XIMAN LIU

DATA ANALYSIS AND REGRESSION

Assignment-3 | Total Points: 30 pts for DSC 423 / 20 pts for DSC 323

Due Date: 4/19/2021 by 11:59 pm

Note:

- All assignments should be submitted in a **single MS WORD format**, no PDFs or any other file types will be accepted. If you submit any other file type, it will not be graded.
- No extensions will be given unless for a documented reason specified in the syllabus, no late assignments past the due date even a couple of minutes late will be accepted as you have an extra day (8-days) to submit your assignments.
- Submitting work that is not yours is grounds for an automatic 'F' for the entire course – this includes taking content and ideas from others or consulting others to complete your deliverables other than your instructor.
- SAS software and virtual server stalls, gets slow and crashes; so start early and keep multiple backups in multiple places/mediums. Late submission or inability to do the assignment due to server and/or software issues will not be accepted. Any issues relating with SAS, contact IS using the phone number provided in the syllabus, I won't be able to help you with DePaul software related issues.

***Note:* For all questions, immaterial if whether the relevant output is asked to be attached or not, make sure to include it. Also, it is important to include the sign (negative/positive or increase/decrease, and units of measurements e.g. $ or $ 99 million,%, etc.) otherwise points will be deducted.**

Problem 1 [5 pts] – ONLY for GRADUATES

A university career center collects information on the job status and starting salary of graduating seniors. Data recently collected over a two-year period included over 900 seniors who had found employment at the time of graduation. The information was used to model starting salary Y as a function of two qualitative independent variables: COLLEGE at four levels {Business, Engineering, Liberal Arts, Nursing} and SEX (male and female).

1. Define the dummy variables to include college (use Business as your baseline) in a regression model for starting salary Y

COLLEGE	Z1	Z2	Z3
Business	0	0	0
Engineering	1	0	0
Liberal Arts	0	1	0
Nursing	0	0	1

Three dummy variables for college.

Define:

Z1 = 1 if college = Engineering; Z1 = 0 otherwise;

Z2 = 1 if college = Liberal Arts; Z2 = 0 otherwise;

Z3 = 1 if college = Nursing; Z3 = 0 otherwise;

Z1 = 0 and Z2 = 0 and Z3 = 0 if college = Business.

2. Write down the general regression model relating starting salary Y to both college and sex.

   $Y = \beta_0 + \beta_1 Z1 + \beta_2 Z2 + \beta_3 Z3 + \beta_4 DSEX + e$
   Dummy variable DSEX = 1 if sex = 'male'

3. How would your model change if students in Engineering have the same starting salary as students in Business? Show the final regression model.

   Engineering: $Y_E = \beta_0 + \beta_1(1) + \beta_2(0) + \beta_3(0) = \beta_0 + \beta_1$
   Business: $Y_B = \beta_0 + \beta_1(0) + \beta_2(0) + \beta_3(0) = \beta_0$

   Because $Y_E = Y_B$, hence $\beta_0 + \beta_1 = \beta_0$, so $\beta_1 = 0$
   With that result, we can tell that Engineering(Z1) does not have effect on Y, hence it can be removed in the model.

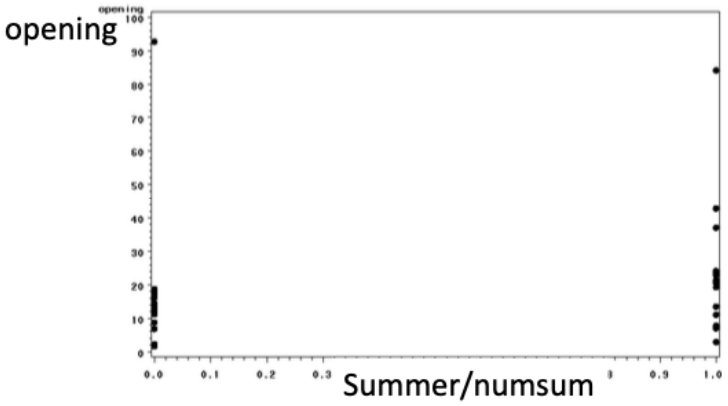
   All in all, $Y = \beta_0 + \beta_2 Z2 + \beta_3 Z3 + \beta_4 DSEX + e$

Problem 2 [5 pts] – ONLY for GRADUATES
Answer the following Questions:

1. Why the number of dummy variables used in regression model is always equal to the number of levels -1? (1 point)

   The number of dummy variables required to represent a particular categorical variable depends on the number of values that the categorical variable can assume. To represent a categorical variable that can assume k different values, a researcher would need to define k - 1 dummy variables. The number of levels is captured by the intercept and is specified when the dummy variables are all set to zero. If the number of dummy variables used in regression model is always equal to the number of levels, it will cause the regression to fail. A kth dummy variable is redundant; it carries no new information. And it creates a severe multicollinearity problem for the analysis. Using k dummy variables when only k - 1 dummy variables are required is known as the dummy variable trap. Also, there is always a baseline level as reference.

