5.98969	35.87639	-6.4216	41.2369622						5.98969	35.87639	0.209669	21.0			
5	21.9	30.09822	-8.19822	67.21081	-13.089	171.321953		EngDispl	FE			8.19822	67.21081	0.374348	37.4			
6	38.7	40.99768	-2.29768	5.279333	3.710999	13.7715119	std dev	1.370863	8.942652			2.29768	5.279333	0.059372	5.9			
7	21.4734	23.1622	-1.6888	2.852045	-13.5156	182.671476	variance	1.879265	79.97103			1.6888	2.852045	0.078646	7.9			
8	34.763	35.54795	-0.78495	0.616147	-0.226	0.05107655	covariance	-10.0548				0.78495	0.616147	0.02258	2.3			
9	37.4	40.99768	-3.59768	12.9433	2.410999	5.81291512	B coefficient	-5.35038				3.59768	12.9433	0.096195	9.6			
10	35.5	35.05252	0.44748	0.200238	0.510999	0.26111975						0.44748	0.200238	0.012605	1.3			
11	29	26.63021	2.36979	5.615905	-5.989	35.8681356						2.36979	5.615905	0.081717	8.2			
12	25.6	24.64849	0.95151	0.905371	-9.389	88.1533439						0.95151	0.905371	0.037168	3.7			
13	42	40.99768	1.00232	1.004645	7.010999	49.1541039						1.00232	1.004645	0.023865	2.4			
14	28.7009	28.1165	0.5844	0.341523	-6.2881	39.5402169						0.5844	0.341523	0.020362	2.0			
15	37.055	36.04338	1.01162	1.023375	2.065999	4.26835096						1.01162	1.023375	0.0273	2.7			
16	32.3	35.05252	-2.75252	7.576366	-2.689	7.23072756						2.75252	7.576366	0.085217	8.5			
17	21.8	26.13478	-4.33478	18.79032	-13.189	173.949753						4.33478	18.79032	0.198843	19.9			
18	41.2	42.9794	-1.7794	3.166264	6.210999	38.5765059						1.7794	3.166264	0.043189	4.3			
19	24.3325	27.12564	-2.79314	7.801631	-10.6565	113.561018						2.79314	7.801631	0.114791	11.5			
20	34.9	35.54795	-0.64795	0.419839	-0.089	0.00792122						0.64795	0.419839	0.018566	1.9			
21	35.8	38.0251	-2.2251	4.95107	0.810999	0.65771902						2.2251	4.95107	0.062154	6.2			
22	21.4734	23.1622	-1.6888	2.852045	-13.5156	182.671476						1.6888	2.852045	0.078646	7.9			
23	41.5	42.9794	-1.4794	2.188624	6.510999	42.3931051						1.4794	2.188624	0.035648	3.6			
24	28.5668	34.55709	-5.99029	35.88357	-6.4222	41.2446685						5.99029	35.88357	0.209694	21.0			



Data5R2numcy | Data5R1 numcy | **Data3R1 EngD** | Data4R2 EngD | Accuracy | Rand() | Ranc

Ready

Type here to search

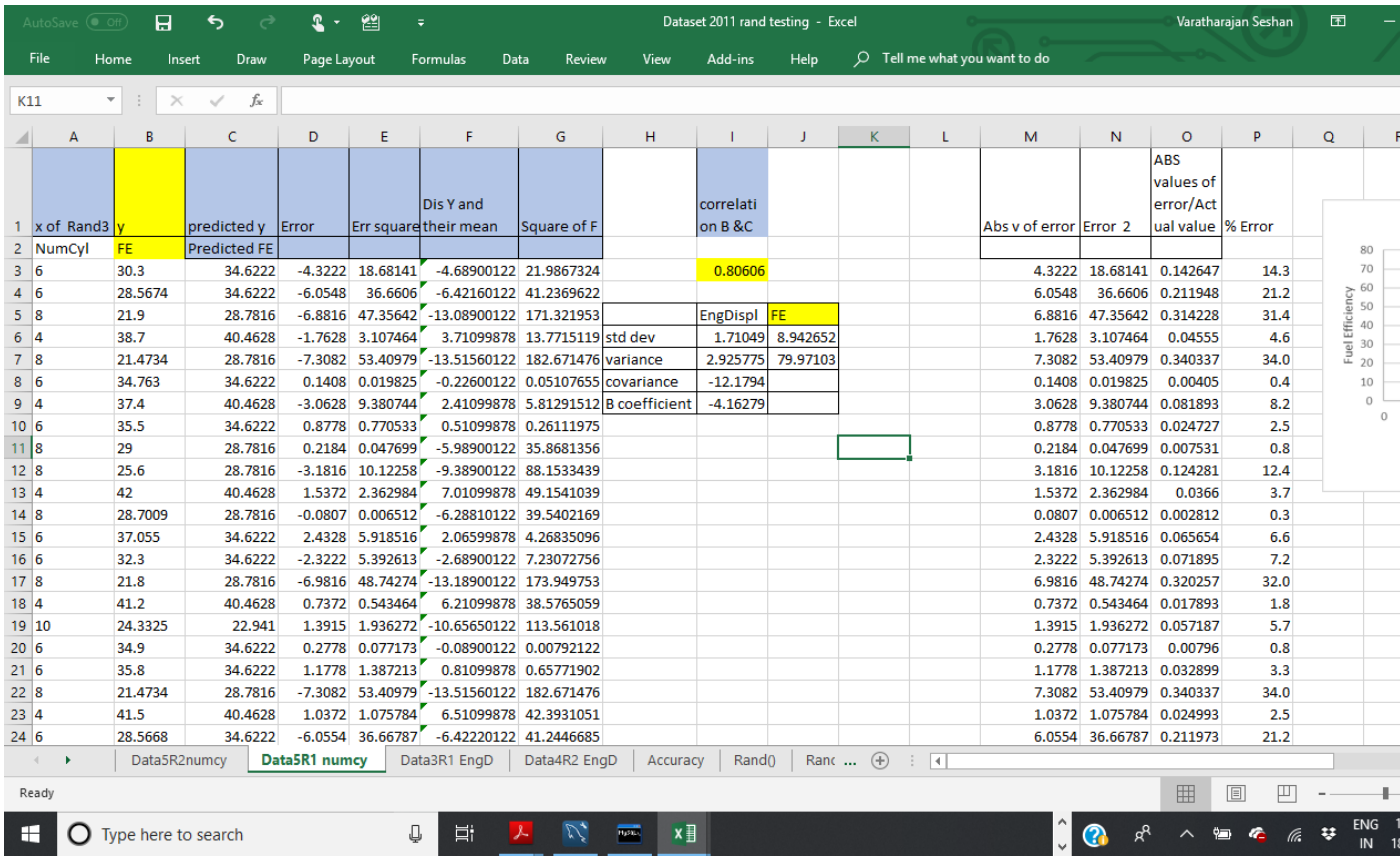
	n	82

			Prediction of FE in Rand3 test case done and calculated the following
MAD		3.870526098	
MSE		25.37700219	
RMSE		5.03755915	
MAPE		11.50998577	Mean absolute percentage error

