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NZQA | Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Scholarship 2023
Statistics

Time allowed: Three hours
Total score: 32

QUESTION BOOKLET

There are four questions in this booklet. Answer ALL FOUR questions.

Each question is equally weighted.

Write your answers in Answer Booklet 93201A.

Pull out Formulae and Tables Booklet S–STATF from the centre of this booklet.

Show ALL working. Start your answer to each question on a new page. Carefully number each question.

Check that this booklet has pages 2–13 in the correct order and that none of these pages is blank.

YOU MAY KEEP THIS BOOKLET AT THE END OF THE EXAMINATION.

QUESTION ONE

(a) The Energy Efficiency and Conservation Authority (EECA) maintains a database that provides estimates of how energy is used across different sectors of the New Zealand economy.

The Sankey diagrams shown in Figure 1 visualise the flow of energy from fuel category to end use category, and show how the different fuel types are used across the residential, commercial, industrial, and agriculture sectors.

Figure 1: Energy usage for 2021, from fuel to end use group, compared by sector

Residential sector
All Residential Sectors stationary energy usage for 2021, from fuel to end use group

Commercial sector
All Commercial Sectors stationary energy usage for 2021, from fuel to end use group

Industrial sector
All Industrial Sectors stationary energy usage for 2021, from fuel to end use group

Agricultural sector
All Agriculture, Tertiary, and Fishing Sectors stationary energy usage for 2021, from fuel to end use group

Source: www.eeca.govt.nz/insights/data-tools/energy-end-use-database/

In the Sankey diagrams shown in Figure 1, the size of each flow bar is proportional to the volume of energy it represents. For instance, for the residential sector, over 50% of the energy used was electricity, and 100% of the energy used by electronics and lighting was electricity.

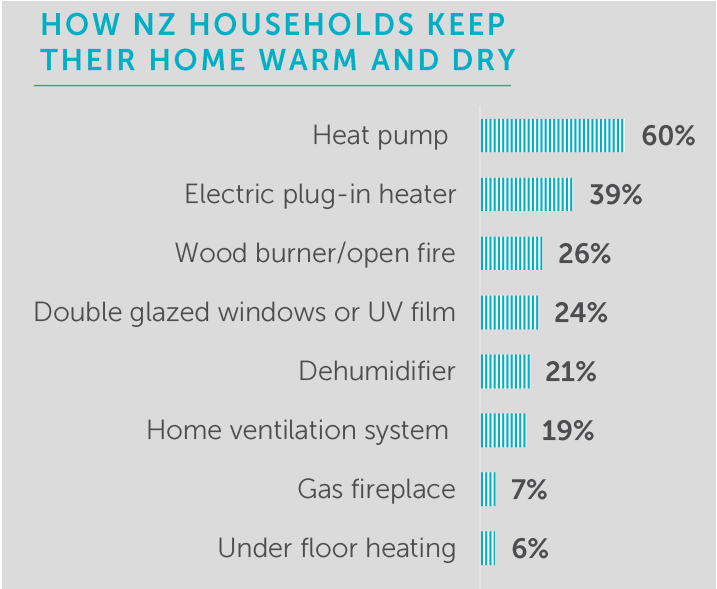
Use the Sankey diagrams to make FOUR statements that compare the use of different fuel types across the four sectors using estimated relative proportions.

(b) Heat pumps require less electricity and less time to increase the temperature in a room compared to traditional electric heaters. They can save money during winter, but as they can also be used for cooling, people often use them during summer as well.

(i) The Aotearoa Housing Survey is a study commissioned by AMI Insurance and Habitat for Humanity NZ. A nationally representative sample of 3039 New Zealand households completed an online survey in March 2022.

Figure 2 provides one of the graphics included in the report about the Aotearoa Housing Survey.

