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932011

SUPERVISOR'S USE ONLY

SCHOLARSHIP EXEMPLAR

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

QUALIFY FOR THE FUTURE WORLD
KIA NOHO TAKATŪ KI TŌ ĀMUA AO!

Tick this box if you have NOT written in this booklet

Scholarship 2022
Statistics

Time allowed: Three hours
Total score: 32

ANSWER BOOKLET

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

Write your answers in this booklet.

Make sure that you have Formulae Booklet S–STATF.

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

Check that this booklet has pages 2–24 in the correct order and that none of these pages is blank.

Do not write in any cross-hatched area (▨). This area may be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Question	Score
ONE	
TWO	
THREE	
FOUR	
TOTAL	

ASSESSOR'S USE ONLY

Q1a)

Dairy cattle have increased from 1980 with about 3,000,000 to the mid 2010s with just under 7,000,000. In recent years there has been a slight ~~increase~~ decrease in dairy cattle. Beef cattle by contrast have decreased from just over 6,000,000 in the mid 1970s to just under 4,000,000 in the mid 2010s. ~~For~~ In recent years this has begun to increase. ~~Since~~ Since dairy cattle have a higher impact than Beef cattle this suggests the enivormental impact of cattle has been worsening over time but has begun to improve in recent years.

From 1980 total cattle has increased from about 8,000,000 to just over 10,000,000. While sheep have declined from 70,000,000 ~~to from~~ in 1980 to around 27 500 000 in 2020. Since cattle have a greater environmental impact than sheep this suggests the enivormental impact of farming has been worsening from 1980 to 2020

Between 1990 and 2000 the amount of fertilite sold has increase from about 50 tonnes to about 450 tones. There is an unusual drop in 2005 and 2008. This perhaps reflects

rare instances of economic hardship such as the financial crash in 2008.

Farm area by continent has fallen from just over 15 500 000 in 2003 to 13500000 km in 2019.

Since farm area has been shrinking and need to be localised has been increasing this indicates increasing difficulty with crop growth.

b) colour - In both graphs colours are used to indicate high / low proportion. In the nitrogen graph purple is used to represent low concentrations of Nitrogen and yellow is used to represent higher. In the human land cover graph purple has been used to represent a ~~[illegible]~~ low proportion of human modified landcover and yellow to represent a high proportion of human modified land cover. Since the graphs have the colours similarly distributed over locations this suggest that areas with higher concentration of nitrogen have a greater proportion of human modified land cover and vice versa.

C i)
There is a general increasing trend from ~~0~~ just before 1988 to around 275 millions in 2024. There are 3 unusual peaks one in around 2008 one in around 2021. ~~[illegible]~~ There is a

seasonal pattern with a peak about once a year. This tends to line up with the last quarter and perhaps spring time when crops are planted.

ii) This model is not very useful for predicting value of imported fertilisers in 2022. The bracket is wide anywhere between $15 millions of dollars, and 250 millions of dollars. This is not useful to use for predicting. Also the most recent data point is an unusual peak which means it is unclear whether following years will continue to follow the long term trend. A Holt-Winters model scales more recent data as more important so it may be overestimating the impact this will have on the long term trend. Or whatever factor caused this drastic jump may continue to affect the data meaning the model underestimates the effect it will have on the long term trend.

Q2 a)

i) So that the data of each cow on a treatment can be compared to the same cow on another treatment. This controls for confounding variables like longer cows who may be more likely to produce more methan gas. This is particularly effective for small sample sizes where randomization alone cannot distribute all confounding variables

equally.

Aii)
Using a Re-Randomization test. This test uses a process of generating random samples to compare how likely a difference (the size measure in your data) would have occured by chance. If the Re-Randomization test has a low tail proportion less than 0.05 this suggests it is likely the treatment has an effect.

b) We would conduct a study that was a comparison of two independant groups. A study could that devide 800 cows (experimental units) into two groups. These experimental units will be randomly assigned into these two groups. The treatment group which will receive the Agrizen soil and the control group which will recive the standard soil. We will then record the ammount of nitrogen in the urine of the cows. The proportion of nitrogen in the urine will be the variable of interest. Then we will construct a bootstrap confidence interval to analyse if there is a lower proportion of nitrogen in cows that used Agrizen soil than standard.

c) The median sentiment score was around 0.55 This suggests a slight positive bias in the articles. The middle quartile is between about 0.475 and 0.675 This suggests a relatively small spread with most articles appearing neutral.

Headlines that included the word change appear to be slightly more positive than ~~articles~~ Headlines without the word change. Articles that included the word change had a median of 0.575 where article that didn't had a median of 0.525. However there is still a significant ammount of overlap in the data. Both articles whose headlines did or didn't include the word change had a similar spread with an interquartile range of about 0.15.

Q3a

i) The survey could be made representative of the NZ population at most recent censes by using quotas. This will identify different demographics and their propotion of New Zealanders to construct quotas (limits of both how few and how many) of a certain group are represented in the survey. This would make the ~~data~~ sample very similar to the population and ~~that~~ allow the data to be representative of the wider NZ population.

ii) Comparision between 2 independent groups

pol 1 − pol 2 $\pm$ 1.5 × average moe

Moe $\frac{1}{\sqrt{n}}$ $\frac{1}{\sqrt{1097}}$ = 0.0302

= 3.021.

