Regression (Week 17)

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Data: RobotGLP.sav

Data is available on 'Workshop Materials' folder on Moodle.

1 Learning objectives

The aim of this lab is to help you to use SPSS to conduct regression analysis, which is useful in explaining the relationship between a set of *independent* variables and a *dependent variable*.

At the end of this lab, we hope that you will be able to

- Understand the meaning of independent and dependent variables
- Select appropriate independent variables to explain a dependent variable

- Produce and interpret basic SPSS outputs for multiple regression
- Understand the meaning of multicollinearity, how to detect and remedy it

> ❗ Important
>
> FYI, many students of the previous cohorts used regression when they wrote their MSc dissertations.

2 Why Regression

In marketing research, we often need to determine the impact of a set of marketing variables on one variable – a factor we want to understand or predict. Furthermore, among those variables we may want to find out which variables matter most, and which variables are not so important that we can ignore. Regression analysis can help us findings the answers to these questions.

In this workshop, we want to investigate factors that influence consumers' decision to join a green loyalty program – This LP encourages behaviours from hotel guests that are good for environment (e.g., reuse towels).

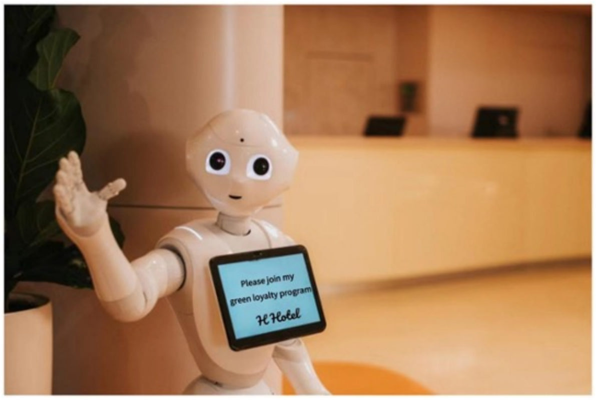


Figure 1: Hotel receptionist (Image courtesy of Jingxi)

In this lab, we consider the following case. A hotel manager who recently launch a green loyalty program (GLP) wants to know about factors that affect consumers' intention to join the hotel GLP. The hotel manager decides to develop a survey and asks the hotel's guests to fill in an offline survey. The survey form was handed in to hotel guests by a frontline service robot (see the image above). The survey contains items to measure the following constructs:

- Intention to join the green loyalty program
- Anticipated guilt if not joining the green loyalty program

- Perceived attractiveness of hotel receptionist
- Age
- Gender

`Anticipated guilt`, `Perceived Attractiveness`, `Age`, `Gender` are called the independent variables and `Intention to join the green loyalty program` is the dependent variable. The notion of the dependent variable comes from our prediction that its value depends on the values of the independent variables. The relationship between `Intention to join the green LP` the and the four independent variables can be written as:

Intention to join the green LP ~ Anticipated Guilt + Perceived Attractiveness + Age + Gender + error.

You can read the above expression as a consumer' intention to join the green loyalty program is influenced by the consumer's anticipated of guilt, perceived attractiveness, age, and gender, and some unknown factors represented by an error term. The relationship can be represented by a mathematical expression as below. The names of the variables are shortened.

$$Intent = \beta_0 + \beta_1 * Guilt + \beta_2 * Attract + \beta_3 * Age + \beta_4 * Gender. \tag{1}$$

where β_0, β_1, β_2, β_3, and β_4 are parameters that capture the impact of each of the independent variables on `intention`.

We use regression procedure in SPSS to find out the estimates for all parameters using sample data (β_0 is just a constant so it is not of our interest).

> ! Important
>
> Variable `Intent`, `Guilt`, and `Attract` were average scores of a multi-item scale where each item in the scale were measured using a Likert scale ranging from 1 = strongly disagree to 7=strongly agree. `Age` is a continuous variable, and `Gender` is a 0,1 variable.

If you want to examine whether `Guilt` is a significant factor, then you want to test $H0$: $\beta_1 = 0$ against $H1$: $\beta_1 \neq 0$. SPSS will report the p-value associated with $H0$. If p-value is less than 0.05, you reject $H0$ otherwise retain it. If you reject $H0$, you can conclude that `Guilt` is a significant factor that influences `intent`.