Figure 2: Graphic of survey results for how New Zealand households keep their home warm and dry

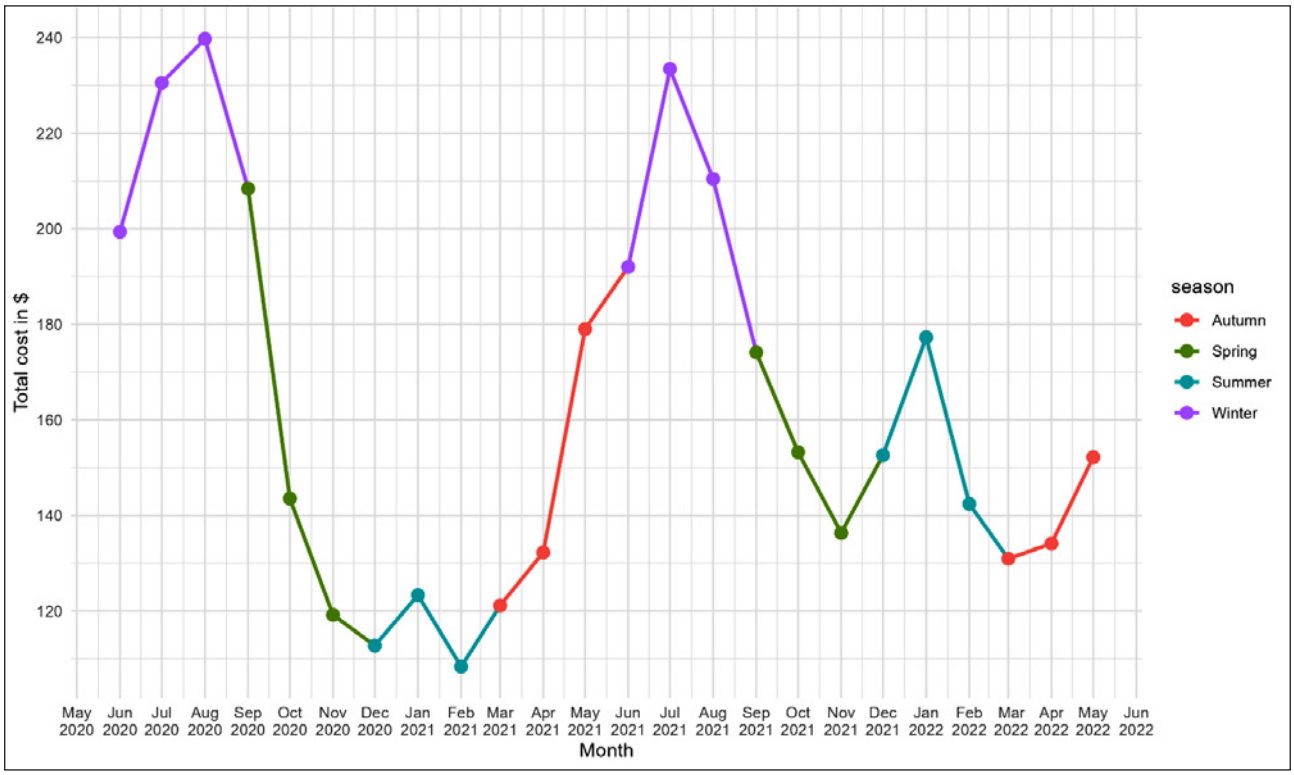


Source: www.ami.co.nz/pdfs/AMI%20Habitat%20for%20Humanity%20warmth%20survey%20results.pdf

Use the information provided to construct and interpret a confidence interval to estimate how much higher the percentage of New Zealand households that use a heat pump to keep their home warm and dry is, compared to those that use an electric plug-in heater.

A two-person household in Auckland installed a heat pump at the start of June 2021 (winter). Figure 3 shows the monthly electricity bills for the 12 months before and the 12 months after the household installed the heat pump.

