PROPHET MODEL

Dr. Aric LaBarr

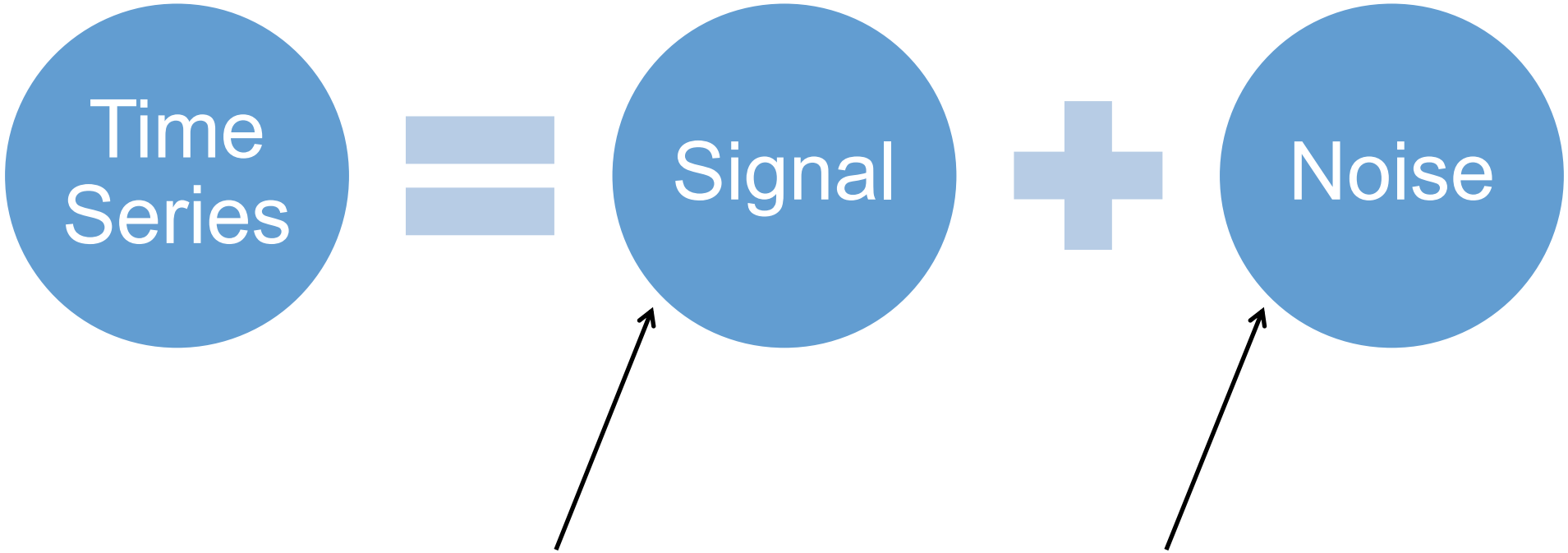
Institute for Advanced Analytics

MODEL STRUCTURE

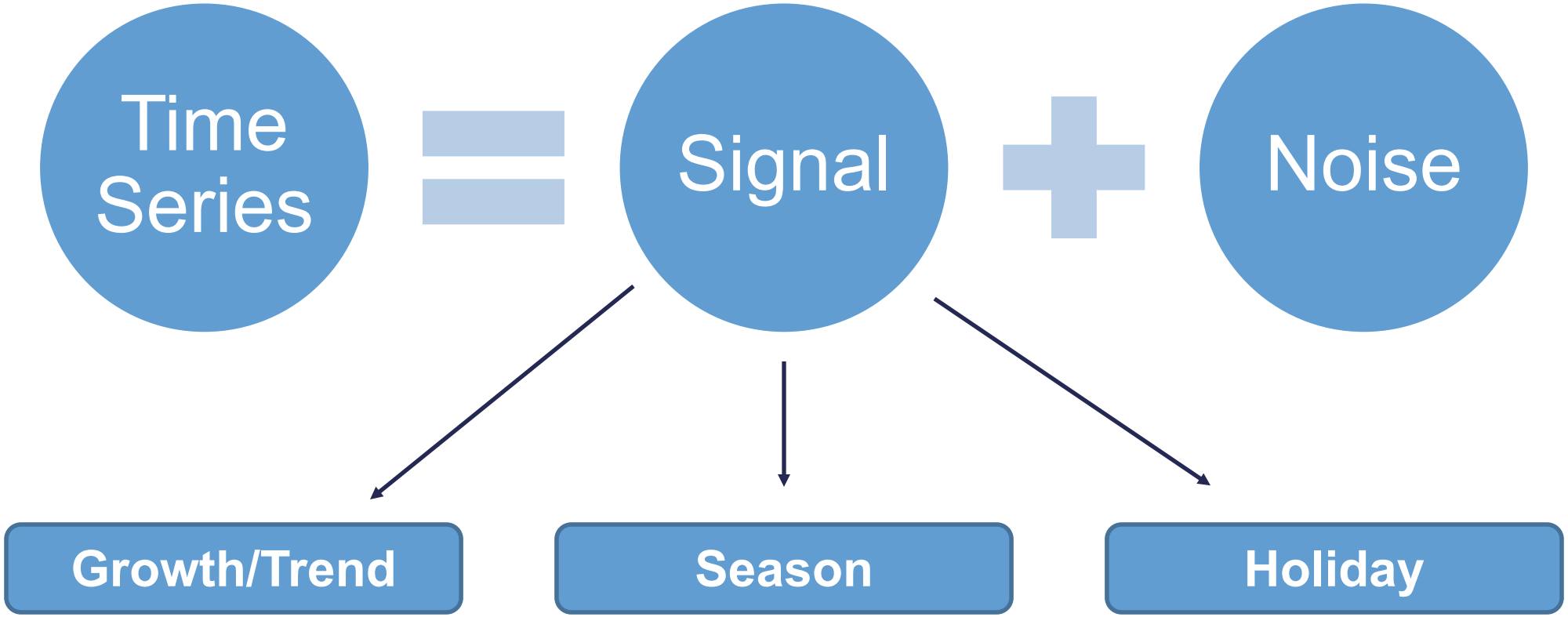
Facebook's Model

- Introduced by Facebook (Taylor & Letham) in 2018.
- Used for forecasting univariate time series by decomposing it into pieces.
  - Similar to exponential smoothing, BSTS, etc.

