**HETEROGENEOUS EFFECTS ACTIVITY GUIDANCE**

**Activity learning goals:**

* Use interactions in multiple regression models to allow effects of variables to depend on the values of other variables.
* Correctly interpret coefficients on interactions of two dummy explanatory variables..

**Introducing the activity:**

Suppose a university is considering increasing the number of tutors it hires, but it wants a good estimate of the effect of tutoring on student outcomes first. The university chooses a representative sample comprised of 100 students and randomly assigns a tutor to half of them. *tuti* is a dummy variable equal to 1 if a tutor was assigned to student *i* and 0 otherwise. The university also collects data on test scores (*yi*), student gender (*malei*), and grade point average (*GPAi*), recorded in the preceding term.

**Guiding students during the activity:**

1. *The administrators start their analysis by estimating the following model:*

*How should we interpret , the coefficient on the tutor dummy variable? Is an unbiased estimate of the Average Treatment Effect (ATE)? Why or why not?*

This question reviews material they have seen before, and most students should recognize that the coefficient on the tutor dummy does indeed represent the causal effect of a student having a tutor on test scores because tutors were randomly assigned. When talking to students, it may be worthwhile to verify that they understand that the estimate of *β1* is the ATE only under the assumption of perfect compliance (all students who had tutors assigned use the services of these tutors). You may also want to point out that controlling for gender and GPA is unnecessary for getting an unbiased estimate in this case, but it should result in a more precise estimate of the tutoring effect.

Ask students to answer this question first and then pause the activity to make sure everyone is up to speed before letting the students move on to the next question.

1. *The university wants to know if the effect of tutors is different for male students relative to female students. The original regression model assumes effects for each of these groups (i.e., males and females) are the same. Suppose you estimate the following model separately for males and females:*
   1. *How do you interpret your two sets of estimates of and ?*Most students should recognize that the estimates of *β1* represent the effects of tutoring specifically for males and females. The coefficients on GPA should not be interpreted causally—Instead, *β2* represents the expected difference in test scores between two students (male for one estimate, female for the other) who have GPAs that differ by one unit.
   2. *Write down a regression model that would be estimated on the whole sample that allows the effect of tutoring to differ for males and females but assumes the effect of GPA is the same for males and females. Interpret the coefficients of your new model.*  
        
      This is where the students try to invent something they’ve never seen before. Some groups succeed by adding an interaction between male and tutor to their model:

The groups that do not succeed still benefit from the exercise as they learn why it might be useful to include an interaction in a model.

* 1. *State a hypothesis in terms of your regression coefficients that you would use to test whether the effect of tutoring differs for males and females.*  
       
     Answering this question requires students to think hard about the interpretation of the coefficient on the interaction. Those students who successfully included the interaction term should recognize that its coefficient represents the difference in the effect for male students relative to female students. This implies that a null hypothesis that the effects are identical is equivalent to a null hypothesis that the coefficient on the interaction is zero.

**Wrapping up the activity:**

This activity leads naturally to a brief lecture on why you might include an interaction in a model and how you interpret it. It’s also important to to point out here that we have only interacted two dummy variables. If we interact a continuous variable with a dummy variable, we are allowing the slope of the regression line to differ for the groups represented by the dummy variable. This naturally leads to further discussion of continuous-continuous interactions.