Figure 3: Total cost of electricity per month



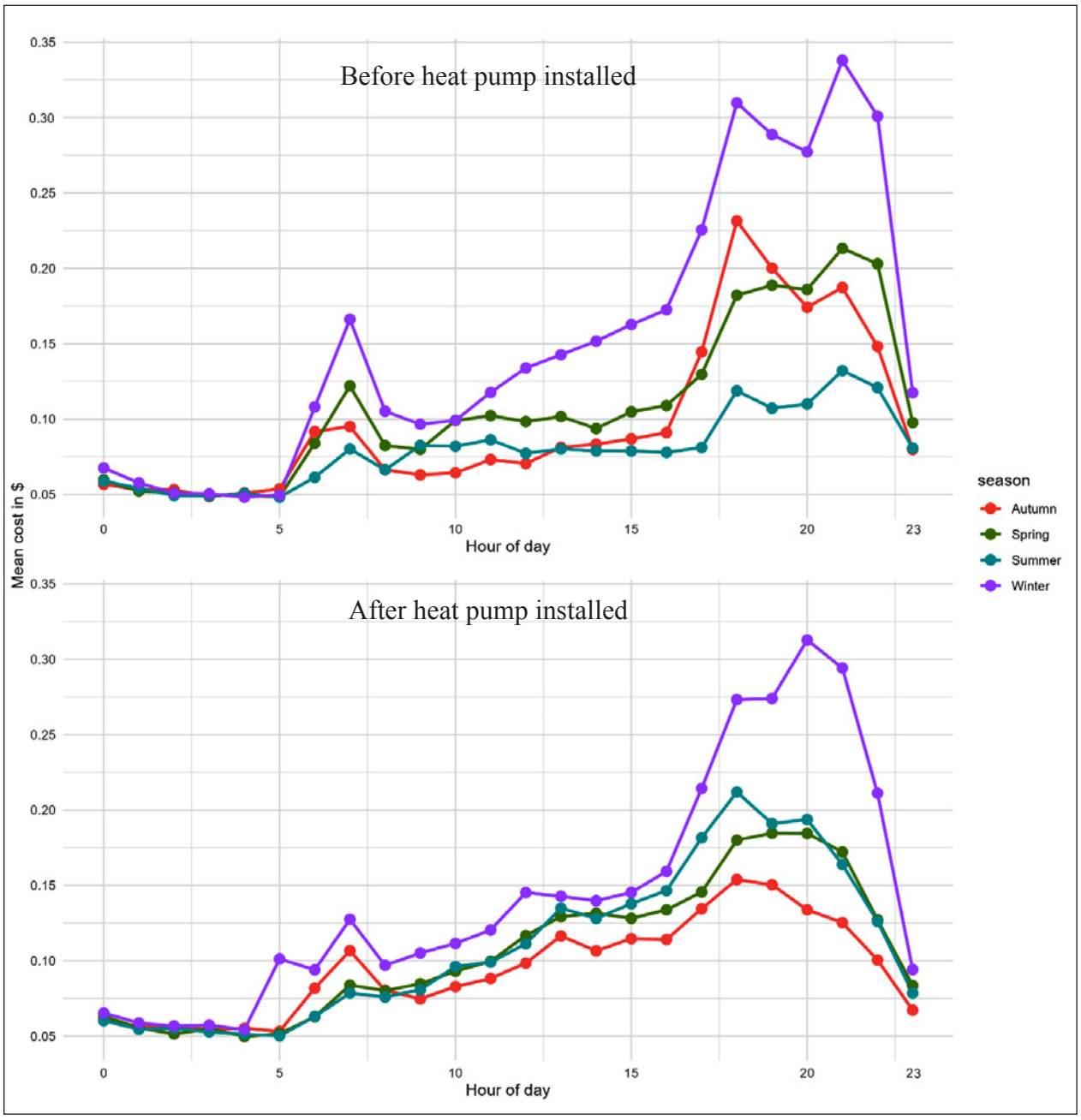
The household was able to download data from the electricity company's website that recorded the amount and cost of energy they used for each half hour of a particular day. Table 1 shows some rows of this data. Note for this household, the cost of electricity per kWh does not change through the day.

Table 1: Electricity usage each half hour

Type	Date	Start Time	End Time	Usage	Units	Cost
Electricity usage	1/06/2021	5:00	5:29	0.38	kWh	$0.11
Electricity usage	1/06/2021	5:30	5:59	0.38	kWh	$0.11
Electricity usage	1/06/2021	6:00	6:29	0.44	kWh	$0.13
Electricity usage	1/06/2021	6:30	6:59	0.81	kWh	$0.23
Electricity usage	1/06/2021	7:00	7:29	0.25	kWh	$0.07

The data downloaded was used to create Figure 4, which shows the mean hourly cost of electricity for this household during the 12 months before and the 12 months after installing the heat pump, compared across the different seasons of the year.

Figure 4: Comparison of mean electricity costs per hour before and after heat pump installed



(ii) Using key features of the data shown in Figures 3 and 4, discuss THREE electricity cost patterns that have either remained similar or have changed for this household after the installation of the heat pump.

(iii) Identify ONE way that Figure 4 makes it difficult to compare the household's electricity usage before and after the heat pump was installed, and suggest a different way the electricity usage and cost data (see Table 1) could be visualised.