3.02 × 1.5 = 4.53

2012 to 2014	2014 to 2018	2018 & 2019
54 - 52 ± 4.53	64 - 54 ± 4.53	69 - 64 ± 4.53
(-2.53, 6.53)	(5.47, 14.53)	(0.47, 9.53)

2019 to 2020

72 - 69 ± 4.53

(-1.53, 7.53)

The claim is false.

Between 2012 to 2014 the real population increase in people who think climate change is a problem now is somewhere between -2.53 and 6.53 since these values go above and below zero we cannot determine there is a real difference in the population.

Between 2019 & 2020 the real population increase in people who think climate change is a problem now is somewhere between -1.53 and 7.53 since these values go above and below zero we cannot determine there is a real difference in the population. However since one of the values (the 2021 results) is above 7% using the rule of thumb to calculate margin of error should not be

used as it over estimates the margin of error. This means it is possible there is a real population difference between the people who consider climate change a problem now between 2019 and 2020.

However the claim is still false as there is not a difference in the first year provided 2012 - 2016.

b)

i)

67.9 of 133 students aged Y9 to Y13
73.7 of 95 students aged Y7 to Y8
49.2 of 63 students aged Y1 to Y6

~~Students most likely to indicate the better climate~~

Mod Y9 to Y13 = 0.0867
8.67%.

Y7 to Y8 = 0.1026
10.26%.

Y1 to Y6 = 0.12598
12.6%.

$73.7 - 67.9 \pm 1.5 \times \frac{8.67 + 10.26}{2}$

$= (-8.3975, 19.9475)$

$49.2 - 73.7 \pm 1.5 \times \frac{10.26 + 12.6}{2}$

-24.5 ± 17.415

$(-41.915, -7.085)$

The data suggests the real population difference between Y1 to Y6 and Y7 to Y8 is between -8.3975 and 19.9975. Since this goes both above and bellow 0 this suggests there is no real difference in the population

The ~~data~~ data suggest the real population difference between Y7 to Y8 and Y9 to Y13 is between (-41.915 and -7.085). Since there a both bellow zero this suggest that less students aged Y9 to Y13 believe climate change is a problem.

This does not support the claim that students who consider climate change a problem tend to be older than children who don't.

ii) It is not likely to be representative. We would expect to see a relatively equal proportion of students at all mandatory ages Y1 - Y11 and slightly less at Y12 this. This means we would expect the largest group to be Y1 to Y6

and the smallest group to be 47 to 48. Since census at school is opted into by teachers it likely reflects ease of teachers ability to run it in the classroom. This is contingent on availibilty of classes, interest in activity and ability to focus. These will all increase with students age which is NS likely why we see a skew towards older children.

Q4

a) Bootstrapping - compare number of kids and adults in photos construct bootstrap confidence interval to estimate true proportion across entire event.

This means it is difficult to determine if true proportions are constant across groups. Kids may be more likely to be photographed than adults and may be overrepresented. Photos are unlikely to capture entirety of target group. Protests aren't necessarily attended by the same people throughout some people leave/arrive during so may not capture total number of people who attended at any point.

b) - school students may be more likely to stay for whole thing while busy adults may pop in and out, may overrepresent.

i) That the crowd density is the same across different areas of the crowd. Proportions are independent likely across areas near to each other likely to have higher crowd density.

ii)

Squares measure 5 by 5 meters. 25m².

18,000 ÷ 25 = 720

Around 720 units

Between 20.4 and 23.2 within one unit

20.4 × 720 = 14,688

23.2 × 720 16,704

The organizer claimed over 17,000 people attended. The estimate using this method suggest somewhere between 14,688 and 16,704 people attended. This does not support the organizers claim.