2. Why doesn't it make sense to analyze the residual plots for a dummy variable? Use an appropriate image to explain your answer. (1 point)



The residual plots represent residuals on vertical axis and independent variable on the horizontal axis. Dummy variables only have 0 and 1, hence the graph looks like above, which is meaningless to analyze residuals.

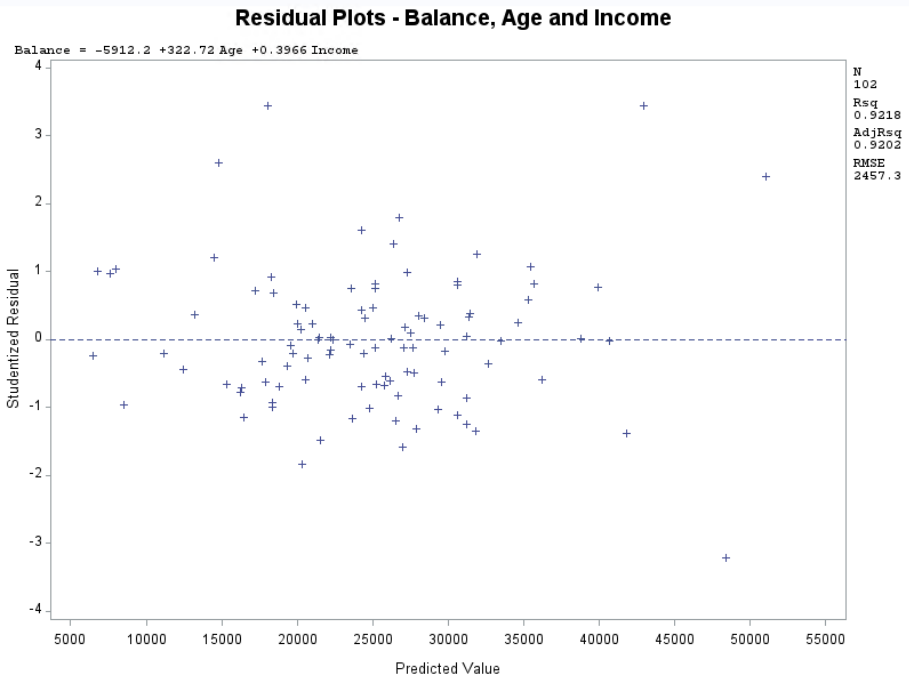
3. Why are linear regression used? List 3 reasons. (3 points)
   (1) determining the strength of predictors.
   (2) forecasting an effect.
   (3) trend forecasting.

Problem 3 [5 pts] – to be answered by everyone

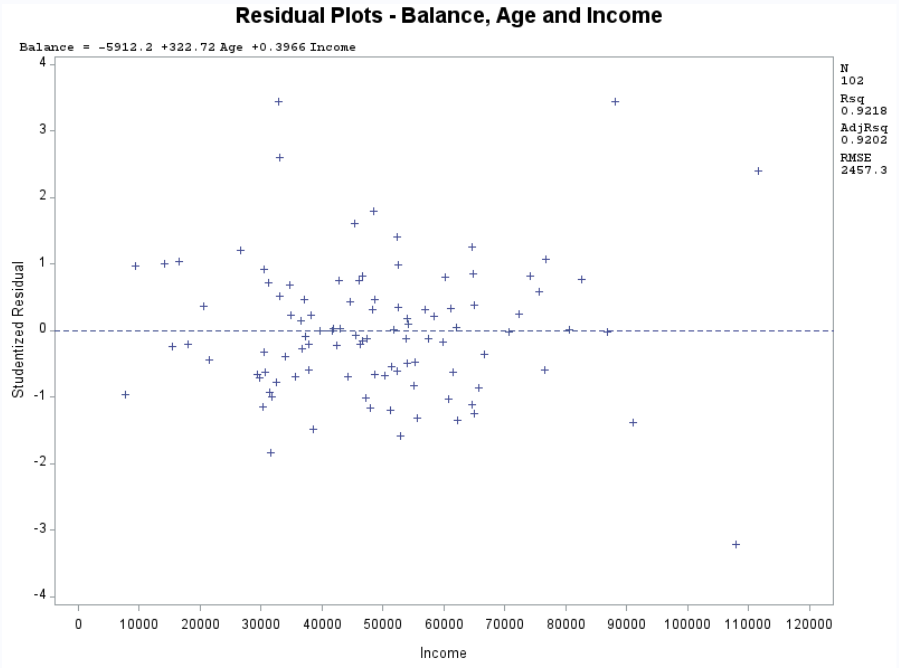
You will continue the analysis of the banking.txt dataset that was analyzed in Assignment 2 – data file is attached. Answer this question based on your final model from assignment-2.

a) Analyze the residuals of the regression model you found in your previous assignment. Include the residual plots. Discuss your findings.