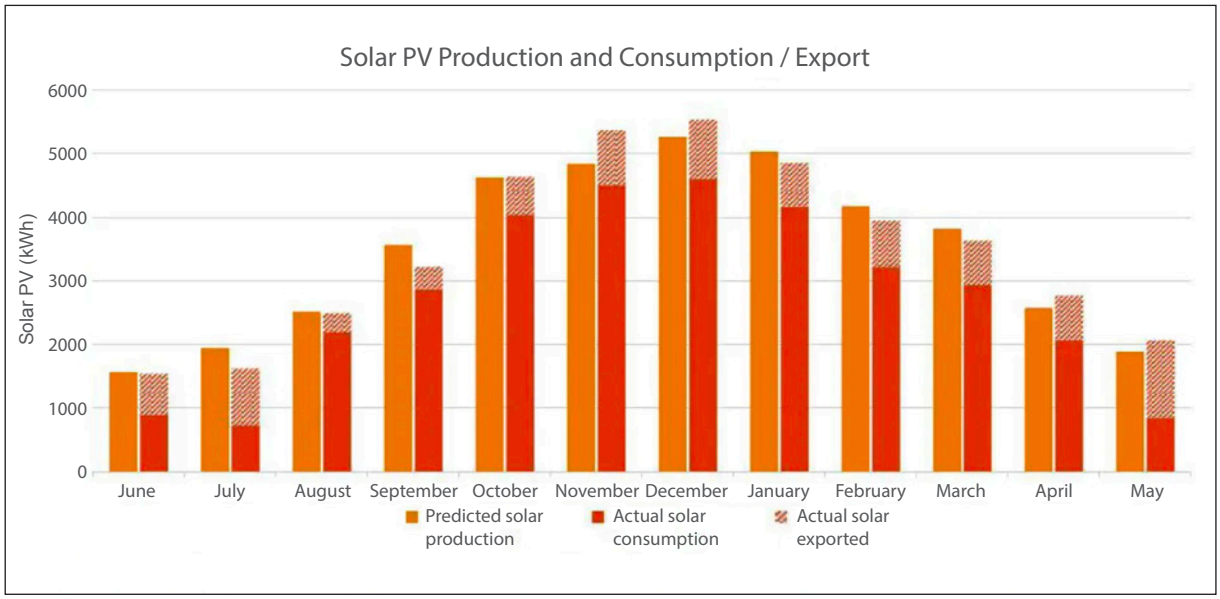
QUESTION TWO

(a) Solar energy is an alternative form of energy and is derived from the sun's radiation. It is a renewable and clean source of energy that can be harnessed through a variety of technologies, such as solar photovoltaic (PV) panels.

Report 1 was adapted from information provided by Sunergy, a company that provides solar PV systems.

Report 1

We provide accurate data prediction by collecting and analysing real-time, local data on sunshine hours, angles, etc., to best position and specify the array and system. This graph shows actual results on a dairy farm the company installed in Canterbury. Light orange (left) was our prediction and dark orange & lined (right) was actual production – averaging just below predicted (seven of the 12 months).



Dark orange (right lower) was actual consumption, which was lower than production. In this case, solar production was greater each month than power consumed, resulting in maximum energy bill savings, plus a supplementary income from power exported to the grid. The deviation between predicted and actual production of power was 0.57%.

Adapted from: https://sunergysolar.co.nz/solar-for-schools

(i) Explain how the deviation of 0.57% may have been calculated, using an example from data provided in Report 1.

(ii) The predicted production of solar energy was higher than the actual production of solar energy for seven of the twelve months.

Use a probability distribution model to evaluate whether there is sufficient evidence to conclude that more than half of the time, the predicted production of solar energy will be higher than the actual production of solar energy.

In your answer, justify the selection of the probability distribution model that you used.

(b) LED lights use far less electricity than traditional incandescent lights, but there have been concerns about negative effects on the alertness of office workers. A study was carried out to investigate whether the light source used in an office affected the ability to process written information.

