

Department of Statistics
First Year Statistics
Mid-Semester Test: First Semester, 2014

VERSION 1

ANSWERS ON PAGE 16

Instructions:

- All questions have a single correct answer.
- All questions carry the same mark value.
- If you do not know the answer, then take a guess.
- Multiple answers to a question will ALL be marked wrong.
- Incorrect answers are not penalised.

There are 20 questions.

Formulae are provided (appended to the back of the test paper).

Answer ALL questions on the ANSWER SHEET provided (attached to the front of the test paper).

- Hand in your answer sheet **only**.
- Keep a personal record of your answers on the test paper—answers will be announced on Cecil tomorrow.

References

Antonioli, C. and Reveley, M. A. (2005). Randomised controlled trial of animal facilitated therapy with dolphins in the treatment of depression. *BMJ*, **331**(7527), 1231.

Battisti, M. and Deakins, D. (2011). BusinessMeasure perspectives from New Zealand small firms: Crisis management and the impact of the Canterbury earthquakes. Study report, New Zealand Centre for small and medium enterprise Research, Massey University.

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Questions 1 and 2 refer to the following information.

The average body temperature for healthy humans is often given as 37 degrees Celsius (98.6 degrees Fahrenheit). Body temperatures were recorded for 50 adults who had been randomly selected from a population of healthy adults. A bootstrap confidence interval for the population mean was constructed and the three plots (Sample, Re-sample and Bootstrap distribution) from the iNZightVIT Bootstrap confidence interval construction output are shown in Figure 1.

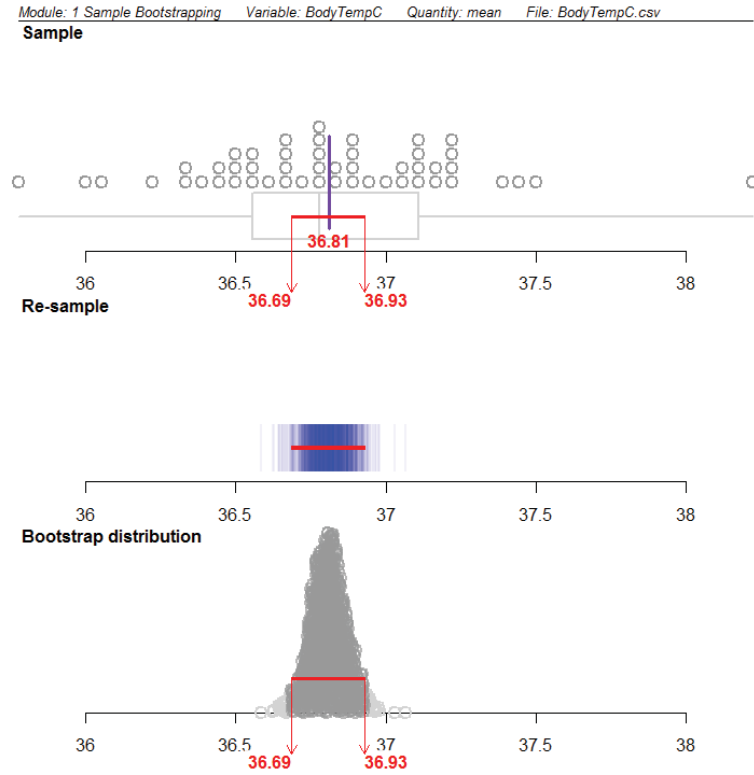


Figure 1: Bootstrap confidence interval construction output

1. Which **one** of the following statements is **false** for the plots shown in Figure 1 on the previous page?
- (1) Each vertical line in the Re-sample plot is one of the observations obtained by randomly re-sampling with replacement from the original sample of 50 healthy adults.
 - (2) We use the central 95% of the Bootstrap distribution to find the lower and upper limits of the bootstrap confidence interval.
 - (3) The Re-sample plot shows the extent of the variation of the means of the 1000 re-samples taken with replacement from the original sample.
 - (4) The Bootstrap distribution plot and the Re-sample plot are two different ways of plotting the means of the 1000 re-samples taken with replacement from the original sample.
 - (5) The mean body temperature of the sample of 50 healthy adults was 36.81 degrees Celsius.
2. Which **one** of the following statements is the **best** interpretation of this bootstrap confidence interval?
- (1) It's a fairly safe bet that the body temperature of each healthy adult in the population is somewhere between 36.69 and 36.93 degrees Celsius.
 - (2) The mean body temperature of the population of healthy adults is less than 37.00 degrees Celsius.
 - (3) It's a fairly safe bet that the mean body temperature of the population of healthy adults is somewhere between 36.69 and 36.93 degrees Celsius.
 - (4) It's a fairly safe bet that the mean body temperature of the sample of 50 healthy adults is somewhere between 36.69 and 36.93 degrees Celsius.
 - (5) The body temperature of each healthy adult in the population is somewhere between 36.69 and 36.93 degrees Celsius.