Prophet Structure

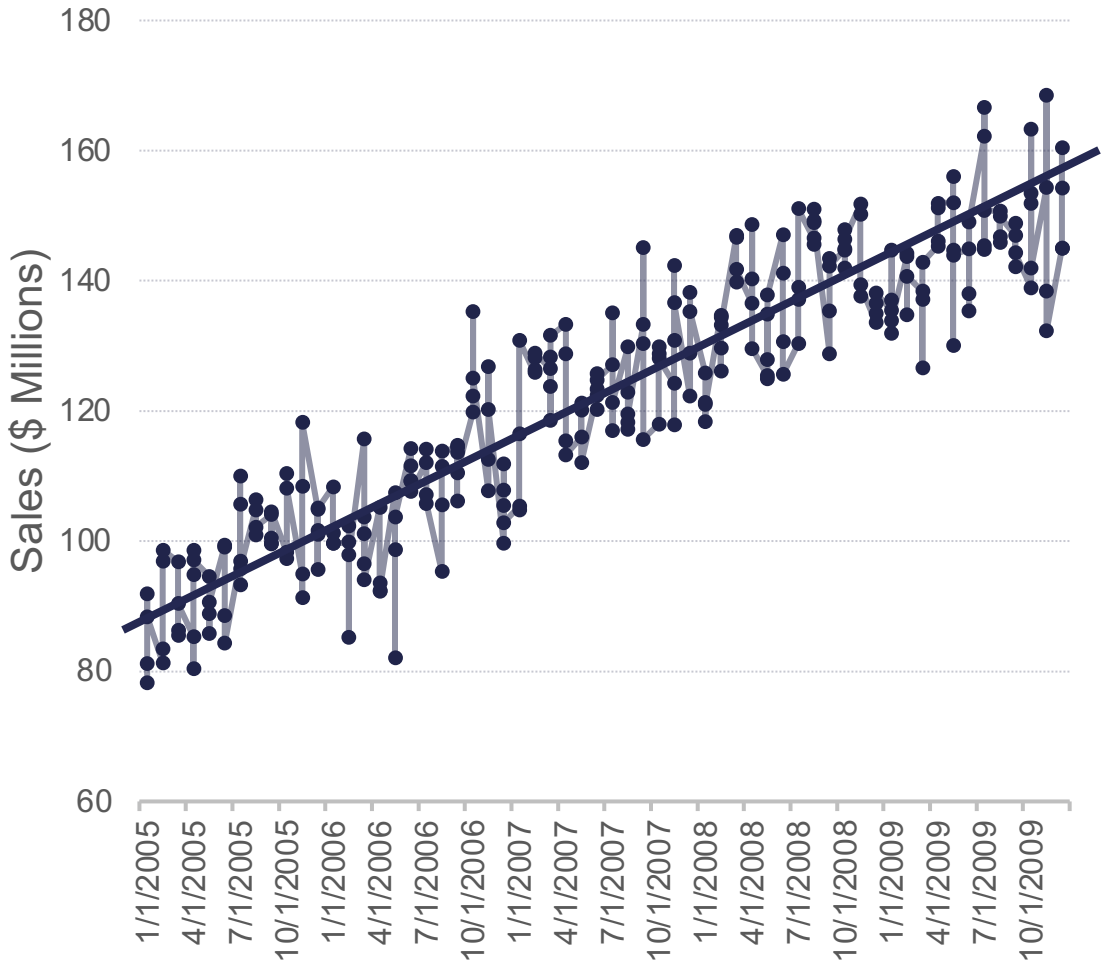


Prophet Signal – 3 Pieces



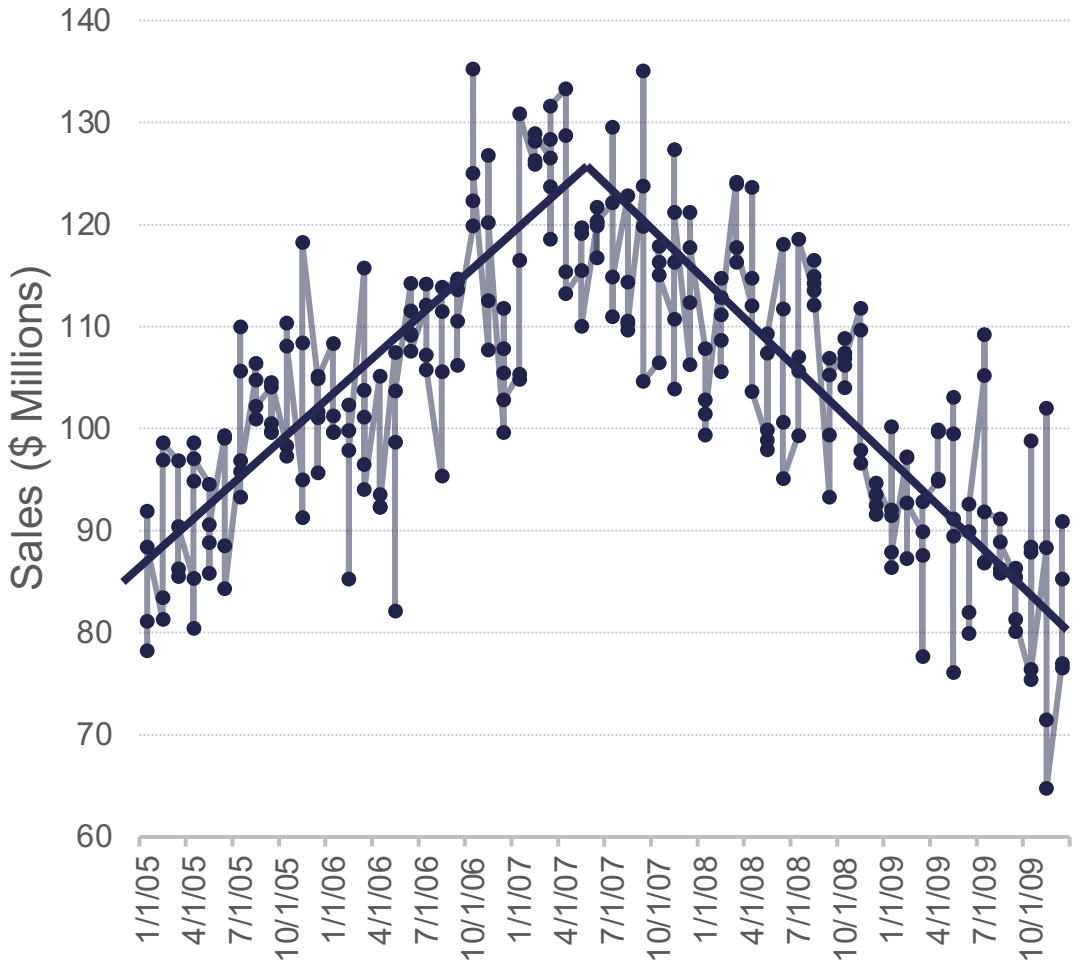
Growth/Trend