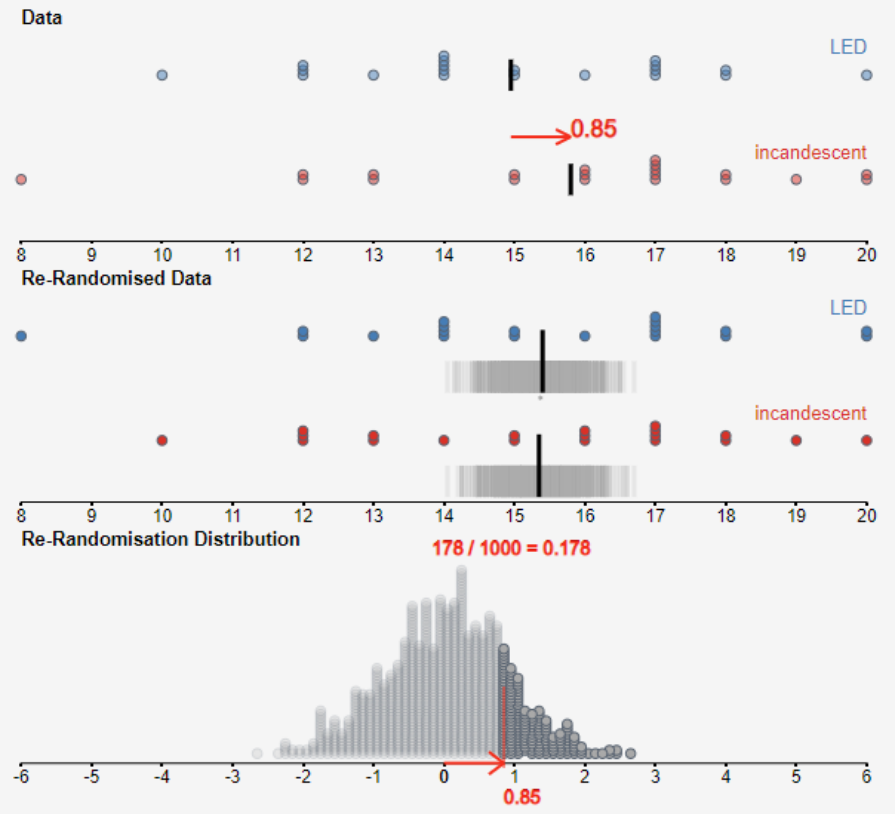
A group of university students was given a proofreading task. The students were randomly allocated to carry out the task, either in an office with LED lighting, or in one with incandescent lighting. Both offices were identical, and the amount of light emitted from each light source was measured to be identical.

Each student was given the same three news articles to proofread, each article being 570–600 words long and containing 20 spelling errors. The students were given three minutes to find as many errors as possible. Each student participant was given an alertness score based on the number of correctly detected errors in the news articles.

(i) A randomisation test was carried out using the difference between the mean alertness score for each light condition.

Figure 5 shows the output from this test.

Figure 5: Randomisation test output



Interpret the randomisation test output.

(ii) Discuss how a similar study could be designed so that each student's ability to process written information could be taken into account.

QUESTION THREE

Trees in cities can contribute to lowering urban temperature during heatwaves by blocking shortwave radiation and increasing water evaporation.

(a) Treepedia is a project where researchers model the tree cover in different cities using images from Google Street View. The images are used to determine a "greenness" score for streets in the city, called the Green View Index.

The Green View Index is generated by calculating the percentage of street images obstructed by tree canopy for a particular street, and is intended to capture the perceived "greenness" for someone walking down each street.

Figure 6 shows the distributions of the "greenness" scores (Green View Index) for the streets of two cities: Sydney and Vancouver. The median Green View Index is shown by the vertical green line.

Figure 6: Distributions of Green View Index for Sydney and Vancouver

Source: http://senseable.mit.edu/treepedia

(i) Briefly discuss why you think Treepedia has used the median, rather than the mean, as the "overall" measure of "greenness" for a city.

(ii) Use the distributions shown in Figure 6 to explain whether Sydney or Vancouver has the higher standard deviation for the Green View Index ("greenness" scores).

(iii) Streets with a Green View Index of less than 10% can be considered as the least leafy.

Use appropriate probability distribution models to estimate the proportion of streets that have a Green View Index of less than 10% for each of the cities shown in Figure 6 (Sydney and Vancouver).

Clearly state the names and parameters of the probability distribution models you have used.

(b) An alternative to planting more trees in cities to reduce the heat, is to consider the colour of roads, pavements, and building materials.

