# MSBA 7004
# Operations Analytics

## Class 10-1: Revenue Management
## 2023

# Learning Objectives

- Explain the concept of revenue management.
- Understand customer segmentation and price discrimination.
- Apply tools for capacity reservation and overbooking management.

# Operations Management Options +++

## MANAGING SUPPLY

- Capacity management
- Process (bottleneck) analysis
- Queueing analysis
- Inventory and supply chain management

## MANAGING DEMAND

Revenue management
(a.k.a. yield management)

# Matching Supply to Demand When Supply Is Fixed

## Examples of fixed supply:


Travel industries (fixed number of seats, rooms, cars, etc.).


Advertising time (limited number of time slots).


Telecommunications bandwidth.


Size of the TPG program.


Doctor’s appointments.

## Revenue management is a solution:

- If adjusting supply is impossible – adjust the demand!
- Segment customers into high willingness to pay and low willingness to pay.
- Limit the number of tickets sold at a low price, that is, control the average price by changing the mix of customers.

# Examples

Hotel Room Pricing

Airlines and Seat Pricing

Disneyland's Tiered Pricing


Uber Surge Pricing


**eCommerce and Flash Sales**

**Cruise Line Cabin Upgrades**


**Streaming Services and Content Licensing**


**Online Advertising Auctions**

**Ride-Sharing Subscription Plans**

# Revenue Management

*"The process of allocating the right **type** of capacity,*

*to the right kind of customer, at the right price and time,*

*to maximize revenue or yield…"*

*The Art of Managing Yield,* AmericanAirlines *Annual Report, 1987*

American Airlines VS PEOPLExpress

## HOW SHOULD AA COMPETE?

- Give up the low-end market?
- Use price discrimination?
- Increase routes or schedules?
- Spin off a new budget airline?
- Acquire People Express?
- “Play dirty”?

## THE DECISION

Ultimate Super Saver
January 1985

70% of tickets with higher prices
30% of tickets with lower prices

*Newsvendor Model?*

## RESULT – DOWNFALL OF PE

From US$1 billion profit in 1985
to near-bankrupt in 1986

Acquired by Continental in 1987

# Revenue Management

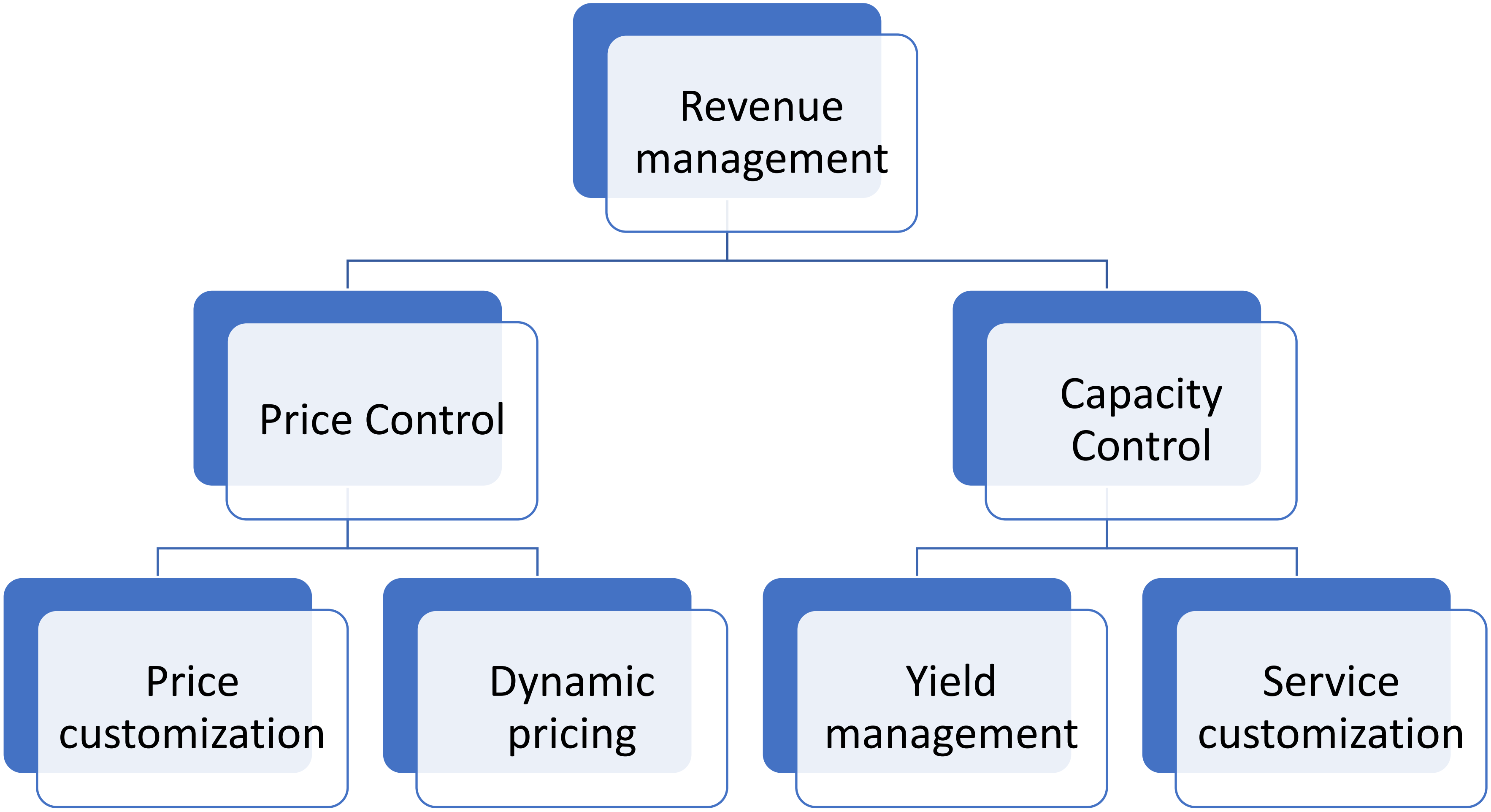
**Evaluate your customer**
- Understand your customer, your competition, and strategy