- Uses trend lines (time) as regressors in the model.



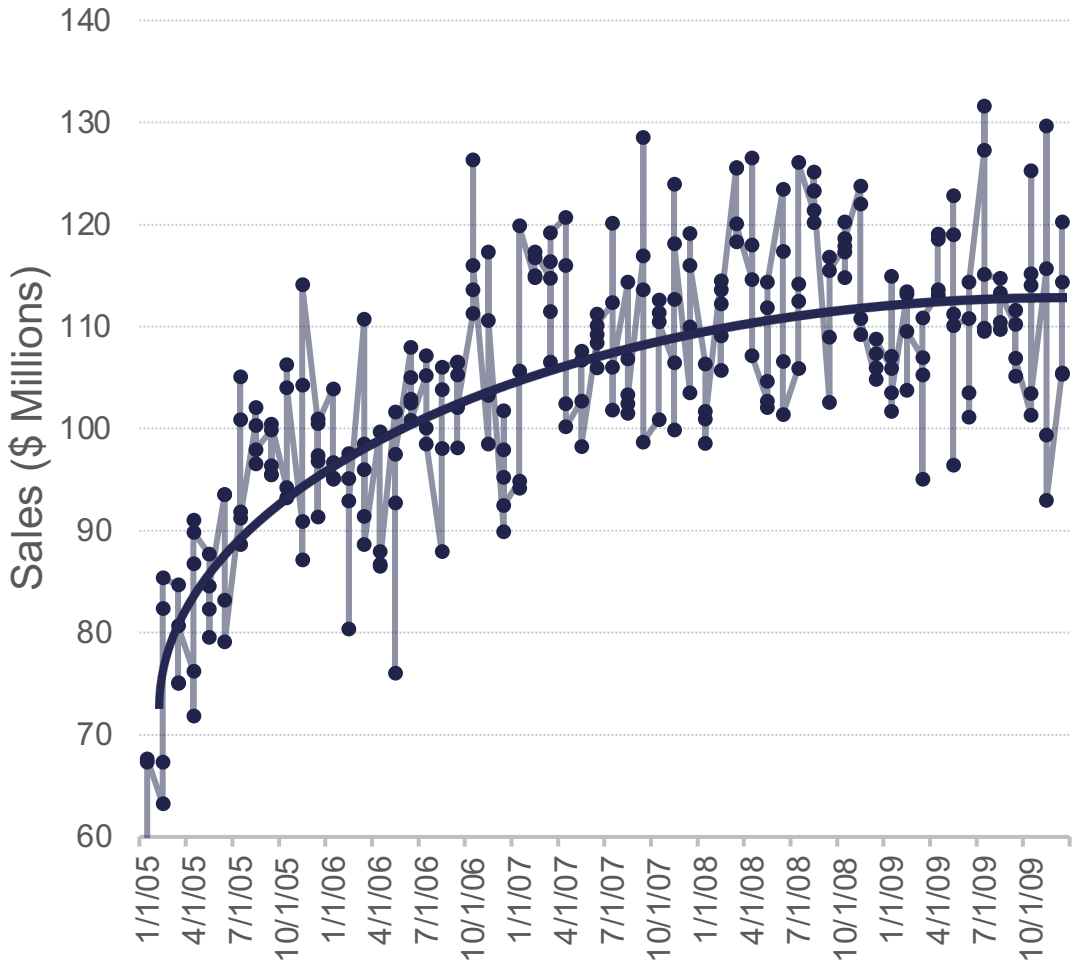
Growth/Trend

- Uses trend lines (time) as regressors in the model.
- This trend is **piecewise** – broken into different pieces of the data using **knots** (if needed).
- User can specify knots or automatically chosen (if needed).