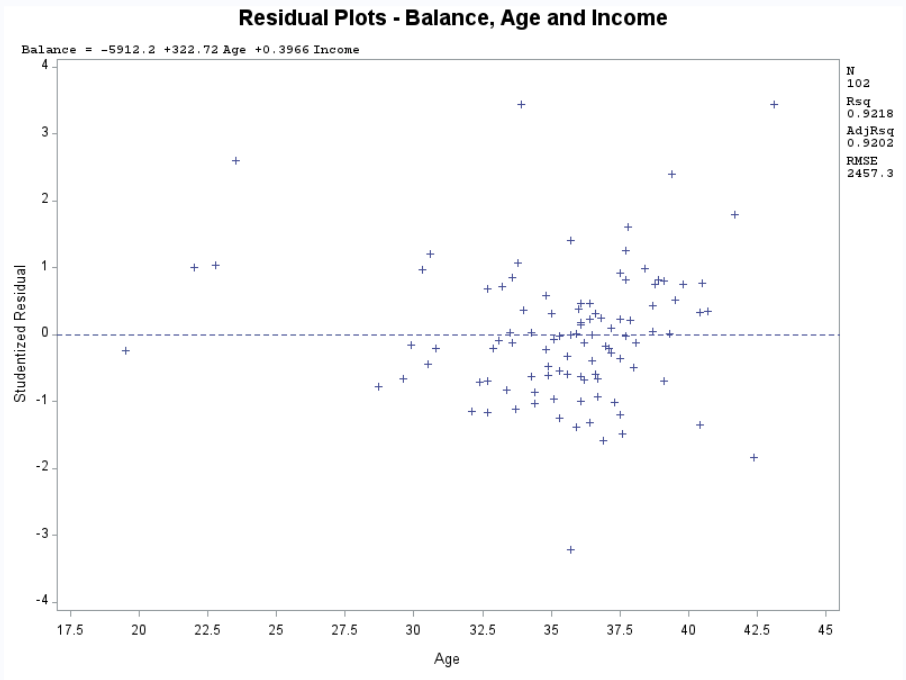
The REG Procedure



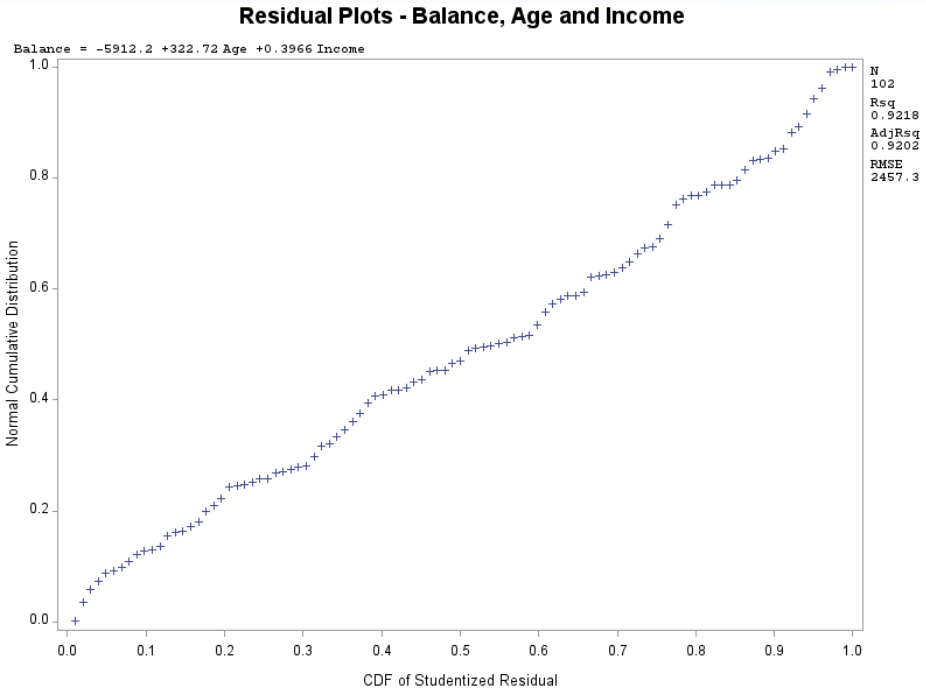
The REG Procedure



The REG Procedure



The REG Procedure



The scatter plots of Predicted Value, Income and Age are not randomly scattered around the zero line, in that case we cannot say they have constant variance. The shape of three scatter plots also violates independence assumption.