If you hypothesize that `Guilt` is a significant factor and has a positive impact on satisfaction, then you want to test $H0$: $\beta_1 = 0$ against $H1$: $\beta_1 > 0$. SPSS will report the p-value associated with $H0$. You have to divide the p-value by 2. If the p-value/2 is less than 0.05, you reject $H0$ otherwise retain it. If you reject $H0$, you can conclude that `Guilt` has a significant positive influence on `Intent`.

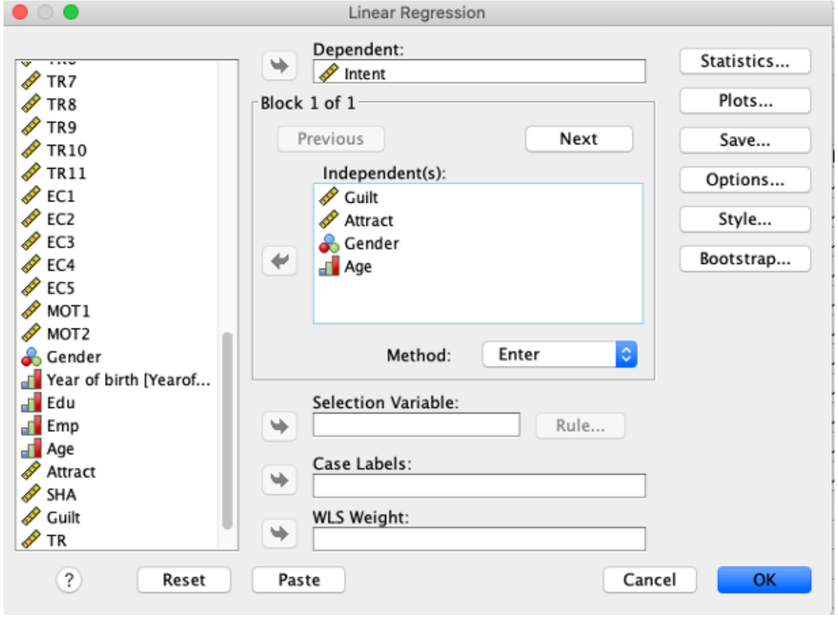
3 Conducting Multiple Regression with SPSS

Open RobotGLP.sav – Thanks to Jingxi for allowing us to use a subset of her data to test the above model.

To conduct a regression analysis in SPSS, click the following: **Analyze→Regression→Linear.**

Enter `Intent` into the dependent variable box.

Enter `Guilt`,`Attract`, `Age`,Gender‘ into the independent variable(s) box.



Dependent: Intent

Block 1 of 1

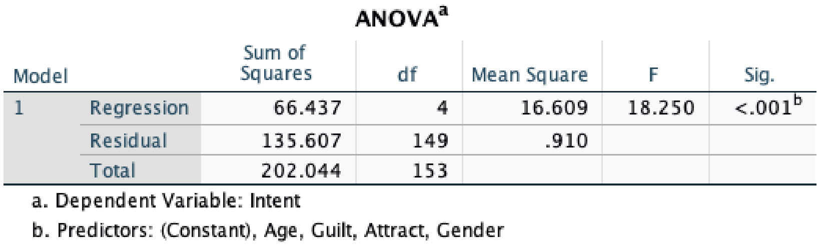
Independent(s): Guilt, Attract, Gender, Age

Method: Enter

Click `OK`

SPSS produces four tables. The first one does not offer much information. Therefore, we focus our attention to the next three tables.

1. ANOVA table: Is the model meaningful?



ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	66.437	4	16.609	18.250	<.001[b]
	Residual	135.607	149	.910		
	Total	202.044	153			

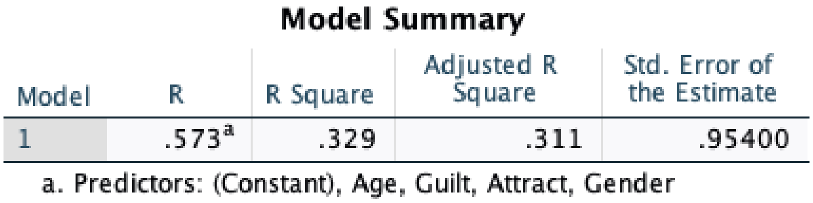
a. Dependent Variable: Intent

b. Predictors: (Constant), Age, Guilt, Attract, Gender

This table tells whether or not the model is meaningful. If the sig value is less than 0.05, then the model is meaningful. If p-value is greater than 0.05, then model should be dismissed and don't interpret other outputs. In this example, the sig. value is less than 0.05; therefore we have a meaningful model. We can proceed with the next output.