Average % Error	
Average Test Accuracy	

R square by calculation	0.678755
As per plot	0.6981

In the similar way we have predicted using Rand2 Beta coefficient values of EngDispl values and Numcyl values



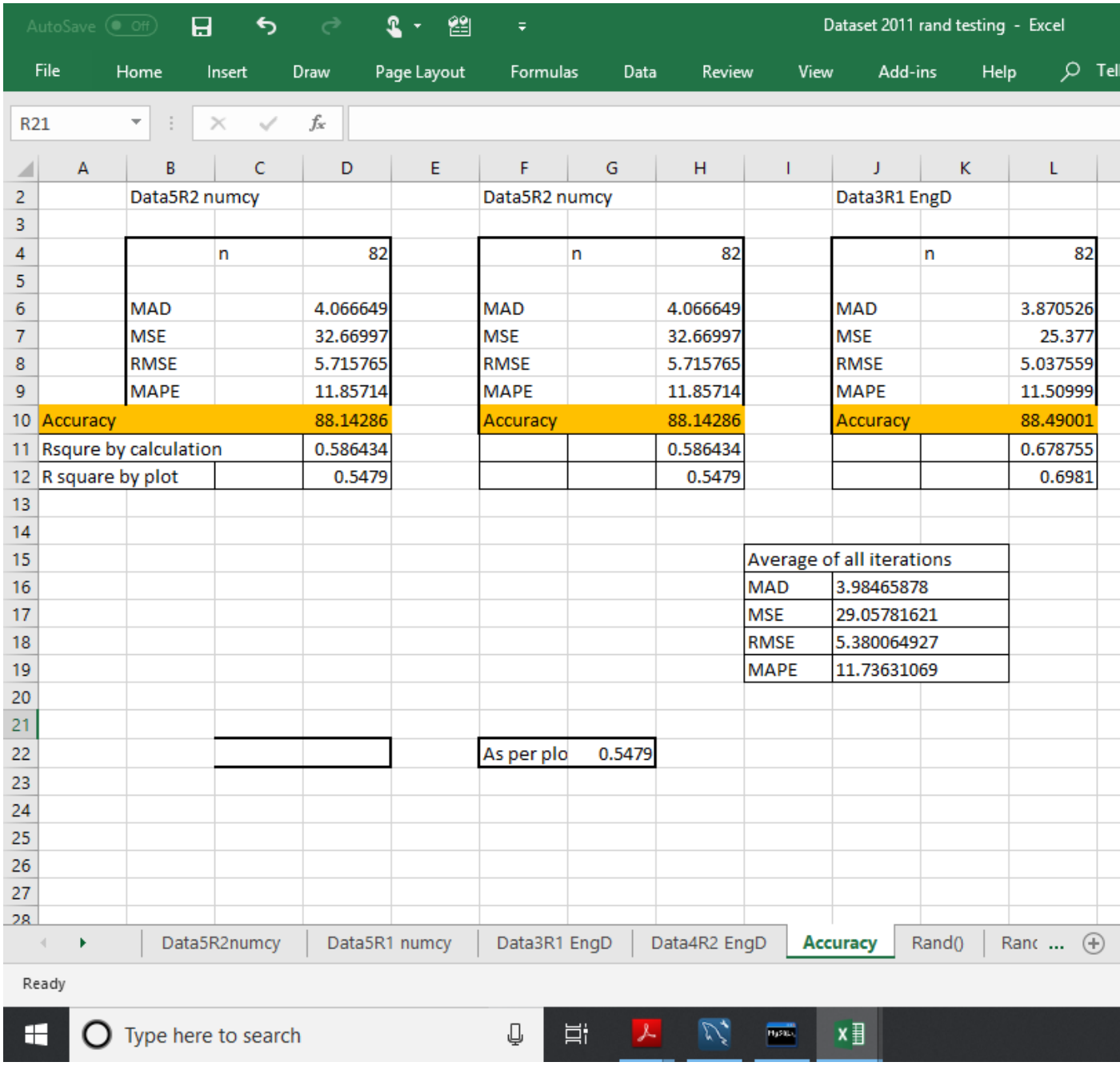
	n	82				
MAD		4.06664878				
MSE		32.66996772				
RMSE		5.715764841				
MAPE		11.8571359	Mean absolute percentage error			

R square by calculation	0.586434

As per plot	0.5479

a. Take 2 parts for modeling and 1 part for testing at a time randomly.
b. Check the modeling Error statistics (as given in previous point 5) of the model and test on the 3rd part of the data for testing the error.
c. Iterate this process 3 time to cover all possible selection of 2 parts for modeling and the 3rd part for testing. There are 3 possible combination in this way. So you would end up with creating 3 models on three different dataset.
d. Calculate the average model accuracy (Use Error formulas from 5.) and average test accuracy. Judge if they are consistent and provide your comment on what you observe.
e. Compute the Beta coefficients by taking average of the three models.
f. Test the final Accuracy by implementing the model on 2011 dataset.