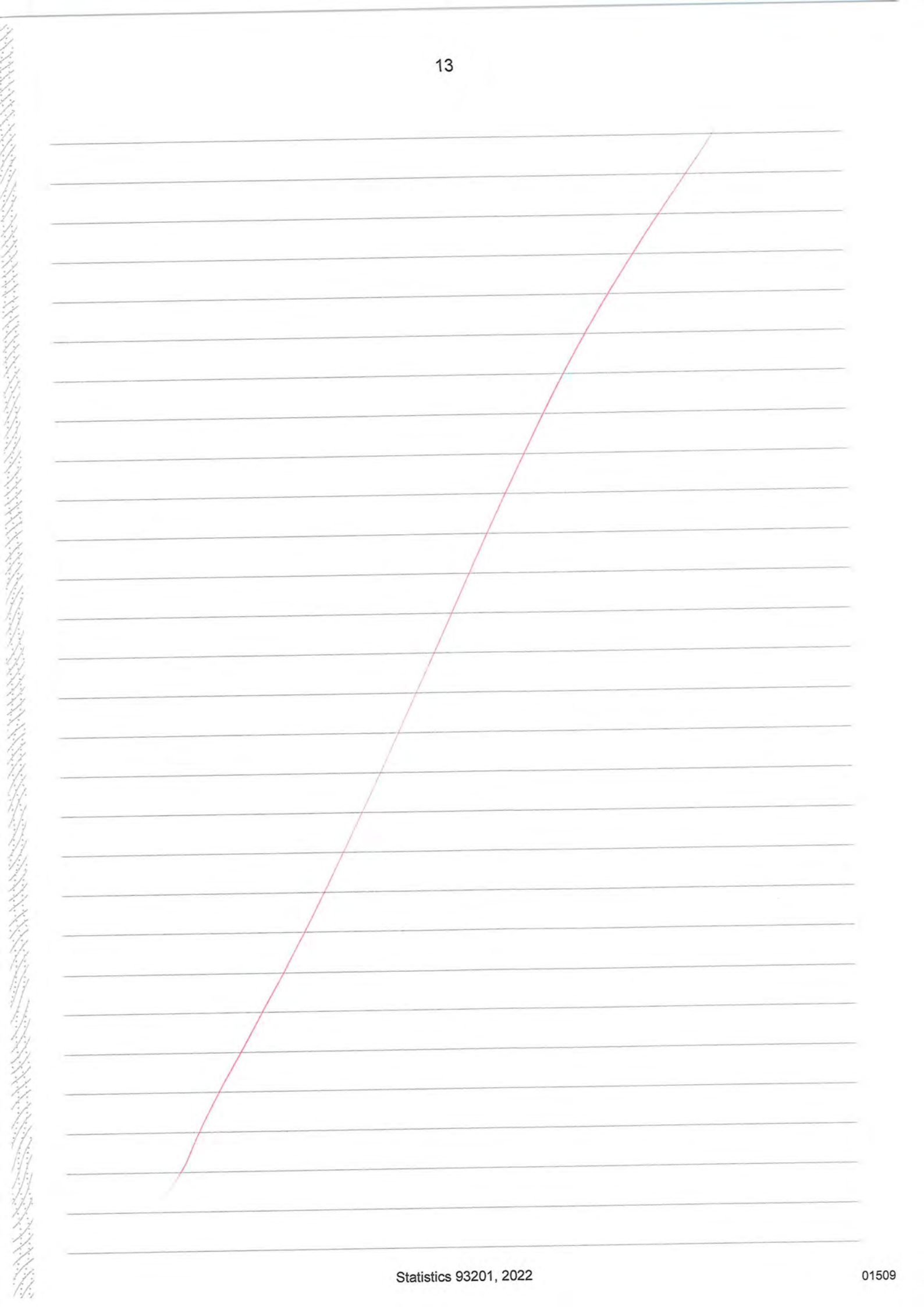
c)

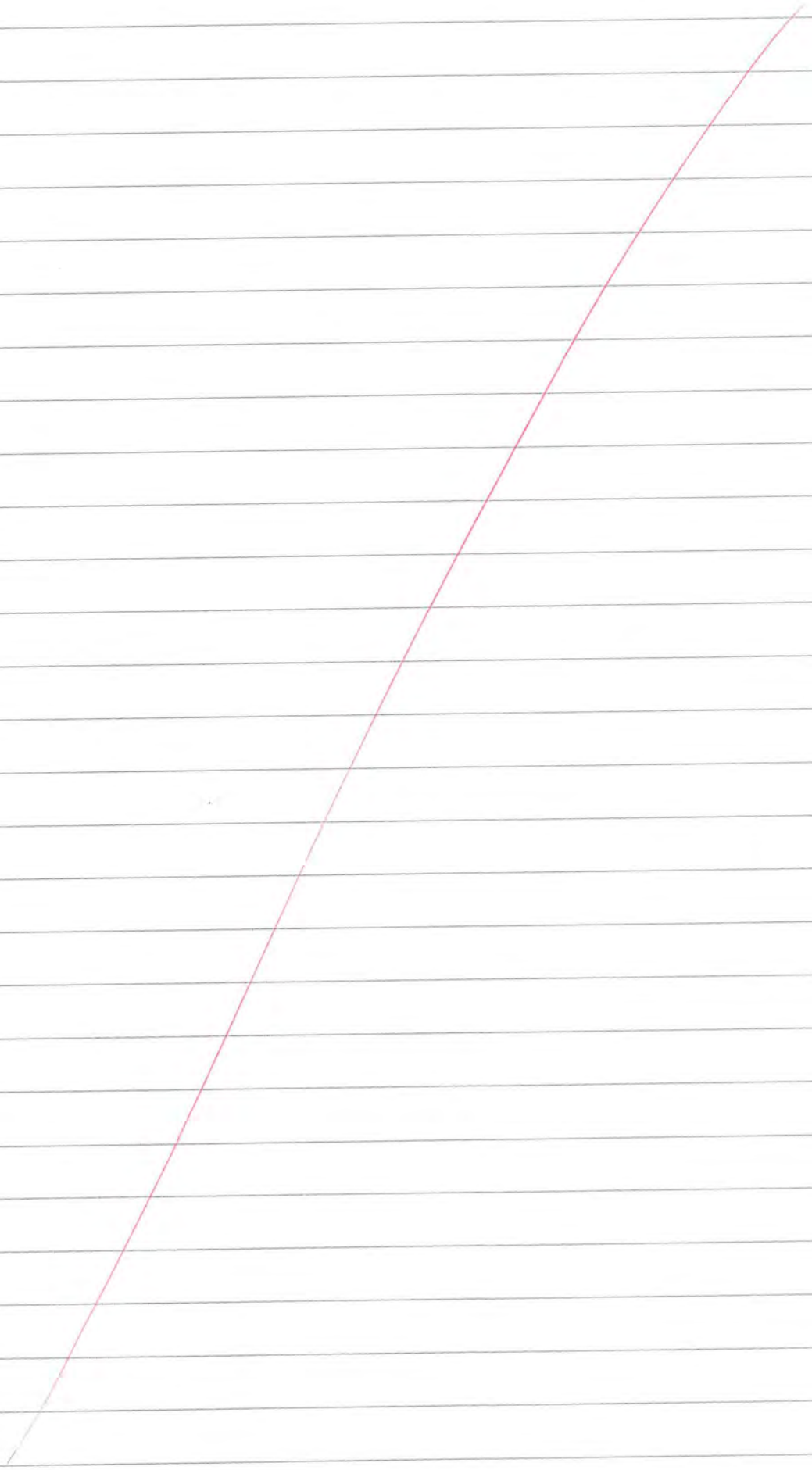
~~The number of deaths related to~~ ~~disaster~~ We years

