ESM

Time series data relies on the assumption that the observations at a certain time point depend on previous observations in time.

Naïve Model, Average Model

**Exponential Smoothing**

• This is what exponential smoothing does (however, it is a WEIGHTED average, not a simple average)

• Models only require a few parameters.

• Equations are simple and easy to implement.

We will discuss the common types of Exponential Smoothing:

• Single

• Linear / Holt (incorporates trend)

• Holt-Winters (incorporates trend and seasonality)

ESM are great for “one-step ahead” forecasting

Single ESM  
The Single Exponential Smoothing model **equates the predictions at time t equal to the weighted values of the previous time period along with the previous time period’s prediction**

We can apply a weighting scheme that decreases exponentially the further back in time we go.

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As you can see, as we go further back in time, the weights decrease exponentially (more weight is put on the most recent observations).

The larger the value of the 𝜃, the more the most recent observation is emphasized. One-step-ahead forecasts are the typical method for calculating the optimal value of 𝜃 in the Exponential Smoothing model**. • The value of 𝜃 that minimizes the one-step-ahead forecast errors is considered the optimal value.**

**Estimates that are not statistically significant should not be disqualified (in fact, a significance test usually tests if q = 0….which simplifies down to the average model). • Models were originally derived without statistical distribution consideration (estimates are fine even without normality!). • HOWEVER, normality is needed if trying to construct a confidence interval.**

**Trending ES**

The Single Exponential Smoothing model are better used for short-term forecasts.

The SES model cannot adequately handle data that is trending up or down.

There are multiple ways to incorporate a trend in the Exponential Smoothing Model.

• Linear / Holt Exponential Smoothing

• Damped Trend Exponential Smoothing

**The Linear Exponential Smoothing** model has two components. • The second component incorporates trending into the model

There are only two parameters to estimate here (both smoothing or “weight” parameters)

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**Phi = between 0 and 1**

**Seasonal ESM or Holt Winters**

Exponential Smoothing models can also be adapted to account for seasonal factors.

• Seasonal models can be additive or multiplicative in the seasonal effect in the Exponential Smoothing Model. • Holt Winters Additive Exponential Smoothing (includes trend)

• Holt Winters Multiplicative Exponential Smoothing (includes trend)

In seasonal exponential smoothing, weights decay with respect to the seasonal factor.

The Linear Exponential Smoothing model has three components. • Level, Trend and Seasonal

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The Linear Exponential Smoothing model has three components.

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**Forecasting Strategy:**

The accuracy of forecasts depends on your definition of accuracy.

Different across different fields of industry.

Good forecasts should have the following characteristics:

• Be highly correlated with actual series values

• Exhibit small forecast errors

• Capture the important features of the original time series.

**Judgement Forecasting:**

When using data, forecasts are found using quantitative (or modeling) approaches. However, **there are instances where models are unavailable (or potentially past data is unavailable) and a qualitative or judgement forecast is used.**

Occasionally, qualitative and quantitative approaches are merged.

**Accuracy vs. Goodness-of-Fit**

• **A diagnostic statistic calculated using the same sample that was used to build the model is a goodness-of-fit statistic.**

**• A diagnostic statistic calculated using a hold out sample that was not used in the building of the model is an accuracy statistic.**

**Hold Out Sample:**

A hold-out sample in time series analysis is different than a cross-sectional analysis.

• The hold-out sample is always at the end of the time series, and doesn’t typically go beyond 25% of the data. • IF YOU HAVE A SEASONAL TIME SERIES (Fall 2) Ideally, an entire season should be captured in a hold-out sample.

1. Divide the time series into two or three segments – training and validation (hold-out) and/or test.

2. Derive a set of candidate models.

3. Calculate the chosen accuracy statistic by forecasting the validation data set.

4. Pick the model with the best accuracy statistic.

5. Provide the accuracy of the model on the test data set.

Model Diagnostics

Likelihood-based and error based.

MAPE: **easy to understand**, penalize large error, **gives %**

Overweight to over predictions, Actual are zero, Overemphasis on outliers

MAE: easy , not scale variant, || not scale variant, treats over and under predictions same.

RMSE (Square Root of Mean Square Error)

* Overweights the larger errors
* Not scale invariant

Symmetric Mean Absolute Percent Error

* Divide by 0
* Still asymmetric
* no interpretation

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