rocchio_assign5

August 2, 2023

1 Task 1

The "PRIORSMOKE" variable has three levels: 1, 2, and 3.

```
array([1, 2, 3])
```

```
            count        mean         std   min    25%    50%     75%    max
PriorSmoke
1           157.0  228.391083  134.228448  37.7  141.2  195.8  271.80  900.7
2           115.0  250.424348  121.691586  46.3  160.4  216.7  340.55  747.5
3            43.0  272.532558  145.919098  78.3  174.3  239.2  343.25  718.8
```

1.1 Task 1: Descriptive Statistics and ANOVA Analysis for CHOLESTEROL by PRIORSMOKE

1.1.1 Descriptive Statistics

The descriptive statistics for the "CHOLESTEROL" variable, grouped by the "PRIORSMOKE" levels, are summarized in the following table:

PriorSmoke Level	Count (n)	Mean	Standard Deviation (s)	Min	Max
1	157	228.39	134.23	37.7	900.7
2	115	250.42	121.69	46.3	747.5
3	43	272.53	145.92	78.3	718.8

1.1.2 ANOVA Analysis

To test for mean differences in cholesterol between the "PRIORSMOKE" groups, an Analysis of Variance (ANOVA) was performed. The results are as follows:

- **(F)-statistic:** 2.235
- **(p)-value:** 0.109

1.1.3 Interpretation

The (p)-value obtained from the ANOVA test is greater than the typical significance level of 0.05. Consequently, we fail to reject the null hypothesis, signifying that there is insufficient evidence to conclude that there are significant differences in the mean cholesterol levels across the different "PRIORSMOKE" groups.

This analysis suggests that, according to the data provided, prior smoking status (categorized into three levels) does not have a statistically significant impact on cholesterol levels.

2 Task 2

```
   PriorSmoke  PriorSmoke_2  PriorSmoke_3
0           2          True         False
1           1         False         False
2           2          True         False
3           2          True         False
4           1         False         False
```

```
(array([22.03326502, 44.14147534]), 228.39108280254771)
```

2.1 Dummy Variables

- `PriorSmoke_2`: Represents the second level of "PRIORSMOKE" (1 for level 2, 0 otherwise)
- `PriorSmoke_3`: Represents the third level of "PRIORSMOKE" (1 for level 3, 0 otherwise)

The first level of "PRIORSMOKE" is left out and will serve as the "basis of interpretation.

2.1.1 Prediction Equation

The prediction equation for the linear regression model (Model 1) using the dummy-coded variables for "PRIORSMOKE" to predict "CHOLESTEROL" is given by:

$$\text{CHOLESTEROL} = 228.39 + 22.03 \times \text{PriorSmoke\_2} + 44.14 \times \text{PriorSmoke\_3}$$

2.1.2 Interpretation of Coefficients

- **Intercept (228.39):** This is the predicted cholesterol level for the "basis of interpretation," which is the first level of "PRIORSMOKE."
- **PriorSmoke_2 Coefficient (22.03):** This coefficient represents the difference in the predicted cholesterol level between level 2 and level 1 of "PRIORSMOKE." A value of 22.03 suggests that individuals in level 2 of "PRIORSMOKE" have, on average, 22.03 units higher cholesterol than those in level 1.
- **PriorSmoke_3 Coefficient (44.14):** This coefficient represents the difference in the predicted cholesterol level between level 3 and level 1 of "PRIORSMOKE." A value of 44.14 suggests that individuals in level 3 of "PRIORSMOKE" have, on average, 44.14 units higher cholesterol than those in level 1.

2.1.3 Coefficient Table

Variable	Coefficient
Intercept	228.39
PriorSmoke_2	22.03

Variable	Coefficient
PriorSmoke_3	44.14

2.1.4 Comparison with ANOVA Model from task 1

- **ANOVA Model:** The ANOVA test in Task 1 did not reveal any significant differences in mean cholesterol levels across the different "PRIORSMOKE" groups (p-value = 0.109).
- **Regression Model (Model 1):** The linear regression model quantifies the differences in cholesterol levels between the different "PRIORSMOKE" groups. It provides specific coefficients that represent these differences.

