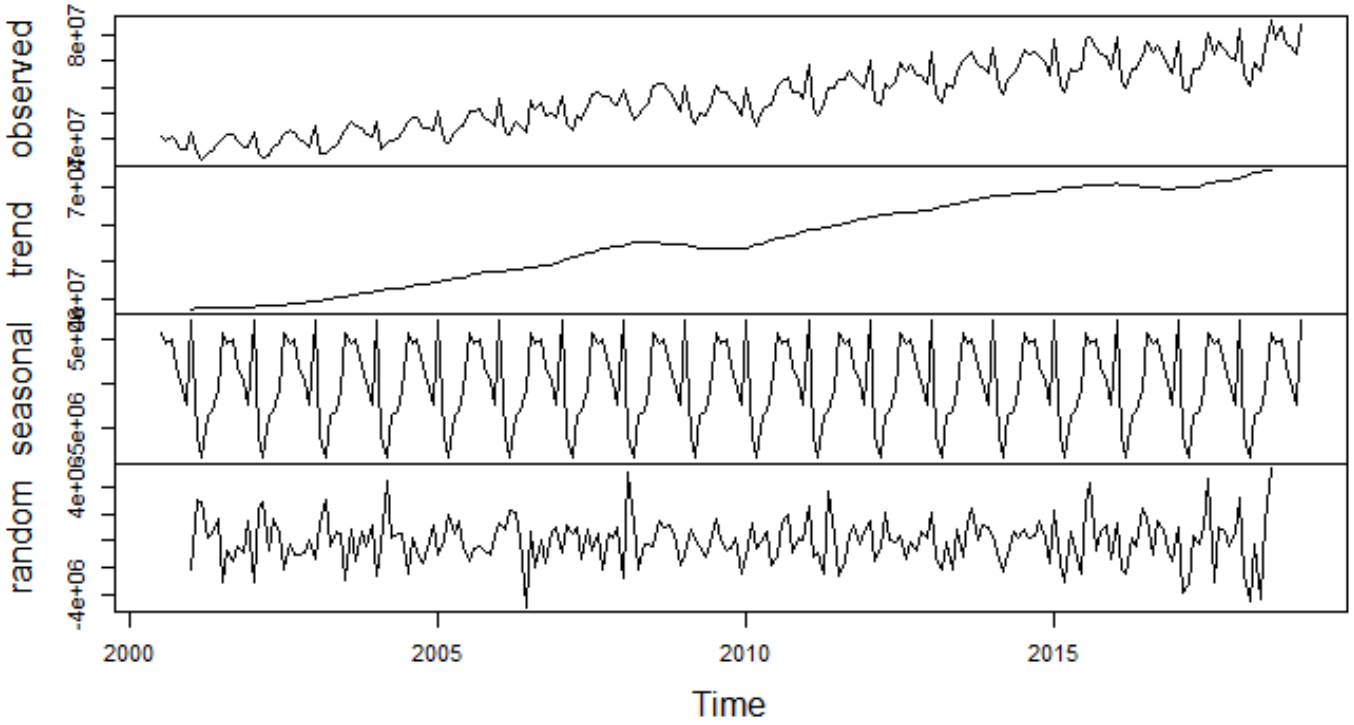
LRC Revenue Estimate Model Explanation

Holt-Winters Model

A triple exponential smoothing model, known as the Holt-Winters model, is a statistical forecasting model the Legislative Research Council (LRC) utilizes for estimating revenues. The model utilizes historical revenue data and smooths the data with three parameters - level, trend, and seasonality and creates a model fitted to actuals based on historical data. The fitted model is then used to forecast future revenues. More recent values contribute to the forecast more than earlier values, meaning revenues in 2018 will be weighted more than revenues in 1999. The charts below illustrate the breakout of different components within the sales and use tax data. The top chart shows the observed sales and use tax data, while the second chart removes the seasonality to show the trend in sales and use tax. The third chart displays the seasonality and corresponding values tied to sales and use tax. The bottom chart displays the randomness aspect, also known as the white noise, within the data.