The residual plots for Balance, Age, and Income represents it is normal distribution and linearly. There are possible outliers in the first three graphs because studentized residuals are greater than 2 or less than -2.

b) Conduct a global F-test for overall model adequacy. Write down the test hypotheses and test statistic and discuss conclusions. Include the relevant output.

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	7043053576	3521526788	583.20	<.0001
Error	99	597790568	6038289		
Corrected Total	101	7640844145			

Null hypothesis:

H_o: $\beta_1 = \beta_2 = \beta_3 = \ldots = \beta_k = 0$

Alternative hypothesis:

H_a: At least one coefficient $\beta_j \neq 0$

Test statistic:

F = Model / Error = 3521526788 / 6038289 = 583.199444081

Therefore, F = 583.199444081 and with p-value less than 0.05 (at alpha=0.05). The null hypothesis of no association between balance(y) and age & income(x-var) is rejected. At least one x-variable has a significant effect on changes in balance. F-test gives strong support to the fitted model.

c) Copy and paste your FULL SAS code into the word document along with your answers.

```
PROC IMPORT datafile="C:\Users\XLIU115\Desktop\Assignment3\banking.txt"
out=salary replace;
getnames=yes;
RUN;


PROC CORR;
var Balance Age Income;
RUN;
```

```
PROC REG CORR;
title "Regression Model - Remove Education";
model Balance = Age Income;
RUN;


PROC REG;
title "Residual Plots - Balance, Age and Income";
model Balance = Age Income;
plot student.*predicted.;
plot student.*(Age Income);
plot npp.*student.;
RUN;
```

Problem 4 [15pts] – to be answered by everyone

A national homebuilder builds single-family homes and condominium style townhouses.
The file housesales.txt provides information on the selling price (PRICE), lot cost (COST), type of home (HOME) (SF=single family home or T=condominium style) and region of the country (REGION) (M=Midwest, S=south) for closings during one month.

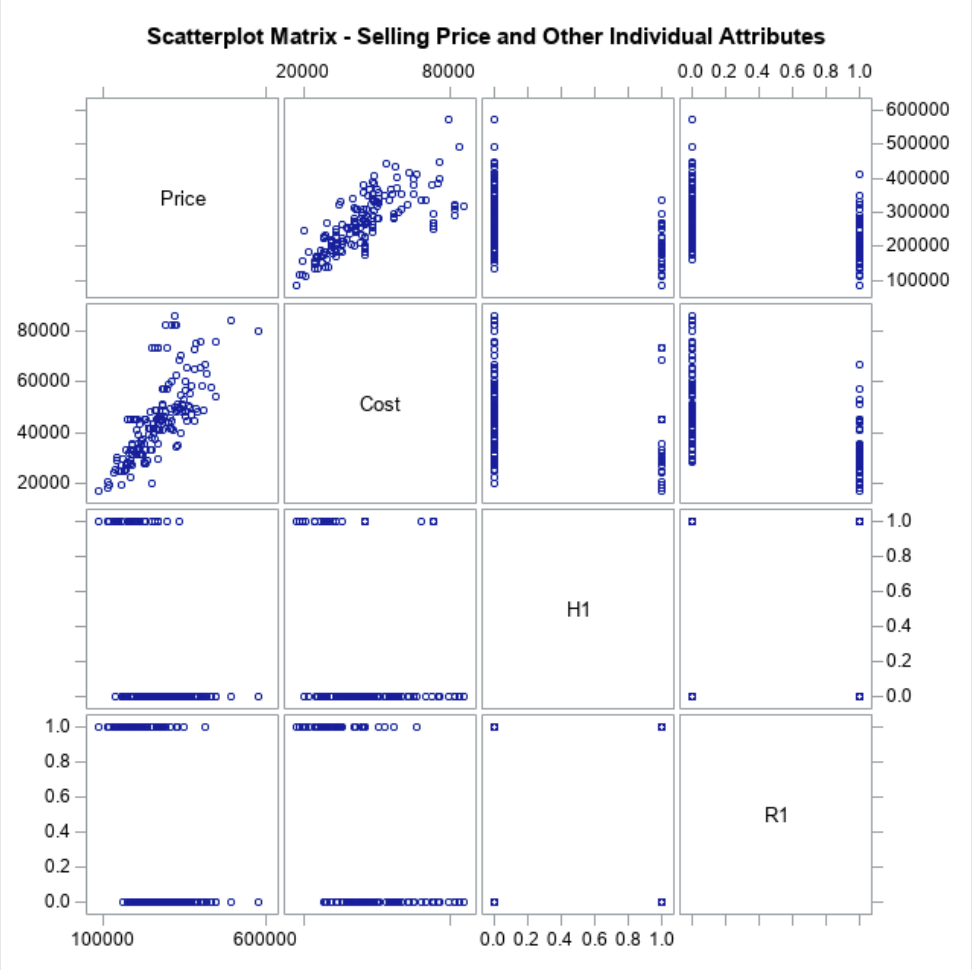
a) Define the dummy variables for region and home (write them down here), and create them in SAS.