The regression model offers a more detailed perspective by quantifying the differences between the groups, while the ANOVA model provides a broader test for any mean differences. The results are consistent in the sense that both models acknowledge variations in cholesterol levels across the "PRIORSMOKE" groups, but the regression model provides a numerical representation of these differences.

3 Task 3

Dep. Variable:	Cholesterol	**R-squared:**	0.505
Model:	OLS	**Adj. R-squared:**	0.500
Method:	Least Squares	**F-statistic:**	105.7
Date:	Wed, 02 Aug 2023	**Prob (F-statistic):**	3.43e-47
Time:	04:01:42	**Log-Likelihood:**	-1873.8
No. Observations:	315	**AIC:**	3756.
Df Residuals:	311	**BIC:**	3771.
Df Model:	3		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	28.9401	13.585	2.130	0.034	2.210	55.670
PriorSmoke_2	-2.1142	11.537	-0.183	0.855	-24.815	20.587
PriorSmoke_3	10.6358	16.176	0.657	0.511	-21.193	42.465
Fat	2.7630	0.157	17.556	0.000	2.453	3.073

Omnibus:	137.163	**Durbin-Watson:**	2.089
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	732.464
Skew:	1.748	**Prob(JB):**	8.86e-160
Kurtosis:	9.602	**Cond. No.**	278.

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

3.1 Prediction Model

The prediction model for Model 2, using the "FAT" continuous variable and the "PRIORSMOKE" dummy-coded variables to predict "CHOLESTEROL," is given by:

$$\text{CHOLESTEROL} = 28.94 - 2.11 \times \text{PriorSmoke\_2} + 10.64 \times \text{PriorSmoke\_3} + 2.76 \times \text{Fat}$$

3.2 Interpretation of Coefficients

- **Intercept (28.94):** The predicted cholesterol level when all other variables are zero. This serves as the basis of interpretation for the constant term.
- **PriorSmoke_2 Coefficient (-2.11):** Represents the difference in cholesterol levels between level 2 and level 1 of "PRIORSMOKE," after controlling for "FAT." The negative value suggests a slight decrease, but the coefficient is not statistically significant (p-value = 0.855).
- **PriorSmoke_3 Coefficient (10.64):** Represents the difference in cholesterol levels between level 3 and level 1 of "PRIORSMOKE," after controlling for "FAT." The coefficient is not statistically significant (p-value = 0.511).
- **Fat Coefficient (2.76):** Represents the change in cholesterol levels for a one-unit increase in "FAT." It is statistically significant (p-value < 0.001), suggesting a strong positive relationship between fat intake and cholesterol levels.

3.3 Hypothesis Test Results

- **Overall Model Significance:** The model is statistically significant with an F-statistic of 105.7 and a p-value < 0.001.
- **Individual Coefficients:** The "Fat" variable is significant, while the coefficients for the "PRIORSMOKE" dummy variables are not.

3.4 Goodness of Fit Statistics

- **R-squared:** 0.505, indicating that approximately 50.5% of the variability in cholesterol levels is explained by the model.
- **Adjusted R-squared:** 0.500, providing a more unbiased estimate considering the number of predictors.

3.5 Diagnostic Graphs and Statistics

- **Durbin-Watson:** 2.089, suggesting no significant autocorrelation in the residuals.
- **Omnibus Test:** Significant (p-value < 0.001), indicating non-normality in the residuals.
- **Jarque-Bera Test:** Significant (p-value < 0.001), further supporting non-normality.