**Design product**
- To segment customers and time

**Control price**
- Pricing strategy

**Control capacity**
- Reservation strategy

# Revenue Management



# Revenue Management

- Price Control
  - Price customization
  - Dynamic pricing

- Capacity Control
  - Yield management
  - Service customization

# Pricing

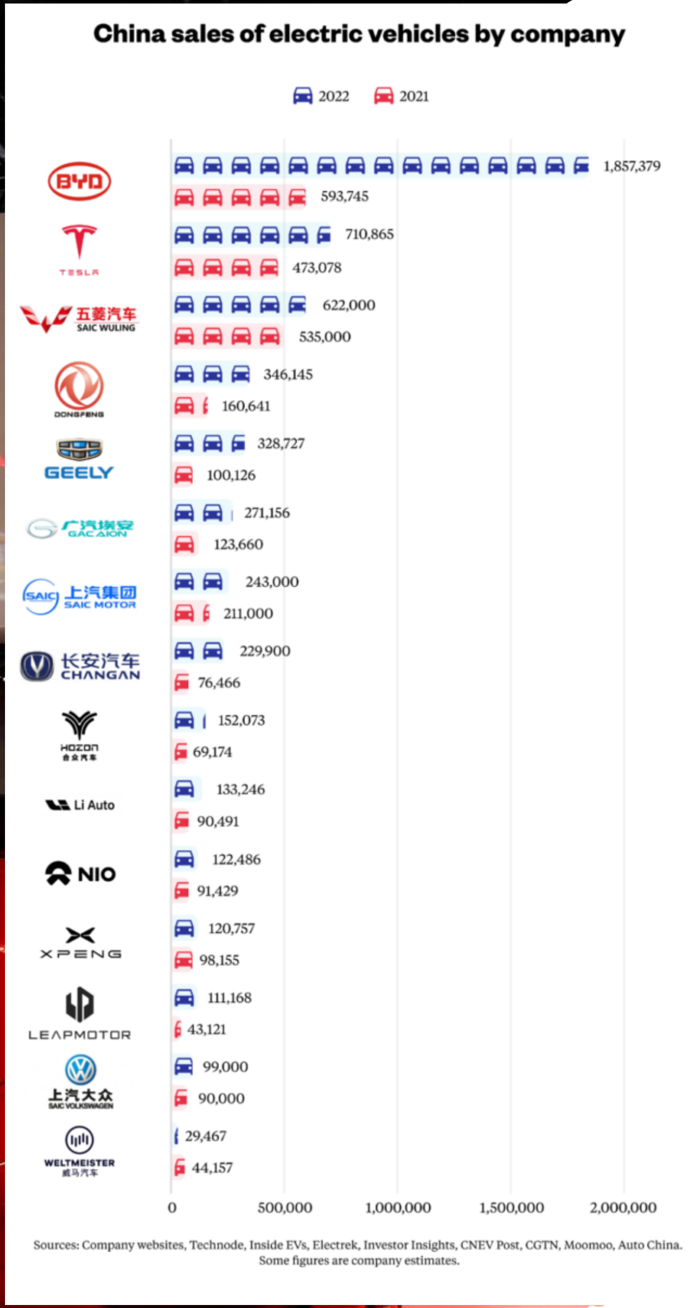
## PRICING A PRODUCT/SERVICE

- Intrinsic value
- Classical economics: supply and demand

## TRADITIONAL APPROACHES

| | Based on |
|---|---|
| Cost-plus | **Costs** |
| Market based | **Competition** |
| Value based | **Customers** |

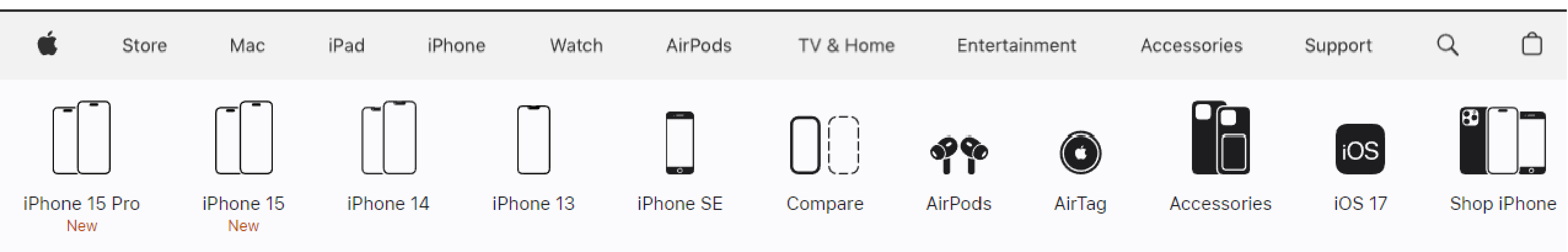

集发电 储电 充电于一体
互动娱乐区
Model Y


China sales of electric vehicles by company
2022
2021
BYD
1,857,379
593,745
TESLA
710,865
473,078
五菱汽车 SAIC WULING
622,000
535,000
DONGFENG
346,145
160,641
GEELY
328,727
100,126
GAC AION
271,156
123,660
上汽集团 SAIC MOTOR
243,000
211,000
长安汽车 CHANGAN
229,900
76,466
HOZON
152,073
69,174
Li Auto
133,246
90,491
NIO
122,486
91,429
XPENG
120,757
98,155
LEAPMOTOR
111,168
43,121
上汽大众
99,000
90,000
WELTMEISTER
29,467
44,157
0
500,000
1,000,000
1,500,000
2,000,000
Sources: Company websites, Technode, Inside EVs, Electrek, Investor Insights, CNEV Post, CGTN, Moomoo, Auto China.
Some figures are company estimates.

# Pricing: iPhone

- 2008: iPhone 3G only
- 2023: iPhone 15 Pro

  and many more..



# Pricing: iPhone

## IPHONES ON SALE IN 2008

iPhone 3G
HK$5,400 / HK$6,200

## IPHONES ON SALE IN 2023

iPhone 15 series
HK$6,899 – HK$13,599

iPhone 14 (Plus)
From HK$5,999

iPhone 13
From HK$5,099

iPhone SE
From HK$3,699

# Pricing: An Important Tool

## ONE PRICE DOES NOT FIT ALL

*How much will you pay for an iPhone 15 Pro Max 256GB?*

**Model.** Which is best for you?

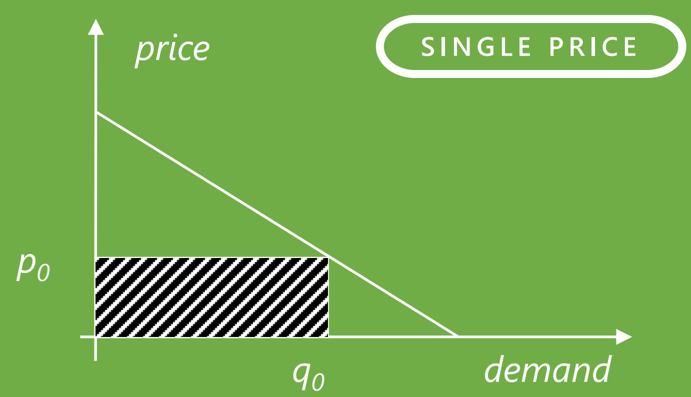
**iPhone 15 Pro**
6.1-inch display[1]

**iPhone 15 Pro Max**
6.7-inch display[1]

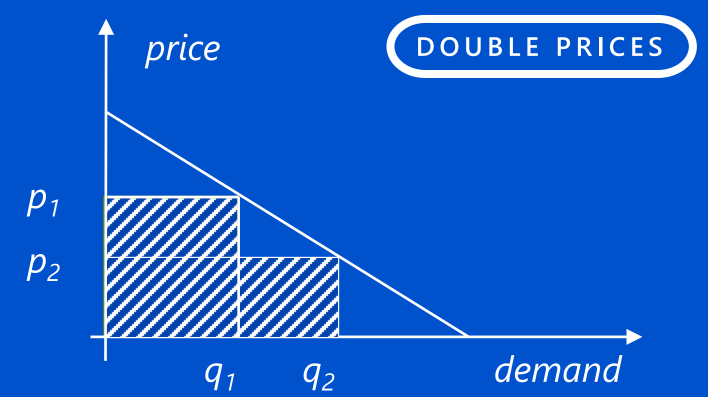
**Need help choosing a model?**
Explore the differences in screen size and battery life.