For the requirement of iterations in the question the same is repeated with Rand 1 and Rand2 variables and the consolidate finding is given below



Based on the findings the MAPE values of all tests are found to be vey close though the test is done on various input variable and the accuracy is found to be around 88.3%

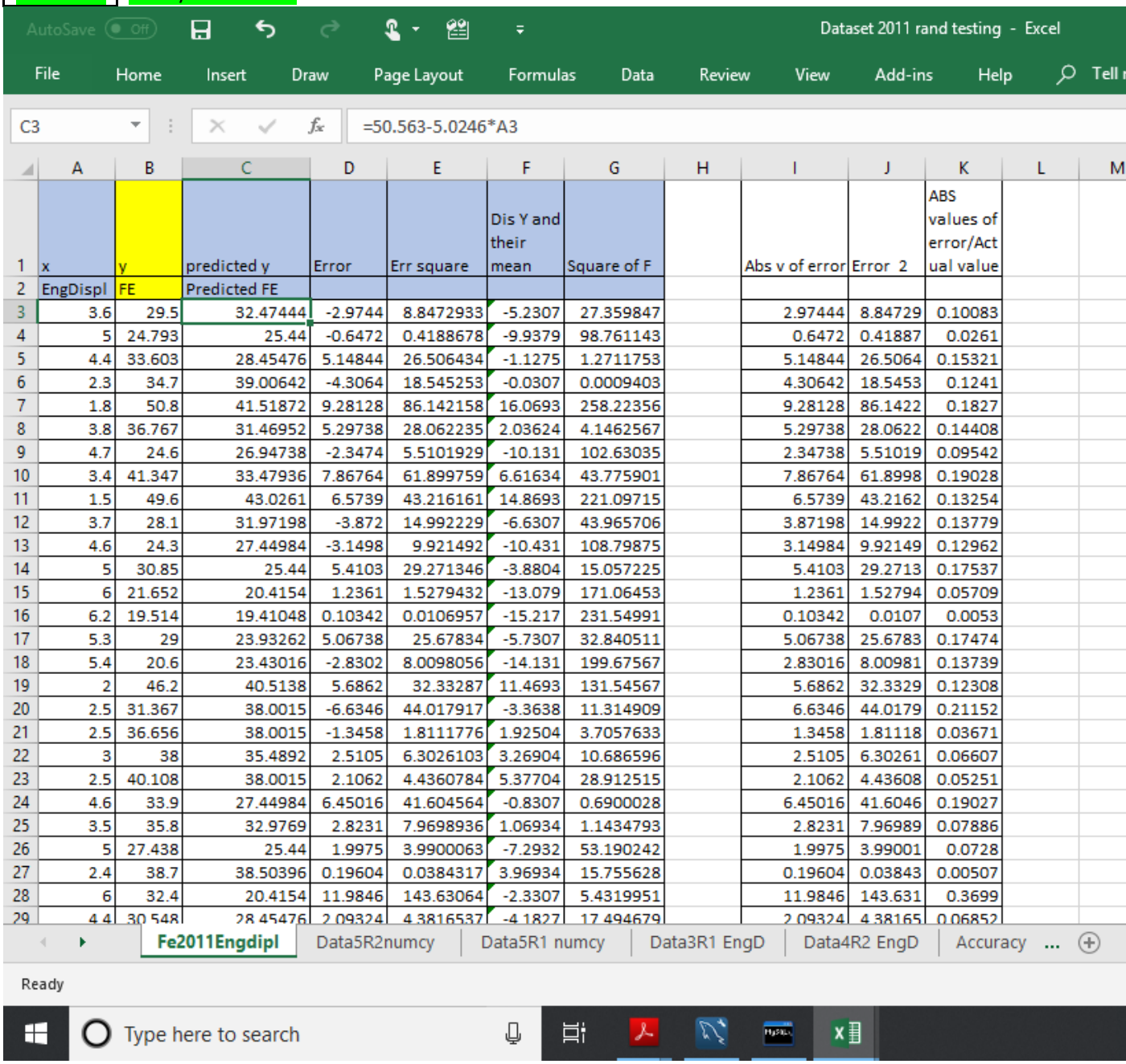
The average of the all the model of Engdispl Beta coefficient is given below and further the average Beta coefficient is applied and predicted the FE as given in the screenshot below. And the MAPE values and accuracy is calculated as per the requirement in the question(Test the final Accuracy by implementing the model on 2011 dataset.) and the same is given below. Relevant excel sheets are attached separated in the submission,

	Eng displ
	-4.8939
	-5.36912

	-5.35080
Average	-5.20460667

	n	245		
MAD		4.025664653		
MSE		31.19592662		
RMSE		5.585331379		
MAPE		11.17662112	Mean absolute percentage error	