2. Model Summary table: How good is the model?

Having known the model is meaningful, how do we know whether it is good enough? The Model Summary table provides the answer to this question.



Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.573[a]	.329	.311	.95400

a. Predictors: (Constant), Age, Guilt, Attract, Gender

The model summary table tells you how well the independent variables explain variation in the dependent variable. The adjusted R^2 is 0.311 indicating that about 31% of the variation in the intention score is explained by the four independent variables (Guilt, Attract, Age, and Gender). Theoretically, the maximum possible value for adjusted R-square is 100% indicating a perfect model!

Adjusted R^2 is R^2 that is adjusted for the number of independent variables in the model. The more independent variable you have in the model, the larger the R^2 will be. The adjusted R^2 prevents the inflation. You can use the following convention to qualify the impact of the set of the independent variables on the dependent variable[1]:

R^2 0.02 small effect

0.13 medium

0.26 large

ℹ Task

Knowing the adjusted R^2, indicate the strength of the impact of Guilt, Attract, Age, and Gender.

⚠ Warning

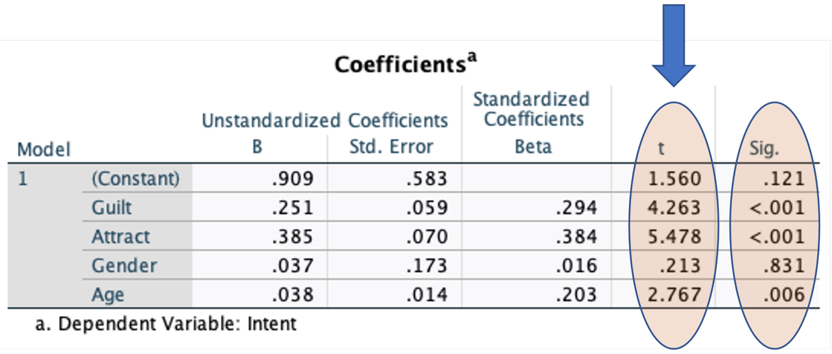
Maximizing R^2 value should not be your main goal in regression. Do not be tempted to select variables with the aim of increasing R^2 value. R^2 value in social sciences are

[1] Ellis, Paul D. 2011. The Essential Guide to Effect Sizes, p.41

typically in the range of 0.1 to 0.5. Selecting variables should be motivated by theories.

3. Coefficients

t = B / Std. error



Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.909	.583		1.560	.121
	Guilt	.251	.059	.294	4.263	<.001
	Attract	.385	.070	.384	5.478	<.001
	Gender	.037	.173	.016	.213	.831
	Age	.038	.014	.203	2.767	.006

a. Dependent Variable: Intent

If p-value <= 0.05, the associated variable is significant (null hypothesis is rejected).

If p-value > 0.05, the associated variable is **NOT** significant (null hypothesis is not rejected).

For 1-sided test, if you used the older version of SPSS eg ver 26 or below, you need to divide the p-value by half.

A t-value is used by SPSS to compute a p-value.

This table tells us which of the independent variables significantly explain or predict the dependent variable. In this case three variables significantly explain `Intent`. These are `Guilt`, `Attract`, and `Age`, whereas `Gender` is not significant. Furthermore, the standardized beta values tell us which variable has the strongest impact on `Intent`. In this case `Attract` is the strongest predictor followed by `Guilt` and `Age`.

ℹ Task

If you want to make a prediction, use the unstandardized coefficients (B). If someone assigns a rating of three on `Guilt`, `Attract` can you predict her intention level? (round-off your answer)

4 Multicollinearity Problems

High correlation among independent variables is problematic in multiple regression because it is hard for us to determine the individual contribution of each of the independent variables in the model. For example, if `Attract` is highly correlated with `Guilt`, then we cannot conclude that `Attract` have the strongest influence on `Intent` because `Guilt` also gives contribution to the magnitude of Attract-Intent relationship (it looks stronger than it should be). In other words, the coefficients associated with the regression estimates are biased – not the same as their true population values.