# Pricing: An Important Tool

## ONE PRICE DOES NOT FIT ALL




*total revenue* $= p_0 * q_0$



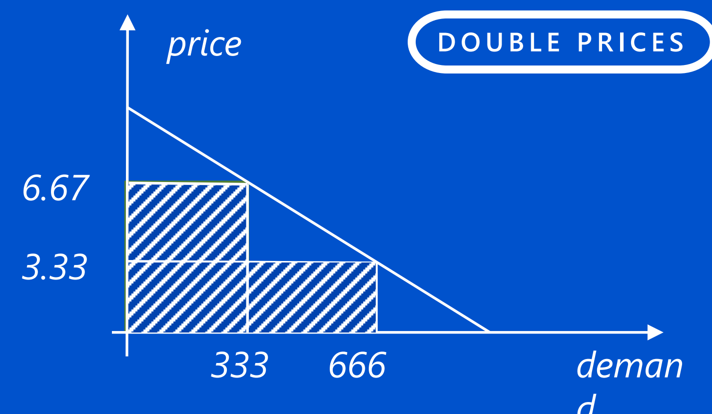

*total revenue* $= p_1 * q_1 + p_2 * (q_2 - q_1)$

# Price Discrimination – Example +++

***demand = 1000 – 100 * price***

***revenue = price * (1000 – 100 * price)***

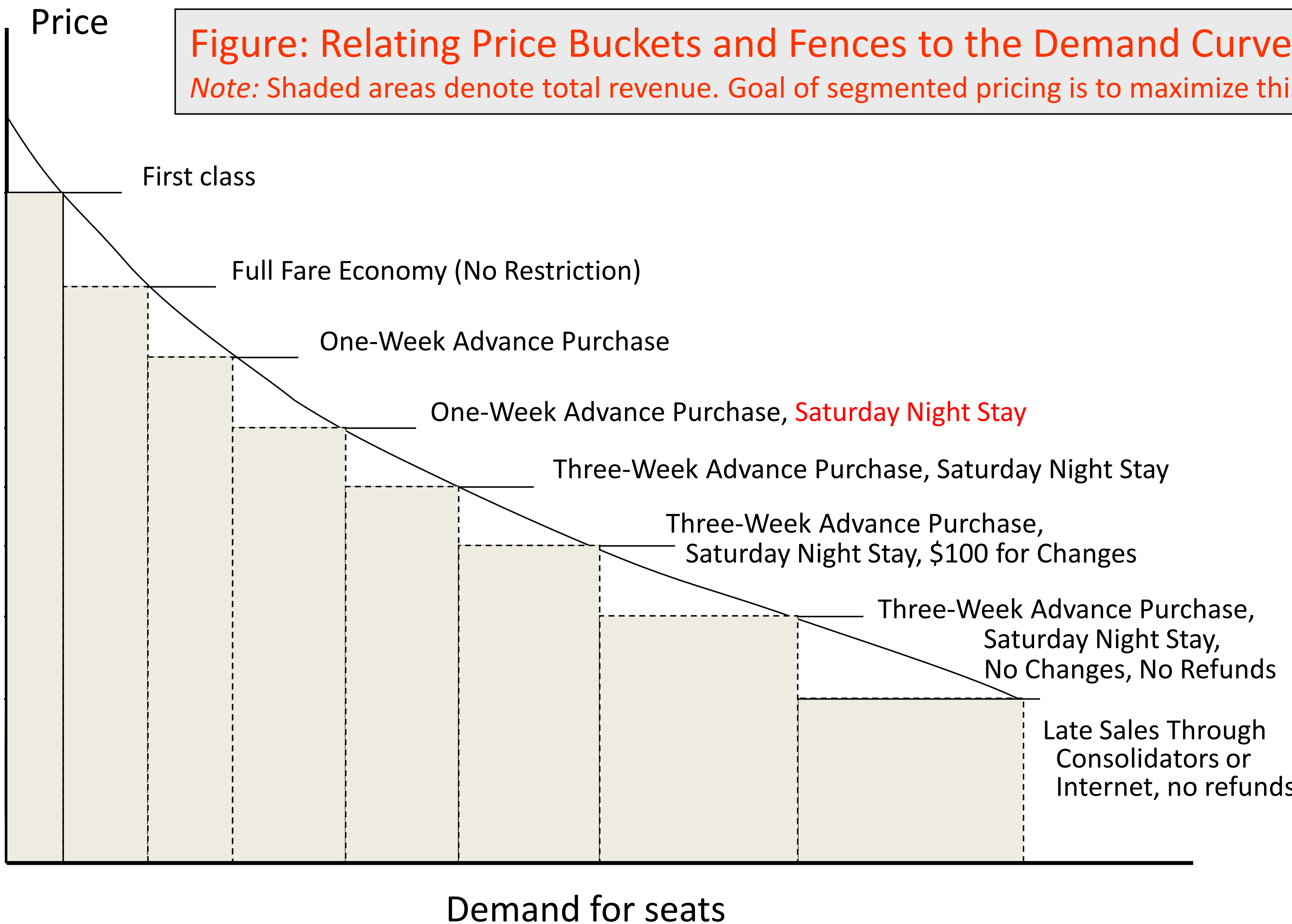

*total revenue = 2,500*




*total revenue = 3,330*

# Figure: Relating Price Buckets and Fences to the Demand Curve

*Note:* Shaded areas denote total revenue. Goal of segmented pricing is to maximize this.



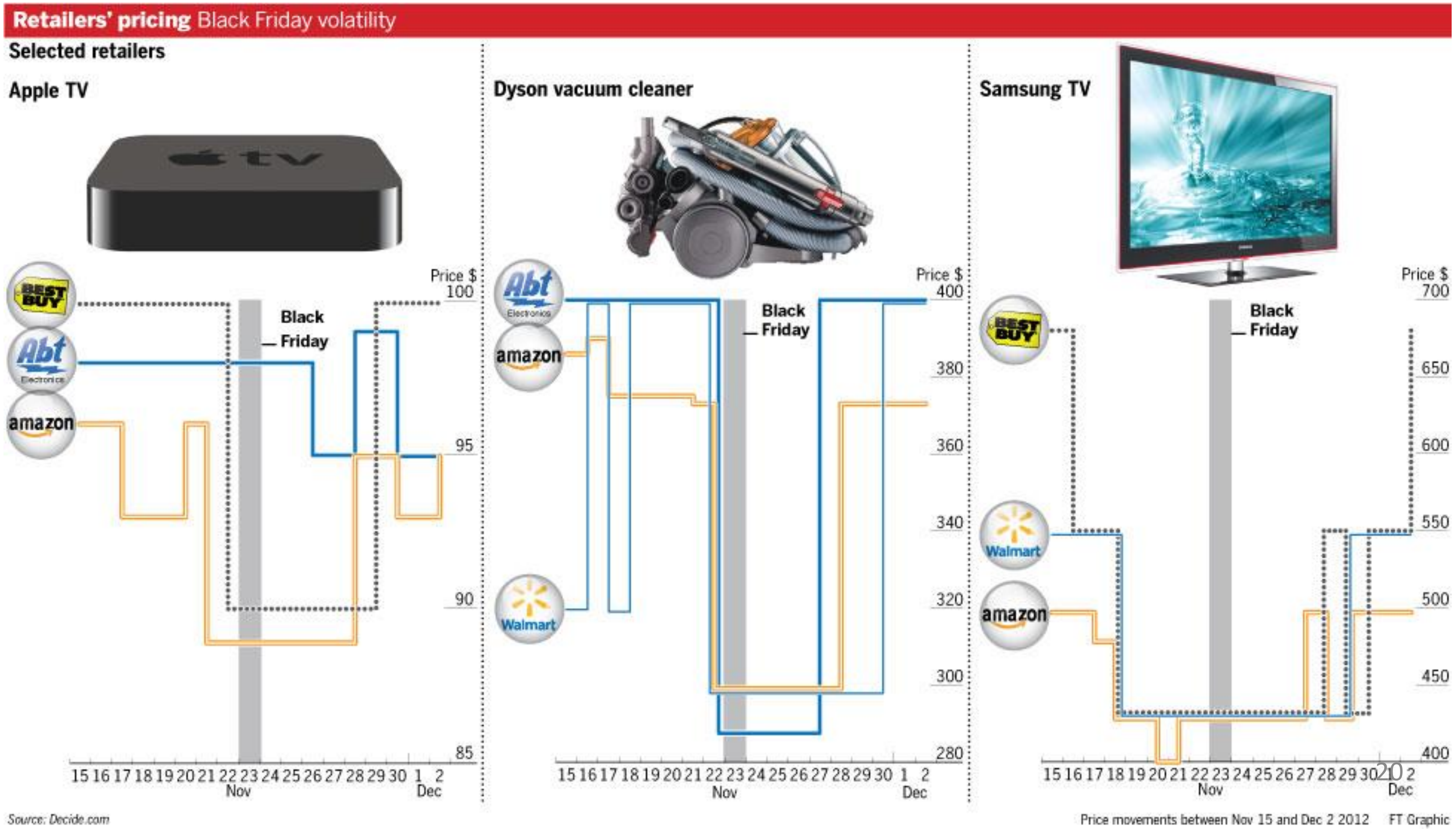
# Price Discrimination and Customization

- Other examples
  - Demographics: Age, gender
  - Brand, distribution channel
  - Order volume
  - Location
  - Service (warranty)
  - Look/color