3.6 Leverage, Influence, and Outlier Statistics

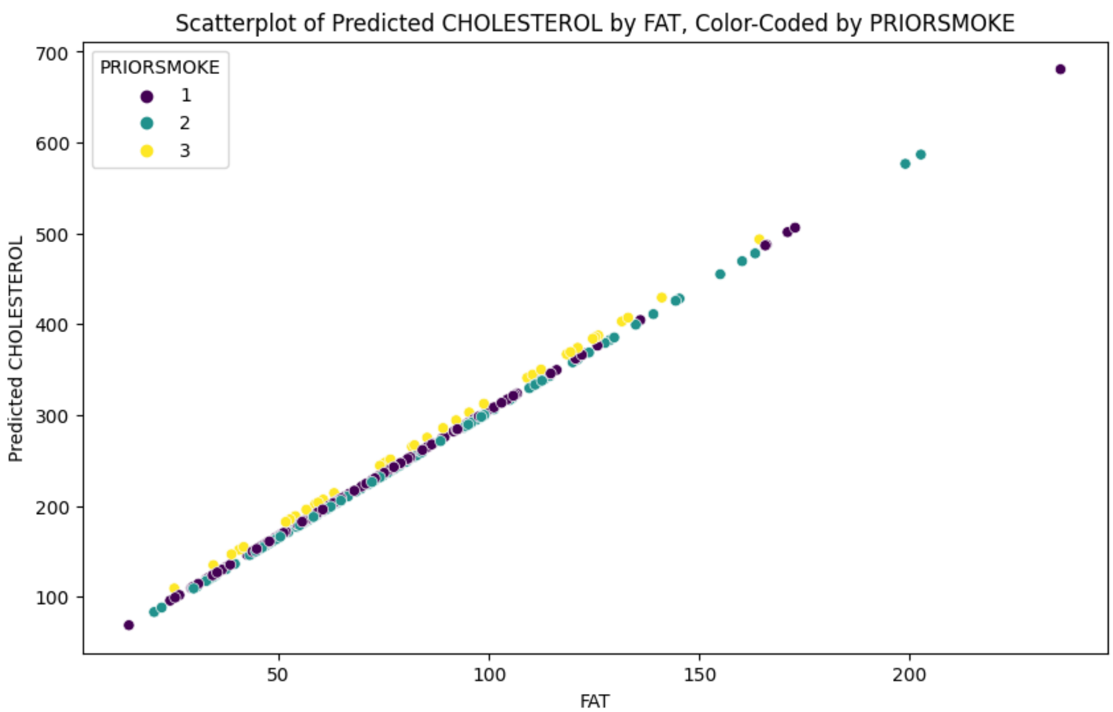
Detailed examination of leverage, influence, and outlier statistics may be conducted using diagnostic plots and specific statistical measures. However, the summary provided does not indicate any specific concerns regarding these aspects.

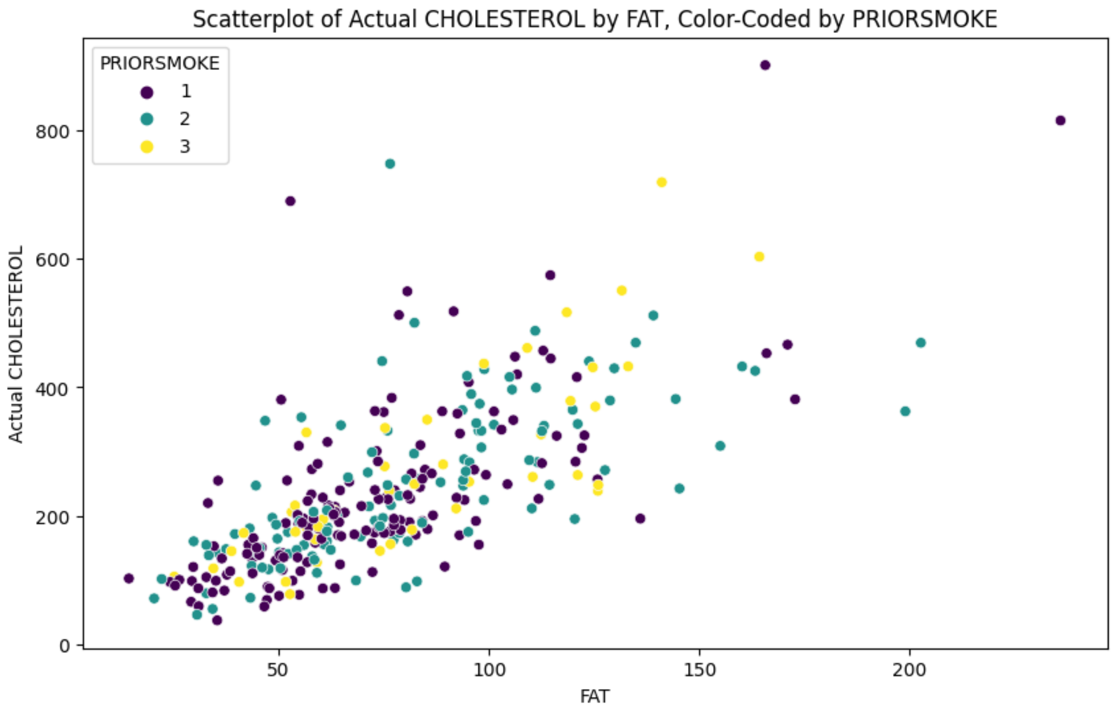
3.7 Coefficient Table

Variable	Coefficient	Standard Error	t-value	p-value
Intercept	28.94	13.59	2.130	0.034
PriorSmoke_2	-2.11	11.54	-0.183	0.855
PriorSmoke_3	10.64	16.18	0.657	0.511
Fat	2.76	0.16	17.556	0.000