The situation where an independent variable is highly correlated with another variable is referred to as multicollinearity problem. To diagnose whether multicollinearity exists, you can check it in two ways.

1. Inspect the correlation coefficient among the independent variables. To do correlation analysis in SPSS, follow this step: **Analyze→Correlation→Bivariate**. If two variables is highly correlated with the correlation coefficient is larger than 0.9, your model may suffer from a multicollinearity problem. In practice, you should be cautious, if the correlation is 0.7.

Task

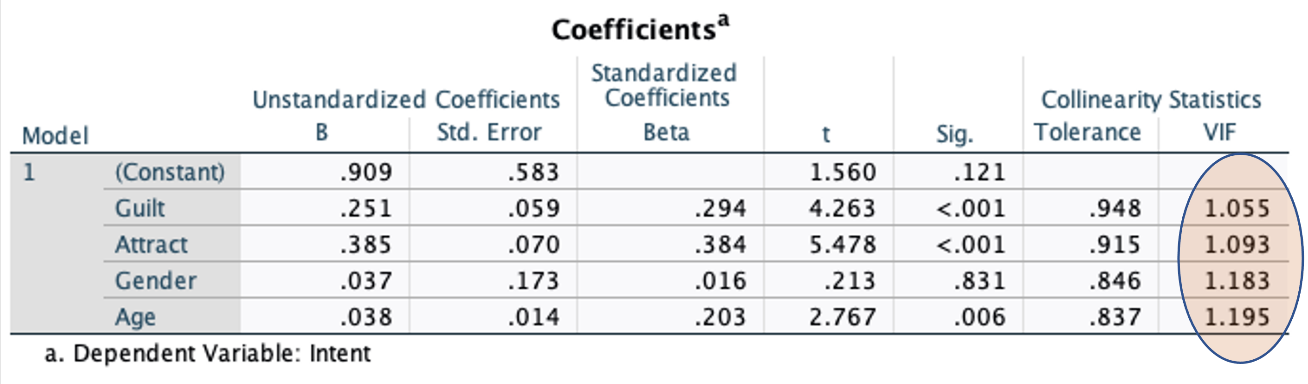
Check the correlation coefficients among the predictors in the model.

2. Rerun your regression.

- Click: **Analyze→Regression→Linear**.
- Click `Statistics` options.
- Select `Collinearity diagnostic`. Click `Continue` and Click `OK`.
- Inspect the **VIF (Variance Inflation Factor** values in the output.

Tip

Multicollinearity exists if VIF (variance inflation factor) > 10.



Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.909	.583		1.560	.121		
	Guilt	.251	.059	.294	4.263	<.001	.948	1.055
	Attract	.385	.070	.384	5.478	<.001	.915	1.093
	Gender	.037	.173	.016	.213	.831	.846	1.183
	Age	.038	.014	.203	2.767	.006	.837	1.195

a. Dependent Variable: Intent

Task

See the above output, does the model suffer from a multicollinearity problem?

5 If Multicollinearity Exists

What should you do if multicollinearity exists?

You can deal with it using one of the following techniques:

1. Omit one or more highly correlated independent variables
2. Create a composite variable e.g., by taking the average score of two variables if the two variables causes multicollinearity **averaging** or using Principle Component Analysis (beyond the scope of our workshops)
3. Use the model that suffers from multicollinearity but for prediction purposes only.
4. Collect more samples

6 Heteroskedasticity Problem

One of the assumptions in regression is that residuals or errors should be constant across any values of independent variables. This is referred to as the **homoskedasticity** assumption. The opposite of homoskedasticity is **heteroskedasticity** where residuals are not constant (i.e., heteroskedastic errors) (*learn how to pronounce these words, it took me a while to get used to them!*).

If heteroskedasticity exists, hypotheses tests about the regression parameters are not correct anymore. See lecture slide for more details. One of the recommended techniques to handle heteroskedasticity is to adjust the standard errors of the regression estimates (i.e., values in the `Std. error` column in the SPSS output).

> ℹ Task
>
> Rerun your regression with heteroskedasticity-adjusted standard errors and compare the results with the original regression you had previously conducted. Continue reading the text below.