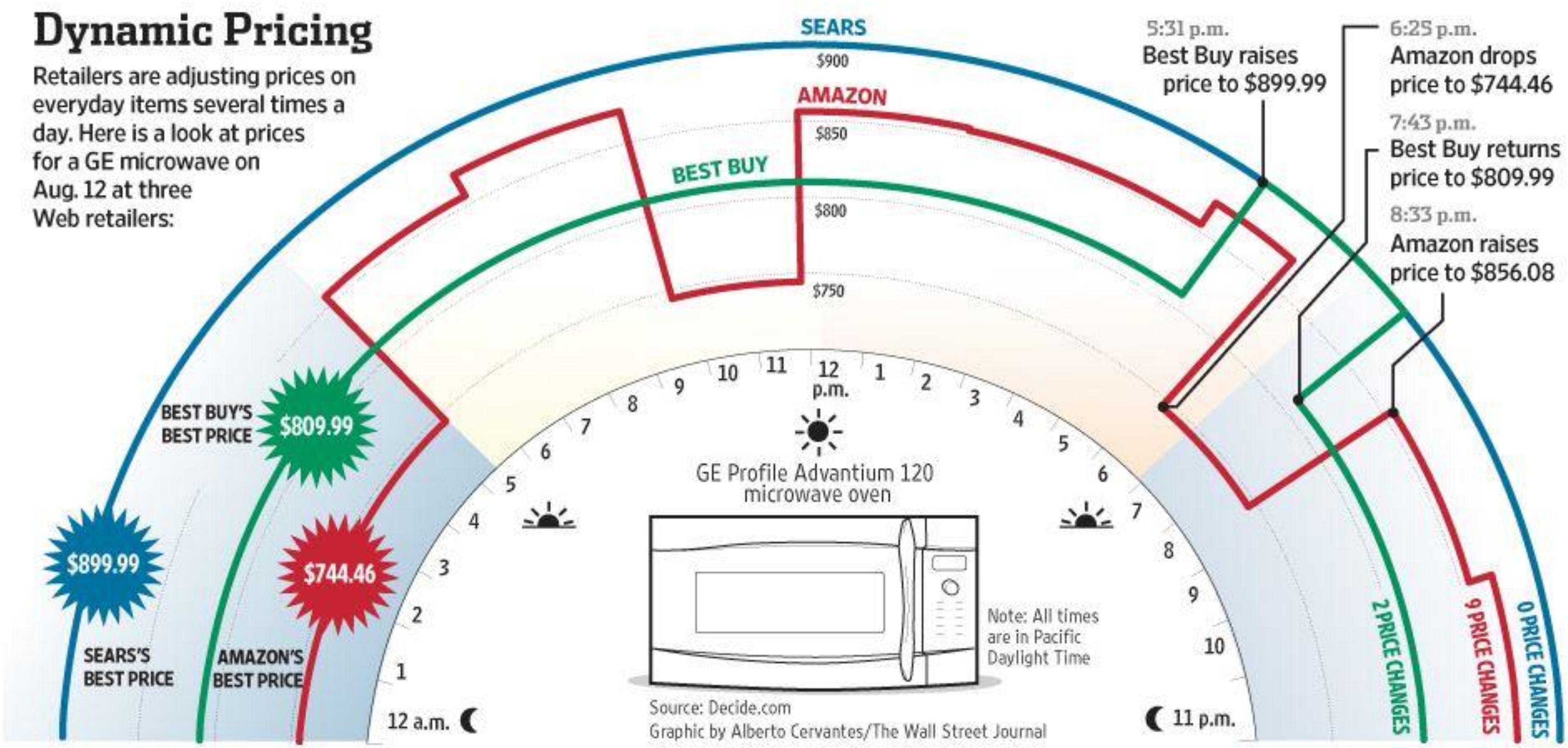
- Ethic considerations
  - Privacy, anti-discrimination, fairness

# Dynamic Pricing

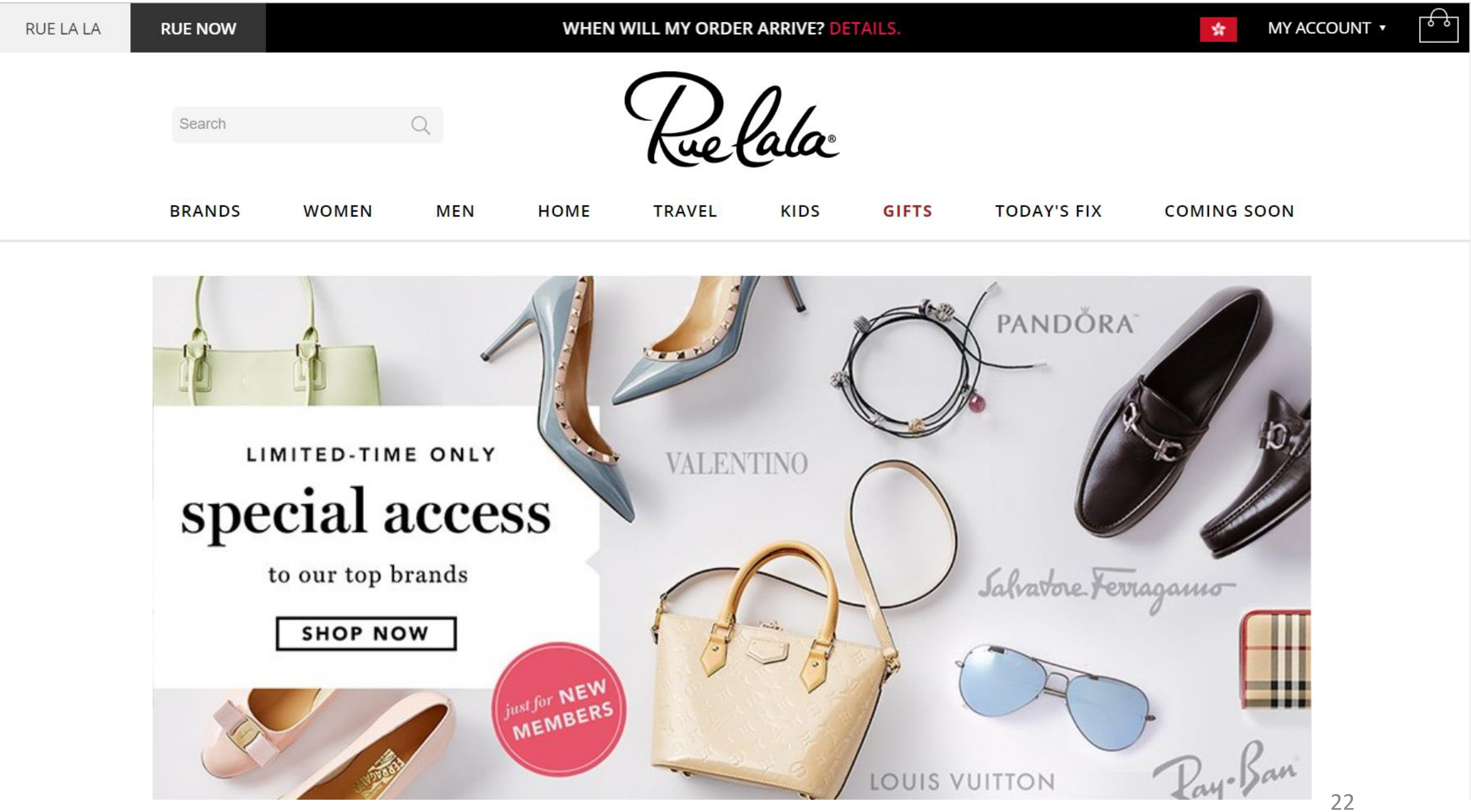
For a single product, set price dynamically *over time*, and set one price for all the customers.