Growth/Trend

- Uses trend lines (time) as regressors in the model.
- This trend can also be a **logarithmic trend**.
- Similar to the dampened trend approach in exponential smoothing.



Seasonal

- Fourier variables are used to account for the seasonal patterns.
- Originally designed for daily data with weekly and yearly seasonal effects.
- Expanded flexibility on seasonal terms.

$$X_Y = \cos\left(\frac{2\pi t}{365.25}\right) + \sin\left(\frac{4\pi t}{365.25}\right) + \cos\left(\frac{6\pi t}{365.25}\right) + \cdots + \sin\left(\frac{20\pi t}{365.25}\right)$$

$$X_W = \cos\left(\frac{2\pi t}{7}\right) + \sin\left(\frac{4\pi t}{7}\right) + \cos\left(\frac{6\pi t}{7}\right)$$

Seasonal

- Fourier variables are used to account for the seasonal patterns.
- Originally designed for daily data with weekly and yearly seasonal effects.
- Expanded flexibility on seasonal terms.

Yearly season set to 10 terms by default

$$X_Y = \cos\left(\frac{2\pi t}{365.25}\right) + \sin\left(\frac{4\pi t}{365.25}\right) + \cos\left(\frac{6\pi t}{365.25}\right) + \cdots + \sin\left(\frac{20\pi t}{365.25}\right)$$

$$X_W = \cos\left(\frac{2\pi t}{7}\right) + \sin\left(\frac{4\pi t}{7}\right) + \cos\left(\frac{6\pi t}{7}\right)$$

Seasonal

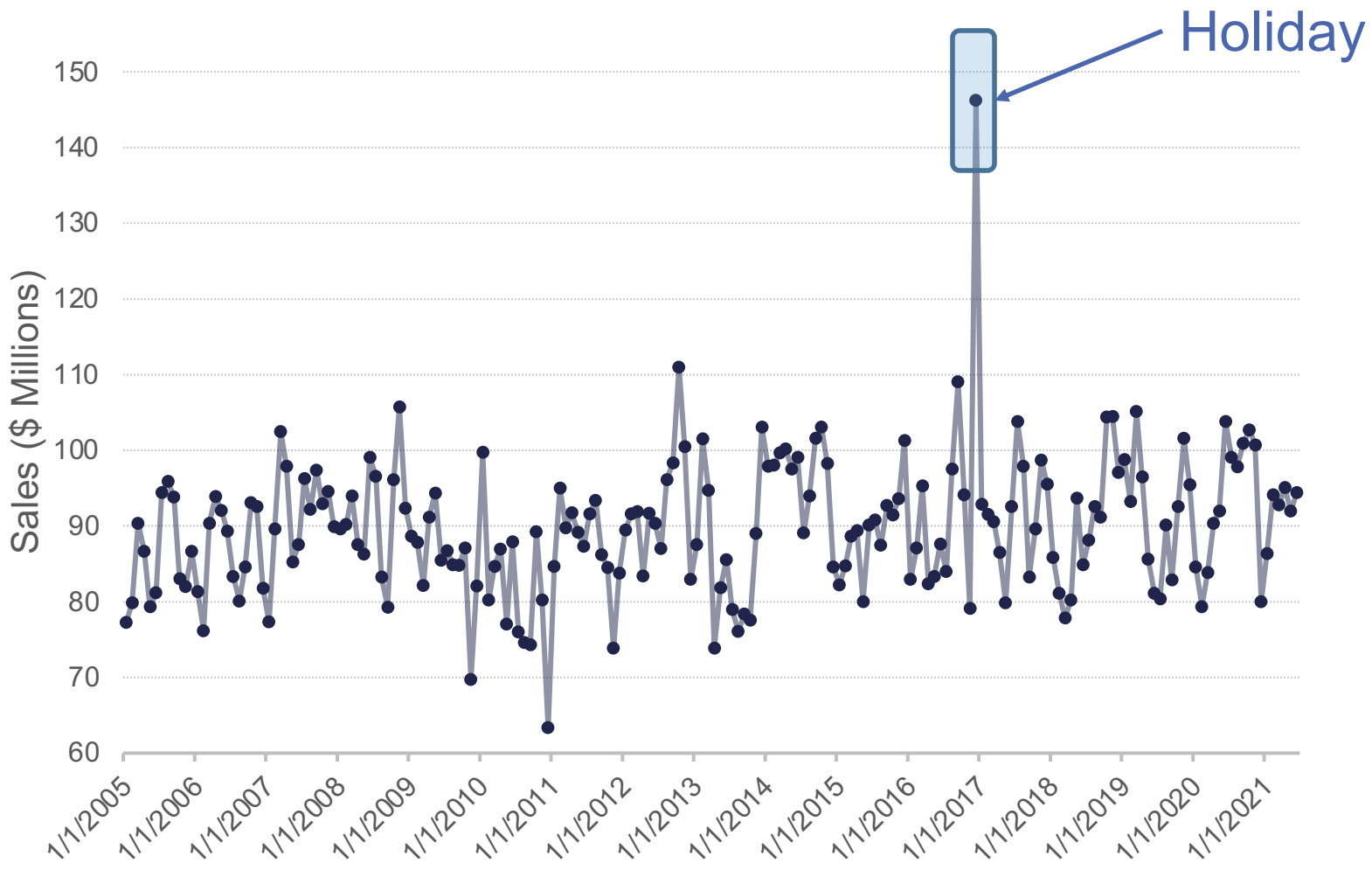
- Fourier variables are used to account for the seasonal patterns.
- Originally designed for daily data with weekly and yearly seasonal effects.
- Expanded flexibility on seasonal terms.