To rerun your regression, install and use the 'HeteroskedasticityV3.spd' macro developed by yours truly[2]. The macro produces regression outputs with/without heteroscedasticity-adjusted standard errors.

[2] Daryanto, A. (2020). Tutorial on heteroskedasticity using heteroskedasticityV3 SPSS macro. The Quantitative Methods for Psychology, 16(5), 8-20

7 Installing the HeteroskedasticityV3 Macro

SPSS in the Lab PCs or from cloud may not permit you to install the add-on macro because you do not have an admin right to do so. However, it is worth trying to install the macro, it may work! Alternatively, you need to install the macro in your personal PC where you have an admin right to install it.

You can download the macro from these websites:

- https://github.com/ahmaddaryanto/Heteroskedasticity
- Click the green button `Code`, and select `Download ZIP`.
- Go to the download folder on your PC or laptop.
- Locate the HeteroskedasticityV3.spd and install.
- If you have an admin right, double click the file, and follow the instruction on your screen
- If the above does not work, click **Extensions→Utilities→Install Custom Dialog**. Locate the file, and install.

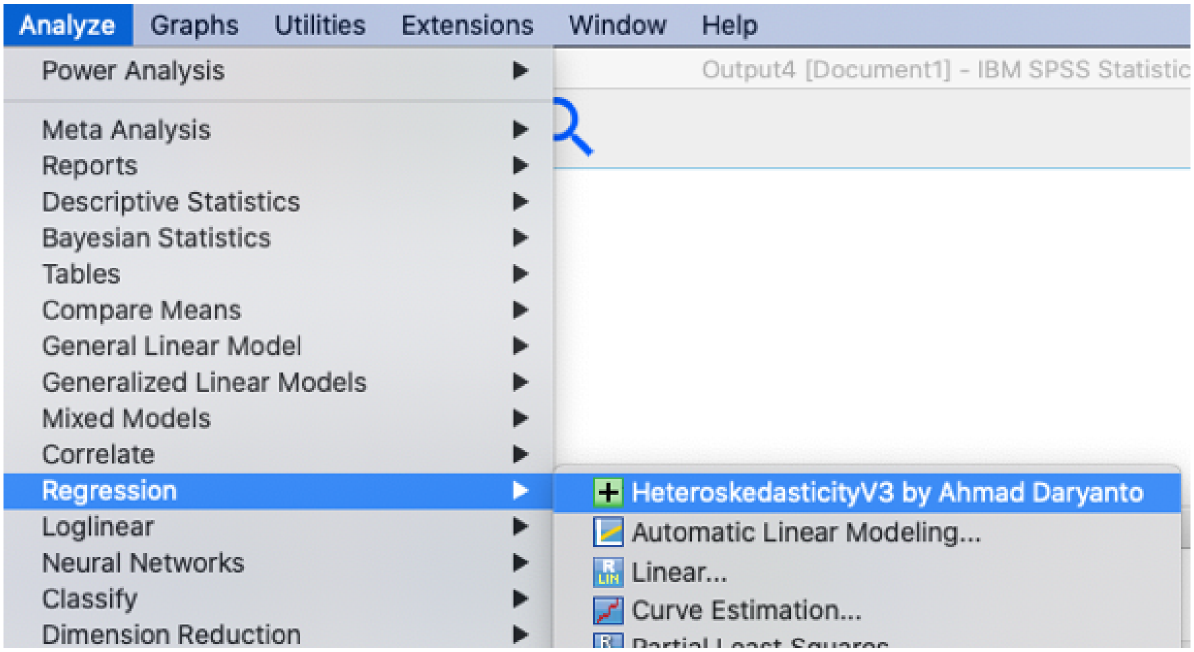