# Dynamic Pricing

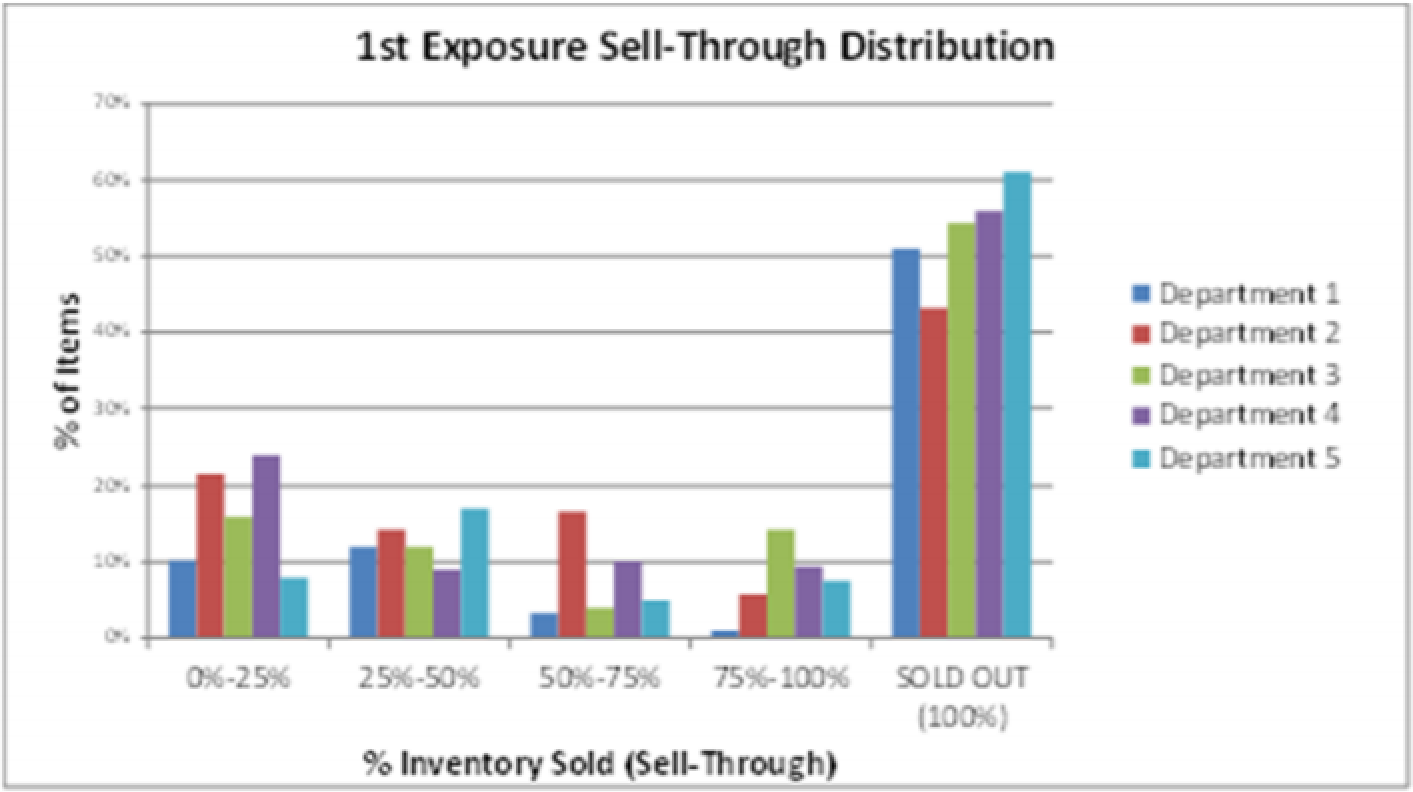


# Rue La La


RUE LA LA
RUE NOW
WHEN WILL MY ORDER ARRIVE? DETAILS.
MY ACCOUNT
Search
Rue lala
BRANDS
WOMEN
MEN
HOME
TRAVEL
KIDS
GIFTS
TODAY'S FIX
COMING SOON
LIMITED-TIME ONLY
special access
to our top brands
SHOP NOW
just for NEW MEMBERS
VALENTINO
PANDORA
Salvatore Ferragamo
LOUIS VUITTON
Ray-Ban

# Rue La La

- Price Optimization for first time offerings
  - Result: Overall 10% increase in total revenue



# Revenue management

- Price Control
  - Price customization
  - Dynamic pricing

- Capacity Control
  - Yield management
  - Service customization

# Reserving Capacity

- You manage a hotel with 200 rooms in Indianapolis, IN. The NCAA Championship Game is coming up. Sports fans either book a room in advance or wait until the last minute.
  - Advance booking: Bargain rate
  - Late booking: Premium rate
- Suppose you can easily get 200 advance reservations and fill up your hotel.
  - Should you fill up rooms with advance customers? Why?
  - How many rooms should be set aside for last-minute customers? What information do you need?

# The Classic Newsvendor Model

- A newsvendor stocks newspapers to sell that day
- Trade-offs:
  - If stocks too few newspapers, miss potential sales.
  - If stocks too many newspape[illegible] wasted on unsold newspapers.

*How many newspapers should be stocked?*

# The Classic Newsvendor Model

## Newsvendor Model

- A decision-making framework for Single period inventory decision.
- Uncertain Demand: Demand is random and follows a probability distribution.
- Perishable Inventory: Products are perishable or have a limited shelf life.
- Overage cost $c_o$(cost of ordering too much) versus Underage cost $c_u$ (cost of ordering too little).
- Objective: Determine the optimal order quantity to minimize expected cost.

## Solution

- Critical Ratio (CR): $C_u/(C_o + C_u)$
- Optimal order quantity Q* satisfies $P(Demand \leq Q^*) = CR$

# Reserving Capacity and Newsvendor

| **Room Reservation** | **Newsvendor Problem** |
|---|---|
| Hotel rooms are "perishable" | Newspapers are "perishable" |
| Random last-minute demand | Random newspaper demand |
| Decide how many rooms to reserve for last-minute customers | Decide how many newspapers to purchase |
| If reserve too few rooms, miss potential premium customers | If stock too few newspapers, miss potential sales |
| If reserve too many rooms, revenue lost on empty rooms | If stock too many newspapers, money wasted on unsold newspapers |

# Reserving Capacity

- Assume
  - Number of last-minute customers is normally distributed with mean 75 and st dev 25
  - Advance booking: $200/night
  - Late booking: $500/night
- How many rooms should be set aside for last-minute customers?

$C_u$ = $500 – $200 = $300

$C_o$ = $200

Critical ratio = 300 / (200+300) = 0.6 z = 0.25

Should reserve 82 rooms for last-minute customers (75+0.25*25 = 81.25, round up)

# Overbooking

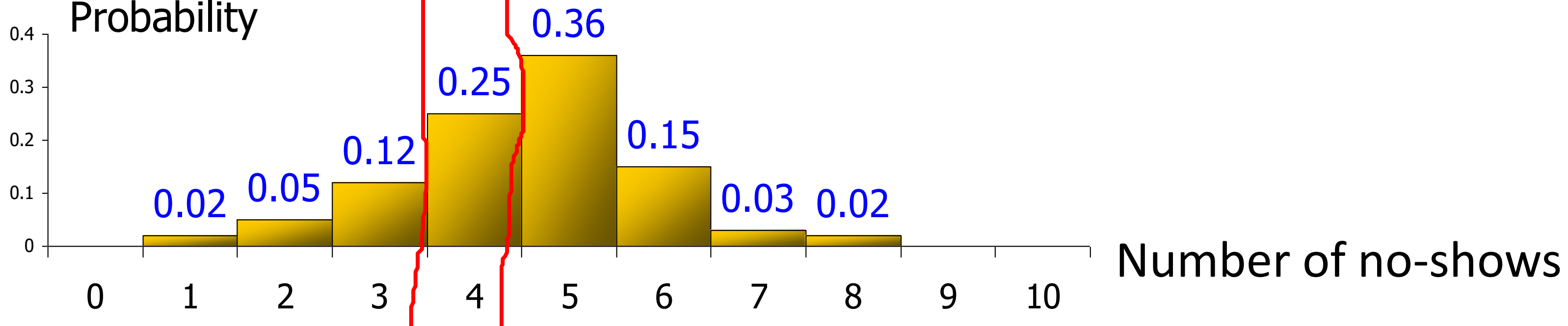
- Suppose you cannot charge latecomers a different rate because of a city ordinance that prohibits “price gouging” during the Final Four weekend
- You can easily get 200 reservations and fill up your hotel
- But you are afraid that some people with reservations may not show up
- How many reservations should you take?
  - More than 200?
  - How many more?
  - What information do you need?

