FEEDBACK TUTORIAL LETTER

1st SEMESTER 2019

ASSIGNMENT 1 AND 2

STATISTICS FOR ECONOMIST
SEC311S
Course Name: STATISTICS FOR ECONOMIST
Course Code: SSEC311S
Department: MATHEMATICS AND STATISTICS
Course Duration: ONE SEMESTER
NQF Level and Credit: NQF CREDITS: 12  NQF LEVEL: 5

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ASSIGNMENT 1 MEMO

Question 1 [24 marks]

The return on two investments X and Y in multiples of 10 thousand dollars is given by the following joint probability distribution.

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.4</td>
<td>0.12</td>
<td>0.08</td>
</tr>
<tr>
<td>1</td>
<td>0.15</td>
<td>0.08</td>
<td>0.03</td>
</tr>
<tr>
<td>2</td>
<td>0.1</td>
<td>0.03</td>
<td>0.01</td>
</tr>
</tbody>
</table>

1.1 Determine the marginal probability mass function \( p(x) \)

\[
p(x) = 0.6, \ x = 0 \\
\quad = 0.26, \ x = 1 \\
\quad = 0.14, \ x = 2 \\
\quad = 0 \quad \text{elsewhere}
\]

1.2 Determine the marginal probability mass function \( p(y) \)

\[
p(y) = 0.65, \ y = 0 \\
\quad = 0.23, \ y = 1 \\
\quad = 0.12, \ y = 2 \\
\quad = 0 \quad \text{elsewhere}
\]

1.3 Find \( E(X) \)

\[
E(X) = \sum_x xp(x) \\
\quad = 0 \times 0.6 + 1 \times 0.26 + 2 \times 0.14 \\
\quad = 0.54
\]

1.4 Find \( E(Y) \)

[2 marks]
\[ E(Y) = \sum_x y p(y) \]
\[ = 0 \times 0.65 + 1 \times 0.23 + 2 \times 0.12 \]
\[ = 0.47 \]

1.5 Find \( Var(X) \) [3]

\[ Var(X) = \sum_x x^2 p(x) - [E(X)]^2 \]
\[ = 0^2 \times 0.65 + 1^2 \times 0.23 + 2^2 \times 0.12 - [0.54]^2 \]
\[ = 0.528 \]

1.6 Find \( Var(Y) \) [3]

\[ Var(Y) = \sum_x y^2 p(y) - [E(Y)]^2 \]
\[ = 0^2 \times 0.65 + 1^2 \times 0.23 + 2^2 \times 0.12 - [0.47]^2 \]
\[ = 0.4891 \]

1.7 Find \( E(XY) \) [3]

\[ E(XY) = \sum_x \sum_y x y p(x,y) \]
\[ = 1 \times 1 \times 0.08 + 1 \times 2 \times 0.03 + 2 \times 1 \times 0.03 + 2 \times 2 \times 0.01 \]
\[ = 0.24 \]

1.8 Find \( Cov(X,Y) \). [2]

\[ Cov(X,Y) = E(XY) - E(X) \times E(Y) \]
\[ = 0.24 - 0.54 \times 0.47 \]
\[ = -0.0138 \]

1.9 Find and interpret the correlation coefficient \( \rho_{xy} \) [3]
\[ \rho_{xy} = \frac{\text{Cov}(X,Y)}{\sigma_X \sigma_Y} = \frac{-0.0138}{\sqrt{0.528}\sqrt{0.4891}} = -0.027 \]

Because the correlation coefficient is -0.027, which is a negative value close to zero, there exists a weak negative linear relationship between the two investment returns. In other words, as the return on investment X increases the return on investment Y decreases and vice-versa.

**Question 2 [29 marks]**

<table>
<thead>
<tr>
<th>Employee</th>
<th>Morning</th>
<th>Afternoon</th>
<th>Night</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>31</td>
<td>25</td>
<td>35</td>
</tr>
<tr>
<td>B</td>
<td>33</td>
<td>26</td>
<td>33</td>
</tr>
<tr>
<td>C</td>
<td>28</td>
<td>24</td>
<td>30</td>
</tr>
<tr>
<td>D</td>
<td>30</td>
<td>29</td>
<td>28</td>
</tr>
<tr>
<td>E</td>
<td>28</td>
<td>26</td>
<td>27</td>
</tr>
</tbody>
</table>

a) Write down the null and alternative hypothesis for the treatments (workers) and blocks (times of the day)  

**Treatments**

\( H_0: \mu_F = \mu_X = \mu_R = \mu_I = \mu_J \)

\( H_1: \text{At least two means are different} \)

**Blocks**

\( H_0: \mu_M = \mu_A = \mu_N \)

\( H_1: \text{At least two means differ} \)

b) Construct an ANOVA table.  