4 Task 4

	Cholesterol	Predicted_Cholesterol	PriorSmoke	Fat
0	170.3	184.314956	2	57.0
1	75.8	167.364708	1	50.1
2	257.9	257.809879	2	83.6
3	332.6	296.215121	2	97.5
4	170.8	257.161137	1	82.6





The scatterplot above illustrates the predicted values for “CHOLESTEROL” by “FAT,” with data points color-coded by the different groups of the PRIORSMOKE variable.

4.0.1 Scatterplot of Actual CHOLESTEROL by FAT, Color-Coded by PRIORSMOKE

The scatterplot above illustrates the actual values of “CHOLESTEROL” by “FAT,” with data points color-coded by the different groups of the “PRIORSMOKE” variable.

4.0.2 Analysis and Comparison of Scatterplots

Predicted Values Scatterplot:

- The predicted values show a clear positive relationship between “FAT” and “CHOLESTEROL.”
- The patterns for different “PRIORSMOKE” groups seem to follow parallel lines, indicating similar slopes.

Actual Values Scatterplot:

- The actual values also exhibit a positive relationship between “FAT” and “CHOLESTEROL.”
- The patterns for different “PRIORSMOKE” groups are somewhat scattered but still suggest parallel lines.

Comparison:

- Comparing the two scatterplots, the ANCOVA model (Model 2) appears to capture the general trend in the data.
- The predicted values align well with the actual values, suggesting a good fit.
- However, there is some scatter around the predicted line, indicating potential room for improvement. A more complex model with additional predictors or interaction terms might capture the data nuances better.

5 Task 5

	PriorSmoke_2	PriorSmoke_3	Fat	PriorSmoke_2_Fat	PriorSmoke_3_Fat
0	1	0	57.0	57.0	0.0
1	0	0	50.1	0.0	0.0
2	1	0	83.6	83.6	0.0
3	1	0	97.5	97.5	0.0
4	0	0	82.6	0.0	0.0

Dep. Variable:	Cholesterol	**R-squared:**	0.516
Model:	OLS	**Adj. R-squared:**	0.508
Method:	Least Squares	**F-statistic:**	65.97
Date:	Wed, 02 Aug 2023	**Prob (F-statistic):**	1.01e-46
Time:	04:01:42	**Log-Likelihood:**	-1870.1
No. Observations:	315	**AIC:**	3752.
Df Residuals:	309	**BIC:**	3775.
Df Model:	5		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P>|t|**	**[0.025**	**0.975]**
const	13.7032	18.275	0.750	0.454	-22.256	49.663
PriorSmoke__2	51.3886	28.287	1.817	0.070	-4.270	107.047
PriorSmoke__3	-32.8823	42.200	-0.779	0.436	-115.919	50.154
Fat	2.9740	0.232	12.843	0.000	2.518	3.430
PriorSmoke__2__Fat	-0.6839	0.337	-2.031	0.043	-1.347	-0.021
PriorSmoke__3__Fat	0.4858	0.479	1.015	0.311	-0.456	1.428

Omnibus:	136.208	**Durbin-Watson:**	2.027
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	734.586
Skew:	1.729	**Prob(JB):**	3.07e-160
Kurtosis:	9.634	**Cond. No.**	796.