0.630435	R 2 by calculation

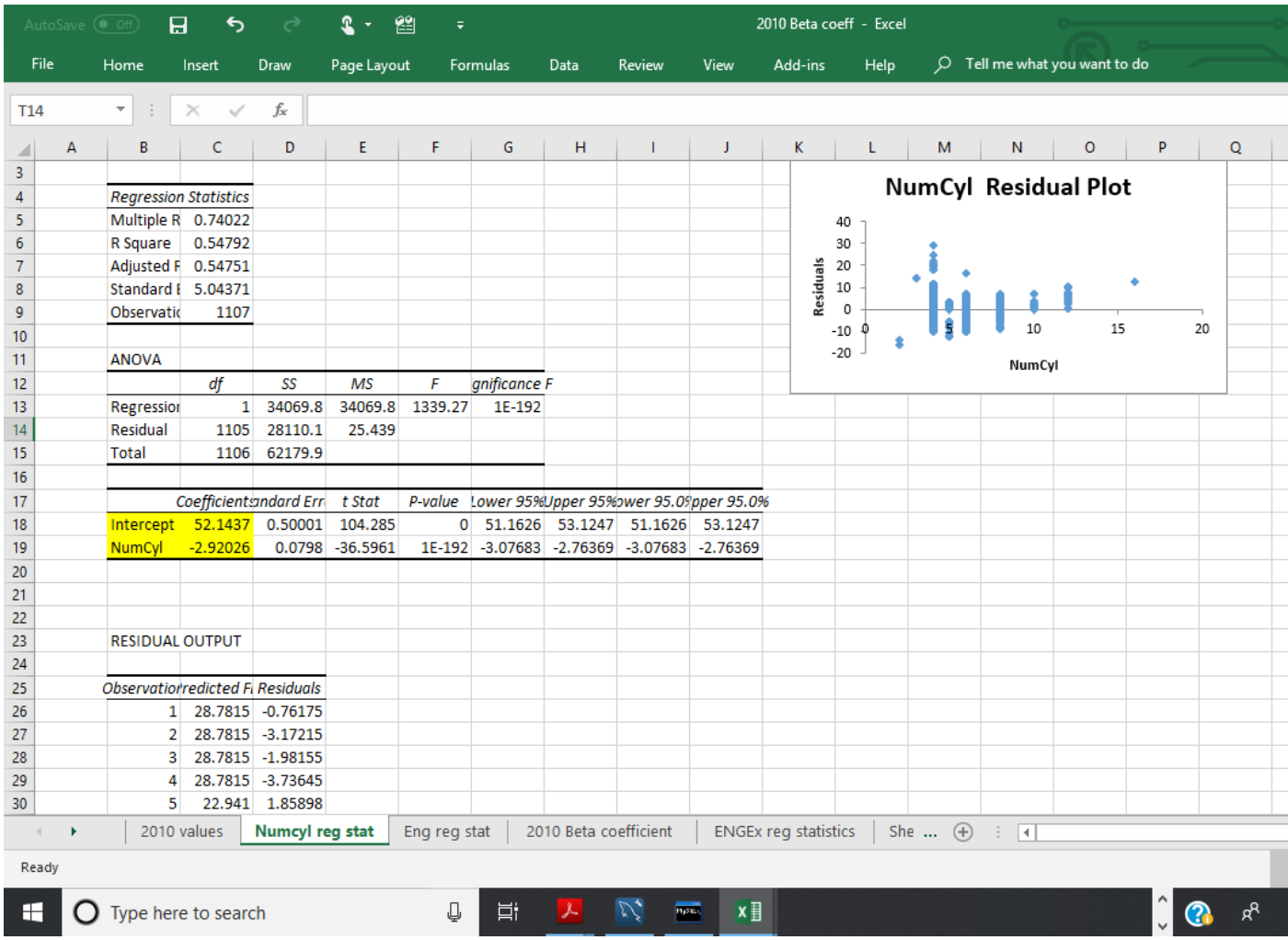


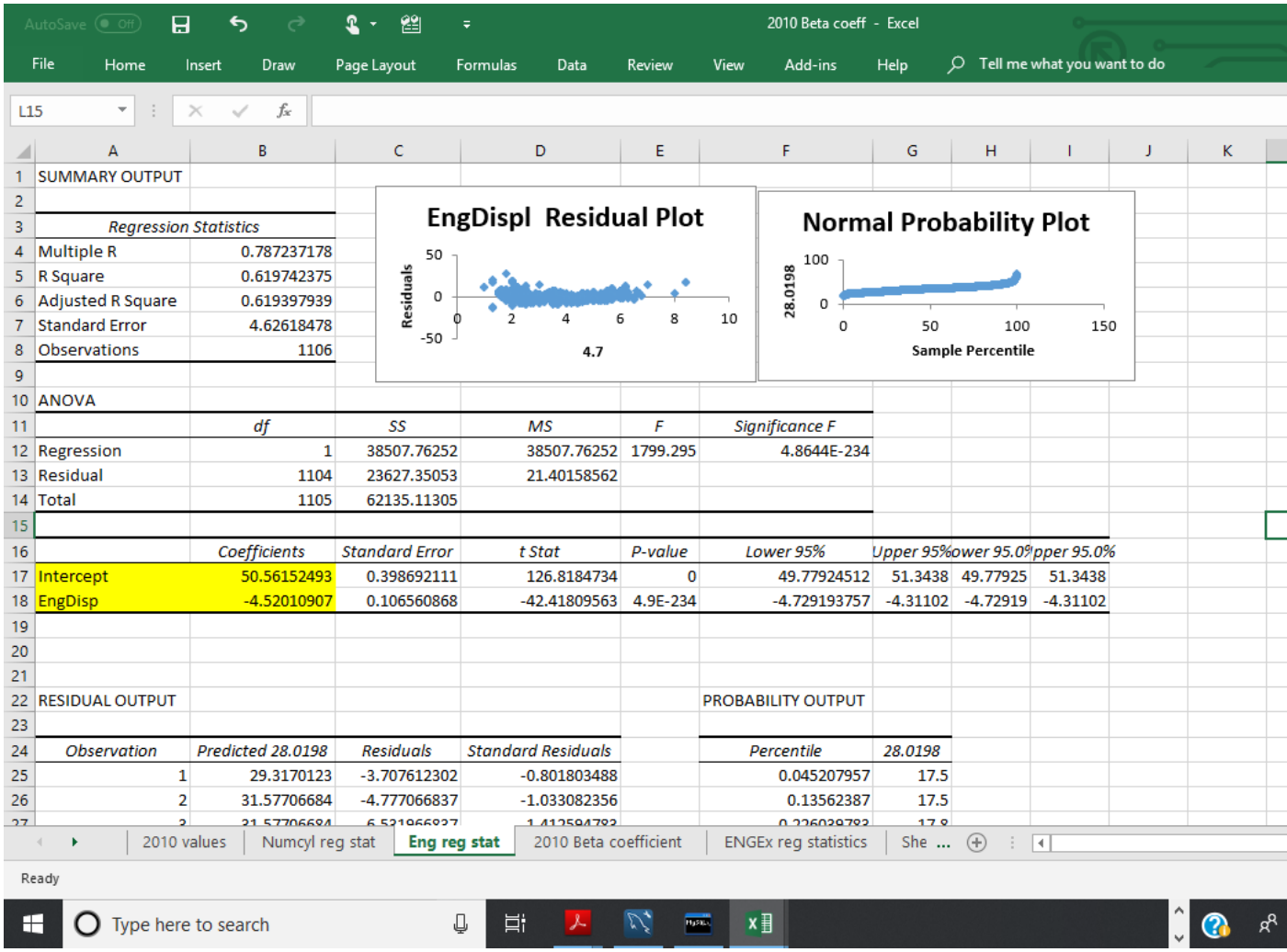
	A	B	C	D	E	F	G	H	I	J	K	L	M
1	x	y	predicted y	Error	Err square	Dis Y and their mean	Square of F		Abs v of error	Error 2	ABS values of error/Actual value		
2	EngDispl	FE	Predicted FE										
3	3.6	29.5	32.47444	-2.9744	8.8472933	-5.2307	27.359847		2.97444	8.84729	0.10083		
4	5	24.793	25.44	-0.6472	0.4188678	-9.9379	98.761143		0.6472	0.41887	0.0261		
5	4.4	33.603	28.45476	5.14844	26.506434	-1.1275	1.2711753		5.14844	26.5064	0.15321		
6	2.3	34.7	39.00642	-4.3064	18.545253	-0.0307	0.0009403		4.30642	18.5453	0.1241		
7	1.8	50.8	41.51872	9.28128	86.142158	16.0693	258.22356		9.28128	86.1422	0.1827		
8	3.8	36.767	31.46952	5.29738	28.062235	2.03624	4.1462567		5.29738	28.0622	0.14408		
9	4.7	24.6	26.94738	-2.3474	5.5101929	-10.131	102.63035		2.34738	5.51019	0.09542		
10	3.4	41.347	33.47936	7.86764	61.899759	6.61634	43.775901		7.86764	61.8998	0.19028		
11	1.5	49.6	43.0261	6.5739	43.216161	14.8693	221.09715		6.5739	43.2162	0.13254		
12	3.7	28.1	31.97198	-3.872	14.992229	-6.6307	43.965706		3.87198	14.9922	0.13779		
13	4.6	24.3	27.44984	-3.1498	9.921492	-10.431	108.79875		3.14984	9.92149	0.12962		
14	5	30.85	25.44	5.4103	29.271346	-3.8804	15.057225		5.4103	29.2713	0.17537		
15	6	21.652	20.4154	1.2361	1.5279432	-13.079	171.06453		1.2361	1.52794	0.05709		
16	6.2	19.514	19.41048	0.10342	0.0106957	-15.217	231.54991		0.10342	0.0107	0.0053		
17	5.3	29	23.93262	5.06738	25.67834	-5.7307	32.840511		5.06738	25.6783	0.17474		
18	5.4	20.6	23.43016	-2.8302	8.0098056	-14.131	199.67567		2.83016	8.00981	0.13739		
19	2	46.2	40.5138	5.6862	32.33287	11.4693	131.54567		5.6862	32.3329	0.12308		
20	2.5	31.367	38.0015	-6.6346	44.017917	-3.3638	11.314909		6.6346	44.0179	0.21152		
21	2.5	36.656	38.0015	-1.3458	1.8111776	1.92504	3.7057633		1.3458	1.81118	0.03671		
22	3	38	35.4892	2.5105	6.3026103	3.26904	10.686596		2.5105	6.30261	0.06607		
23	2.5	40.108	38.0015	2.1062	4.4360784	5.37704	28.912515		2.1062	4.43608	0.05251		
24	4.6	33.9	27.44984	6.45016	41.604564	-0.8307	0.6900028		6.45016	41.6046	0.19027		
25	3.5	35.8	32.9769	2.8231	7.9698936	1.06934	1.1434793		2.8231	7.96989	0.07886		
26	5	27.438	25.44	1.9975	3.9900063	-7.2932	53.190242		1.9975	3.99001	0.0728		
27	2.4	38.7	38.50396	0.19604	0.0384317	3.96934	15.755628		0.19604	0.03843	0.00507		
28	6	32.4	20.4154	11.9846	143.63064	-2.3307	5.4319951		11.9846	143.631	0.3699		
29	4.4	30.548	28.45476	2.09324	4.3816537	-4.1827	17.494679		2.09324	4.38165	0.06852		

