Week 1: Descriptive Analytics

- An Operational Decision Problem

- Forecasting with Past Historical Data
- Moving Averages
- Exponential Smoothing

- Thinking about Trends and Seasonality

- Forecasting for New Products
- Fitting distributions

Session 4

New Product Problem

- In the case of new products or new designs in the market, there is limited demand data.

- How to Forecast in such cases?
  - Subjective techniques…

Subjective Forecasting Methods

- Composites
  - Sales Force Composites: Aggregation of sales personnel estimates.
- Customer Surveys
- Jury of Executive Opinion
- The Delphi Method
  - Individual opinions are compiled and reconsidered. Repeat until overall group consensus is (hopefully) reached.

Forecasting Demand: An Application

- An outdoor wear company (Andes) has a new product: A new men's hiking shoe design.
- Andes Inc. has sold this particular design called *Drifter* for one season only. In the past season, they
  - made a forecast of 1200 units
  - produced Q=1500 units, and
  - sold 1397 units.
- As you can see, not much demand data is available.
- How can Andes think about descriptive statistics for *Drifter*?

Fitting a Distribution by Tracking Errors

- If there is limited demand data for new products…
  - We start with subjective forecasts.
  - However, we can do better with more data.
- Often, there is additional demand data from *other* products that you forecast in the past.
  - This is informative of *how forecasts in your firm deviated from demand*.
- We will learn one approach on how to fit a Normal distribution to such available data.
- We can use similar approaches for other distributions.

Andes Inc: Men's Shoes

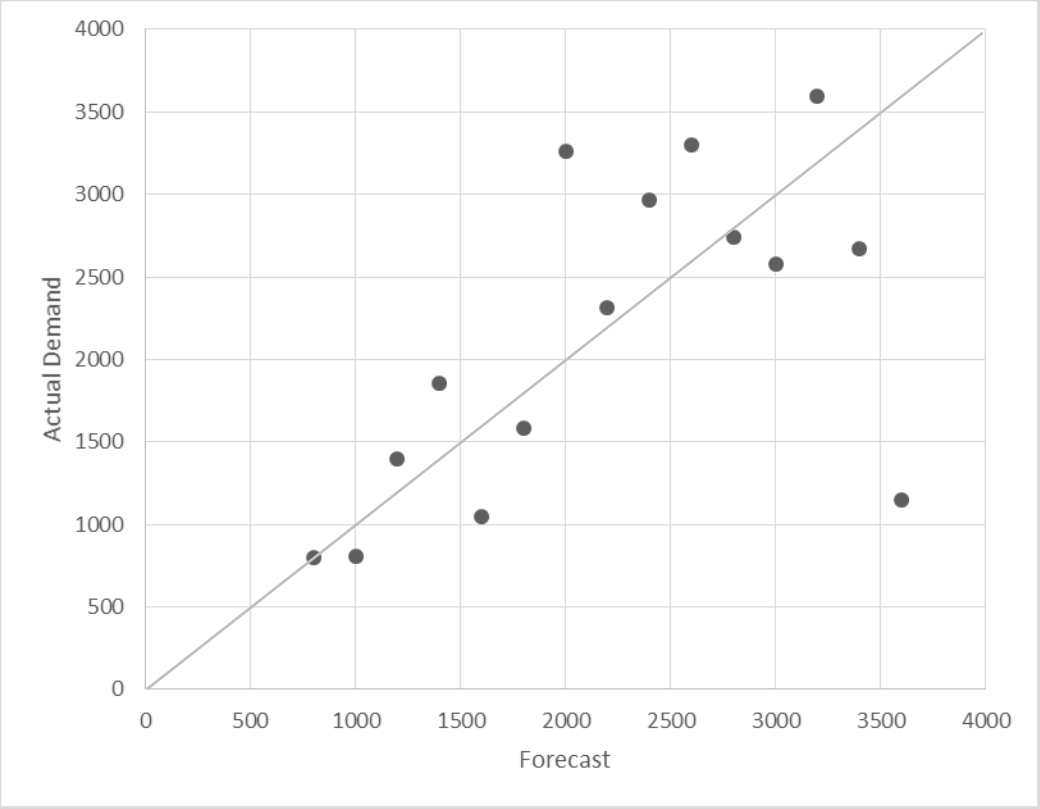
Product	Forecast	Produced	Sales	Actual Demand
Tale	800	1000	796	796
Lancic	1000	1250	805	805
Drifter	1200	1500	1397	1397
Manas	1400	1750	1750	1857
Tsake	1600	2000	1049	1049
Screen	1800	2250	1585	1585
Ayers	2000	2500	2500	3265
Pau	2200	2750	2314	2314
Omega	2400	3000	2967	2967
Nomad	2600	3250	3250	3299
Snake	2800	2500	2500	2739
Maui	3000	3750	2578	2578
Rainier	3200	4000	3598	3598
Carbon	3400	4250	2672	2672
Bear lake	3600	4500	1148	1148
Average	2200			2138
Std Deviation	894			963

