NCEA Level 3 · AS 91580: Time Series Investigations

Name: _____ Date: _____

Hi! This standard is all about spotting patterns in data collected over time, trend, seasonal ups and downs, and using them to forecast. Work through the sheet in order, and always link your maths back to the real-world context of the data.

Revision summary

- Time series data = measurements recorded at regular time intervals (e.g. quarterly sales). Look for: trend (long-term direction), seasonality (regular repeating pattern), and irregular/random variation.
- Additive model: Data = Trend + Seasonal + Irregular ($y = T + S + I$). Use when seasonal swings stay roughly constant in size over time.
- Centred Moving Average (CMA) smooths out seasonality to reveal the trend. For quarterly data (period 4) use a 4-point moving average then centre it (average two consecutive 4-point means).
- Seasonal effect for a season = average of (actual value − CMA) for that season. Seasonal effects should sum to ≈ 0 across the cycle; if not, adjust each by subtracting the mean.
- Forecasting: extend the trend line (from the CMA or a fitted trend), then add the relevant seasonal effect for that season: Forecast = Trend estimate + Seasonal effect.
- Interpret in context: describe trend (increasing/decreasing, by how much), seasonal pattern (which seasons are high/low and why), and comment on the reliability of forecasts.
- Statistical enquiry cycle (PPDAC): Problem, Plan, Data, Analysis, Conclusion, state a purpose, explore the data, and write conclusions in context.

Key skills

1. A café in Devonport records quarterly hot-chocolate sales (in hundreds of cups): Q1 = 8, Q2 = 5, Q3 = 4, Q4 = 9. Calculate the 4-point moving average for these four quarters.

2. State what the 'seasonal effect' of a particular quarter tells you in an additive time series model.

3. The additive model gives a trend estimate of 42 units for the next winter quarter, and winter has a seasonal effect of −6.5. Forecast the value for that quarter.

4. Explain why we 'centre' a moving average when working with quarterly data.

Achieved

5. A garden centre in Henderson records quarterly plant sales ($000): 2022 Q1 22, Q2 30, Q3 18, Q4 14; 2023 Q1 26, Q2 34, Q3 22, Q4 18. Describe the trend and the seasonal pattern you can see.

6. Using the garden-centre data above, calculate the first two 4-point moving averages and the first centred moving average.

7. A power company's data shows the CMA (trend) for electricity use rising by about 5 units per quarter, reaching 210 units at Q4 2023. The Q1 seasonal effect is +18. Forecast Q1 2024.

8. The seasonal effects for a quarterly series are found to be Q1 = +6, Q2 = +11, Q3 = −4, Q4 = −11. Check whether they need adjusting, and adjust if required.

Merit

9. A Ponsonby ice-cream shop's quarterly revenue shows a clear seasonal pattern with Q2 (summer months Jan–Mar) highest. The CMA trend is increasing steadily. Explain how you would produce a forecast for next summer (Q2), and why the additive model is suitable here.

10. A tourism operator sees quarterly visitor numbers with a strong seasonal pattern, but the summer peaks are getting larger and larger each year as the business grows. Explain why forecasts from a simple additive model with constant seasonal effects could become unreliable, and what this means for the operator.

11. For a quarterly dataset, a student calculated seasonal effects but forgot to centre their 4-point moving average. Explain what problem this causes and how it would show up when they compare their trend to the actual data.

Excellence

12. Two analysts model the same quarterly rainfall series for Whangārei. One uses an additive model, the other a multiplicative model (Data = Trend × Seasonal × Irregular). The trend is roughly flat over the period. Argue what you would expect about the two sets of forecasts, and under what condition they would give nearly identical results.

13. A student claims: 'If I add up all the CMA (centred moving average) values and compare with the sum of the original data over the same complete years, they should be about equal.' Evaluate whether this claim is justified.

14. A local council forecasts quarterly water demand using an additive model built on 3 years of data. The forecasts extend 8 quarters (2 years) ahead. Discuss, with justification, the factors that limit how much confidence should be placed in the 8th forecast compared with the 1st.