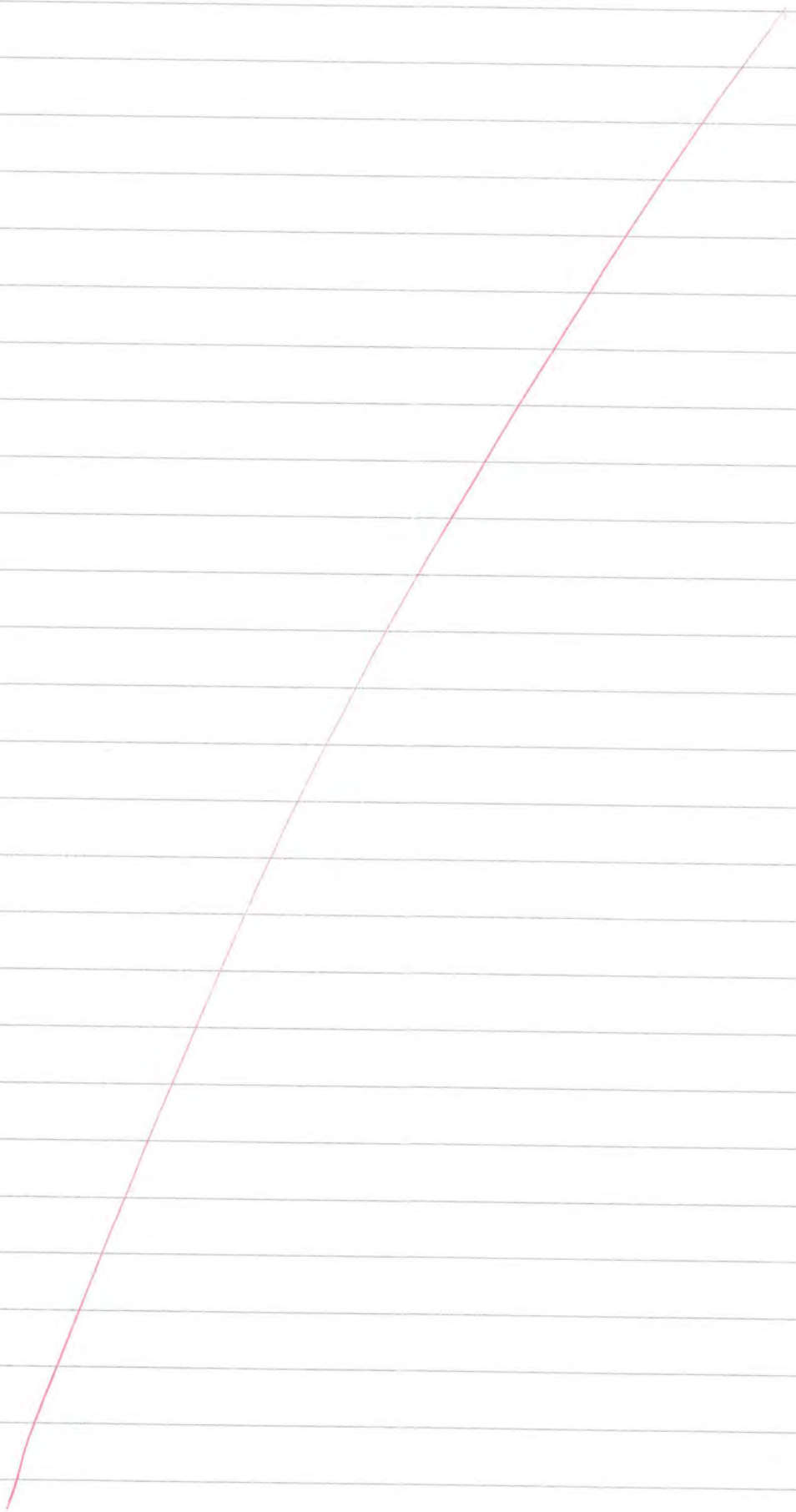
	chances by date	chances by model
0	0.075	~~0.015~~ 0.015
1	0.075	0.062
2	0.15	0.13
3	0.175	0.19
4	0.15	0.2
5	0.1	0.16