$$X_Y = \cos\left(\frac{2\pi t}{365.25}\right) + \sin\left(\frac{4\pi t}{365.25}\right) + \cos\left(\frac{6\pi t}{365.25}\right) + \cdots + \sin\left(\frac{20\pi t}{365.25}\right)$$

$$X_W = \cos\left(\frac{2\pi t}{7}\right) + \sin\left(\frac{4\pi t}{7}\right) + \cos\left(\frac{6\pi t}{7}\right)$$

Weekly season set to 3 terms by default

Holiday – Point (Pulse) Intervention



Date	Holiday Variable I_t
8/2016	0
9/2016	0
10/2016	0
11/2016	0
12/2016	1
1/2017	0
2/2017	0

Prophet Model

```
holidays <- data.frame(
  holiday = 'Sep11',
  ds = as.Date(c('2001-09-01', '2001-10-01', '2001-11-01',
                 '2001-12-01', '2002-01-01', '2002-02-01',
                 '2002-09-01')),
  lower_window = 0,
  upper_window = 0
)

prophet.data <- data.frame(ds = seq(as.Date('1990-01-01'), as.Date('2007-03-01'), by = 'm'), y = training)

Prof <- prophet(holidays = holidays)
Prof <- add_country_holidays(Prof, "US")
Prof <- add_seasonality(Prof, name='monthly', period=30.5, fourier.order=6)
Prof <- fit.prophet(Prof, prophet.data)
```