REGION	R1
M	0
S	1

HOME	H1
SF	0
T	1

Two dummy variables.
Define:
H1 = 1 if HOME = condominium style; H1 = 0 if HOME = single family home otherwise;
R1 = 1 if REGION = south; R1 = 0 if REGION = Midwest otherwise.

b) Analyze the association between selling price and each individual attribute (cost, home and region) using appropriate statistics and graphs. Discuss your findings. Include the relevant output.



Residual Plots - Selling Price, Cost, Home and Region

The REG Procedure

Number of Observations Read	168
Number of Observations Used	168

Correlation				
Variable	Cost	H1	R1	Price
Cost	1.0000	-0.1080	-0.5716	0.7263
H1	-0.1080	1.0000	0.1784	-0.4282
R1	-0.5716	0.1784	1.0000	-0.4908
Price	0.7263	-0.4282	-0.4908	1.0000

The scatter plot represents the positive linear regression relationship between selling price and cost. There is a strong association and almost no outliers. The correlation value is 0.7263 and quite close to 1 which means the assumption above is correct.
The residual plots for dummy variables are meaningless because they only have values of 0 and 1.

c) Fit an adequate regression model for sales price as a function of lot cost, region of country, and type of home. Remove the terms that are not significant. The final model should only contain variables that are significantly associated with sale price. Write down the model equation. Include the relevant output.

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	126123	16018	7.87	<.0001
Cost	1	3.50527	0.29817	11.76	<.0001
H1	1	-72566	9755.37424	-7.44	<.0001
R1	1	-9081.58833	9890.76247	-0.92	0.3599

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	116426	12038	9.67	<.0001
Cost	1	3.65986	0.24597	14.88	<.0001
H1	1	-73847	9650.41822	-7.65	<.0001

Sales Price = 126,123 + 3.50527 * Cost – 72,566 * H1 – 9,081.58833 * R1
(where H1 = 1 if HOME = 'T' and R1 = 1 if REGION = 'S')
The result of T-test shows that Cost and H1 both have important effect on sales price with p-value of them are less than 0.0001.
The p-value for R1 is 0.3599 which is greater than 0.05, in that case we cannot say R1 does not have effect on sales price.

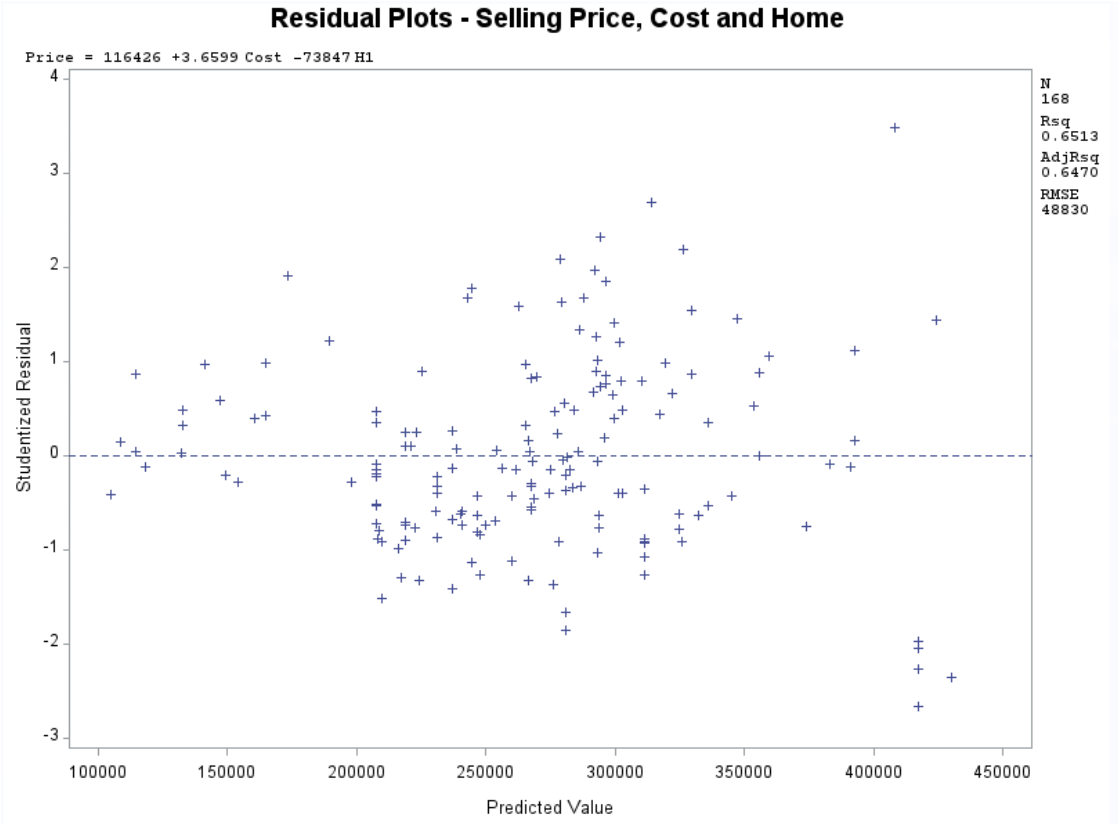
The second graph shows the situation after deleting dummy variable R1.
This time we have below as final model:
Sales Price = 116,426 + 3.65986 * Cost - 73,847 * H1
We try T-test again and find both cost and H1 have significant associated with sale price with both p-value of them are less than 0.0001.