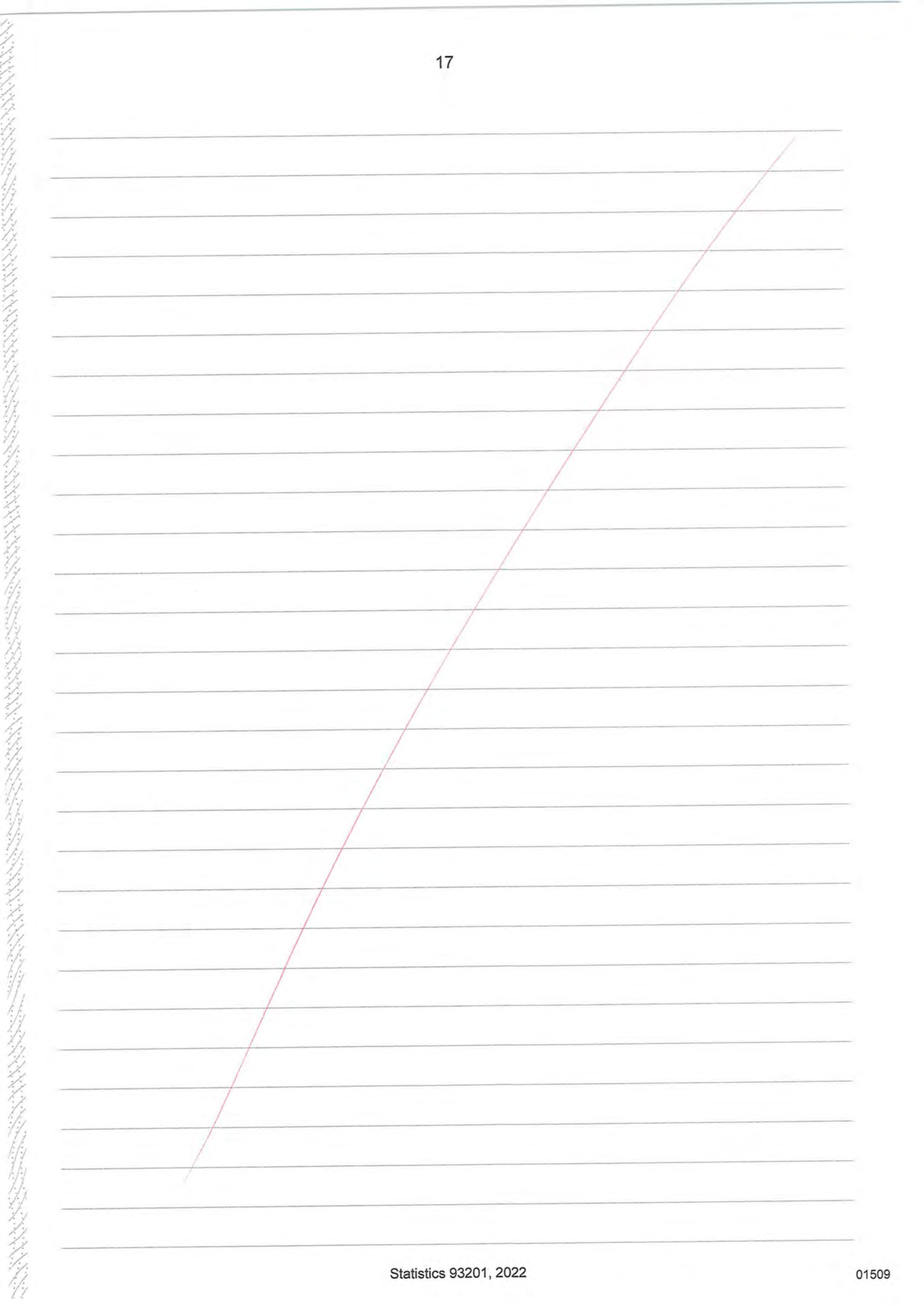
	date	model
6	0.075	0.12
7	0.05	0.07
8	0.1	0.04
9	0.05	0.01
10	0.025	0.007