Questions 3 to 6 refer to the following information.

Researchers (Antonioli and Reveley, 2005) undertook a study to determine whether swimming with dolphins could be therapeutic for patients suffering from clinical depression. Thirty subjects, aged 18–65 and each with a clinical diagnosis of mild to moderate depression, were recruited. The 30 subjects were taken to an island off the coast of Honduras where they were randomly assigned to one of two groups. Both groups engaged in the same amount of swimming and snorkelling each day, but one group (dolphin therapy) did so in the presence of bottlenose dolphins and the other group (no-dolphin therapy) did not. At the end of two weeks each subject was observed and their level of depression was evaluated, as it had been at the beginning of the study, and it was determined whether they showed substantial improvement (reduced level of depression). The researchers found that 10 of the 15 subjects in the dolphin therapy group showed substantial improvement, compared to 3 of the 15 subjects in the no-dolphin therapy group.

3. Which **one** of the following statements is **true**?

- (1) There was blocking in this study; the subjects were blocked on whether they received dolphin therapy or no-dolphin therapy.
- (2) For the researchers to be able to conclude that swimming with the dolphins had been therapeutic, the subjects should have been randomly sampled from some population.
- (3) This is an observational study because each subject was ‘observed’ in order to evaluate the change in their level of depression.
- (4) It would have been impossible to use any form of blinding in this study.
- (5) The 30 subjects were randomly assigned to one of the two groups to try to make the groups, overall, as similar as possible.

4. Which **one** of the following statements is **false**?

If the dolphin therapy had made no difference in depression levels then:

- (1) both groups would have had the same number of subjects who showed substantial improvement over the two week period.
- (2) the 13 subjects who had shown substantial improvement would have shown substantial improvement regardless of the group to which they were assigned.
- (3) the difference between the two groups can be simulated by randomly re-allocating the observed data to the two groups.
- (4) we would say that the observed difference between the two groups ‘happened by chance alone’.
- (5) the observed difference between the two groups would be explained as the result of the random allocation of the 30 subjects to the two groups.

Questions 5 and 6 refer to the following additional information.

A randomisation test was performed on the data. The test output gives a re-randomisation distribution for the difference between the proportion of subjects showing improvement in the dolphin and no-dolphin therapy groups as displayed in Figure 2. (Note: $10/15 - 3/15 = 7/15 = 0.467$)

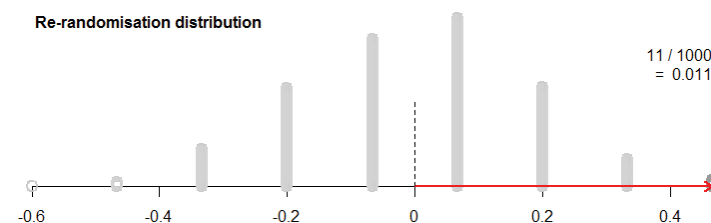


Figure 2: Re-randomisation distribution for dolphin therapy data

5. Which **one** of the following statements about this test output is **true**?

- (1) If 1000 different researchers repeated this study, then about 11 of those 1000 studies would produce an observed difference between the group proportions of at least 0.467.
- (2) If 1000 different researchers repeated this study, then about 11 of those 1000 studies would produce an observed difference between the group proportions of 0.467.
- (3) 11 out of 1000 re-randomisations under chance alone produced a difference between the group proportions of between 0 and 0.467.
- (4) At least 11 of 1000 re-randomisations under chance alone produced a difference between the group proportions of 0.467.
- (5) 11 out of 1000 re-randomisations under chance alone produced a difference between the group proportions of at least 0.467.

