Assignment 1

GV903 Advanced Research Methods – 2021/2022
University of Essex, Department of Government

Instructions

This assignment is due on Tuesday, 16 November at 9:45 am. Please submit on FASER. Instructions can be found in the module handbook on Moodle.

Please create a new document with your answers. Use of LaTeX in conjunction with `knitr` via RStudio is strongly encouraged for creating the answer document. Up to ten bonus points can be given for proper use of this technology and good formatting. Please submit a PDF document on FASER along with the `.Rnw` (or `.tex`) source document if applicable.

The number of points you can obtain for each question or task is given in square brackets. The points add up to 100 and determine your final mark for this assignment. The bonus points come on top of these points, but the final mark is capped at 100. The final mark you earn for this assignment is given by the equation

$$m = \min \left\{ 100, b + \sum_{i=1}^{n} p_i \right\}, \tag{1}$$

where p_i denotes the number of points you earn for question or task i, n is the number of tasks in this assignment, and b is the number of bonus points you earn for use of technology and formatting. All answers are evaluated on three criteria: how clearly the results are presented; how correct the results are; and how elegant, computationally efficient, and/or sophisticated the solution is (where applicable). Good luck!

1 Tenure-track applications

Consider the following fictitious scenario: The job market for academics on *Academic Island* has been getting tighter. Each year, 3,000 new PhDs flood the market, but there are only 165 tenure-track positions available. The probability of getting a tenure-track offer per application is 0.012. Assume that there is no a priori knowledge about differences in ability or performance between the graduates, hence the same probability applies to all applicants per application.

Imagine you are one of those PhD students.

1. How many tenure-track offers do you expect to secure if you apply to all open positions in a given year? [6 points]

2. How many applications do you expect to write to secure your first offer? [6 points]

3. How many applications do you expect to write to secure three tenure-track job offers? [6 points]

4. What is the probability that you get between 4 and 6 offers if you send out all 165 applications? [6 points]

5. What is the probability that you end up without a job after 165 applications? [6 points]

6. If you want to make 90 per cent sure that you get a position, how many applications do you have to write? [6 points]

Show the solutions using equations where feasible; insert the respective numbers, and write a brief explanation. Where feasible, write an `R` function that can compute the result using arbitrary parameters (instead of the numbers given above). In the bodies of the functions you write, use functions from only the `base` package. (I. e., do not use existing distribution functions.) Show that your functions work using the parameters from the respective task.

2 Student satisfaction

The UK government and its regulators measure research and teaching quality in UK universities in order to decide on the allocation of future university funding and outcomes. In the domain of teaching, this is done by the Office for Students (OfS), which administers the National Student Survey (NSS) to final-year undergraduate students across the UK each year to measure student satisfaction. For example, 2,733 students responded to the 2021 NSS at the University of Essex, 171 of whom rated the teaching in the Department of Government. University administrators routinely use NSS results to motivate faculty to deliver teaching that leads to higher student satisfaction. Due to the Covid-19 pandemic and the resulting online teaching, the vast majority of universities saw their student satisfaction scores go down significantly. The metric universities usually look at is Question 27 (Q27) in the NSS: "overall satisfaction." In Q27, respondents are asked to select on a five-point scale from "disagree strongly" to "agree strongly" to what extent they agree with the following statement: "Overall, I am satisfied with the quality of the course." The answer categories are usually aggregated into how many per cent of all respondents per university or subject have ticked positive answer categories ("agree strongly" or "agree mildly") over all five answer categories. For example, the University of Essex saw an aggregated percentage of 72.28 % of third-year students being overall satisfied. In the 2020 NSS, 82.27 % of the 1,816 respondents were overall satisfied. In this part of the assignment, we will analyse the NSS data statistically. Please answer the following questions.