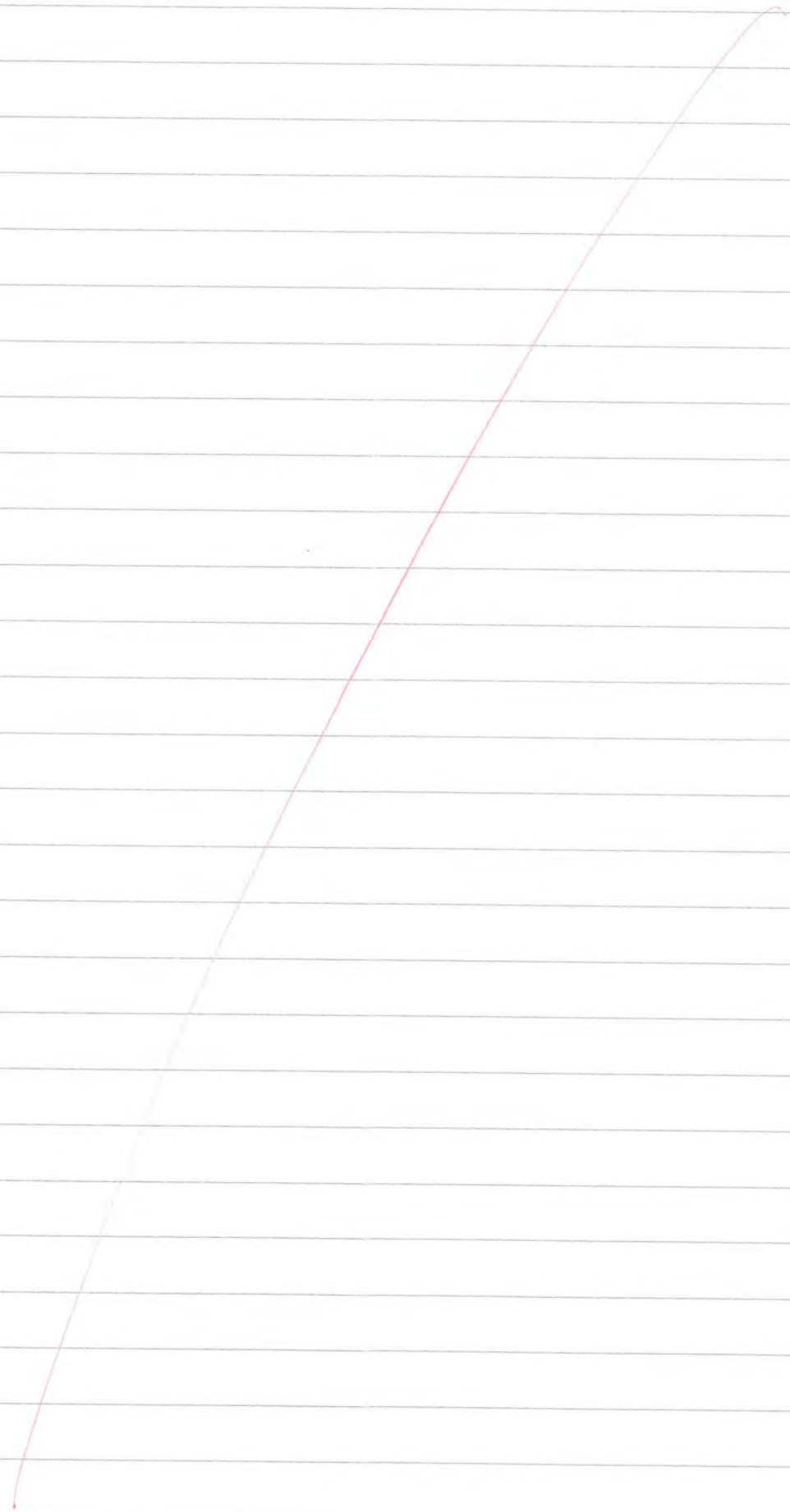
The proportions produced by the model are not very similar to the real proportions of the data.
This make sense because for a poisson distribution to be because for a poisson distribution to fit the data the trials have to be random, independent, proportional to time and not occur simultaneously. These events are neither independent nor unable to occur simultaneously. As having one wither event eg. extreme winds can make another weather event eg. storm more likely and both of these are able to occur simultaneously.
The data also appears to be bimodal which would not support a poisson distribution.
There for this is not an appropriate model.

