BUS 173
Applied Statistics

Lecture 15-20

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Modeling for Time Series Forecasting

✓Forecasting is a necessary input to planning, whether in business, or government. Often, forecasts are generated subjectively and at great cost by group discussion, even when relatively simple quantitative methods can perform just as well or, at very least; provide an informed input to such discussions.

✓**Statistical Forecasting**: The selection and implementation of the proper forecast methodology has always been an important planning and control issue for most firms and agencies. Often, the financial well-being of the entire operation rely on the accuracy of the forecast since such information will likely be used to make interrelated budgetary and operative decisions in areas of personnel management, purchasing, marketing and advertising, capital financing, etc.

Modeling for Time Series Forecasting

✓For example, any significant over-or-under sales forecast error may cause the firm to be overly burdened with excess inventory carrying costs or else create lost sales revenue through unanticipated item shortages. When demand is fairly stable, e.g., unchanging or else growing or declining at a known constant rate, making an accurate forecast is less difficult. If, on the other hand, the firm has historically experienced an up-and-down sales pattern, then the complexity of the forecasting task is compounded.

✓There are two main approaches to forecasting. Either the estimate of future value is based on an analysis of factors which are believed to influence future values, i.e., **the explanatory method**, or else the prediction is based on an inferred study of past general data behaviour over time, i.e., **the extrapolation method**.

Modeling for Time Series Forecasting

✓For example, the belief that the sale of doll clothing will increase from current levels because of a recent advertising blitz rather than proximity to Christmas illustrates the difference between the two philosophies. It is possible that both approaches will lead to the creation of accurate and useful forecasts, but it must be remembered that, even for a modest degree of desired accuracy, the former method is often more difficult to implement and validate than the latter approach.

Forecasting Performance Measures

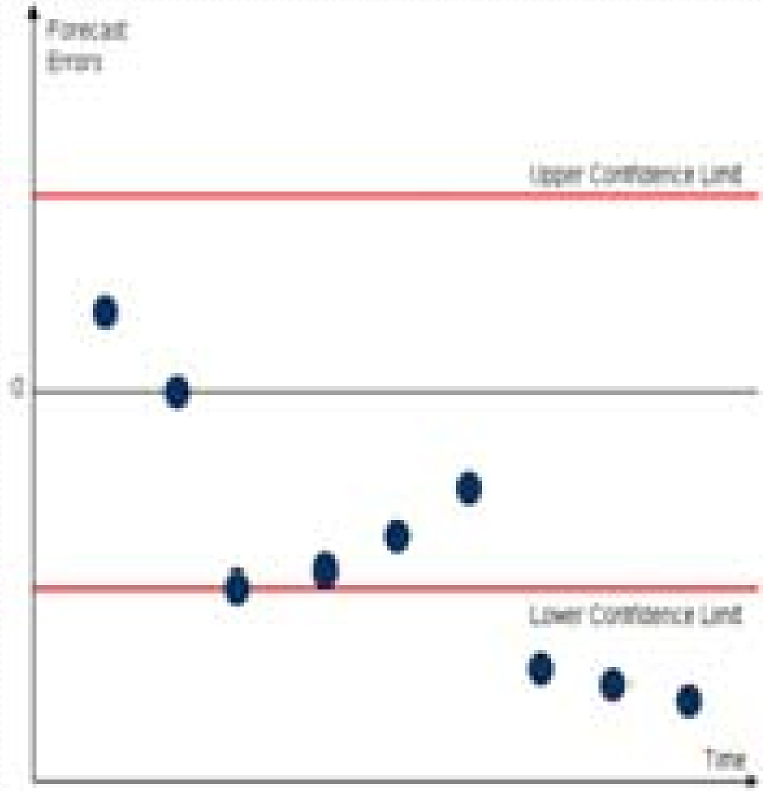
✓If the forecast error is stable, then the distribution of it is approximately normal. With this in mind, we can plot and then analyze forecast errors on the control charts to see if there might be a need to revise the forecasting method being used.

✓To do this, if we divide a normal distribution into zones, with each zone one standard deviation wide, then one obtains the approximate percentage we expect to find in each zone from a stable process.

✓Control limits could be one-standard-error, or two-standard-error, and any point beyond these limits (i.e., outside of the error control limit) is an indication the need to revise the forecasting process.