Auto-Regressive Integrated Moving Average (ARIMA) Model

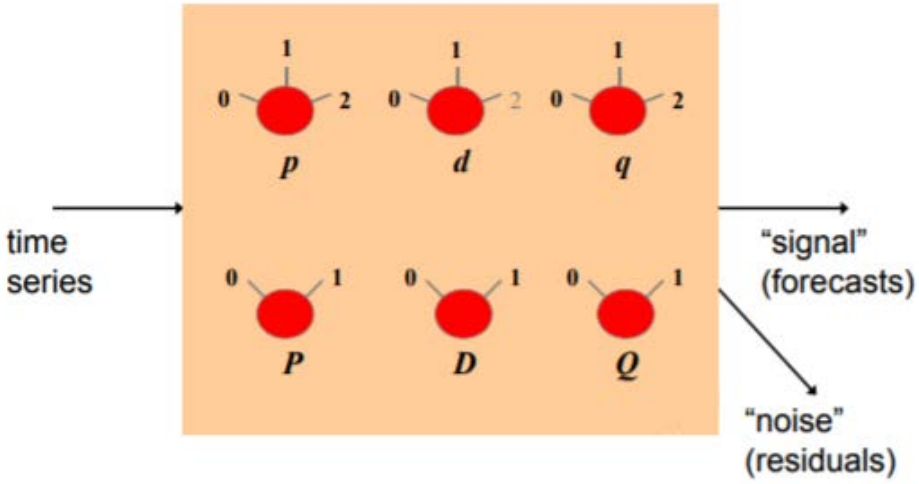
The statistical forecasting model of ARIMA is one of the most used approaches to analyzing time series. The LRC also utilizes this model to estimate revenues. ARIMA uses historical data to create a fitted model by adjusting the correlation, differential, and moving average components within the data. The fitted model is then used to forecast future revenues.

p = # of autoregressive terms	d = # of differences	q = # of moving-average terms
P = # of seasonal autoregressive terms	D = # of season differences	Q = # of seasonal moving-average terms

The autoregressive term (AR) is increased or decreased depending on how the behavior of the data moves toward its mean.

The moving-average term (MA) is increased or decreased depending on how random "shocks" are felt in two or more consecutive periods.

The complete model is called an "ARIMA(p,d,q)(P,D,Q)" model.
The FY19 Sales & Use Tax revenue estimate utilizes an ARIMA (2,0,2)(0,1,1)[12] with drift. The number 12 indicates the number of periods (months). Drift adds a constant component to account for the trend over time seen in the data.

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ARIMA(2,0,2)(0,1,0)[12] with drift         : -808.7491
ARIMA(2,0,2)(0,1,1)[12]                    : Inf
ARIMA(2,0,2)(0,1,1)[12] with drift         : -867.0448
ARIMA(2,0,2)(1,1,0)[12]                    : -829.9181
ARIMA(2,0,2)(1,1,0)[12] with drift         : -835.8219
ARIMA(2,0,3)(0,1,0)[12]                    : -798.5975
ARIMA(2,0,3)(0,1,0)[12] with drift         : -807.0853
ARIMA(3,0,0)(0,1,0)[12]                    : -779.9012
ARIMA(3,0,0)(0,1,0)[12] with drift         : -787.6177
ARIMA(3,0,0)(0,1,1)[12]                    : Inf
ARIMA(3,0,0)(0,1,1)[12] with drift         : -852.1379
ARIMA(3,0,0)(0,1,2)[12]                    : Inf
ARIMA(3,0,0)(0,1,2)[12] with drift         : -852.967
ARIMA(3,0,0)(1,1,0)[12]                    : -815.321
ARIMA(3,0,0)(1,1,0)[12] with drift         : -821.5455
ARIMA(3,0,0)(1,1,1)[12]                    : Inf
ARIMA(3,0,0)(1,1,1)[12] with drift         : -853.3603
ARIMA(3,0,0)(2,1,0)[12]                    : -823.913
ARIMA(3,0,0)(2,1,0)[12] with drift         : -830.5023
ARIMA(3,0,1)(0,1,0)[12]                    : -790.5958
ARIMA(3,0,1)(0,1,0)[12] with drift         : -794.0562
ARIMA(3,0,1)(0,1,1)[12]                    : Inf
ARIMA(3,0,1)(0,1,1)[12] with drift         : -863.508
ARIMA(3,0,1)(1,1,0)[12]                    : -825.9724
ARIMA(3,0,1)(1,1,0)[12] with drift         : -828.8221
ARIMA(3,0,2)(0,1,0)[12]                    : -798.7824
ARIMA(3,0,2)(0,1,0)[12] with drift         : -807.3628
ARIMA(4,0,0)(0,1,0)[12]                    : -793.451
ARIMA(4,0,0)(0,1,0)[12] with drift         : -797.515
ARIMA(4,0,0)(0,1,1)[12]                    : Inf
ARIMA(4,0,0)(0,1,1)[12] with drift         : -863.4116
ARIMA(4,0,0)(1,1,0)[12]                    : -828.1839
ARIMA(4,0,0)(1,1,0)[12] with drift         : -831.5248
ARIMA(4,0,1)(0,1,0)[12]                    : -792.0053
ARIMA(4,0,1)(0,1,0)[12] with drift         : -795.5562
ARIMA(5,0,0)(0,1,0)[12]                    : -791.8887
ARIMA(5,0,0)(0,1,0)[12] with drift         : -795.5387