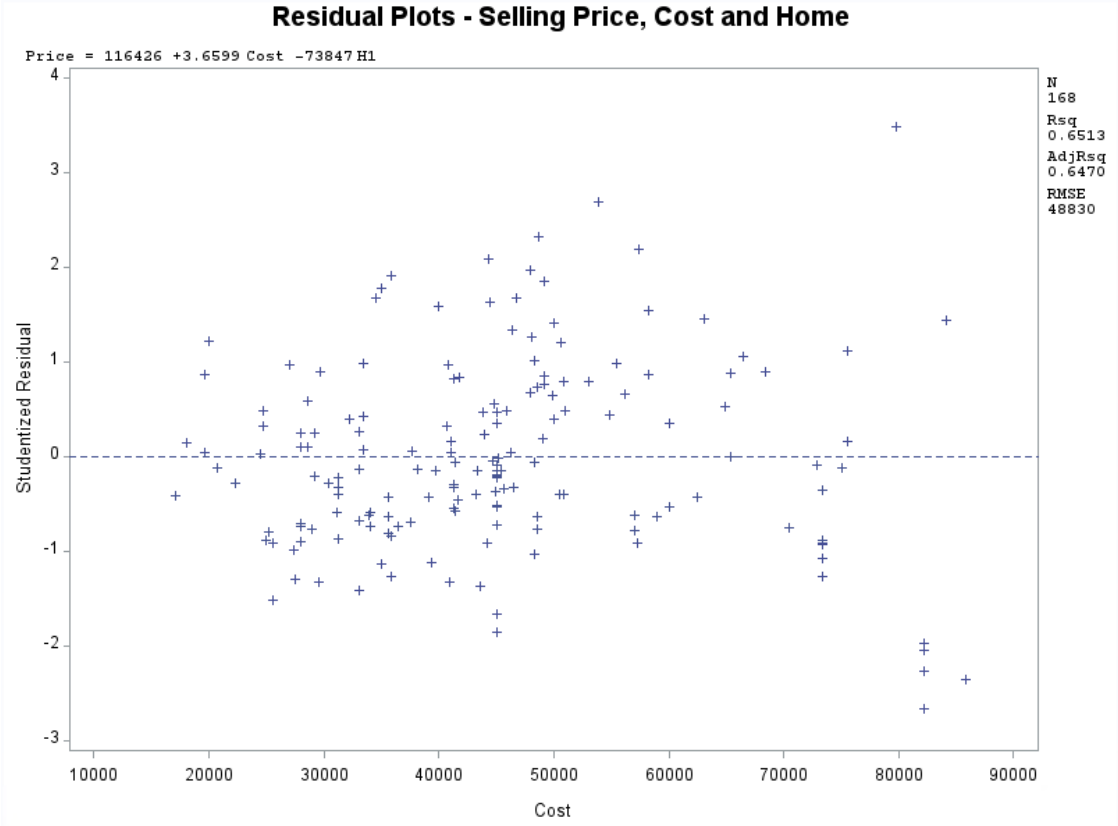
d) Conduct a global F-test for overall model adequacy. Write down the test hypotheses and test statistic and discuss conclusions. Include the relevant output.