✓The plotted forecast errors on this chart, not only should remain with the control limits, they should not show any obvious pattern, collectively. We define the best forecast as the one which yields the forecast error with the minimum variance.

Forecasting Performance Measures and Control Chart for Examine Forecasting Errors



A Control Chart for Examining Periodic Forecasting Errors

Forecasting Methods

✓Regression Analysis

✓Trend Analysis: Uses linear and nonlinear regression with time as the explanatory variable, it is used where pattern over time have a long-term trend.

✓Modeling Seasonality and Trend: Seasonality is a pattern that repeats for each period. For example annual seasonal pattern has a cycle that is 12 periods long, if the periods are months, or 4 periods long if the periods are quarters. We need to get an estimate of the seasonal index for each month, or other periods, such as quarter, week, etc, depending on the data availability.

Forecasting Methods

✓ Modeling Seasonality and Trend:

- ✓ Seasonal Index: Seasonal index represents the extent of seasonal influence for a particular segment of the year. The calculation involves a comparison of the expected values of that period to the grand mean. A seasonal index is how much the average for that particular period tends to be above (or below) the grand average. A seasonal index of 1.00 for a particular month indicates that the expected value of that month is 1/12 of the overall average. The formula for computing seasonal factors is: $S_i = D_i/D$, where: S_i = the seasonal index for ith period,

  D_i = the average values of ith period,

  D = grand average,

  i = the ith seasonal period of the cycle.

Trend + Seasonal Forecasting Method

✓Incorporating seasonality in a forecast is useful when the time series has both trend and seasonal components. The final step in the forecast is to use the seasonal index to adjust the trend projection. One simple way to forecast using a seasonal adjustment is to use a seasonal factor in combination with an appropriate underlying trend of total value of cycles.

✓A Numerical Application: The table on next page provides monthly sales ($1000) at a college bookstore. The sales show a seasonal pattern, with the greatest number when the college is in session and decrease during the summer months.

Trend + Seasonal Forecasting Method

M T	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	196	188	192	164	140	120	112	140	160	168	192	200	1972
2	200	188	192	164	140	122	132	144	176	168	196	194	2016
3	196	212	202	180	150	140	156	144	164	186	200	230	2160
4	242	240	196	220	200	192	176	184	204	228	250	260	2592
Mean:	208.6	207.0	192.6	182.0	157.6	143.6	144.0	153.0	177.6	187.6	209.6	221.0	2185
Index:	1.14	1.14	1.06	1.00	0.87	0.79	0.79	0.84	0.97	1.03	1.15	1.22	12

✓Suppose we wish to calculate seasonal factors and a trend, then calculate the forecasted sales for July in year.

✓The first step in the seasonal forecast will be to compute monthly indices using the past four-year sales. For example, for January the index is:

S(Jan) = D(Jan)/D = 208.6/182.083 = 1.14

where D(Jan) is the mean of all four January months, and D is the grand mean of all past four-year sales.

Trend + Seasonal Forecasting Method

✓Next, a linear trend is calculated using the annual sales:

$$Y = 1684 + 200.4T,$$

✓The main question is whether this equation represents the trend. If we construct a scatter-diagram, we may notice that a Parabola might be a better fit. Using the Polynomial Regression, the estimated quadratic trend is:

$$Y = 2169 - 284.6T + 97T^2$$

✓Predicted values using both the linear and the quadratic trends are presented in the table in the next page. Comparing the predicted values of the two models with the actual data indicates that the quadratic trend is a much superior fit than the linear one, as often expected.

Trend + Seasonal Forecasting Method

Determination of the Annual Trend for the Numerical Example

Year No:	Actual Sales	Linear Regression	Quadratic Regression
1	1972	1884	1981
2	2016	2085	1988
3	2160	2285	2188
4	2592	2486	2583

✓We can now forecast the next annual sales; which, corresponds to year 5, or T = 5 in the above quadratic equation:

Y = 2169 - 284.6(5) + 97(5)2 = 3171 sales for the following year. The average monthly sales during next year is, therefore: 3171/12 = 264.25.

✓Finally, the forecast for month of July is calculated by multiplying the average monthly sales forecast by the July seasonal index, which is 0.79; i.e., (264.25).(0.79) or 209.