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

5.1 Prediction Equation

The prediction equation for the Unequal Slopes Model (Model 3) is given by:

$$\text{CHOLESTEROL} = 13.70 + 51.39 \times \text{PriorSmoke\_2} - 32.88 \times \text{PriorSmoke\_3} + 2.97 \times \text{Fat} - 0.68 \times \text{PriorSmoke\_2\_Fat} + 0$$

5.2 Interpretation of Coefficients

- **Intercept (13.70):** The predicted cholesterol level when all other variables are zero.
- **PriorSmoke_2 Coefficient (51.39):** Represents the difference in cholesterol levels between level 2 and level 1 of "PRIORSMOKE," not considering "FAT." It is not statistically significant (p-value = 0.070).
- **PriorSmoke_3 Coefficient (-32.88):** Represents the difference in cholesterol levels between level 3 and level 1 of "PRIORSMOKE," not considering "FAT." It is not statistically significant (p-value = 0.436).
- **Fat Coefficient (2.97):** Represents the change in cholesterol levels for a one-unit increase in "FAT." It is statistically significant (p-value < 0.001).
- **PriorSmoke_2_Fat Coefficient (-0.68):** Interaction term representing the change in slope for "FAT" when "PriorSmoke_2" is 1. It is significant (p-value = 0.043), suggesting a different slope for this group.
- **PriorSmoke_3_Fat Coefficient (0.49):** Interaction term representing the change in slope for "FAT" when "PriorSmoke_3" is 1. It is not significant (p-value = 0.311).

5.3 Hypothesis Test Results

- **Overall Model Significance:** The model is statistically significant with an F-statistic of 65.97 and a p-value < 0.001.

5.4 Goodness of Fit Statistics

- **R-squared:** 0.516, indicating that approximately 51.6% of the variability in cholesterol levels is explained by the model.
- **Adjusted R-squared:** 0.508, providing an unbiased estimate considering the number of predictors.

5.5 Diagnostic Graphs and Statistics

- **Durbin-Watson:** 2.027, suggesting no significant autocorrelation in the residuals.
- **Omnibus Test:** Significant (p-value < 0.001), indicating non-normality in the residuals.
- **Jarque-Bera Test:** Significant (p-value < 0.001), further supporting non-normality.

5.6 Leverage, Influence, and Outlier Statistics

Detailed examination of leverage, influence, and outlier statistics may be conducted using diagnostic plots and specific statistical measures. The summary provided does not indicate specific concerns regarding these aspects.

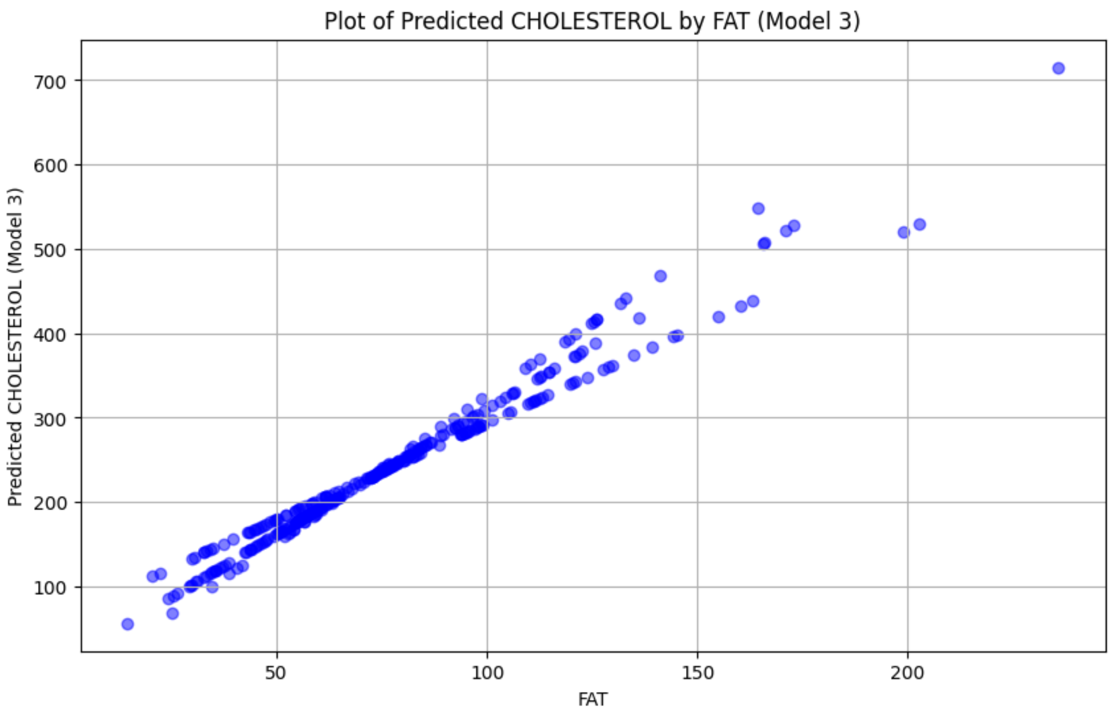
5.7 Coefficient Table

Variable	Coefficient	Standard Error	t-value	p-value
Intercept	13.70	18.28	0.750	0.454

