Lecture 8 Overview

Question

How should your company manage its inventory?

Inventory Management 101

Distribution Strategies

Newsvendor Model

Pictures of newspaper hawkers

"Boys Selling Newspapers on Brooklyn Bridge"
by Lewis Hine (1908)

Newspaper hawkers in Mexico City, Mexico (2010)

Newspaper hawkers aka newsboys

From “Newspaper hawker” by Wikipedia

- A newspaper hawker or newsboy is a street vendor of newspapers without a fixed newsstand
- Newsboys were not considered to be employees of the newspapers
- Newsboys purchased the papers from wholesalers, and sold them as independent agents
- Unsold papers could not be returned! 😭

What was life like as a newspaper hawker?

- The newsboys typically earned around 30 cents a day
- Cries of "Extra, extra!" were often heard late into the night as newsboys attempted to hawk every last paper

The newsvendor model

Inputs

- Selling price ***p***
- Production / procurement cost ***c***
- Salvage value ***s***

Outputs

- Underage cost c^u
- Overage cost c^o
- Target service level / critical fractile α^*
- Optimal order quantity q^*

Sequence of Events

Submit order, receive inventory

Sell products during sales period

Salvage any leftover inventory

Assumptions

- The demand ***D*** is random
- No inventory replenishment

Let’s go through an example

- Parameters: p = 5, c = 4, s = 1
- Suppose you ordered q = 70

<u>Case 1: D = 50</u>

Sales = 50, salvaged units = 20

Profit

$= 70 \times (-4) + 50 \times 5 + 20 \times 1$

$=$ **−10**

😭

<u>Case 2: D = 80</u>

Sales = 70, salvaged units = 0

Profit

$= 70 \times (-4) + 70 \times 5 + 0 \times 1$

$=$ **+70**

🤑

Why the assumptions matter

- If demand is deterministic…
  - Then set the order quantity equal to the demand
- If inventory can be replenished…
  - Then order a little bit
  - And order a bit more whenever you run out of inventory
- The newsvendor problem is interesting because…
  - You need to order BEFORE you know what is the demand
  - And you can't get more inventory if you run out

Let’s play the bakery game

Suppose that you are the manager of a store selling pineapple buns

- You need to decide how many buns **q** to order the night before
- Each bun costs $4
- Each bun is sold for $10
- Unsold buns are discarded at a loss

How many buns **q** should you order?

A delicious pineapple bun (Chinese: 菠蘿包)

Let's play the bakery game

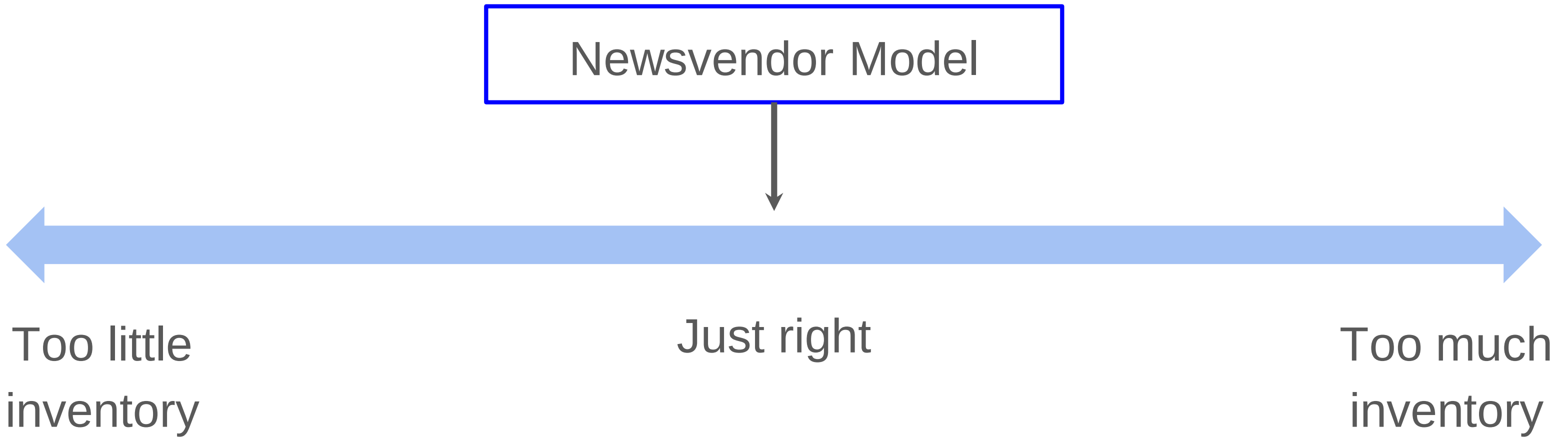
- It depends on the demand
- Suppose demand is **normally distributed** with **mean 100** and **std dev 30**
- Here are 20 realizations of demand