[4]  

[19]
\[
\sum_{0 \leq i < m \leq n} X_{ij} = 31 + 25 + 35 + \ldots + 27 = 433
\]

\[
\sum_{0 \leq i < m < n} X_{ij}^2 = 31^2 + 25^2 + 35^2 + \ldots + 27^2 = 12639
\]

\[
SSTOT = \sum X_{ij}^2 - \frac{\left(\sum X_{ij}\right)^2}{n} = 12639 - \frac{(433)^2}{15} = 139.73
\]

\[
SST = \frac{1}{b} \sum X_{ij}^2 - \frac{\left(\sum X_{ij}\right)^2}{n} = \frac{91^2}{3} + \frac{92^2}{3} + \frac{82^2}{3} + \frac{87^2}{3} + \frac{81^2}{3} - \frac{(433)^2}{15} = 33.73
\]

\[
SSB = \frac{1}{k} \sum X_{ij}^2 - \frac{\left(\sum X_{ij}\right)^2}{n} = \frac{150^2}{5} + \frac{130^2}{5} + \frac{153^2}{5} = 62.53
\]

\[
SSE = SSTOT - SST - SSB = 139.73 - 33.73 - 62.53 = 43.47
\]

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worker</td>
<td>4</td>
<td>33.73</td>
<td>33.73/4</td>
<td>8.43/5.43 = 1.55</td>
</tr>
<tr>
<td>Shift</td>
<td>2</td>
<td>62.53</td>
<td>62.53/2=31.27</td>
<td>31.27/5.43 = 5.76</td>
</tr>
<tr>
<td>Error</td>
<td>8</td>
<td>43.47</td>
<td>43.47/8 = 5.43</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>139.73</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

c) At the 1% confidence level, can we conclude that there is a difference in the mean production level by shift or by employee? [6]

For Workers:

\[ F_{0.01}(4,8) = 7.01 \]
We fail to reject $H_0$ and conclude that the workers do not differ in the number of units they produce.

For Shifts

$F_{0.01}(2,8) = 8.65$

We reject $H_0$ and conclude that at least two shifts differ in their production.

**Question 3 [10 marks]**

H0: The proportions of the types of defects and the production shift are statistically independent.

H1: The proportions of the types of defects and the production shift are associated.

Computation of expected values ($E_i$) and test statistic ($D^2$):

$$E_i = \frac{\text{Column total} \times \text{row total}}{\text{Grand total}}$$

$$D^2 = \sum \frac{O_i^2}{E_i} - n$$

<table>
<thead>
<tr>
<th>Shift</th>
<th>Type of defect</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>1</td>
<td>15(22.5)</td>
<td>21(20.99)</td>
</tr>
<tr>
<td>2</td>
<td>26(22.99)</td>
<td>31(21.44)</td>
</tr>
<tr>
<td>3</td>
<td>33(28.50)</td>
<td>17(26.57)</td>
</tr>
<tr>
<td>Total</td>
<td>74</td>
<td>69</td>
</tr>
</tbody>
</table>

$$D^2 = \sum \frac{O_i^2}{E_i} - n$$

$$= \frac{15^2}{22.51} + \frac{26^2}{22.99} + \ldots + \frac{20^2}{14.63} - 309$$

$$= 19.19$$

$X_{(10.05)}^2 = 12.592$

Conclusion:
Because $D^2 = 19.18 > X^2_{0.05} = 12.592$ we reject Ho.

Thus the manager has demonstrated that there is significant relationship between the proportions of the types of defects and the production shift.

**Question 4 [24 marks]**

a) Determine the regression equation

\[ \hat{Y} = -63.570 + 5.543X_1 - 2.860X_2 + 17.886X_3 + 33.074X_4 \]  

b) What selling price would you estimate for a residence with the living area of five thousand square feet, two floors, 5 bedrooms, and three baths?

\[ \hat{Y} = -63.570 + 5.543(5) - 2.860(2) + 17.886(5) + 33.074(3) = 147.077 \]

c) Conduct a global test of hypothesis to determine whether any of the net regression coefficients differ from zero.

\[ Ho : \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0 \]
\[ H1 : \text{Not all } \beta \text{s are equal to zero} \]

From ANOVA table, the attained significance level (p-value) is .000.

Since this p-value is less than $\alpha = 0.05$ we reject Ho.