Best model: ARIMA(2,0,2)(0,1,1)[12] with drift
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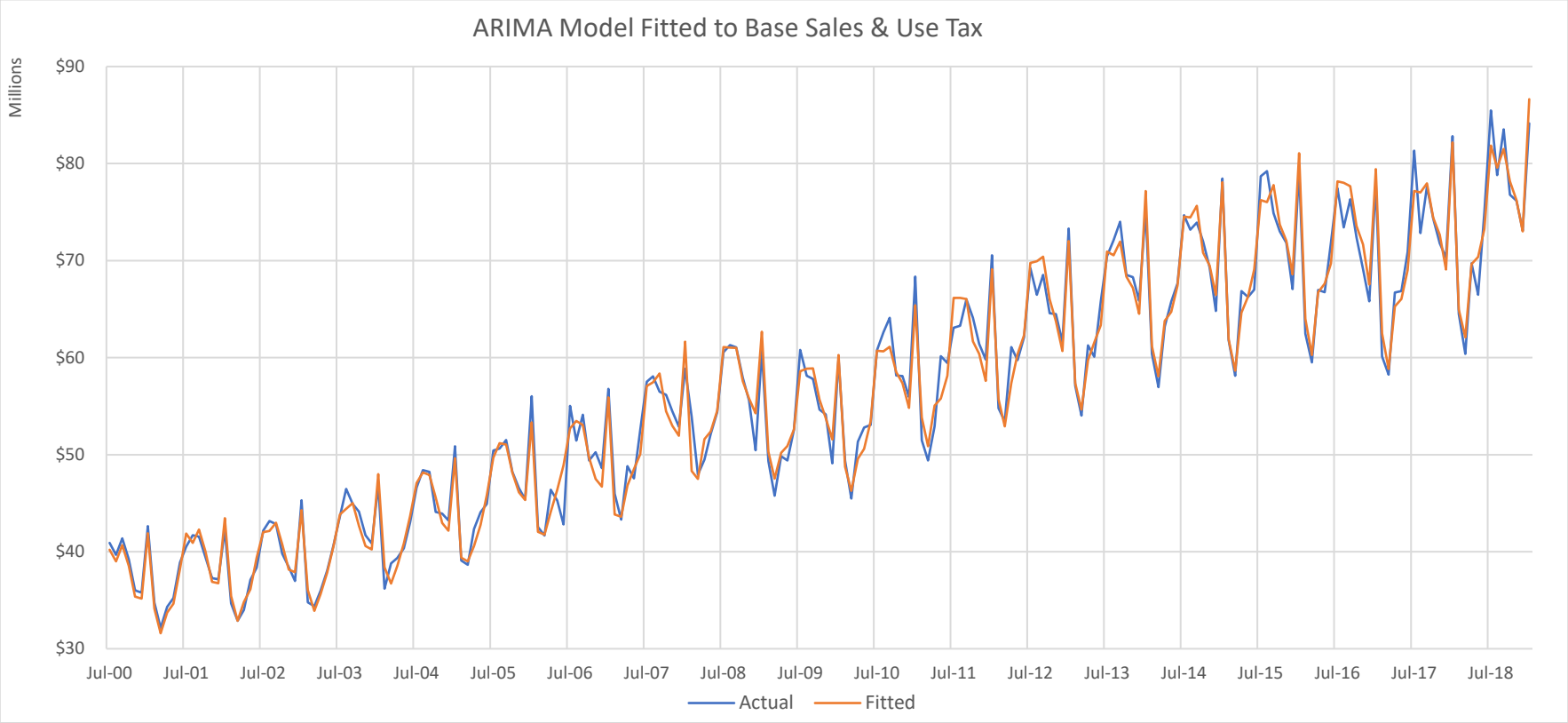
The strategy of the LRC revenue estimate is to use the statistical model providing the smallest variance from actuals and the most historically accurate forecast for any revenue stream. The LRC uses only historical actual revenue numbers in the forecasting models mentioned above.

Below is the ARIMA model for base sales & use tax fitted to actual values. The half-penny increase has removed to show an equivalent comparison.



The graph below shows the fitted model and the forecasted FY19 and FY20 base sales and use tax forecast.