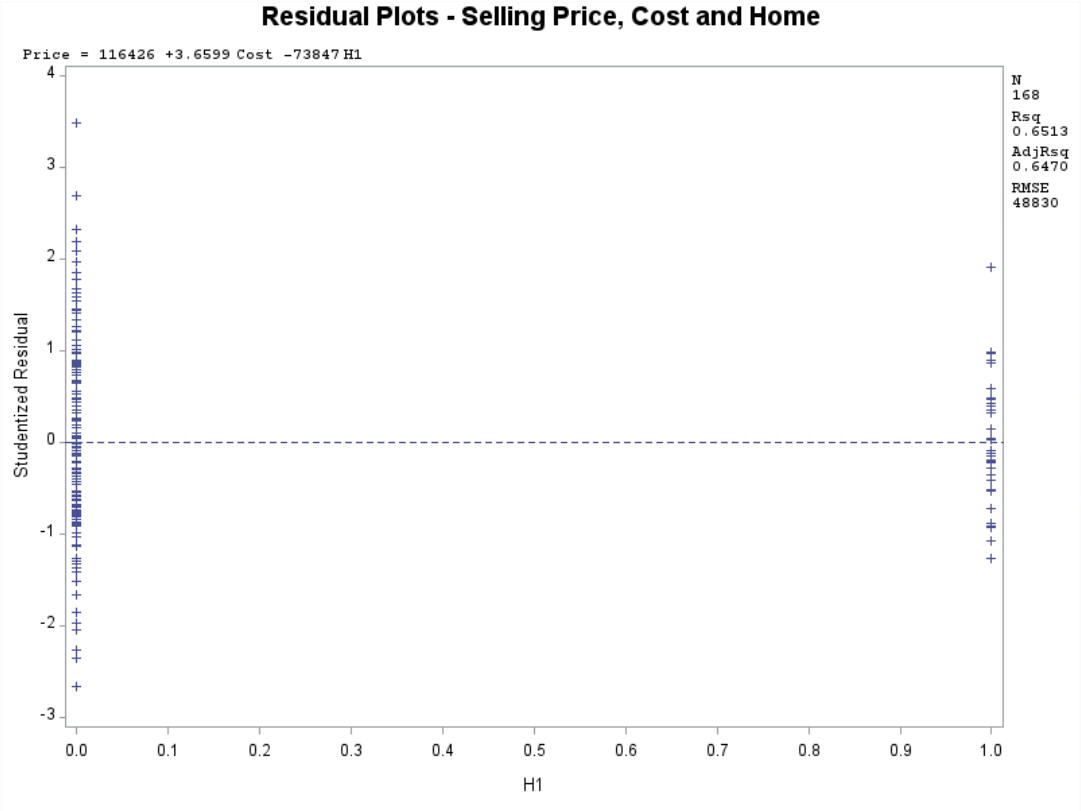
Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	7.347041E11	3.67352E11	154.07	<.0001
Error	165	3.934247E11	2384392143		
Corrected Total	167	1.128129E12			

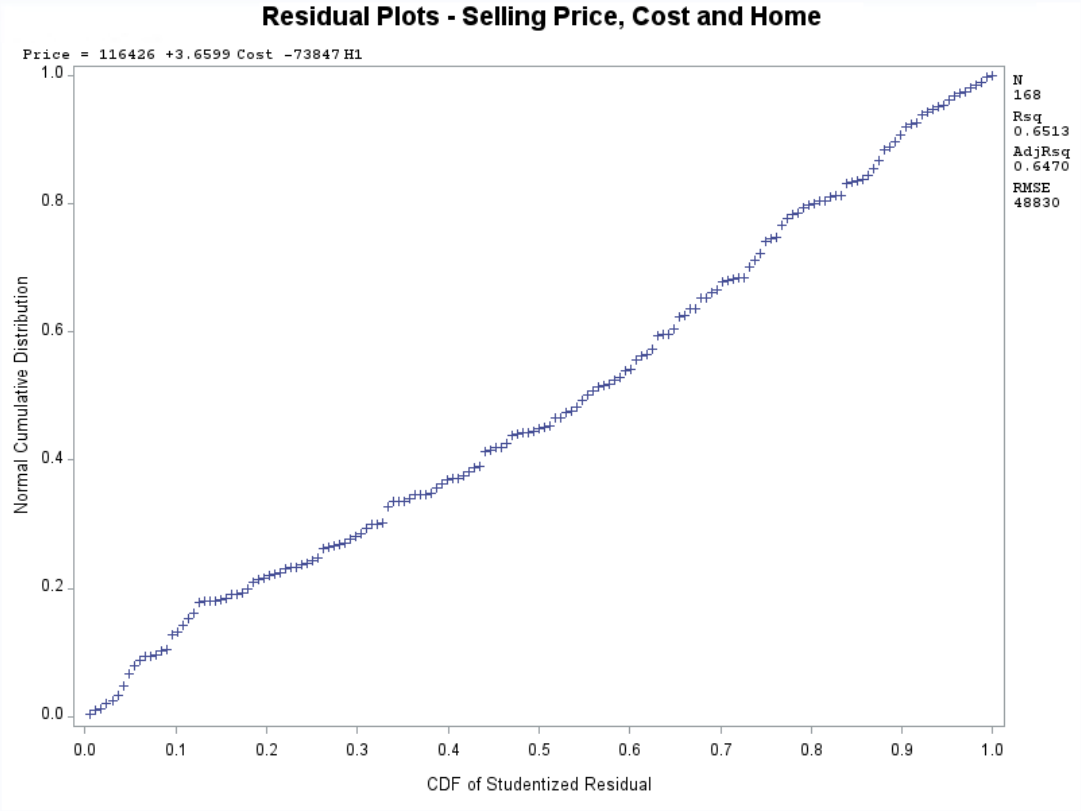
Null hypothesis:
H_o: $\beta_1 = \beta_2 = \beta_3 = \ldots = \beta_k = 0$
Alternative hypothesis:
H_a: At least one coefficient $\beta_j \neq 0$
Test statistic:
F = Mean Square Model / Mean Square Error = 3.67352E11 / 2384392143 = 154.065261907
Therefore, F = 154.065261907 and with p-value less than 0.05 (at alpha=0.05). The null hypothesis of no association between sales price(y) and cost & H1(x-var) is rejected. At least one x-variable has a significant effect on changes in sales price. F-test gives strong support to the fitted model.