Therefore, we conclude that not all $\beta$s are equal to zero.

d) Conduct a test for the individual regression coefficients. Would you consider deleting any of the independent variables? (Use 5% significance level).

We need to test the following hypotheses:

\[ Ho : \beta_1 = 0 \quad H1 : \beta_1 \neq 0 \]
\[ Ho : \beta_2 = 0 \quad H1 : \beta_2 \neq 0 \]
\[ Ho : \beta_3 = 0 \quad H1 : \beta_3 \neq 0 \]
\[ Ho : \beta_4 = 0 \quad H1 : \beta_4 \neq 0 \]

Rejection rule:
If p-value is less than $\frac{\alpha}{2} = 0.025$, then we reject Ho.

We notice the p-values corresponding to $X_2$ and $X_3$ (0.780 and 0.116) are far bigger than $\frac{\alpha}{2} = 0.025$

Therefore, regression coefficients associated with those variables are not significantly different from zero.
These two variables may be deleted from the model.
The coefficients associated with $X_1$ and $X_4$ variables are significantly different from zero as their corresponding p-values are very close to $\frac{\alpha}{2} = 0.025$. (0.014 and 0.013 respectively).

e) Determine and interpret the coefficient of determination. [4]

$$R^2 = \frac{SSR}{SST} = \frac{44028.952}{54660.490} = 0.805$$

Interpretation:
80% of the variation in bedroom occupation is explained by the variables

Question 5 [13 marks]
a) On a piece of graph paper, plot the per capita electricity consumption against the year code.
Is there a linear relationship between the two variables? [4]
b) Fit a model of the form \( y = b_0 [b_1]^x \) to the data.

\[
y = b_0 (b_1)^x
\]
\[
\ln(y) = \ln(b_0) + x \ln(b_1)
\]
\[
\ln(y) = A + xB
\]

Where,

\( A = \ln(b_0) \) and \( B = \ln(b_1) \)

<table>
<thead>
<tr>
<th>( x )</th>
<th>( y )</th>
<th>( Y = \ln(y) )</th>
<th>( X^2 )</th>
<th>( xY )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>823</td>
<td>6.712956201</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
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<td>952</td>
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<td>25</td>
<td>4760</td>
</tr>
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<td>10</td>
<td>1125</td>
<td>7.025538315</td>
<td>100</td>
<td>11250</td>
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<td>75990</td>
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<td>3005</td>
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<td>1225</td>
<td>105175</td>
</tr>
<tr>
<td>40</td>
<td>3272</td>
<td>8.093156698</td>
<td>1600</td>
<td>130880</td>
</tr>
</tbody>
</table>
\[
SS_x = \sum x^2 - \frac{(\sum x)^2}{n} = 16250 - \frac{390^2}{13} = 4550
\]

\[
SS_{xy} = \sum xy - \frac{\sum x \sum y}{n} = 1283900 - \frac{390(100.18)}{13} = 1280894.6
\]

\[
B = \frac{SS_{xy}}{SS_x} = \frac{1280894.6}{4550} = 281.52
\]

\[
A = \frac{\sum Y - b \sum x}{n} = \frac{100.18 - 281.52(390)}{13} = -8437.90
\]

\[
\ln(y) = -8437.90 + 281.52x
\]

\[
y = e^{-8437.90} e^{281.52x}
\]

\[
y = -8437.90 \left(1.8306e^{122}\right)^x
\]

c) Use your fitted model to estimate the per capita electricity consumption in 1985

\[
y = -8437.90 \left(1.8306e^{122}\right)^{45} = infinite \text{ number}
\]

**ASSIGNMENT 2 MEMO**

**Question 1 (6 marks)**

**Kruskal Wallis Test Procedure:**

**Null hypothesis:** The k population probability distributions are identical

**Alternative Hypothesis:** At least one of the k population probability distributions differ in location

First rank all the \(n = n_1 + n_2 + \cdots + n_k\) observations and obtain the rank sums R₁, R₂, ..., Rₖ for the k samples
The test statistic is \[ H = \frac{12}{n(n+1)} \sum_{i=1}^{n} \frac{R_i^2}{n_i} - 3(n+1) \]

Decision Rule: Reject \( H_0 \) if \( H > \chi^2_{a, k-1} \)

Question 2 [6 marks]

The Wilcoxon Rank Sum Test

1. The problem objective is to compare the two populations
2. Data are either ordinal, interval/ratio scaled where the normality requirement necessary to perform t-tests for means is unsatisfied.
3. The samples are independent.