# Overbooking and Newsvendor

| Overbooking | Newsvendor Problem |
|---|---|
| Overbooks are "perishable" | Newspapers are "perishable" |
| Random no-shows | Random newspaper demand |
| Decide how many overbooks | Decide how many newspapers to purchase |
| If too few overbooks, miss potential sales | If stock too few newspapers, miss potential sales |
| If too many overbooks, incur loss of good-will | If stock too many newspapers, money wasted on unsold newspapers |

# Overbooking

- Assume
  - The number of no-shows is distributed as follows:




- Room rate is $200 per night
- It costs the hotel $500 per night to book a room in a nearby hotel for an overbooked customer

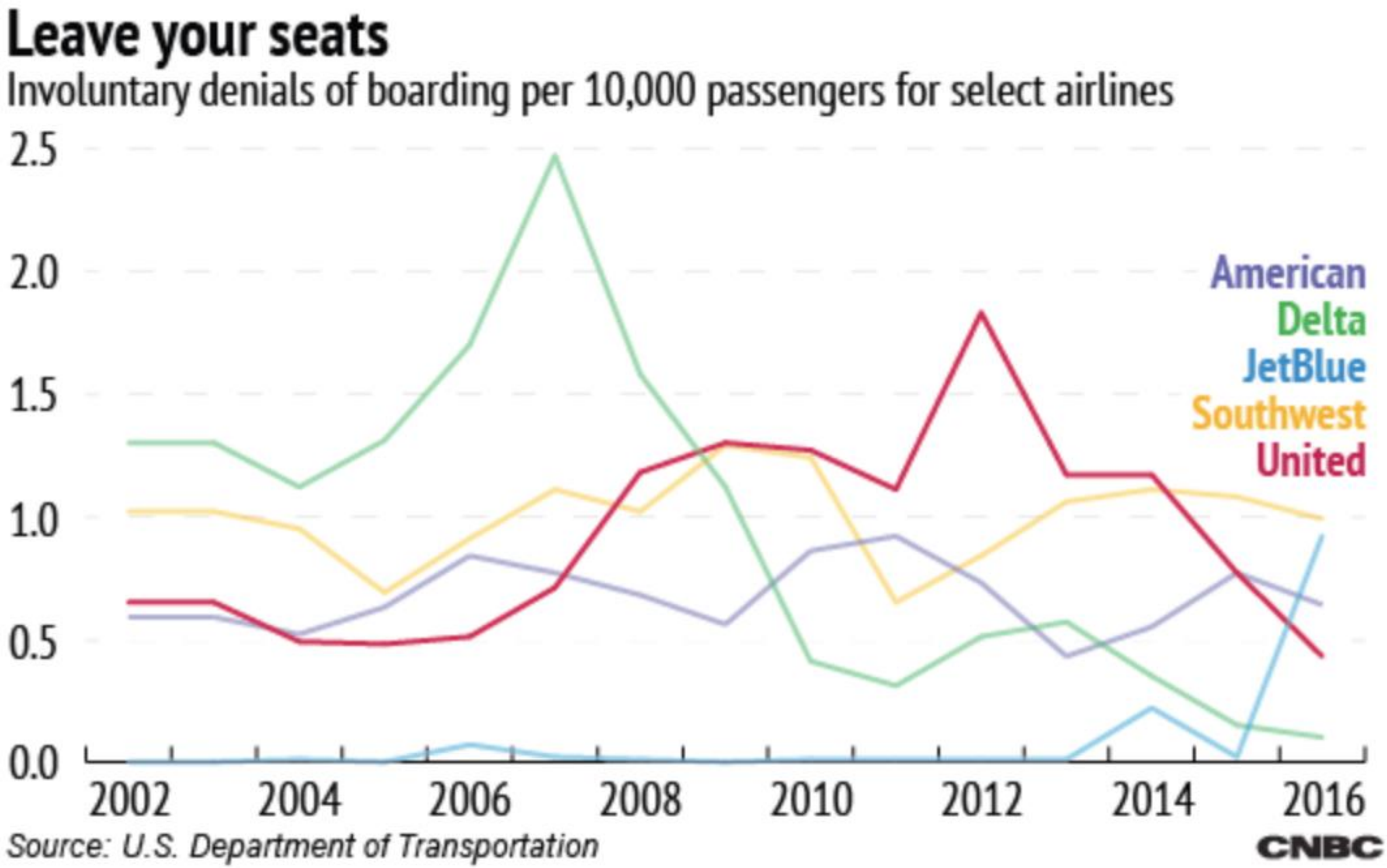
- How many overbooks should you take?

$C_u$ = __$200_____ $C_o$ = _500-$200=$300__

Critical ratio = 200 / (200+300) = 0.4

Should overbook 4 rooms

# Overbooking



# When Overbooking Goes Wrong… +++

Travel » Aviation | Business Traveller | Destinations | Features | Food/Drink | Hotels | Partner Hotels International Edition +

