A Write Your Own Investigative Question

Time series analysis is an essential skill in various fields, such as economics, finance, weather forecasting, and even sports analytics. By learning how to investigate time series, you'll be equipped to interpret and make sense of data that evolves over time. At the beginning of your time series investigation for this achievement standard, you will research topics of interest to you and possible sources of data for time series.

One variable you will look at will be time; this may be hours, days, weeks, months, quarters or even years. Quarterly data splits the year into four. The first quarter, Q1 is January to March, Q2 is April to June, Q3 is July to September and Q4 is October to December. The main variable of interest (related to the topic you are investigating) should be numerical and this needs to include at least five "cycles" of data for that variable. For example, if you were studying daily rainfall, then a cycle would be a week and there should be at least five weeks worth of data. If studying monthly sales data, then a cycle would be a year and there should be at least five years worth of data in your investigation.

You may be given an investigative question or statement for your investigation or you may wish to write your own. A complete investigation should also include a purpose for the investigation. You may wish to include some research or your own insights into the topic as part of that purpose.

Data :

Source : figure.nz

Quarterly Rainfall in Auckland (Tāmaki Makaurau) in mm					
2010 Q1	2010 Q2	2010 Q3	2010 Q4	2011 Q1	2011 Q2
226.4	435.2	154.1	306.7	442.3	291.7

Example Investigative Question - includes a brief purpose for the investigation

Purpose for the investigation : The rainfall (mm) in Auckland (Tāmaki Makaurau) has been causing huge problems in recent times with a large increase in the number of weather events causing severe flooding.

Investigative question : Can any patterns or trends in the Auckland (Tāmaki Makaurau) rainfall data be identified to help with a better understanding of rainfall in this region?

Variables of interest : Time measured in quarters, rainfall measured in mm.

Source : figure.nz

Data :

Monthly Price of Carrots in $, per Kg					
Jan 2013	Feb 2013	Mar 2013	April 2013	May 2013	Jun 2013
$2.40	$2.23	$2.14	$2.10	$1.96	$1.90

Example Investigative Statement - includes a brief purpose for the investigation

Purpose for the investigation : At the moment, there is lots of information in the media about food prices increasing, particularly healthy foods such as fruit and vegetables

Investigative statement : I'm going to study the monthly price of carrots over a ten year period in New Zealand (Aotearoa) and determine if there are any patterns or trends.

Variables of interest : Time measured in months, price of carrots is $ per kg and includes GST.

1 Study the table of data given and write an investigative question or statement. For each question state the variables of interest, including the units of measurement.

Monthly Eftpos Spend on Fuel in New Zealand, NZD Millions over Five Years						
Jan 2021	Feb 2021	Mar 2021	Apr 2021	May 2021	Jun 2021	
525	494	547	542	547	537	

a) Investigative question/statement ………………………………………………………………

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Variables of interest ……………………………………………………………………………

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A **Sources of Variation** - continued

b) I'm investigating the median quarterly earnings of teenagers (aged 15-19) working in the retail sector in New Zealand (Aotearoa). Can any patterns or trends in the data be identified?

   i) Describe how the variables of interest could have been measured.

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   ii) Determine the possible sources of variation.

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c) I'm going to study the number of energy drinks consumed daily in New Zealand (Aotearoa) and determine if there are any patterns or trends.

   i) Describe how the variables of interest could have been measured.

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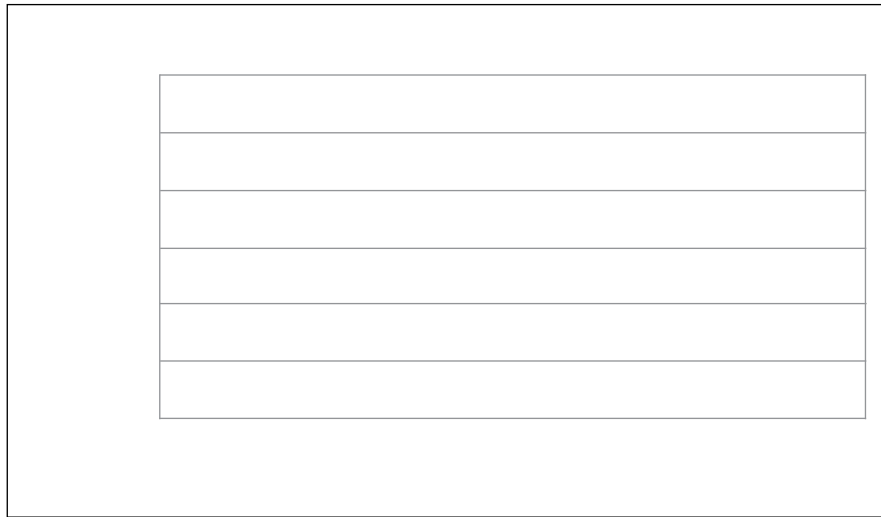
A **Plotting a Time Series Graph by Hand** - continued

b)

Median Quarterly Earnings of Teenagers Aged 15-19, Working in Retail in NZ, in $ over Five Years						
Q2 2020	Q3 2020	Q4 2020	Q1 2021	Q2 2021	Q3 2021	
$3590	$4440	$4480	$3850	$4000	$4810	

c)

Yearly Greenhouse Gas Emissions from Argriculture in NZ, Kilotonnes of CO_2 equivalent						
1990	1991	1992	1993	1994	1995	
33312	33557	33113	33506	34605	35176	

A **Forecast Using Time Series**

One of the reasons for analysing time series data is to make **forecasts** of future values.