Use Excel Data Analysis tool

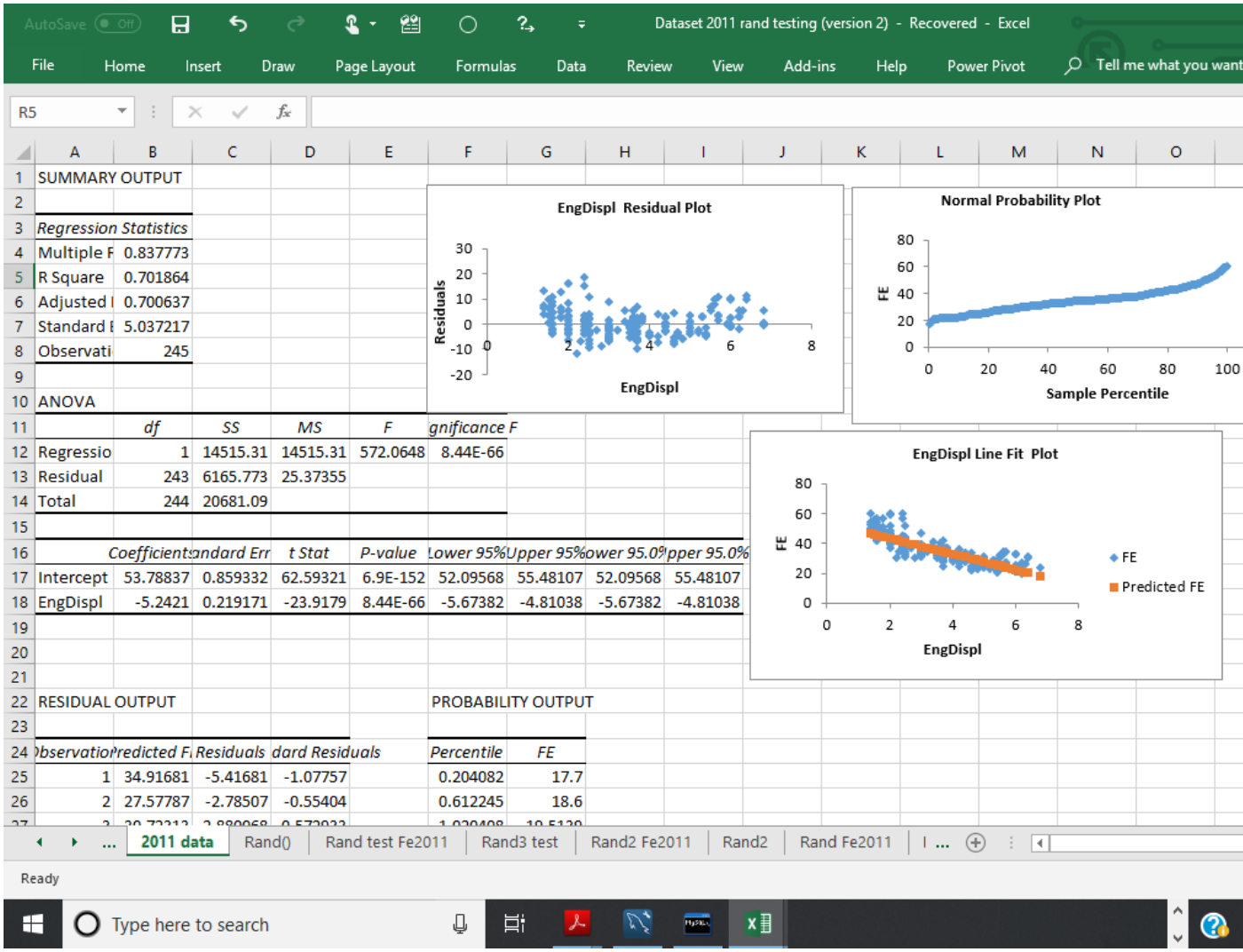
7. Use Data Analysis feature of Excel to bypass the co-efficient calculation formulas and compute the Regression Model directly.

8. You should be able to repeat all the points asked under “Use Excel” using Data Analysis tool. You may need to do the random sampling separately here as well.