Read Report 2.

Report 2

Adapted from: https://www.theguardian.com/sustainable-business/2017/feb/21/urban-heat-islands-cooling-things-down-with-trees-green-roads-and-fewer-cars

Suppose research was conducted in Wellington to investigate whether houses with light-coloured roofs have lower indoor temperatures than houses with dark-coloured roofs.

Discuss the main differences between using an observational study and an experiment for this investigation, including the impact of the type of study design on any conclusions that could be made.

QUESTION FOUR

One approach to determining the "greenness" of cities is to use satellite imagery. To compare the "greenness" of Auckland and Christchurch, a random sample of 100 suburbs from across both cities was selected.

The map coordinates for each suburb were obtained by searching for the suburb on Google Maps. A Google Map satellite image was then generated based on these coordinates, using a square centred around the coordinates that was 150 metres by 150 metres.

A random sample of 1000 pixels was taken from the image (pixels are the very small squares of colour that make up a digital image). Each of these pixels was then analysed to determine if the pixel was a shade of green and the number of green pixels of the 1000 analysed was recorded for the suburb as the "greenness" score.

Figure 7 shows some of this process for the Auckland suburb of Torbay.

Figure 7: An illustration of using a Google Maps satellite image to determine the "greenness" score

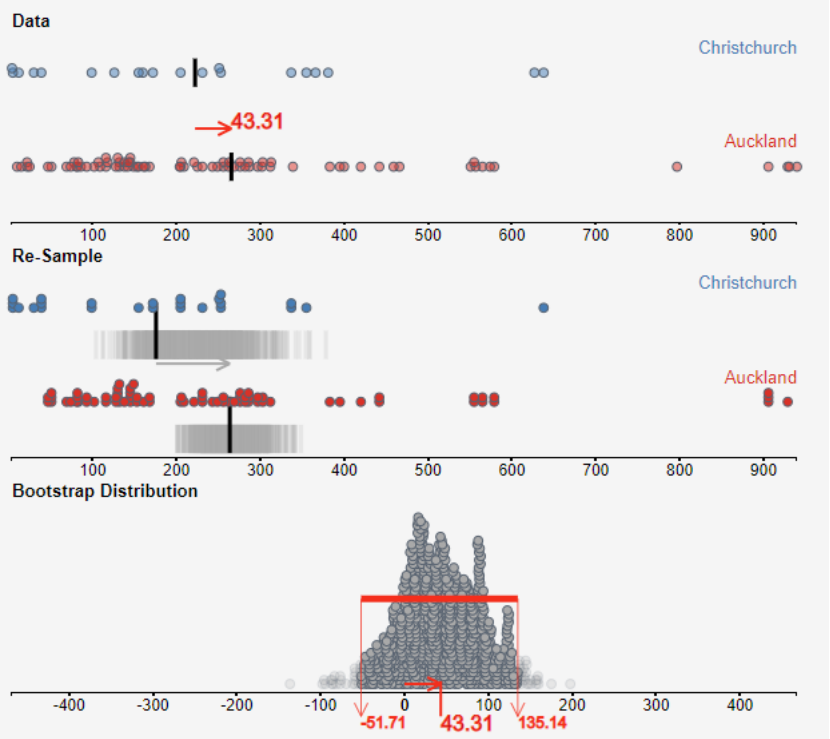
(a) Identify the different sampling strategies used as part of calculating the "greenness" score described above.

For each sampling strategy, briefly discuss any potential issues with using this strategy in terms of estimating and comparing the overall "greenness" of Auckland and Christchurch.

(b) The sample of 100 suburbs was used to construct a bootstrap confidence interval for the difference in mean "greenness" scores between Auckland and Christchurch.

The output from this analysis is shown in Figure 8.

Figure 8: Bootstrap confidence interval construction output



Discuss what can be concluded from both the features of the sample data distributions, and the confidence interval constructed using the sample data.

(c) A student noticed that there are several Auckland suburbs that are particularly green. Knowing that the city of Auckland is larger in area, she suggests that Auckland has an advantage when calculating the mean "greenness" score, as there are suburbs that are quite far from the Auckland city centre which are more likely to be green.

Google Maps was used to calculate the distance from each suburb in the sample and its respective city centre. For example, the distance between the Auckland city centre and the suburb of Torbay is approximately 16.2 km (see Figure 9).