6. Which **one** of the following statements is **not** a valid interpretation of the randomisation test result?

- (1) A difference between the two group proportions of 7/15 or more would have been very unlikely if chance had been acting alone.
- (2) We may claim that the actual swimming with the dolphins was the reason why the number of subjects showing improvement was higher in the dolphin therapy group.
- (3) We have evidence against the chance-was-acting-alone explanation.
- (4) In a study like this, it would be very unlikely to get a difference between the two group proportions of 7/15 or more.
- (5) We may claim that the observed difference between the two group proportions is partially due to chance and partially due to the two groups having different therapies.

Questions 7 to 19 refer to the following information.

The BusinessMEasure project (Battisti and Deakins, 2011) conducted annual surveys of small and medium sized New Zealand firms (SMEs) for five years from 2007 until 2011. An SME was defined to be a firm employing 99 or fewer staff.

The 2011 survey questionnaire was mailed to 3527 of the 471,545 SMEs in New Zealand at that time. The initial mail-out was followed up with a postcard reminder, a reminder letter with a second copy of the survey questionnaire and finally a second postcard reminder. There were 1127 usable responses.

Some of the variables measured are defined as follows:

Gender	The gender of the owner
Employees	The number of full-time equivalent employees
Turnover	Annual turnover for the past 12 months \$100,000 or less \$100,000+ – \$500,000 \$500,000+ – \$1,000,000 \$1,000,000+ – \$5,000,000 more than \$5,000,000
Market share	The respondent’s answer to the question: “How has your market share changed over the past 12 months?” Strongly increased Increased About the same Decreased Strongly decreased
CrisisPlan	Whether or not the firm had a formal written crisis management plan Yes No
CantRegion	Whether or not the firm was in Canterbury Canterbury Other NZ region
Resilience	Whether or not the firm was resilient Resilient Vulnerable
Growth	Whether or not the firm had grown in the past 12 months Yes No

7. Which **one** of the following statements about the study is **false**?

- (1) If a smaller sample had been used then the sampling error would have had the potential to be bigger.
- (2) The postcards and reminder letter were an attempt to reduce the nonresponse rate.
- (3) Using the results of this survey to make inferences about Australian SMEs would be an example of transferring findings.
- (4) Results from this survey are likely to be biased because the survey was sent to only a small proportion of the SMEs in New Zealand.
- (5) If a pilot survey had been used then this would have been one way to reduce potential question effects.

8. Which **one** of the following statements about the variables, as defined on the previous page, is **false**?

- (1) **CrisisPlan** is a nominal variable.
- (2) **Turnover** and **Market share** are numeric variables.
- (3) **Market share** is an ordinal variable.
- (4) **Employees** is a numeric variable and **Gender** is a categorical variable.
- (5) **CrisisPlan** and **CantRegion** are categorical variables.

9. Suppose that a table of random numbers was used to select the 3527 SMEs to take part in the survey. Each SME would have been allocated an identification number from 1 to 471,545. Using the random numbers below identify the first 3 SMEs chosen. Start at the beginning of the row and use consecutive digits.

14042 53536 07779 04157 41172 36473 42123

The first three SMEs sampled would have had identification numbers:

- (1) 1404, 2535 and 2364
- (2) 140425, 353607 and 779041
- (3) 140425, 353607 and 236473
- (4) 14042, 53536 and 7779
- (5) 1404, 2535 and 3607

Question 11 refers to the following additional information.

244 of the firms surveyed reported that they had exported in the past 12 months. The survey report included Table 1 which summarises the percentage of their annual turnover generated by exports for these 244 firms.

Percentage of turnover	Number of firms
1% – 10%	139
11% – 25%	31
26% – 50%	33
51% – 75%	21
76% – 100%	20

Table 1: Percentage of turnover generated by exports

The best approximations for the sample mean and sample standard deviation of these 244 firms is $\bar{x} = 23.19\%$ and $s = 26.36\%$.

10. No longer examined

11. A further 844 firms reported that they had not exported in the past 12 months; that is, none (0%) of their annual turnover had been generated by exports.

Which **one** of the following statements is **true**?

If the information about these 844 firms is included in Table 1 then:

- (1) both the sample mean and sample standard deviation would be unchanged.
- (2) the sample mean would be smaller and the sample standard deviation would be larger.
- (3) both the sample mean and sample standard deviation would be smaller.
- (4) both the sample mean and sample standard deviation would be larger.
- (5) the sample mean would be unchanged and the sample standard deviation would be smaller.