	A	B	C	D	E	F	G	H	I	J	K
1	SUMMARY OUTPUT										
2											
3	*Regression Statistics*										
4	Multiple R	0.787237178									
5	R Square	0.619742375									
6	Adjusted R Square	0.619397939									
7	Standard Error	4.62618478									
8	Observations	1106									
9											
10	ANOVA										
11		*df*	*SS*	*MS*	*F*	*Significance F*					
12	Regression	1	38507.76252	38507.76252	1799.295	4.8644E-234					
13	Residual	1104	23627.35053	21.40158562							
14	Total	1105	62135.11305								
15											
16		*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*		
17	Intercept	50.56152493	0.398692111	126.8184734	0	49.77924512	51.3438	49.77925	51.3438		
18	EngDisp	-4.52010907	0.106560868	-42.41809563	4.9E-234	-4.729193757	-4.31102	-4.72919	-4.31102		
19											
20											
21											
22	RESIDUAL OUTPUT					PROBABILITY OUTPUT					
23											
24	*Observation*	*Predicted 28.0198*	*Residuals*	*Standard Residuals*		*Percentile*	*28.0198*				
25	1	29.3170123	-3.707612302	-0.801803488		0.045207957	17.5				
26	2	31.57706684	-4.777066837	-1.033082356		0.13562387	17.5				
27	3	31.57706684	6.521966837	1.412594783		0.226039783	17.8				


Dataset 2011 rand testing (version 2) - Recovered - Excel
File Home Insert Draw Page Layout Formulas Data Review View Add-ins Help Power Pivot
Tell me what you want
R5
SUMMARY OUTPUT
Regression Statistics
Multiple F 0.837773
R Square 0.701864
Adjusted I 0.700637
Standard E 5.037217
Observati 245
ANOVA
df SS MS F gnificance F
Regressio 1 14515.31 14515.31 572.0648 8.44E-66
Residual 243 6165.773 25.37355
Total 244 20681.09
Coefficients tandard Err t Stat P-value Lower 95% Upper 95% ower 95.0% pper 95.0%
Intercept 53.78837 0.859332 62.59321 6.9E-152 52.09568 55.48107 52.09568 55.48107
EngDispl -5.2421 0.219171 -23.9179 8.44E-66 -5.67382 -4.81038 -5.67382 -4.81038
RESIDUAL OUTPUT
PROBABILITY OUTPUT
bservatio redicted F Residuals dard Residuals
Percentile FE
1 34.91681 -5.41681 -1.07757 0.204082 17.7
2 27.57787 -2.78507 -0.55404 0.612245 18.6
EngDispl Residual Plot
Residuals
EngDispl
Normal Probability Plot
FE
Sample Percentile
EngDispl Line Fit Plot
FE
Predicted FE
EngDispl
2011 data
Rand()
Rand test Fe2011
Rand3 test
Rand2 Fe2011
Rand2
Rand Fe2011
Ready
Type here to search

N26

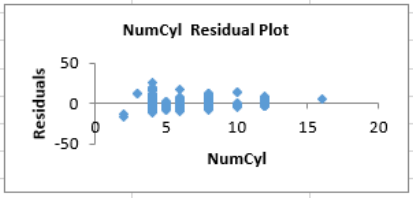
SUMMARY OUTPUT

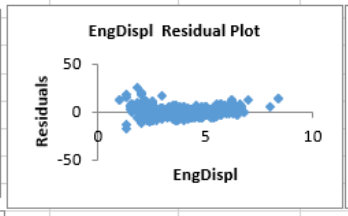
Regression Statistics	
Multiple R	0.802784517
R Square	0.644462981
Adjusted R Square	0.641546086
Standard Error	4.489148668
Observations	1107

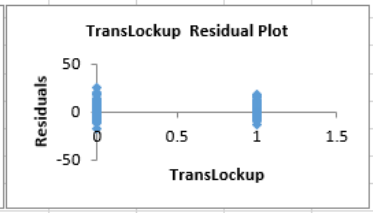
ANOVA

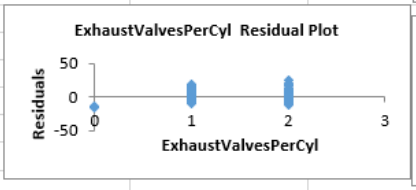
	df	*SS*	*MS*	*F*	*Significance F*
Regression	9	40072.62132	4452.51348	220.9414839	0.0000
Residual	1097	22107.24397	20.15245576		
Total	1106	62179.86529			

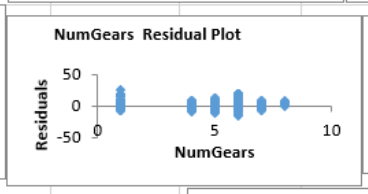
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	54.3472174	1.097260536	49.52991165	0.0000	52.19425086	56.50018394	52.19425	56.50018
EngDispl	-3.860968909	0.280482802	-13.76543905	0.0000	-4.411312303	-3.310625515	-4.41131	-3.31063
NumCyl	-0.488801421	0.184529532	-2.648906205	0.0082	-0.850872137	-0.126730705	-0.85087	-0.12673
NumGears	-0.172517448	0.106502294	-1.619847249	0.1056	-0.381488671	0.036453775	-0.38149	0.036454
TransLockup	-1.444991498	0.299981166	-4.816940741	0.0000	-2.033593195	-0.856389802	-2.03359	-0.85639

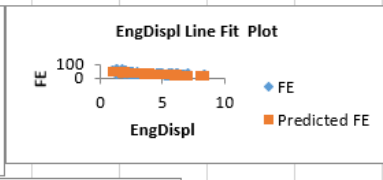


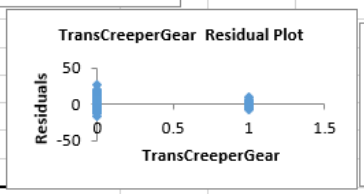


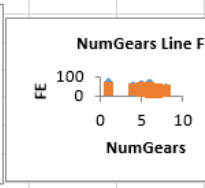










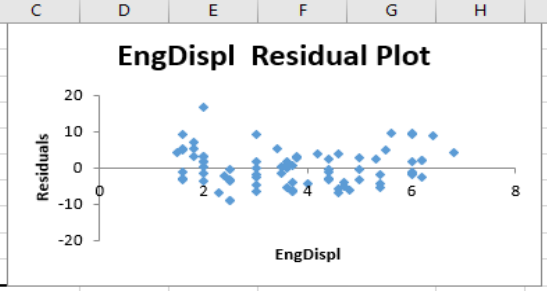


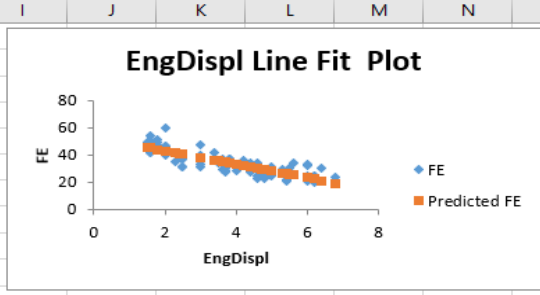
Dataset 2011 rand testing (version 2) - Recovered - Excel