## Passenger dragged off overbooked United flight

By **Christina Zdanowicz** and **Emanuella Grinberg**, CNN

Updated 0658 GMT (1458 HKT) April 11, 2017

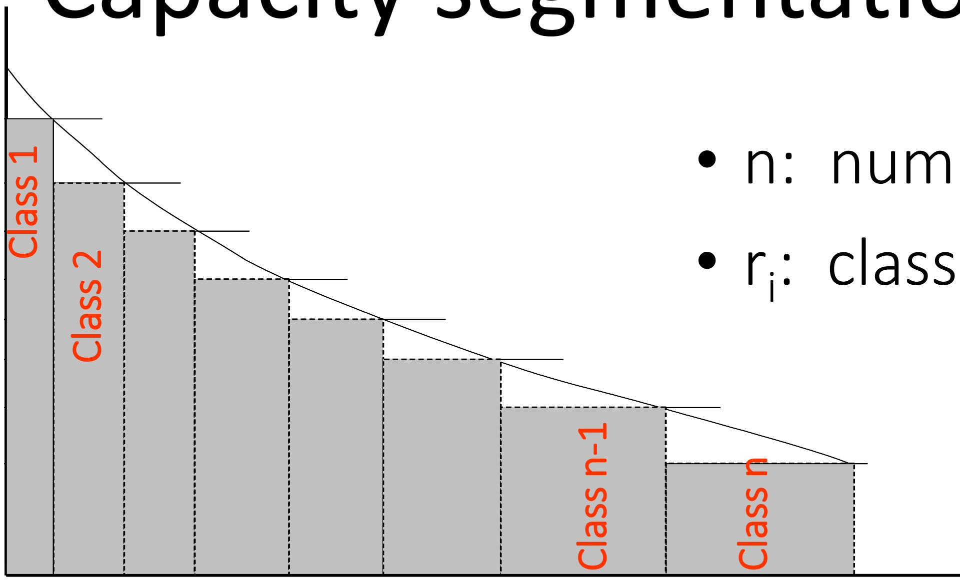
## EXAMPLE – FLIGHT UA3411

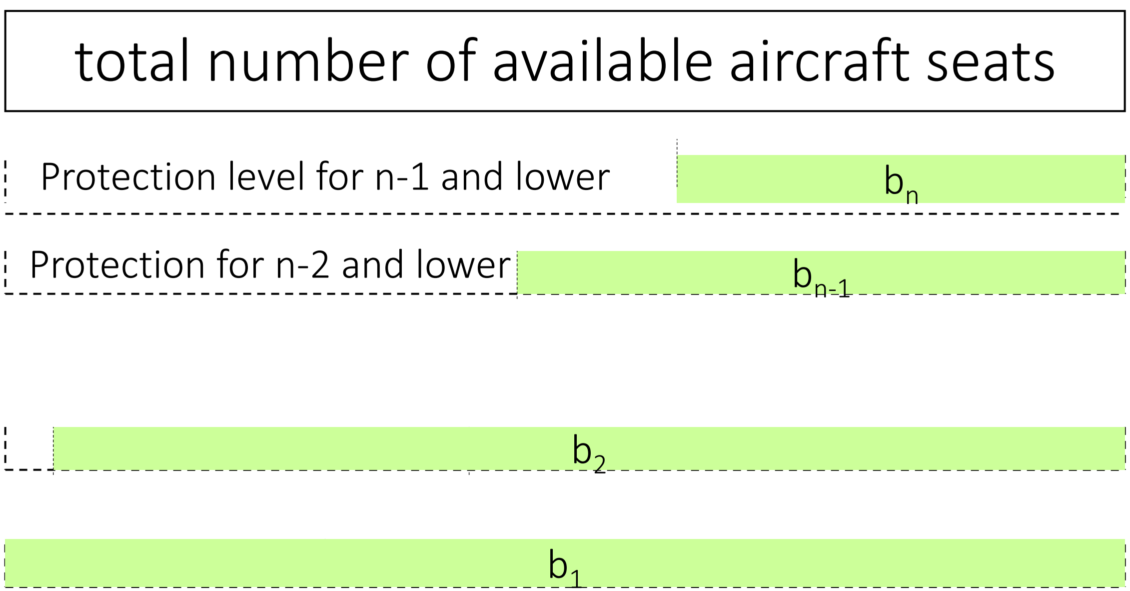
- April 9, 2017, UA3411 from Chicago O’Hare to Louisville
- The plane was full, and everyone had boarded
- 4 crew members needed to fly to Louisville to work on a flight departing later from Louisville
- United asked for 4 volunteers
- Not enough volunteered despite increased perks, so UA subsequently randomly picked a passenger to deboard
- The passenger refused and….
- Can this incident change how airlines approach overbooking?

# When Overbooking Goes Wrong…

# Capacity segmentation and allocation

- n: number of fare classes (n>2)
- $r_i$: class-i fare ($r_1 > r_2 > \ldots > r_n$)




*nested*

booking limits

These fares do not include government fees and taxes. More Fares → → → → End

| Flights | Departs | Arrives | Stops | Refundable Anytime $146 | Restricted Fares $133 | Advance Purchase $118 | Fun Fares $104 |
|---|---|---|---|---|---|---|---|
| 2510 | 6:40am | 8:45am | N/S | ○ | ○ | ○ | ○ |
| 593 | 10:40am | 12:45pm | N/S | ○ | ○ | ○ | ○ |
| 1577/2126 | 12:55pm | 4:00pm | RNO/1 | ○ | ○ | Unavailable | Unavailable |
| 1066 | 5:20pm | 7:25pm | N/S | ○ | ○ | ○ | ○ |

*6 days later*

These fares do not include government fees and taxes. More Fares → → → → → End

| Flights | Departs | Arrives | Stops | Refundable Anytime $146 | Restricted Fares $133 | Advance Purchase $118 | Fun Fares $104 | Internet One-way $69 |
|---|---|---|---|---|---|---|---|---|
| 2510 | 6:40am | 8:45am | N/S | ○ | ○ | ○ | ○ | ○ |
| 593 | 10:40am | 12:45pm | N/S | ○ | ○ | ○ | ○ | Unavailable |
| 1577/2126 | 12:55pm | 4:00pm | RNO/1 | ○ | ○ | Unavailable | Unavailable | Unavailable |
| 1066 | 5:20pm | 7:25pm | N/S | ○ | ○ | Unavailable | Unavailable | Unavailable |

*9 days later*

These fares do not include government fees and taxes. More Fares → → → → → End

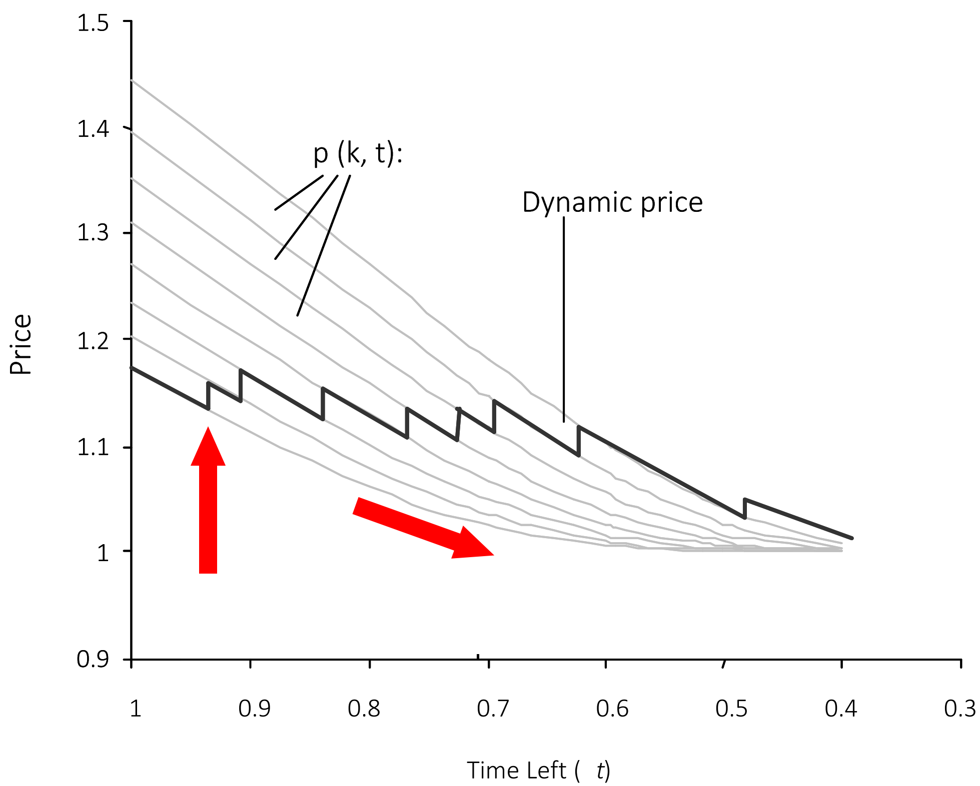
| Flights | Departs | Arrives | Stops | Refundable Anytime $146 | Restricted Fares $133 | Advance Purchase $118 | Fun Fares $104 | Internet One-way $69 |
|---|---|---|---|---|---|---|---|---|
| 2510 | 6:40am | 8:45am | N/S | ○ | ○ | ○ | ○ | ○ |
| 593 | 10:40am | 12:45pm | N/S | ○ | ○ | ○ | ○ | Unavailable |
| 1577/2126 | 12:55pm | 4:00pm | RNO/1 | ○ | Unavailable | Unavailable | Unavailable | Unavailable |
| 1066 | 5:20pm | 7:25pm | N/S | ○ | ○ | ○ | Unavailable | Unavailable |

*12 days later*

These fares do not include government fees and taxes. More Fares → → → → → End

| Flights | Departs | Arrives | Stops | Refundable Anytime $146 | Restricted Fares $133 | Advance Purchase $118 | Fun Fares $104 | Internet One-way $69 |
|---|---|---|---|---|---|---|---|---|
| 2510 | 6:40am | 8:45am | N/S | ○ | ○ | ○ | ○ | ○ |
| 593 | 10:40am | 12:45pm | N/S | ○ | ○ | ○ | ○ | Unavailable |
| 1577/2126 | 12:55pm | 4:00pm | RNO/1 | ○ | Unavailable | Unavailable | Unavailable | Unavailable |
| 1066 | 5:20pm | 7:25pm | N/S | ○ | ○ | Unavailable | Unavailable | Unavailable |

# Typical Pricing Curves




Three deciding factors:

- How many items are left, *k*
- How much time is left, *t*
- How demand will change