12. In both the 2009 and 2011 surveys, data was collected on the industry sector of each SME respondent. Table 2 shows the number of SMEs in each industry sector and the percentage change (%Change) in the number of SMEs from 2009 to 2011.

Industry sector	2009	2011	%Change
Primary Production	98	169	72.4%
Manufacturing	263	306	16.3%
Construction	184	121	−34.2%
Wholesale/Retail	245	206	−15.9%
Business, Property and Finance services	111	109	−1.8%
Other services	385	210	−45.5%
TOTAL	1286	1121	−12.8%

Table 2: Industry sector data

Suppose that the main purpose of the table was to convey information about %Change. Which **one** of the following changes in the presentation of the table would be the **best** improvement?

- (1) Reorder the columns so that the %Change column is next to the **Industry sector** column
- (2) Reorder the rows so that the %Change column is in ascending or descending order.
- (3) Delete the TOTAL row.
- (4) Round the values in the %Change column to the nearest whole number and those in the **2009** and **2011** columns to the nearest 10.
- (5) Reorder the rows so that the **Industry sector** column is in alphabetical order.

Questions 13 and 14 refer to the following additional information.

1059 of the responses, cross-classified by **CrisisPlan** and **CantRegion**, are shown in Table 3.

Recall the following two variable definitions:

- CrisisPlan** Whether or not the firm had a formal written crisis management plan
CantRegion Whether or not the firm was in Canterbury

CrisisPlan	CantRegion		Total
	Other NZ region	Canterbury	
Yes	82	10	92
No	875	92	967
Total	957	102	1059

Table 3: Crisis planning

13. To 3 decimal places, the proportion of these SMEs that did **not** have a formal written crisis management plan is:
- (1) 0.902
 - (2) 0.905
 - (3) 0.913
 - (4) 0.095
 - (5) 0.914
14. To 3 decimal places, the proportion of the Canterbury SMEs that had a formal written crisis management plan is:
- (1) 0.087
 - (2) 0.098
 - (3) 0.096
 - (4) 0.009
 - (5) 0.109

Question 16 refers to the following additional information.

The 2011 survey also collected information about firm size. Respondents were asked for the number of full-time equivalent employees in the firm.

The standard deviation of the number of full-time equivalent employees in the sample of 1127 firms who responded was 16.2.

Let:

μ_{size} be the mean number of full-time equivalent employees for all 471,545 SMEs in New Zealand in 2011.

15. No longer examined

16. The Ministry of Economic Development holds data on the whole population of New Zealand SMEs. In 2010 μ_{size} was calculated to be approximately 3.5.
- Assuming the 2011 data is a random sample, an approximate 95% confidence interval for μ_{size} was calculated as (15.4, 16.4).

Which **one** of the following statements is **false**?

- (1) A claim that the mean number of full-time equivalent employees in SMEs in 2011 is larger than in 2010 is consistent with the data.
- (2) It is not plausible that there has been no change in the average number of full-time equivalent employees in SMEs between 2010 and 2011.
- (3) With 95% confidence we estimate that the mean number of full-time equivalent employees in SMEs in 2011 is somewhere between 15.4 and 16.4.
- (4) With 95% confidence we estimate that the mean number of full-time equivalent employees in SMEs in 2011 is 15.9 with a margin of error of 0.5.
- (5) With 95% confidence we estimate that the difference between the mean number of full-time equivalent employees in SMEs in 2011 and in 2010 is 12.4.

Questions 17 and 18 refer to the following additional information.

Researchers were also interested in answering the question: “What are the determinants of small business resilience?” One of the factors considered was firm performance, which was measured by whether or not the firm had grown in the past 12 months.

318 responses, cross-classified by **Growth** and **Resilience**, are shown in Table 4.

Growth	Resilience		Total
	Resilient	Vulnerable	
Yes	31	43	74
No	71	173	244
Total	102	216	318

Table 4: **Resilience** and **Growth**

- Let:
- p_{YesR} be the proportion of all SMEs that experienced growth in the past 12 months that are resilient
- and
- p_{NoR} be the proportion of all SMEs that experienced no growth in the past 12 months that are resilient.
17. The sampling situation for calculating the standard error of the estimate, $\text{se}(\hat{p}_{\text{YesR}} - \hat{p}_{\text{NoR}})$, is:
- (1) one sample of size 102, many yes/no items.
 - (2) one sample of size 102, several response categories.
 - (3) two independent samples of size 74 and 244.
 - (4) two independent samples of size 102 and 216.
 - (5) one sample of size 318, several response categories.