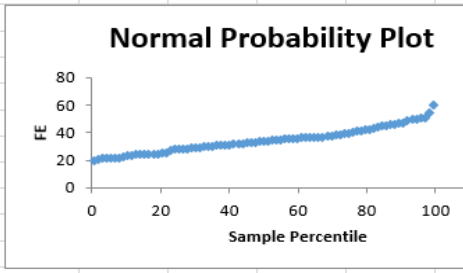
File Home Insert Draw Page Layout Formulas Data Review View Add-ins Help Power Pivot Tell me what you wan

S15

	A	B	C	D	E	F	G	H	I
1	SUMMARY OUTPUT								
2									
3	*Regression Statistics*								
4	Multiple R	0.835503							
5	R Square	0.698065							
6	Adjusted R Square	0.694243							
7	Standard Error	4.968307							
8	Observations	81							
9									
10	ANOVA								
11		*df*	*SS*	*MS*	*F*	*gnificance F*			
12	Regression	1	4508.444	4508.444	182.6459	3.05E-22			
13	Residual	79	1950.042	24.68408					
14	Total	80	6458.487						
15									
16		*Coefficients*	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
17	Intercept	52.88755	1.486641	35.5752	2.2E-50	49.92847	55.84664	49.92847	55.84664
18	EngDispl	-4.95426	0.366584	-13.5147	3.05E-22	-5.68393	-4.22459	-5.68393	-4.22459
19									
20									
21									
22	RESIDUAL OUTPUT					PROBABILITY OUTPUT			
23									
24	*Observation*	*redicted F*	*Residuals*	*dard Residuals*		*Percentile*	*FE*		
25	1	35.05222	-5.55222	-1.12458		0.617284	19.5139		
26	2	28.11626	-3.32346	-0.67315		1.851852	20.6		