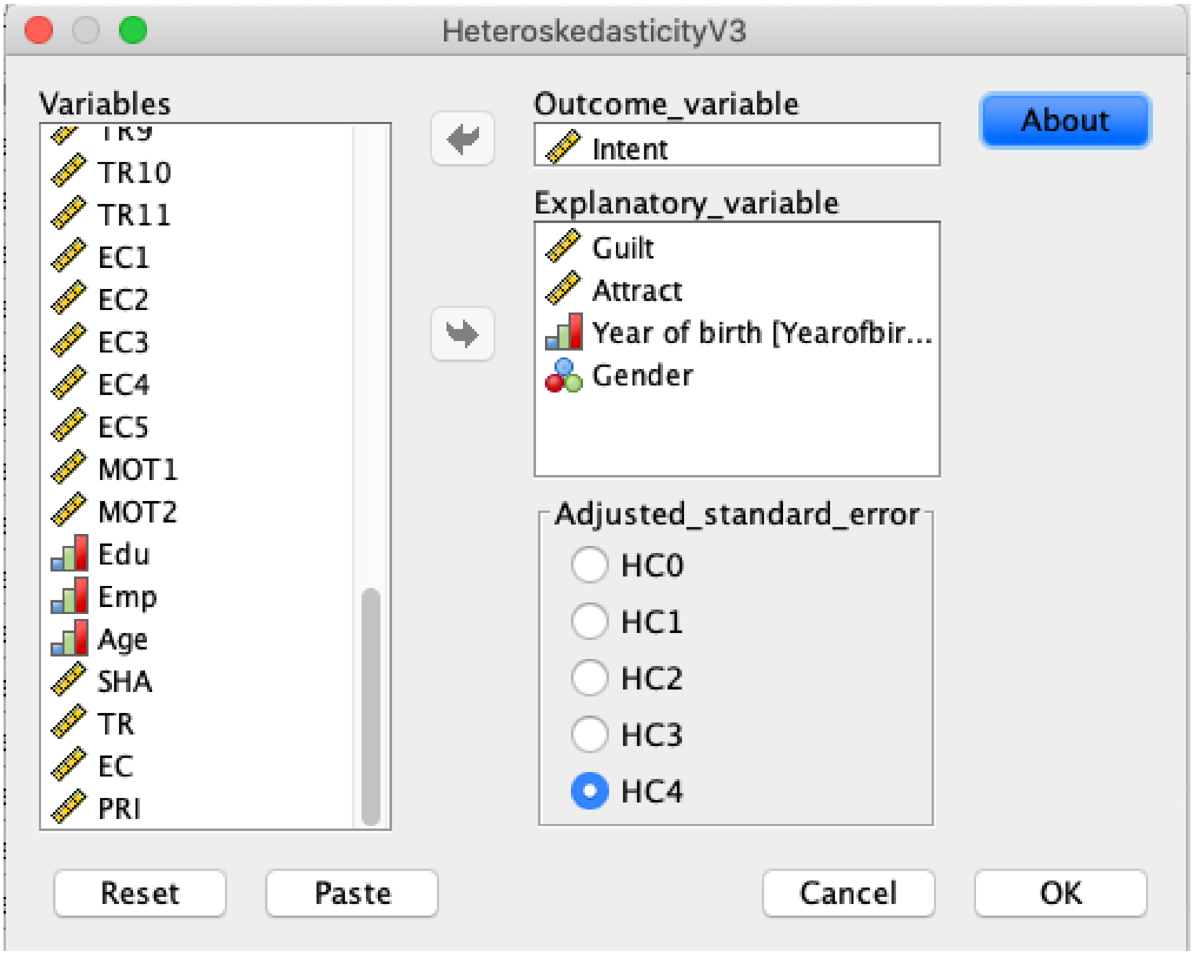


Figure 2: HeteroskedaticityV3 Macro in the SPSS menu after installation

If you do not manage to install the macro. Do not panic! There is another option without installation – see below:



Outcome_variable
Intent

Explanatory_variable
Guilt
Attract
Year of birth [Yearofbir...
Gender

Adjusted_standard_error
○ HC0
○ HC1
○ HC2
○ HC3
● HC4

Figure 3: HeteroskedaticityV3 Macro

8 Running the Macro without Installation

You can run the macro without having it installed on your machine. Follow these steps:

- Go back to the download folder in your PC where you have downloaded several files from this page https://github.com/ahmaddaryanto/Heteroskedasticity (see Section 7)
- HeteroskedasticityV3.sps was included when you download the files from the github page.
- Open the HeteroskedasticityV3.sps on your SPSS – it will be opened as a syntax file,
- Run the syntax file (highlight all the lines, run the selection button, i.e., the green button).
- Next, open this file: **Runthemacro.sps**.
- Change the DV and IVs according to your model specifications, and
- Run the file.

9 Video

Lecture Week 16 on Correlation and Regression

Regression with a categorical iv

Regression diagnostics