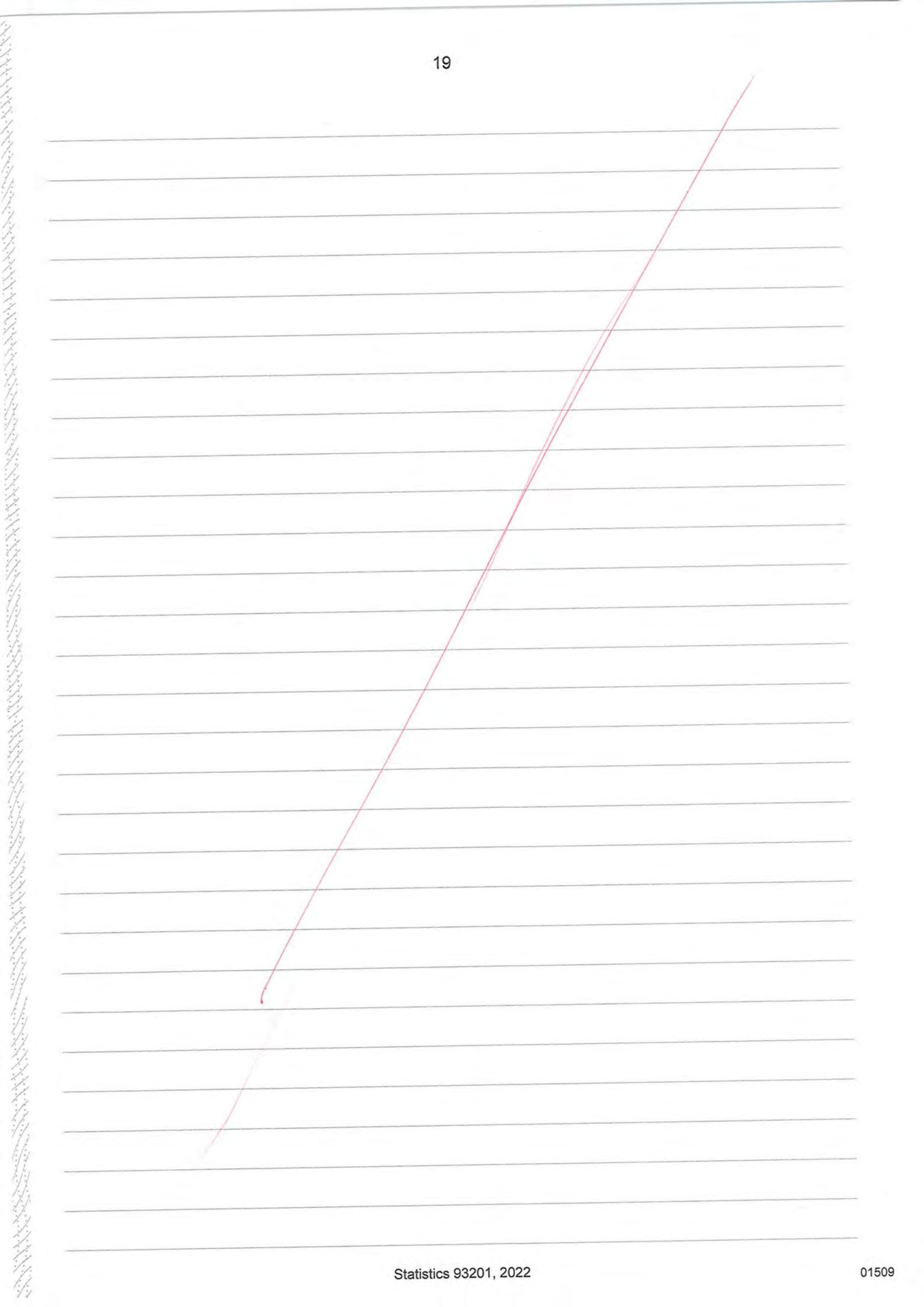


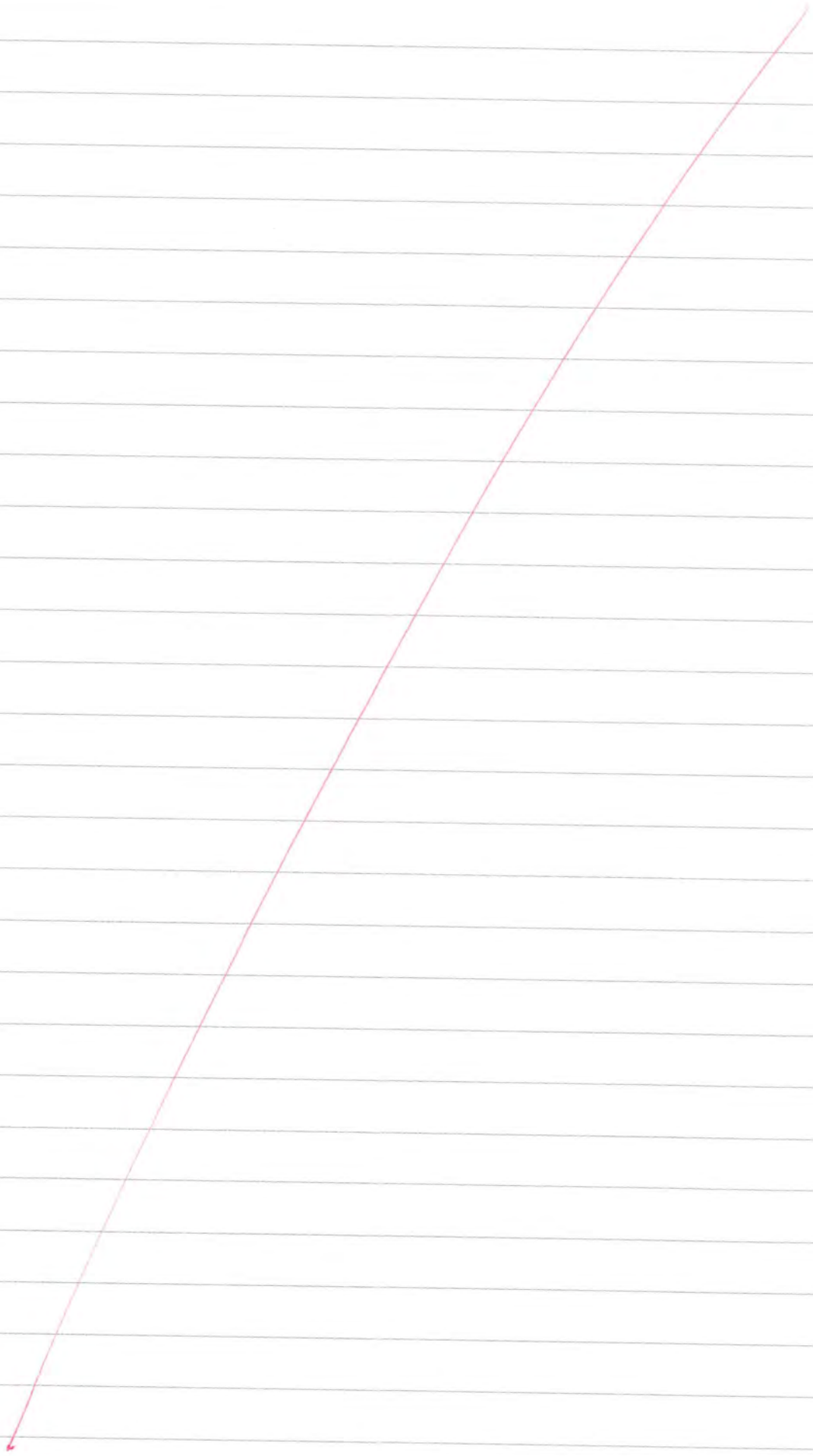


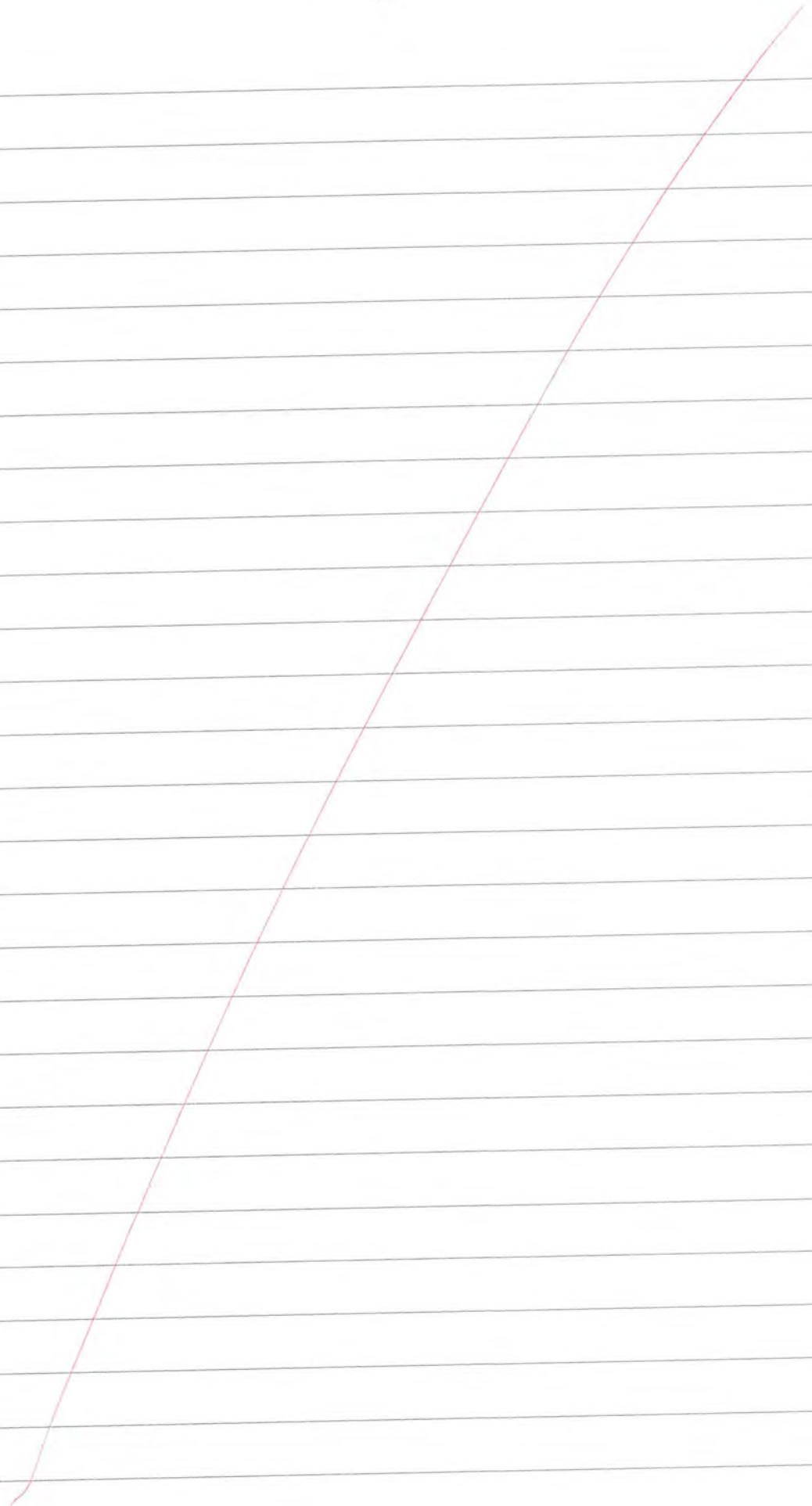












Subject	Statistics	***Standard***	93201	***Total score***	23
Q	***Score***	***Annotation***			
1	6	The candidate's response has got sufficient description of comparisons between the visualisations of farm area, farm counts, livestock numbers and fertiliser amounts, crucially with correct units and numerical evidence. A higher score was prevented due to a lack of identifying of key features within the time series data and their potential impact on future predictions.			
2	5	There were some misconceptions in this candidate's response about the type of analysis required in the results of the experiment for (a)(ii) as it was a paired comparison and not an experiment between independent groups. Subsequently the candidate's response to their own designed experiment for part (b) did not take into account the correct analysis needed.			
3	6	The candidate correctly identified that the only pair of years that required a comparison with the correct margin of error calculated were 2012 to 2014. This response was one of the better seen in the country, even if the language of interpreting the confidence interval could have been more formal in nature. The candidate gained one mark for correctly obtaining from an unfamiliar situation (the eikosogram) correct probabilities. From here the candidate took an incorrect mixed approach of confidence intervals and averaging probabilities. There was no attempt to find correct conditional probabilities.			
4	6	Unusually for part (a) the candidate failed to describe a simple technique for counting and working out a simple proportion of younger march participants, instead they only described the bootstrapping technique used to work out an inference for the correct proportion. Only one assumption was described when talking about estimating the crowd size. The candidate failed to identify sufficiently in context features that discussed the (in)appropriateness of the Poisson model – their responses were too general. They also failed to identify that the assumption of constant lambda was incorrect due to increasing extreme weather events in more recent years.			