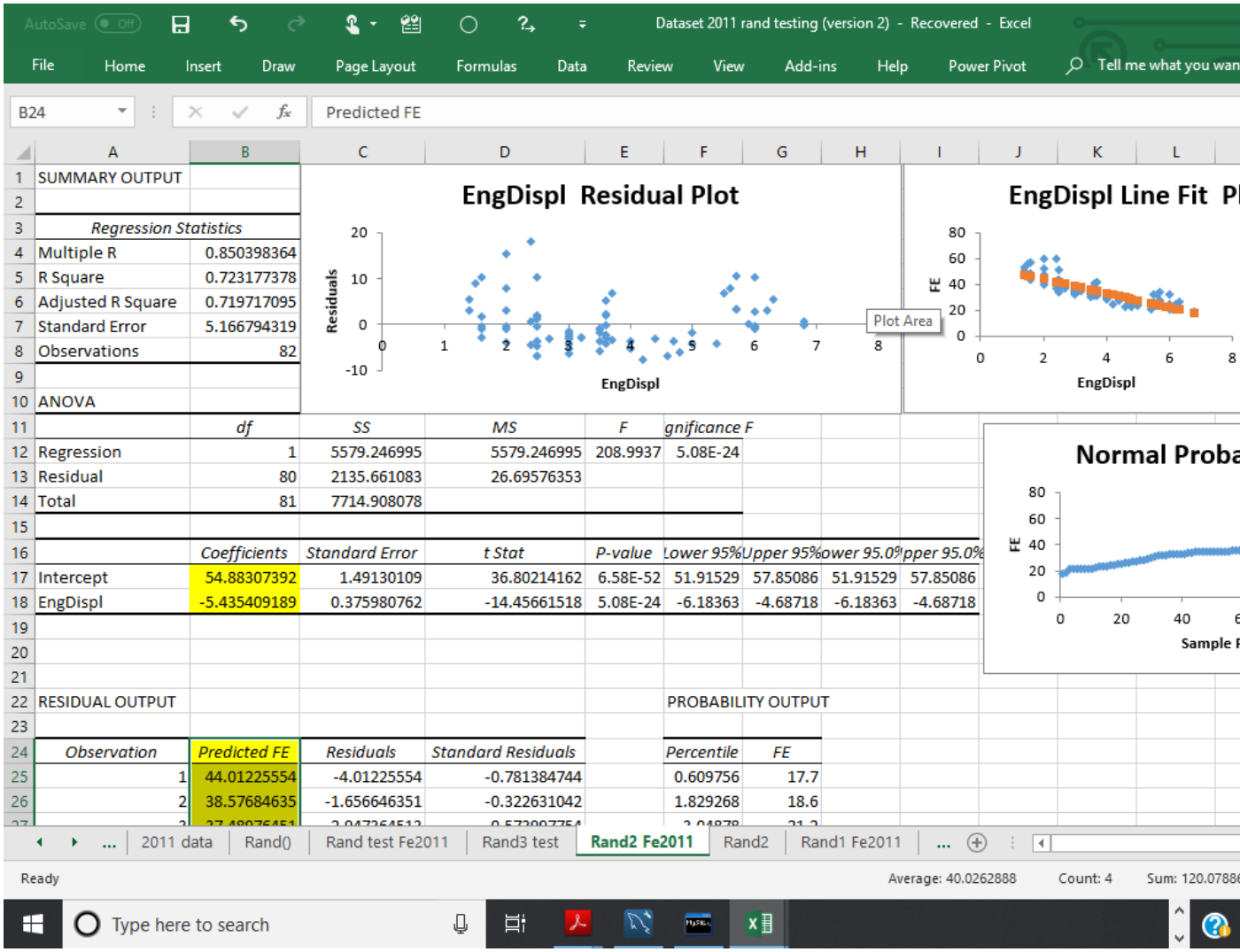


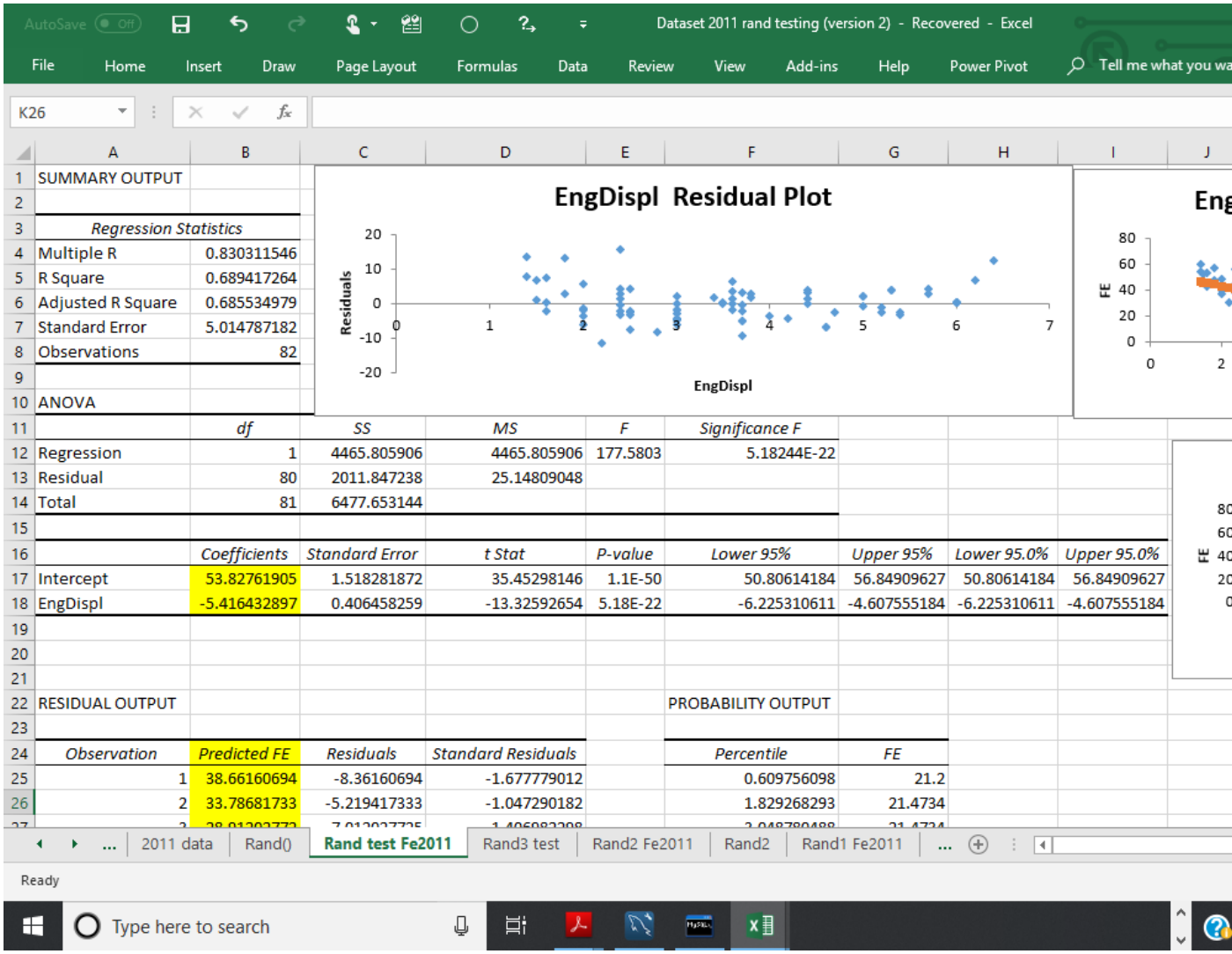


2011 data | Rand() | Rand test Fe2011 | Rand3 test | Rand2 Fe2011 | Rand2 | Rand1 Fe2011

Ready

Type here to search


Dataset 2011 rand testing (version 2) - Recovered - Excel
File Home Insert Draw Page Layout Formulas Data Review View Add-ins Help Power Pivot
Tell me what you wan
B24
Predicted FE
EngDispl Residual Plot
Residuals
EngDispl
Plot Area
EngDispl Line Fit Pl
FE
EngDispl
Normal Proba
FE
Sample
SUMMARY OUTPUT
Regression Statistics
Multiple R 0.850398364
R Square 0.723177378
Adjusted R Square 0.719717095
Standard Error 5.166794319
Observations 82
ANOVA
df SS MS F gnificance F
Regression 1 5579.246995 5579.246995 208.9937 5.08E-24
Residual 80 2135.661083 26.69576353
Total 81 7714.908078
Coefficients Standard Error t Stat P-value Lower 95% Upper 95% ower 95.0% pper 95.0%
Intercept 54.88307392 1.49130109 36.80214162 6.58E-52 51.91529 57.85086 51.91529 57.85086
EngDispl -5.435409189 0.375980762 -14.45661518 5.08E-24 -6.18363 -4.68718 -6.18363 -4.68718
RESIDUAL OUTPUT
PROBABILITY OUTPUT
Observation Predicted FE Residuals Standard Residuals Percentile FE
1 44.01225554 -4.01225554 -0.781384744 0.609756 17.7
2 38.57684635 -1.656646351 -0.322631042 1.829268 18.6
2011 data Rand() Rand test Fe2011 Rand3 test Rand2 Fe2011 Rand2 Rand1 Fe2011
Ready
Average: 40.0262888 Count: 4 Sum: 120.0788
Type here to search



Use MySQL

9. Upload the 2010 and 2011 dataset into a MySQL database named “fuel_economy”. The table name should be “fe2010” and “fe2011” respectively.

10. You have already calculated the beta coefficients for the full 2010 dataset. Insert two additional columns for the beta coefficients in the “fe2010” table
and populate the columns with beta values. You can just take the previously calculate beta values to populate here. Remember the beta values will be constant
for each column here.

11. Once point 10. is done, Calculate the Predicted value for “feb2011” table by using the input variable from “feb2011” and beta coefficients from “feb2010” table.
Insert the predicted values in an additional column in table “feb2010”.

My SQL Part is submitted separately as MYSQL submission for Project 1.1 as part 2

Acknowledgement

This is a quite interesting project and I have gained a lot of knowledge about Excel analytics, MYSQL and finding the linear relationship in R, Excel graphs are very much interesting. I thank the institute Acadgild and the Mentors Mr. Sunil who taught us the R Excel, MYSQL and other subjects to understand the Analytics. I thank the support coordinator Mr. Anuj for guiding me to understand the project related queries and complete the project on time. I once again thank Acadgild for enlighten me on Machine learning through online teaching and various coding support through the support coordinators. Thank you Acadgild.