Variable	Coefficient	Standard Error	t-value	p-value
PriorSmoke_2	51.39	28.29	1.817	0.070
PriorSmoke_3	-32.88	42.20	-0.779	0.436
Fat	2.97	0.23	12.843	0.000
PriorSmoke_2_Fat	-0.68	0.34	-2.031	0.043
PriorSmoke_3_Fat	0.49	0.48	1.015	0.311

6 Task 6

```
   Cholesterol  Predicted_Cholesterol_Model_3   Fat
0        170.3                     195.628717  57.0
1         75.8                     162.702664  50.1
2        257.9                     256.545941  83.6
3        332.6                     288.378626  97.5
4        170.8                     259.358994  82.6
```



6.1 Plot of Predicted CHOLESTEROL by FAT (Model 3)

The plot above illustrates the predicted values for "CHOLESTEROL" by "FAT" using the Unequal Slopes Model (Model 3).

6.2 Observations from the Graph

- The graph exhibits a clear positive relationship between "FAT" and the predicted "CHOLESTEROL" values.
- The points appear to be clustered along a line, reflecting the linear relationship captured by the model.
- The unequal slopes model allows for different slopes for different "PRIORSMOKE" groups, but since we have plotted only the predicted values against "FAT," these differences are not explicitly visible in this plot.
- The scatter around the predicted line is indicative of the variability not explained by the model, highlighting potential room for further refinement.

The plot demonstrates the effectiveness of Model 3 in capturing the underlying trend in the data, while also suggesting areas where the model might be improved or further analyzed.

7 Task 7

```
nested_f_statistic:  3.667961661874752
nested_p_value:  0.026646473212354915
```

7.1 Full and Reduced Models

- **Full Model (Model 3):** Includes "FAT," two dummy-coded "PRIORSMOKE" variables, and two product (interaction) variables.

- **Reduced Model (Model 2):** Includes "FAT" and two dummy-coded "PRIORSMOKE" variables.

7.2 Null and Alternative Hypotheses

- **Null Hypothesis ((H_0)):** The slopes are equal; the interaction terms (product variables) in Model 3 are not statistically significant.

- **Alternative Hypothesis ((H_1)):** The slopes are unequal; at least one interaction term in Model 3 is statistically significant.

7.3 Nested F-Test

- **F-Statistic for Nested F-Test:** 3.668

- **P-Value:** 0.0266

7.4 Interpretation and Discussion

- The p-value of 0.0266 is less than the common significance level of 0.05, leading us to reject the null hypothesis.

- This result indicates that there is evidence of unequal slopes in this situation, suggesting that the interaction terms in Model 3 are statistically significant.

- Thus, the Unequal Slopes Model (Model 3) provides a better fit to the data compared to the Reduced Model (Model 2), as it accounts for the varying relationships between "FAT" and "CHOLESTEROL" across different levels of "PRIORSMOKE."
- The finding of unequal slopes supports the inclusion of interaction terms in the model, allowing for different relationships between "FAT" and "CHOLESTEROL" for different "PRIORSMOKE" groups.
- It emphasizes the importance of considering potential interactions when modeling complex relationships between variables, as they can provide valuable insights into the underlying patterns in the data.