- The subjective forecast for Drifter for next season is 1000 pairs.
- What demand model should Andes use for the Drifter?

Sales vs. Demand: A note

- Note there is a difference between Sales and Demand
  - Sales is censored demand.
  - E.g. If your demand was 1000 units, but you have only 800 units on shelf, the sales is only 800 units.
  - Examples: Popular music players, gaming consoles are often sold out.
- For most operational problems, such as the Newsvendor problem, we need demand distribution data.

Forecast Performance at Andes



- Some demands exceed forecasts, and some demands are lower than forecasts.

Measuring Forecast Performance

Product	Forecast	Produced	Sales	Actual Demand	A/F ratio
Tale	800	1000	796	796	1.00
Lancic	1000	1250	805	805	0.81
Drifter	1200	1500	1397	1397	1.16
Manas	1400	1750	1750	1857	1.33
Tsake	1600	2000	1049	1049	0.66
Screen	1800	2250	1585	1585	0.88
Ayers	2000	2500	2500	3265	1.63
Pau	2200	2750	2314	2314	1.05
Omega	2400	3000	2967	2967	1.24
Nomad	2600	3250	3250	3299	1.27
Snake	2800	2500	2500	2739	0.98
Maui	3000	3750	2578	2578	0.86
Rainier	3200	4000	3598	3598	1.12
Carbon	3400	4250	2672	2672	0.79
Bear lake	3600	4500	1148	1148	0.32
Average	2200			2138	1.01
Std Deviation	894			963	0.31

- We measure forecast vs actual demands, by calculating a ratio of actual demand to the forecast.

Empirical distribution function of forecast accuracy

$$\text{A / F Ratio} = \frac{\text{Actual Demand}}{\text{Forecast}}$$

- Start by evaluating the actual demand to forecast ratio (the A/F ratios) from the *N* past observations.
- A/F ratios measure how much the actual demands deviated from past forecasts.
- … which helps us pin down uncertainty around current forecast.

Choosing a normal demand distribution

- Start with an initial forecast generated from subjective methods (hunches, guesses, etc).
  - Let's assume that the Initial Forecast = 1000 units.

- Evaluate the A/F ratios of the historical data:

$$A/F\ ratio = \frac{Actual\ demand}{Forecast}$$

- Set the mean of the normal distribution to

$$Expected\ actual\ demand = Expected\ A/F\ ratio \times Forecast$$

- Set the standard deviation of the normal distribution to

$$Standard\ deviation\ of\ actual\ demand =$$
$$Standard\ deviation\ of\ A/F\ ratios \times Forecast$$