18. A 95% confidence interval for $p_{\text{YesR}} - p_{\text{NoR}}$ is (0.002, 0.254). Which **one** of the following statements is the **best** interpretation of this interval?

With 95% confidence we estimate that the proportion of all SMEs that experienced growth in the past 12 months that are resilient is:

- (1) 0.002 and the proportion of all SMEs that experienced no growth in the past 12 months that are resilient is 0.254.
- (2) somewhere between 0.002 and 0.254 higher than the proportion of all SMEs that experienced no growth in the past 12 months that are resilient.
- (3) somewhere between 0.002 lower than and 0.254 higher than the proportion of all SMEs that experienced no growth in the past 12 months that are resilient.
- (4) somewhere between 0.002 and 0.254 lower than the proportion of all SMEs that experienced no growth in the past 12 months that are resilient.
- (5) 0.002 higher than the proportion of all SMEs that experienced no growth in the past 12 months that are resilient, with a margin of error of 0.254.

19. 454 of the respondents reported that their business had experienced a crisis in the last five years. Of the 80 from the Canterbury region who reported experiencing a crisis in the last five years, 32 reported that there was potential for extreme harm from the most recent crisis and 3 reported that there was no potential for harm. 165 of the businesses from other NZ regions who reported experiencing a crisis in the last five years said there was potential for moderate or serious harm. Overall 106 businesses reported potential for extreme harm from the most recent crisis.

What was the relative risk of the most recent crisis having potential for harm (moderate, serious or extreme) for businesses from the Canterbury region compared to those from other NZ regions?

- (1) 3.10
- (2) 0.32
- (3) 4.68
- (4) 0.66
- (5) 1.51

20. The rate of caesarean sections in New Zealand is often quoted as a cause for concern. We are interested in investigating the possibility of a link between birth type and deprivation level. Deprivation is measured in quintiles with Quintile 1 being least deprived and Quintile 5 being most deprived. Figure 3 shows the distribution of birth type for each quintile in 2010.

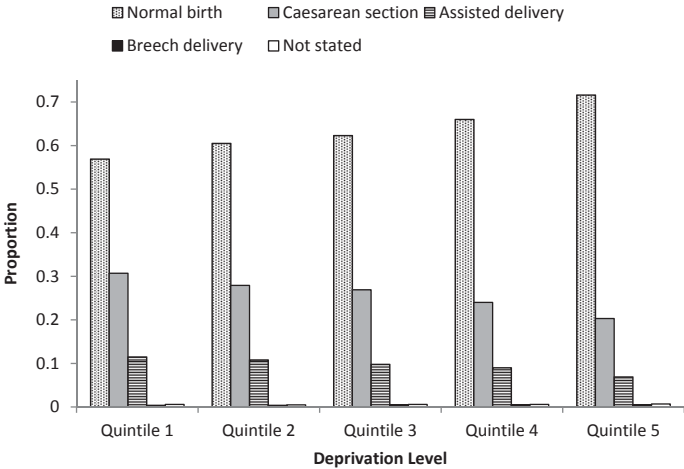


Figure 3: New Zealand births in 2010

Which **one** of the following statements about Figure 3 is **false**?

- (1) The greater the deprivation level, the greater the proportion of caesarean sections.
- (2) Breech deliveries were relatively unusual regardless of the deprivation level.
- (3) Quintiles 1 and 2 had a similar proportion of assisted deliveries.
- (4) The majority of births were normal births.
- (5) It is not possible to tell which quintile had the greatest number of normal births.

ANSWERS

- | | | | | |
|---------|---------|---------|---------|---------|
| 1. (1) | 2. (3) | 3. (5) | 4. (1) | 5. (5) |
| 6. (4) | 7. (4) | 8. (2) | 9. (3) | 11. (3) |
| 12. (2) | 13. (3) | 14. (2) | 16. (5) | 17. (3) |
| 18. (2) | 19. (5) | 20. (1) | | |
-