As well as making a forecast you should discuss how **accurate** you think it might be.

Example : Below is a time series graph showing the number of visitors a museum has each day for four weeks.

a) Extend the graph by estimating what you think might happen for the fifth week. Give reasons for your answer.

b) Forecast the number of visitors for the Saturday of the fifth week. How confident are you in this forecast. Give statistical reasons for your answer.

Answer :

a) Possible method : Put a line of best fit through each Saturday this will give an estimated point for the next Saturday. Do the same for Mondays and then use the pattern of increasing values to Friday and the fact that there does not seem to be much difference between Saturday and Sunday to complete the graph.

b) From the line going through Saturdays I forecast that there will be about 3000 visitors on the next Saturday. This line is a good fit and the forecast is for a time that is close to the given data so, as long as there is no change in conditions, I am confident that the forecast is reasonably accurate. However, there are times when patterns are not followed, for example, the weather might affect this forecast.

Museum Visitor Numbers

1 This time series graph shows the values of sales of hot pies for a bakery over a four year period.

Hot Pie Sales ($000)

a) Extend the graph by estimating what you think might happen for Year 5.

b) Forecast the value of hot pie sales for the Winter of Year 5.
How confident are you in this forecast. Give statistical reasons for your answer.

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A **Glacial Ice Investigation**

The Spreadsheets with the full sets of data are available at : www.sigmapublications.co.nz/timeseries

Glacial Ice Volumes (km³) in New Zealand/Aotearoa						
2020	2019	2018	2017	2016	2015	
34.6	35.7	38.2	40.9	40.7	42.9	

Purpose

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Investigative Statement/Question

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Page 3-4 - Define the Problem

A1 a) I'm going to study the monthly eftpos spend in $NZD Millions in New Zealand over five years and determine if there are any patterns or trends.
Variables of interest: Time measured in months, Monthly Eftpos Spend in $NZD Millions in New Zealand.

b) I'm going to study the median quarterly earnings of teenagers aged 15 to 19 in New Zealand over five years. I wonder, are there any patterns or trends?
Variables of interest: Time measured in quarters, median quarterly earnings, in $, of teenagers aged 15 to 19 in New Zealand.

c) Can any patterns or trends in yearly greenhouse gas emissions from agriculture in NZ be identified to help with a better understanding of this issue?
Variables of interest: Time measured in years, gas emissions due to agriculture measured in the equivalent of Kilotonnes of CO2 in NZ.

d) I'm going to study the number of legal proceedings per month in NZ for motor vehicle thefts in New Zealand over six years and determine if there are any patterns or trends.
Variables of interest: Time measured in months, number of legal proceedings for motor vehicle thefts in NZ.

e) Can any patterns or trends in quarterly broadband usage in NZ be identified to help with a better understanding of broadband consumers?
Variables of interest: Time measured in quarters, broadband usage measured in GB in NZ.

Page 6-8 - Plan the Investigation

A1 Answers for pages 6-8 are examples only :

a) i) The monthly eftpos spending could be measured by consulting the banks who provide the eftpos facilities and could be able to provide that data. Months would be measured as calendar months and are different lengths.

ii) Variation could occur in the definition of fuel and the types of fuel that come in this category would need to be consistent.

b) i) The quarterly earnings will be measured in $NZD and time will be measured in quarters. This data could be sourced by consulting the banks who provide the eftpos facilities and could be able to provide that data. Quarters are measured in three month blocks, with January to March being the first quarter etc.

ii) Variation could occur in the definition of retail, with market stalls for example possibly not being included. Earnings may not include cash payments teenagers may receive or bonuses.

c) i) The number of energy drinks will be measured in a count, time is measured in days.

ii) Variation could occur in what is considered to be an energy drink and the different sized of cans and bottles considered to be one drink. Clear definitions would need to be set up beforehand.

d) i) The time on social media will be measure in minutes spent on social media per hour, time will be measured in hours.