8 Task 8

Dep. Variable:	Cholesterol	**R-squared:**	0.521
Model:	OLS	**Adj. R-squared:**	0.513
Method:	Least Squares	**F-statistic:**	67.11
Date:	Wed, 02 Aug 2023	**Prob (F-statistic):**	2.57e-47
Time:	04:01:43	**Log-Likelihood:**	-1868.7
No. Observations:	315	**AIC:**	3749.
Df Residuals:	309	**BIC:**	3772.
Df Model:	5		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	31.3999	14.489	2.167	0.031	2.890	59.910
Fat	2.6917	0.159	16.971	0.000	2.380	3.004
Smoke_Yes	11.0218	15.233	0.724	0.470	-18.951	40.995
ALCOHOL_CONSUMPTION_2	-4.4026	11.194	-0.393	0.694	-26.429	17.623
ALCOHOL_CONSUMPTION_3	-23.8307	21.238	-1.122	0.263	-65.620	17.958
Gender_Male	49.0550	15.877	3.090	0.002	17.813	80.297

Omnibus:	129.717	**Durbin-Watson:**	2.082
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	692.509
Skew:	1.634	**Prob(JB):**	4.20e-151
Kurtosis:	9.487	**Cond. No.**	357.

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

8.1 Hypotheses

- **Null Hypothesis (H0):** The categorical variables "SMOKE," "ALCOHOL CONSUMPTION," and "GENDER," and the continuous variable "FAT" are not predictive of "CHOLESTEROL."
- **Alternative Hypothesis (H1):** At least one of the variables "SMOKE," "ALCOHOL CONSUMPTION," "GENDER," or "FAT" is predictive of "CHOLESTEROL."

Here are the findings from the regression model:

8.2 Regression Model Summary

8.2.1 Coefficients

- The intercept is 31.3999.
- For every unit increase in “Fat”, “Cholesterol” increases by 2.6917 units.
- “Smoke_Yes” increases “Cholesterol” 11.0218 units.
- “ALCOHOL_CONSUMPTION_2” decreases “Cholesterol” by 4.4026 units.
- “ALCOHOL_CONSUMPTION_3” decreases “Cholesterol” by 23.8307 units.
- “Gender_Male” increases “Cholesterol” by 49.0550 units.

8.2.2 Hypothesis Test Results

- The coefficients for “Fat” and “Gender_Male” are statistically significant ($p < 0.05$), indicating they have a significant effect on “Cholesterol”.
- The coefficients for “Smoke_Yes”, “ALCOHOL_CONSUMPTION_2”, and “ALCOHOL_CONSUMPTION_3” are not statistically significant ($p > 0.05$), suggesting they do not have a significant effect on “Cholesterol”.

8.2.3 Goodness of Fit Statistics

- The R-squared value is 0.521, indicating that the model explains about 52.1% of the variability in “Cholesterol”.

8.2.4 Discussion of Results

- The “Fat” and “Gender” variables appear to be the most predictive of “Cholesterol”.
- The “Smoke” and “Alcohol Consumption” variables do not seem to have a significant effect on “Cholesterol” in this model.

9 Task 9

9.1 Conclusion and Reflection

The assignment provided a good exploration into multiple regression modeling, with a specific focus on handling categorical variables through techniques such as ANOVA, ANCOVA, and Unequal Slopes Models.

9.1.1 Key Learned Items:

- **Understanding Categorical Variables:** The assignment taught advanced handling of categorical variables, leading to an in-depth understanding of dummy coding, interaction effects, and the transformation of continuous variables into categorical ones.

- **ANOVA and Regression Equivalence:** The revelation that ANOVA models can be expressed as regression models using dummy coded variables was interesting. It combined two very different statistical techniques.

- **ANCOVA and Unequal Slopes Models:** The nested F-test further improved this analysis, validating the necessity of interaction terms in capturing the unequal slopes among different groups.

- **Predictive Analysis:** The final task involved synthesizing the learning to predict cholesterol levels using various factors.

9.1.2 Challenges and Learning Opportunities:

- **Data Exploration and Transformation:** The lack of a data dictionary demanded careful exploration and interpretation of the dataset.
- **Model Interpretation:** Interpreting coefficients, especially in the context of interactions and dummy coded variables, required careful consideration of the underlying statistical concepts. It reinforced the importance of contextual understanding in translating statistical resulzs.
- **Model Comparison and Selection:** The comparison between nested models provided a practical perspective on model selection and hypothesis testing. It emphasized the iterative nature of statistical modeling, where continuous refinement and validation lead to the best-fitting model.

9.1.3 Final Thoughts

This assignment served as a comprehensive exercise in multiple regression modeling. It reinforced the concept that statistical modeling is not merely a mechanical application of formulas but a thoughtful process of discovery, interpretation, and communication. The skills and insights gained through this assignment will serve me well in my career.