The Sign Test

1. The problem objective is to compare the two populations
2. Data are on the ordinal scale.
3. The experimental design is matched pairs.

[6 marks]

Question 3 [8 marks]

\( H_0: \text{The two population locations are the same} \)

\( H_1: \text{The location of population 1 is to the right of the location of population 2} \)

Let the test statistic \( T = T_1 = 270 \)

\[ \mu = \frac{n_1(n_1 + n_2 + 1)}{2} = \frac{20(20 + 20 + 1)}{2} = 410 \]

\[ \sigma_T = \sqrt{\frac{n_1n_2(n_1 + n_2 + 1)}{12}} = \sqrt{\frac{20(20)(41)}{12}} = 36.97 \]

\[ Z = \frac{T - \mu}{\sigma_T} = \frac{270 - 410}{36.97} = -3.79 \]

If \( H_0 \) is false, \( Z \) will either be very large. At 5% level of significance, we reject \( H_0 \) if \( Z < -1.645 \). In this case we reject \( H_0 \). We conclude that the location of population 1 is to the right of population 2.

Question 4 [8 marks]

\( H_0: \text{The two population locations are the same} \)

\( H_1: \text{The location of population 1 is to the left of the location of population 2} \)
Let the test statistic $T = T_2 = 40$

\[
\mu = \frac{n_1(n_1 + n_2 + 1)}{2} = \frac{5(5 + 5 + 1)}{2} = 27.5
\]

\[
\sigma_T = \sqrt{\frac{n_1n_2(n_1 + n_2 + 1)}{12}} = \sqrt{\frac{5(5)(11)}{12}} = 4.79
\]

\[
Z = \frac{T - \mu}{\sigma_T} = \frac{40 - 27.5}{4.79} = 2.609
\]

If $H_0$ is false, $Z$ will either be very large. At 5% level of significance, we reject $H_0$ if $Z > 1.645$. In this case we reject $H_0$. We conclude that the location of population 1 is to the left of population 2.

[8 marks]

**Question 5 [12 marks]**

$H_0$: The location of the three population locations are the same

$H_1$: At least two population locations differ

<table>
<thead>
<tr>
<th>Oshakati</th>
<th>Rank</th>
<th>Gobabis</th>
<th>Rank</th>
<th>Windhoek</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>43</td>
<td>7.5</td>
<td>54</td>
<td>13</td>
<td>57</td>
<td>15.5</td>
</tr>
<tr>
<td>39</td>
<td>5.5</td>
<td>33</td>
<td>2</td>
<td>68</td>
<td>20</td>
</tr>
<tr>
<td>62</td>
<td>19</td>
<td>58</td>
<td>17</td>
<td>60</td>
<td>18</td>
</tr>
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<td>73</td>
<td>21</td>
<td>38</td>
<td>4</td>
<td>44</td>
<td>9</td>
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<td>12</td>
<td>43</td>
<td>7.5</td>
<td>39</td>
<td>5.5</td>
</tr>
<tr>
<td>46</td>
<td>10</td>
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<td>14</td>
<td>28</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>34</td>
<td>3</td>
<td>49</td>
<td>11</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>57</td>
<td>15.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>75</strong></td>
<td><strong>60.5</strong></td>
<td></td>
<td><strong>95.5</strong></td>
<td></td>
</tr>
</tbody>
</table>

The test statistic,
\[ H = \frac{12}{n(n+1)} \sum_{i=1}^{n} \frac{R_i^2}{n_i} - 3(n+1) \]
\[ = \left[ \frac{12}{21(22)} \left( \frac{75^2}{6} + \frac{60.5^2}{7} + \frac{95.5^2}{8} \right) \right] - 3(22) \]
\[ = 1.54 \]

**Decision Rule:** Reject \( H_0 \) if \( H > \chi^2_{\alpha, k-1} \)

\[ H > \chi^2_{0.01,2} = 9.21 \]

We fail to reject \( H_0 \) and conclude that the population distribution of the salaries of junior economists are the same for the three cities.