2.1 Was there a decline in student satisfaction?

With the parameters given in the description above, use the binomial distribution to test statistically whether the University of Essex has seen a decline in student satisfaction between 2020 and 2021: Draw the binomial distribution for 2020 and the binomial distribution for 2021 in `R` in a single plot, with the x axis showing the number of satisfied students. In which year do you expect more satisfied students in the sample of respondents (in absolute numbers)? Draw the same plot again with percentages on the x axis instead of counts. Test whether the percentage for 2021 is systematically lower than the distribution for 2020 would predict. Test whether the percentage for 2020 is systematically higher than the distribution for 2021 would predict. Show the critical values, p-values, and test statistics for these tests, and calculate confidence intervals for the student satisfaction percentages. What is the probability that the 2021 percentage score is lower than in 2020 (across the population of all Essex students)? For each of these sub-tasks, show the equations and insert the respective quantities and include a very brief explanation of what you did and why. You can use the binomial distribution functions `R` to obtain the results. Show the `R` code for everything you are doing. [12 points]

2.2 Re-analysis using a normal approximation

When there is a large number of trials, the binomial distribution is approximated by the normal distribution. Please use the normal or standard normal distribution to do the same things as in Task 2.1. Do you get the same results? [12 points]

2.3 Decline in student satisfaction, revisited

The hypothesis tests using binomial and normal distributions above had one weakness: They did not take into account the variance inherent in the test statistic. Instead of testing the *mean* or *percentage* of 2021 in light of the probability distribution for 2020 (or vice-versa), one should test whether the 2021 *distribution* is different from the 2020 distribution, by taking into account the variance around the test statistic.

There is actually a simple way to do this: You can calculate the percentage difference and create a confidence interval for this difference in percentages. The critical value for constructing the confidence interval can be taken from a standard normal distribution. The joint standard error for the percentage difference is given by:

$$SE(p_1 - p_2) = \sqrt{\frac{p_1(1-p_1)}{n_1} + \frac{p_2(1-p_2)}{n_2}}. \tag{2}$$

Apply this method to the percentage difference between 2020 and 2021 for Essex. Is the difference statistically significant? [8 points]

2.4 Did Essex decline more than elsewhere?

The file `nss-uni.csv` contains the overall percentages, percentages in the respective categories, and the number of respondents for both years for all UK universities. Assume for a moment that the number of respondents per institution does not matter and that all universities are equally important cases. Use the empirical distribution of changes across the universities to test (non-parametrically) whether the downturn in student satisfaction between 2020 and 2021 was worse at Essex than at other universities. Include `R` code, a diagram, and a brief explanation to support your analysis. [9 points]

2.5 Simulating answer differences between 2020 and 2021

In Task 2.4, you compared a single data point for Essex to the distribution of changes among all other universities. However, we assumed that each university constituted a single data point. In making that assumption, any particular student's response at a small university was several times as important as any particular student's response at a large university. It would be better if we had the raw individual responses for all respondents from all universities to draw the exact empirical distribution of how satisfied customers were.

The OfS does not release disaggregated data. But we can use our knowledge of distributions to simulate the complete disaggregated dataset of responses. Follow these steps:

1. For each university in the `nss-uni.csv` dataset, create two normal (or binomial) distributions (for the two years) using the respective percentages and numbers of respondents per university and year.

2. Sample as many values from the distribution for 2020 as there are respondents in 2021, for each university.

3. Sample as many values from the distribution for 2021 as there are respondents in 2021, for each university.

4. Compute the pair-wise differences between 2020 and 2021 for each sampled observation, and save the differences in a new vector. This vector of sampled differences will be almost as good as the full, disaggregated dataset the OfS is not providing.

5. Now compare the simulated distribution for Essex respondents to the simulated distribution for all non-Essex respondents, and revisit the question whether student satisfaction at Essex declined more than at other universities, this time taking into account the full distributions of responses.

You can choose an appropriate statistical test and support it with a diagram. Report the `R` code, graphical output, and write a brief description of the steps you took. [11 points]

2.6 Performance of the Department of Government

Within universities, Departments always try their best to show the University leadership that they perform as good as, or better than, other Departments. The file `nss_dept.csv` contains a breakdown of the percentages and respondent numbers for the different Departments at the University of Essex in 2021, for Q27. Test if the Department of Government performed better or worse in student satisfaction than the Department of Economics. Also test if the Department of Government performed better or worse than Sociology. Finally, test whether the Department of Government performed better or worse than the overall university. According to a Departmental memo, the Department of Government performed worse than the overall university, worse than Economics, but better than Sociology. Are these results supported statistically if we take into account the best possible evidence? You can use the percentage difference confidence interval method mentioned above in Task 2.3. [12 points]