

*Problem 1* A researcher wants to investigate the effect of a change in CEO on the profits of a firm. For this purpose she collects data on firm profits for a sample of firms. The data are for three years. A subsample of the firms replace their CEO at the beginning of the third year. The researcher will use the third year profits to assess the effect of the CEO change.

- (i)(10) Initially the researcher compares the average third year profits of the firms that replaced their CEO with the average third year profits of the firms that did not replace their CEO. Formulate a regression model that produces the CEO replacement effect as an OLS estimator. How do you compute the standard error of this estimator, both under homo- and heteroskedasticity.
- (ii)(10) Under what assumption is the estimator in (i) an unbiased estimator of the CEO replacement effect? Use the second year profits to check whether that assumption is correct.
- (iii)(10) If the conclusion in (ii) is that the assumption is not correct, under what assumption can you use the second and third year profits data to estimate the effect of the CEO replacement? What is the effect that you can estimate under this assumption?
- (iv)(10) Formulate a regression model that allows the estimation of the CEO replacement effect under the assumption in (iii) as an OLS estimator. How do you compute the standard errors, both under homo- and heteroskedasticity.
- (v)(10) The researcher suspects that the board of directors of a firm replaces a CEO if there is a downward shock to the profits of the firm in a year. Is the estimator in (iv) an unbiased estimator of the CEO replacement effect if this is true?

- (vi)(10) How can the researcher use the three years of firm profits data to check whether the suspicion is correct?
- (vii)(10) Modify the assumption in (iii) so that the CEO replacement effect can be estimated unbiasedly.
- (viii)(10) Suggest an estimator that estimates the CEO replacement effect under the assumption in (vii).

*Problem 2* Randomized experiments where an intervention is randomly assigned allow for simple estimation of the average effect of that intervention.

- (i)(20) Give the assumption in terms of the selection for intervention indicator and the potential/counterfactual outcomes that ensures unbiased estimation of the effect of the intervention in a randomized experiment.
- (ii)(20) After a randomized experiment is performed it turns out that some individuals who were selected for the intervention did not participate while others who were not selected managed to receive the intervention. However, for all individuals the outcome is observed. Define an intervention indicator and observe that it is not equal to the selection for intervention indicator. Under what assumption can we estimate the average effect of the intervention using the data from this flawed experiment?
- (iii)(20) We can obtain the estimator in (ii) using a linear regression model. Write down that model and rephrase the assumption in (ii) using this model.
- (iv)(20) If the assumption in (iii) does not hold, suggest a consistent estimator of the intervention effect and argue why your estimator is indeed consistent. Express this estimator in terms of the average outcomes and fractions that received the intervention for subsamples.