ii) Variation could occur in the definition of social media, which would need to be clearly defined beforehand. Also self-reporting of usage could lead to under-reporting and ideally an app would be used to accurately monitor this for each person.
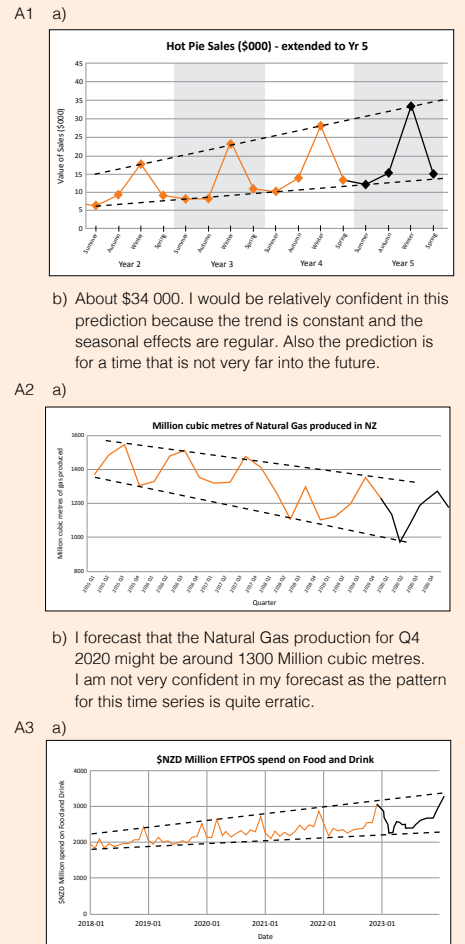
Pages 9-10 - Analyse the Data

A1 a)

Number of Legal Proceedings in NZ

b)

Quarterly Broadband usage per household in NZ

c)

Yearly Greenhouse Gas Emissions from Agriculture in New Zealand
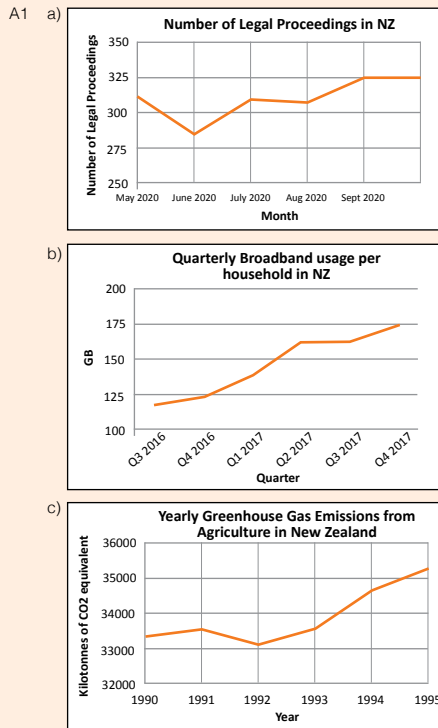
Page 11 - Time Series Graph Using Technology

A1 a)

Monthly Eftpos Spend on Fuel in NZ
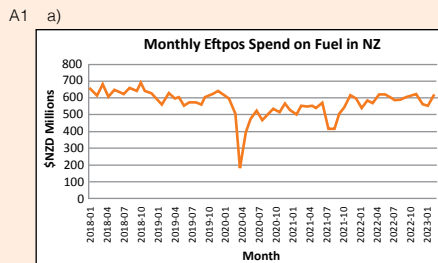
Pages 12-14 - Time Series Analysis

A1 a) Values of hot pie sales have tended to increase over the years. For example winter values have gone up steadily from about $13 000 to about $29 000.

b) The values of hot pie sales are high in winter (colder weather) and low in summer (hot weather).
The autumn of Year 3 appears to be unusual in that the value of sales is lower than what would be expected.

B1 a) The long term trend for both Retail and Fuel Sales is increasing. The Retail data is increasing at a steadier rate than the Fuel Sales which is more erratic.

b) Both datasets show a regular seasonal peak in the fourth quarter, with this being more regular in the Retail Sales data. Both sets of data have significant troughs in the third quarter of 2020.

B2 a) Both the male and female sets of data show a general decreasing trend for unemployment. However this trend is not consistent, with the female data being more irregular than the male data.

b) There is no obvious seasonal pattern to either the male or female unemployment data. There is a significant peak in the unemployment data for both datasets in the third quarter of 2020, the female data shows a larger relative peak than the male data.

Pages 16-17 - Time Series Forecasting 1

A1 a)

Hot Pie Sales ($000) - extended to Yr 5

b) About $34 000. I would be relatively confident in this prediction because the trend is constant and the seasonal effects are regular. Also the prediction is for a time that is not very far into the future.

A2 a)

Million cubic metres of Natural Gas produced in NZ

b) I forecast that the Natural Gas production for Q4 2020 might be around 1300 Million cubic metres. I am not very confident in my forecast as the pattern for this time series is quite erratic.

A3 a)

$NZD Million EFTPOS spend on Food and Drink

b) I forecast that the eftpos spend on food and drink in NZ will be roughly $3300 Million in December 2023. I am fairly confident in this forecast as the pattern for December is quite consistent in being a significant peak in the data, the long term trend is also a steady increase.

Page 18 - Time Series Forecasting 2

A1 a) Doug's earnings tended to increase over the five years. For example in the spring of Year 1 he earnt about $17 000 and from then spring earnings increased steadily to about $30 000 in the spring of the fifth year.

b) There are seasonal highs in spring (when things start growing) and lows in winter (when there is little growth). There are also secondary highs in autumn (pre-winter clean-ups). Doug's earnings in autumn of the second year appear to be a little lower than what would be expected.

c) (see graph for this answer on page 18)

d) $34 000. You can be reasonably confident in this prediction because of the consistency in the trend and seasonal patterns and also because the prediction is not too far into the future.