98	54	143	69	137
89	104	120	90	105
103	67	167	67	106
105	101	122	89	103

Time to play the bakery game in class

What did we learn from the bakery game?

1. When you order too little, you “lose money” on unmet demand
2. When you order too much, you lose money on unsold inventory
3. The optimal order quantity is a scientific method to strike the right balance between too little and too much inventory



How to solve the newsvendor problem

Step 1	Compute the underage cost $\mathbf{c^u} = p - c$ The cost of ordering one unit too little
Step 2	Compute the overage cost $\mathbf{c^o} = c - s$ The cost of ordering one unit too much
Step 3	Compute the target service level / critical fractile $\boldsymbol{\alpha^*} = c^u / (c^u + c^o)$ The target service level is the desired probability that you will be able to meet demand
Step 4	Compute the optimal order quantity $\mathbf{q^*} = F^{-1}(\alpha^*)$ At the inventory level q^*, the probability that demand ≤ inventory level is α^*

The inverse cumulative distribution function $F^{-1}(\cdot)$

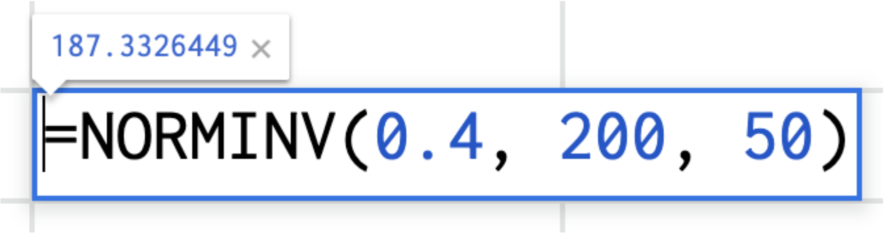
The inverse CDF $F^{-1}(\cdot)$ is a concept from statistics (e.g., CB2200)

What you need to know:

1. The service level is the probability that your order quantity ≥ demand
2. If your order quantity is $\mathbf{q^*} = F^{-1}(\boldsymbol{\alpha^*})$, then your in-stock probability is $\boldsymbol{\alpha^*}$
3. As the probability $\boldsymbol{\alpha^*}$ increases, the order quantity $\mathbf{q^*} = F^{-1}(\boldsymbol{\alpha^*})$ increases

Compute the inverse normal CDF in Google Sheets

- Use the `NORMINV` function in Google Sheets to compute the inverse normal CDF (see [NORMINV function example]())
- Syntax – `NORMINV(x, mean, standard_deviation)`
- Example
  - Demand is normal with mean 200 and std dev 50
  - The target service level $\alpha^* = 0.40$
  - Use the formula `=norminv(0.4, 200, 50)` to calculate $F^{-1}(0.40)$



Example – Solution of the bakery game

Problem parameters: **p** = , **c** = , **s** =

Step 1 Compute the underage cost $\mathbf{c^u}$ =

Step 2 Compute the overage cost $\mathbf{c^o}$ =

Step 3 Compute the target service level / critical fractile $\boldsymbol{\alpha^*}$ =

Step 4 Compute the optimal order quantity $\mathbf{q^*}$ =

Students' slide

Interpretation of the newsvendor solution

- Suppose the critical fractile $\boldsymbol{\alpha^*}$ = 80%, and you order $\boldsymbol{q^*} = F^{-1}(\boldsymbol{\alpha^*})$
  Recall: critical fractile = in-stock probability
  - The probability of NOT being stocked out is _____?
  - The probability of being stocked out is _____?
- When the selling price increases, the optimal order quantity ↑ or ↓ ?
- When the unit cost increases, the optimal order quantity ↑ or ↓ ?
- When the salvage value increases, the optimal order quantity ↑ or ↓ ?

Students' slide

Key takeaways

1. TO DO