FORECASTING

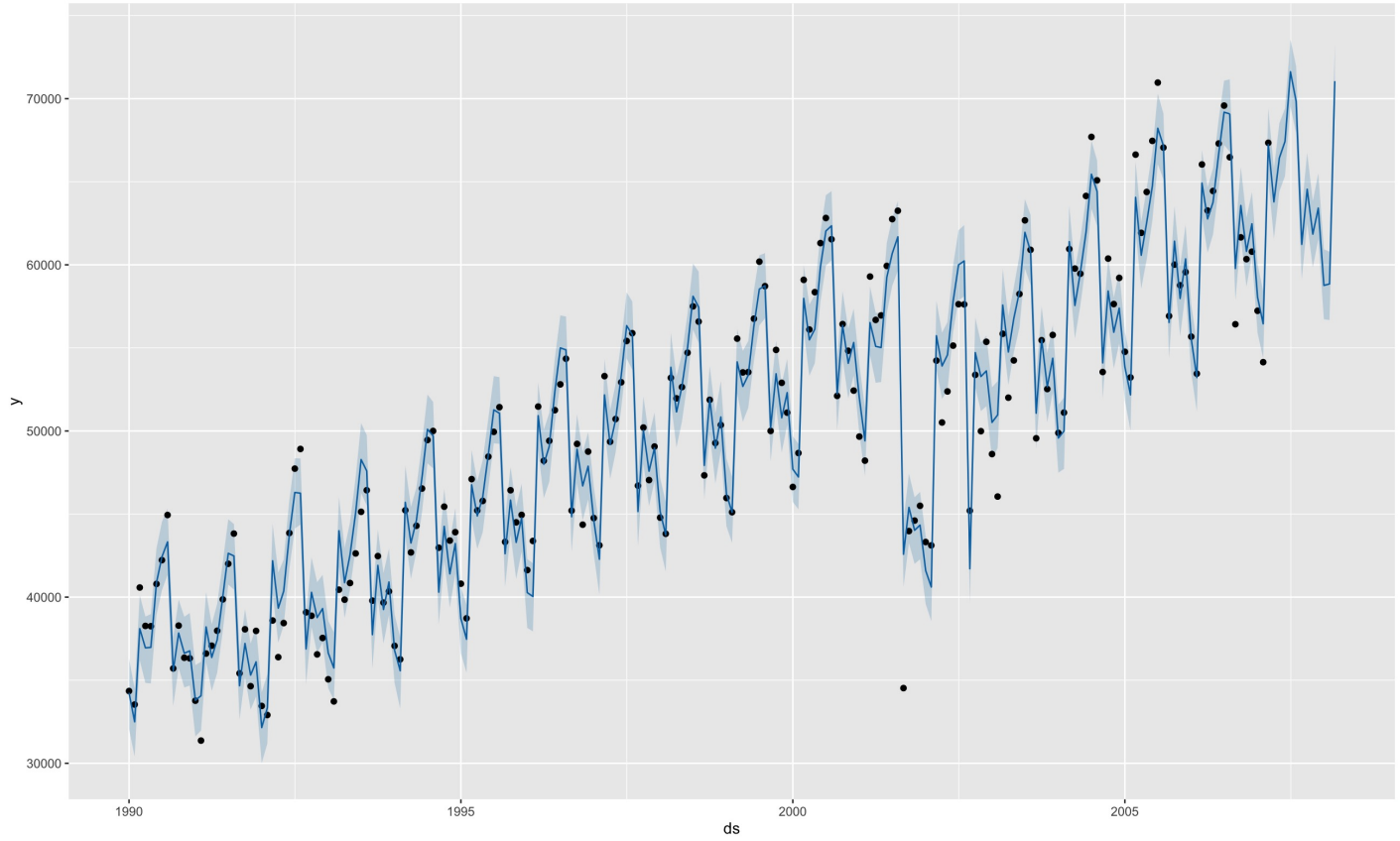
Curve-fitting

- The prophet model doesn’t use any lag values of the target variable.
- Basically, a curve-fitting approach to forecasting.
- Forecasting just extends the curves into the future.

Forecasting with Prophet

```
forecast.data <- make_future_dataframe(Prof, periods = 12, freq = 'month')

plot(Prof, predict(Prof, forecast.data))
```



Forecasting with Prophet

```
Prophet.error <- test - tail(predict(Prof, forecast.data)$yhat, 12)

Prophet.MAE <- mean(abs(Prophet.error))
Prophet.MAPE <- mean(abs(Prophet.error)/abs(test))*100
```

Model Evaluation on Test Data

Model	MAE	MAPE
HW Exponential Smoothing	1134.58	1.76%
Seasonal ARIMA	1229.21	1.89%
Dynamic Regression ARIMA	1180.99	1.80%
Prophet	1449.85	2.25%

Prophet vs. Other Approaches

- Facebook finds value in the prophet algorithm.
- Doesn’t mean your data will find value with the prophet algorithm.
- Only uses curves to fit data and not previous values of the data in your forecasting model.

- **Personally**, I haven’t found too much value in the prophet model.