[12 marks]

**Question 6 [12 marks]**

\( H_0: \) The productivity is the same

\( H_1: \) The productivity has increased

<table>
<thead>
<tr>
<th>Worker</th>
<th>Before</th>
<th>After</th>
<th>D</th>
<th></th>
<th></th>
<th>Rank +</th>
<th>Rank -</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>11</td>
<td>+6</td>
<td>6</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>9</td>
<td>+5</td>
<td>5</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>9</td>
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<td>9</td>
<td>9</td>
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<td></td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>8</td>
<td>+2</td>
<td>2</td>
<td>4.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>5</td>
<td>+2</td>
<td>2</td>
<td>4.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>7</td>
<td>-1</td>
<td>1</td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>9</td>
<td>+2</td>
<td>2</td>
<td>4.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>9</td>
<td>-1</td>
<td>1</td>
<td>1.5</td>
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</tr>
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<td>9</td>
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<td>7</td>
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<td>+2</td>
<td>2</td>
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<td>+4</td>
<td>4</td>
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<td>+3</td>
<td>3</td>
<td>7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Rank sum | 63 | 3 |

\( T_+ = 63 \) and \( T_- = 3 \)

We arbitrary choose \( T = T_+ = 63 \)

When the null hypothesis is false, we expect \( T \) to be either too large or too small.
From the tables of the Wilcoxon signed rank sum test (since the sample is very small), we reject the null hypothesis if \( T \leq 1 \) or if \( T \geq 20 \).

In this case, we reject the null hypothesis and conclude that productivity has increased. [12 marks]

Question 7 [12 marks]

a) [3 marks]

1. The problem objective is to compare 2 populations
2. The data are on the ordinal scale
3. Matched pairs

b) [9 marks]

\( H_0: \pi = 0.5 \)

\( H_1: \pi \neq 0.5 \)

<table>
<thead>
<tr>
<th>Company</th>
<th>Change in share price</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>+</td>
</tr>
<tr>
<td>B</td>
<td>+</td>
</tr>
<tr>
<td>C</td>
<td>+</td>
</tr>
<tr>
<td>D</td>
<td>+</td>
</tr>
<tr>
<td>E</td>
<td>-</td>
</tr>
<tr>
<td>F</td>
<td>.</td>
</tr>
<tr>
<td>G</td>
<td>+</td>
</tr>
<tr>
<td>H</td>
<td>-</td>
</tr>
<tr>
<td>I</td>
<td>+</td>
</tr>
</tbody>
</table>

Negatives = 2, positives = 6 and zero's = 1.

\( n = 8 \)

Let \( x = 6 \).

\[
Z = \frac{x - n(\pi)}{0.5\sqrt{n}} = \frac{6 - 8(0.5)}{0.5\sqrt{8}} = 1.41
\]

5% level of significance, \( Z = 1.645 \).

Since, \( Z = 1.41 < 1.645 \), we fail to reject \( H_0 \) and conclude that the share price for most of the companies will increase.
Question 8 (20 marks)

<table>
<thead>
<tr>
<th>ANOVA</th>
<th>Degrees of freedom</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>2</td>
<td>12.61020</td>
<td>6.30510</td>
<td>97.69</td>
<td>0.001</td>
</tr>
<tr>
<td>Residual</td>
<td>12</td>
<td>0.77453</td>
<td>0.06454</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>13.38473</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>Coefficients</th>
<th>Standard Error</th>
<th>t-Stat</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTERCEPT</td>
<td>-0.02686</td>
<td>0.06905</td>
<td>-0.39</td>
<td>0.7034</td>
</tr>
<tr>
<td>FOREIMP</td>
<td>0.79116</td>
<td>0.06295</td>
<td>12.57</td>
<td>0.0000</td>
</tr>
<tr>
<td>MIDSOLE</td>
<td>0.60484</td>
<td>0.07174</td>
<td>8.43</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

a) The multiple regression equation is:

\[ LTIMP = -0.027 + 0.791(FOREIMP) + 0.605(MIDSOLE) \]  

b) The coefficient of multiple determination is

\[ R^2 = \frac{SSR}{SST} = \frac{12.61020}{13.38473} = 94\% \]  

c) Global test of hypothesis on the significance of the regression coefficients at 5% level based on the p-value.

\[ H_0 : \beta_i = 0 \quad i = 1, 2 \]
\[ H_1 : \beta_i \neq 0 \quad \text{for at least one } i \]
\[ \alpha = 0.05 \]

Test Statistic \[ F_{tr} = \frac{MSR}{MSE} = 97.69 \quad \text{or} \quad p-value = 0.001 \]

Decision Rule: Reject \( H_0 \) if \( F > F_{0.05,2,12} \approx 3.89 \)

Reject \( H_0 \) if \( p-value < \alpha = 0.05 \)

Based on the F-value, \( F = 97.69 > 3.89 \) therefore we reject the Null hypothesis.

Based on the p-value, \( 0.001 < \) the significance level \( = 0.05 \) therefore we reject the Null hypothesis.

At least one of the \( B_i \) is significant at 5% level.  

[10]