Figure 9: A screenshot showing the use of Google Maps to calculate the distance between the Auckland city centre and the suburb of Torbay

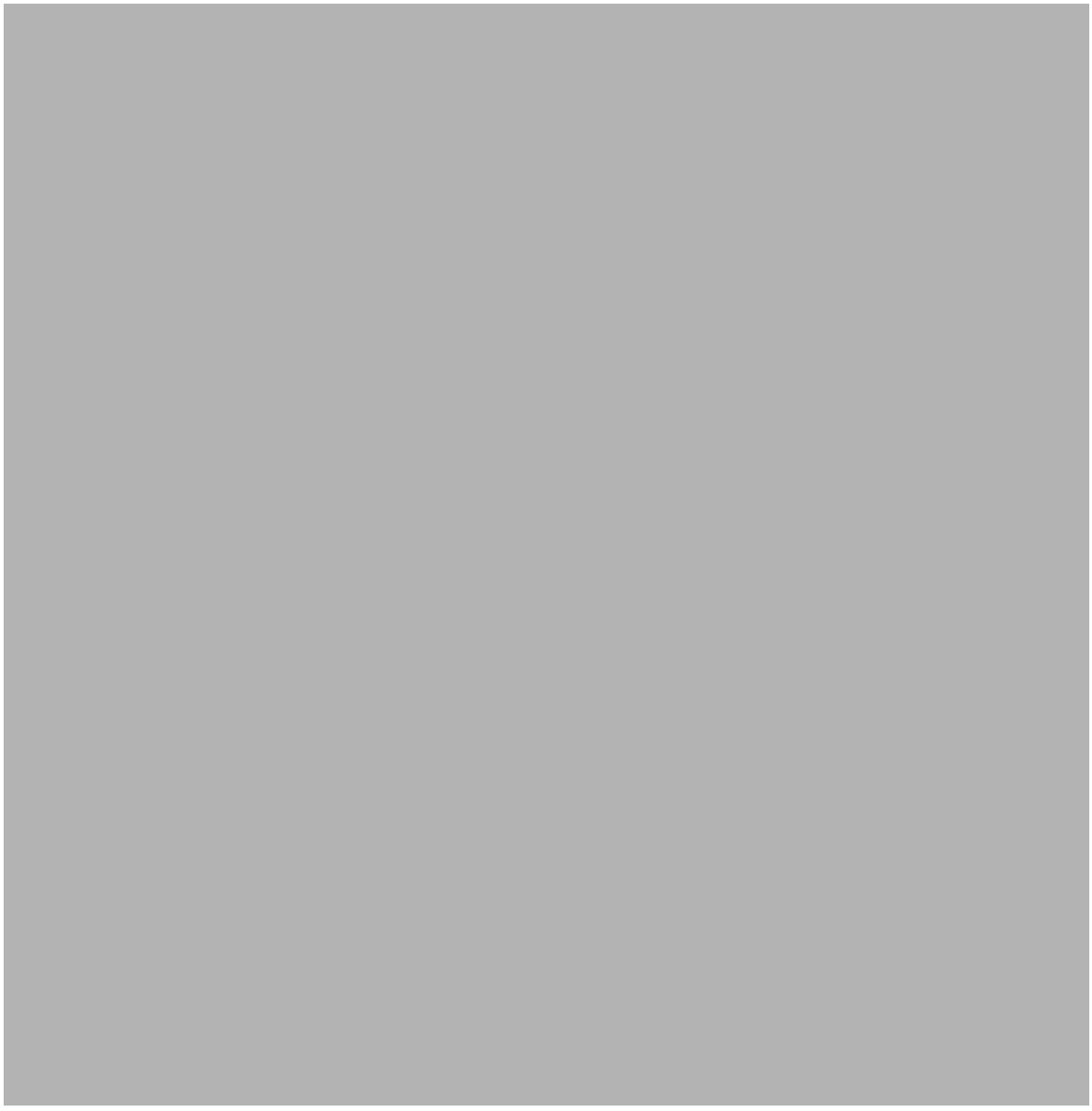
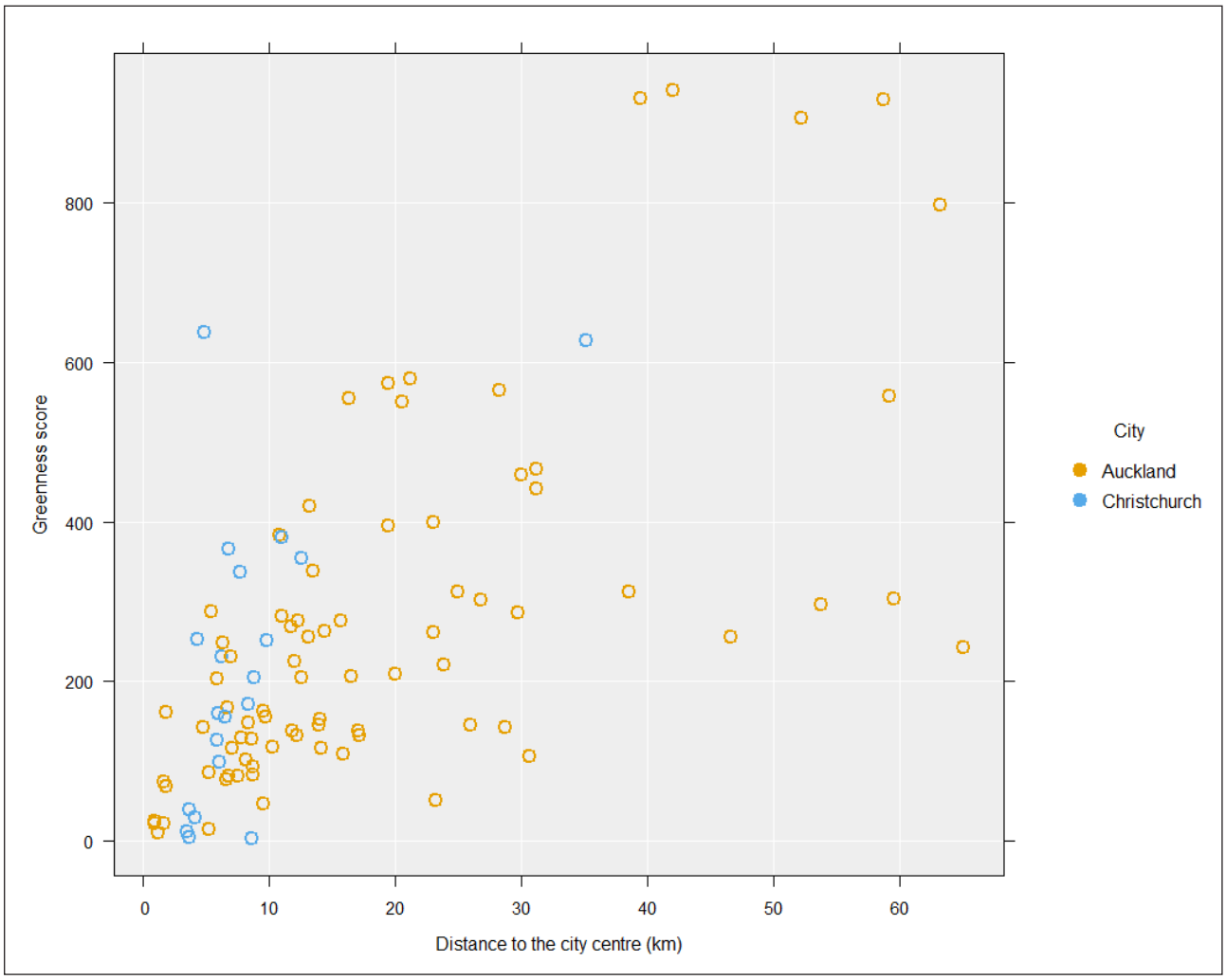


Figure 10 shows a scatterplot comparing the distance to the city centre and the "greenness" score for each of the suburbs in the sample. Additionally, colour has been used to indicate the city each suburb belongs to.

Figure 10: "Greenness" score versus distance to the city centre, compared by city



Identify key features of the data shown in Figure 10, and use these to discuss how the distances from the city centre and the "greenness" scores compare for Auckland and Christchurch.

(d) The student suggests that the comparison of "greenness" between Auckland and Christchurch could be made fairer by changing how suburbs are selected in the sampling process.

Use key features of the data shown in Figure 10 to suggest ONE way the sampling process could be changed.

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