e) Analyze model residuals to check if assumptions on data are satisfied. Discuss your findings. Include the relevant output.


Residual Plots - Selling Price, Cost and Home
Price = 116426 +3.6599 Cost -73847 H1
N
168
Rsq
0.6513
AdjRsq
0.6470
RMSE
48830
Studentized Residual
Predicted Value
4
3
2
1
0
-1
-2
-3
100000
150000
200000
250000
300000
350000
400000
450000


Residual Plots - Selling Price, Cost and Home
Price = 116426 +3.6599 Cost -73847 H1
N
168
Rsq
0.6513
AdjRsq
0.6470
RMSE
48830
Studentized Residual
Cost
4
3
2
1
0
-1
-2
-3
10000
20000
30000
40000
50000
60000
70000
80000
90000


Residual Plots - Selling Price, Cost and Home
Price = 116426 +3.6599 Cost -73847 H1
N
168
Rsq
0.6513
AdjRsq
0.6470
RMSE
48830
Studentized Residual
H1
4
3
2
1
0
-1
-2
-3
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0


Residual Plots - Selling Price, Cost and Home
Price = 116426 +3.6599 Cost -73847 H1
N
168
Rsq
0.6513
AdjRsq
0.6470
RMSE
48830
Normal Cumulative Distribution
CDF of Studentized Residual
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0

Dummy variable H1 is qualitative variable with scattering along 0 and 1, which is meaningless for residual analysis.
The graph of Cost and Predicted Value are not randomly scattered around zero line, which no constant variance. Also, they have funnel shapes, which violate independence assumption.
CDF of Studentized Residual graph represents the model is normal distributed with a linear line.
Probably there are outliers because studentized residuals in cost exist values greater than 3 or less than -3.

f) Discuss what the regression model indicates for the relationship between price and home type (i.e. interpret the coefficient values).

Sales Price(Y) = 116,426 + 3.65986 * Cost - 73,847 * H1
Assume cost is fixed. Then, Sales Price(Y) = $\beta_0 + \beta_1 * H1$
$Y_{SF} = \beta_0 + \beta_1(0) = \beta_0$
$Y_T = \beta_0 + \beta_1(1) = \beta_0 + \beta_1$
$Y_T - Y_{SF} = \beta_1$
Therefore, β_0 is $116,426 is intercept value. In that case, sales price starts at $116,426 irrelevant with cost and home. Assume all the other variables constant, then condominium style will decrease the sale price by $73,847 compared to single family home.

g) Use the regression analysis to determine whether mean sale prices are different for the two regions? Explain.

The p-value for R1 is 0.3599 which greater than 0.05. That shows that dummy variable region is not a significant variable to sales price. Hence it has been removed from the model. Neither the south nor the midwest has a significant effect on the results.

h) Copy and paste your FULL SAS code into the word document along with your answers.

```
TITLE "Analysis - HouseSales";


PROC IMPORT datafile="C:\Users\XLIU115\Desktop\Assignment3\HouseSales.txt"
out=Price replace;
getnames=yes;
delimiter='09'x;
RUN;


DATA Price;
set Price;
```

```
H1=(Type="T");
R1=(Region="M");
RUN;


PROC PRINT data=Price;
RUN;


PROC SGSCATTER;
  title "Scatterplot Matrix - Selling Price and Other Individual Attributes";
  matrix Price Cost H1 R1;
RUN;


PROC REG CORR;
title "Residual Plots - Selling Price, Cost, Home and Region";
model Price= Cost H1 R1;
RUN;


PROC REG;
model Price= Cost H1 R1;
RUN;


PROC REG;
model Price= Cost H1;
RUN;


PROC SGSCATTER;
  title "Scatterplot Matrix - Selling Price, Cost and Home";
  matrix Price Cost H1;
RUN;


PROC REG corr;
title "Residual Plots - Selling Price, Cost and Home";
model Price= Cost H1;
plot student.*predicted.;
plot student.*(Cost H1);
plot npp.*student.;
RUN;
```