Normal distribution forecast

$$\text{Expected actual demand} = 1.01 \times 1000 = 1010$$

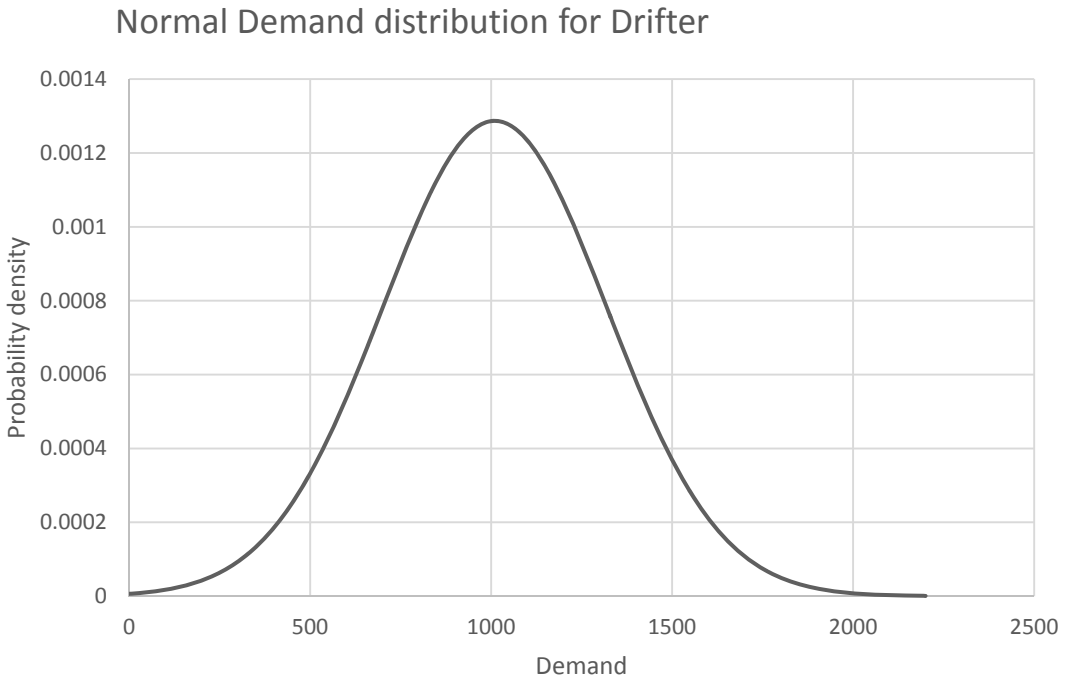
$$\text{Standard deviation of actual demand} = 0.31 \times 1000 = 310$$

- Descriptive Data: normal distribution with mean 1010 and standard deviation 310 to represent demand.

- Note for predictive purposes, we update the distribution to Normal with mean and standard deviation as follows:

$$\mu = 1010$$
$$\sigma = 390.$$

Descriptive Statistics: Normal Demand model



- Drifter Descriptive Stats: Normal Demand distribution with mean 1010 and Standard deviation 310.

Our techniques broadly applicable…

- Can be used for understanding GDP forecasts and actual observations:
  - See Nate Silver's book: The Signal and the Noise: Drowning in 3 feet of water. Chapter 6.

- Forecasting process used at Sport Obermeyer.
  - *Reducing the Cost of Demand Uncertainty through Accurate Response to Early Sales.* Fisher and Raman. Operations Research 1996. vol. 44 - 99.(1), 87

Keep track of your forecast errors…

Figuring out what's causal and what's correlated is a hard thing to do.

- Jan Hatzius, Chief Economist, Goldman Sachs.

Week 1: Descriptive Analytics Recap

- Newsvendor Problem
- Random Variables and Demand Distributions

- Forecasting with Past Historical Data
  - Errors and Biases
- Moving Averages
- Exponential Smoothing
- Descriptive Statistics

- Trends and Seasonality

- Forecasting for New Products
- Fitting Demand distributions

Conclusion

- That’s it for Descriptive Analytics.
- We will cover more tools in the weeks to come –
- We will continue on to prescriptive and predictive analytics.