- **As the number of remaining items decreases, price increases** (price is higher if there are fewer items to sell)

- **As time goes by, price decreases** (price is higher if there is more time left to sell)

- **As demand increases / decreases, so does the price**

# So, Revenue Management...

+++

## DEMAND MANAGEMENT

- Segmentation
- Pricing

+

## NEW TRICKS

- Tactical applications of various concepts
- Systematic/disciplined approaches
- Data/IS-intensive nature

# Challenges?

**CHALLENGES**

**DATA** *source of demand information*

- Data collection
  MSBA7012 Social Media & Digital Marketing Analytics
- Forecasting
  MSBA7013 Forecasting and Predictive Analytics
- Real-time updates
  MSBA7021 Prescriptive Analytics

**ANALYTICAL MODELS**

- Capable of deciding *both* pricing and capacity
- Providing status updates
- Dynamic programming required

# Thank You

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# MSBA 7004
# Operations Analytics

## Second-half course recap

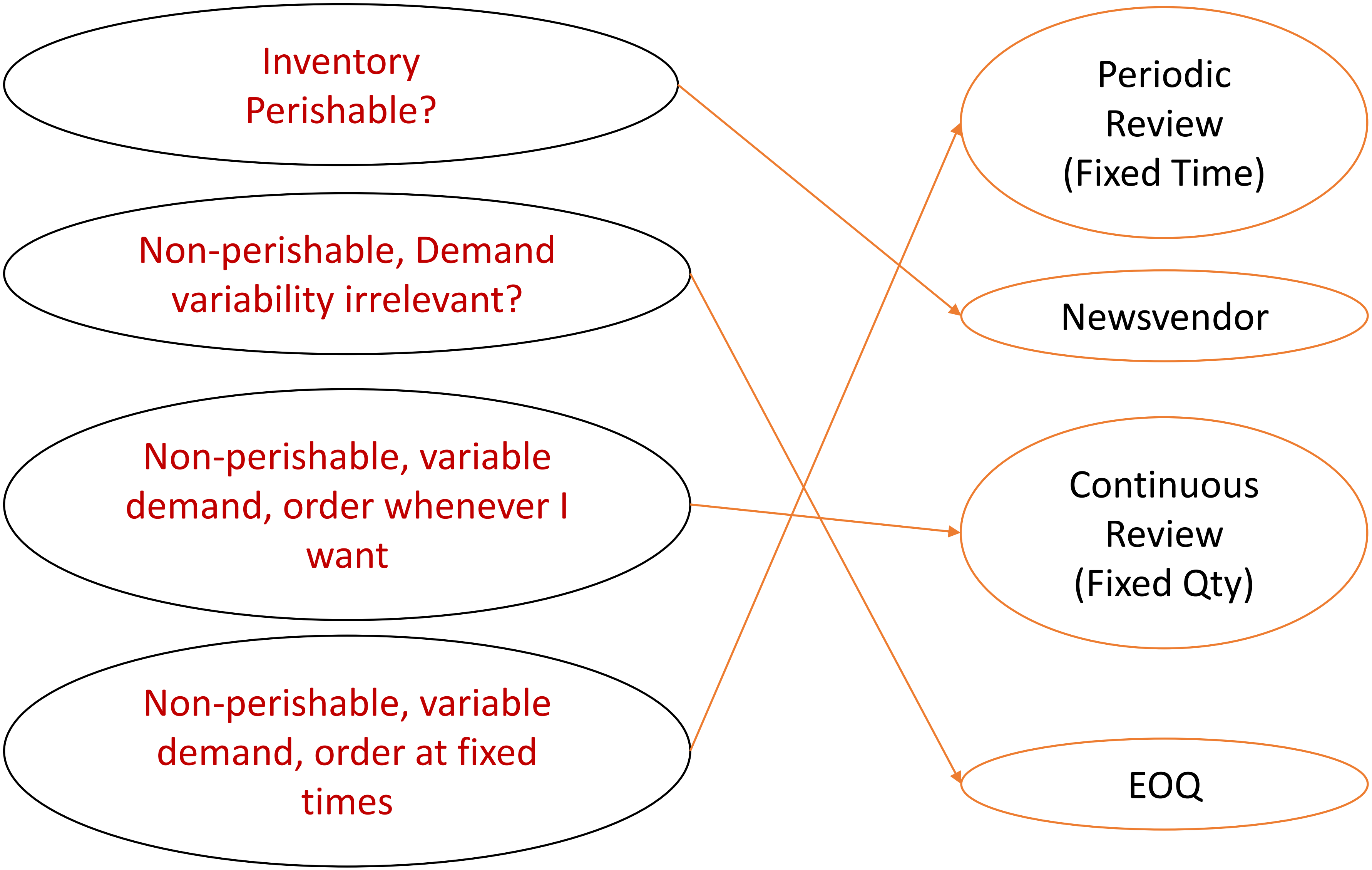
## 2023

# Management Options

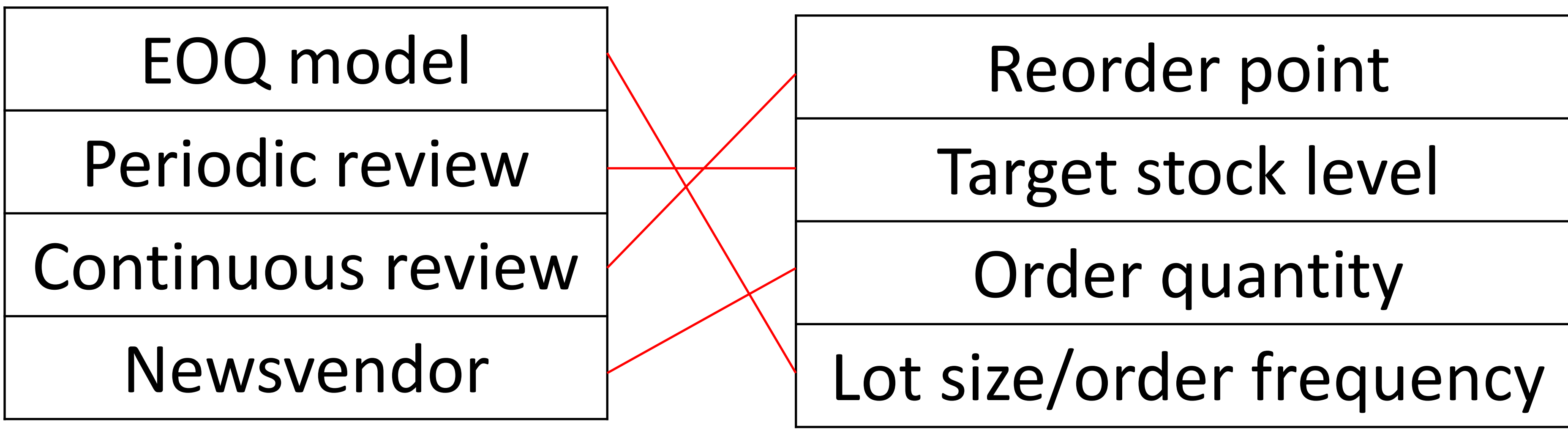
- Managing supply
  - Capacity management
    - Process (bottleneck) analysis
    - Queueing analysis
  - Inventory and supply chain management
  - Project management

- Managing demand
  - Revenue management

# Inventory management

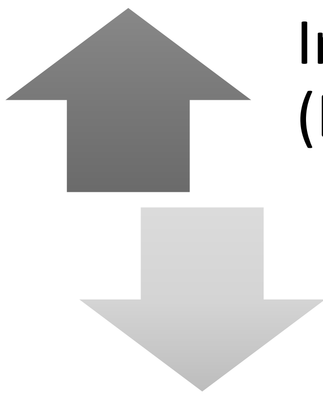


**Match** the inventory model with the decision.



# Economic Order Quantity (EOQ) Model

- How much to order each time?
- The Economic Order Quantity (EOQ) balances



Inventory ordering costs
(Economies of scale)

Inventory holding costs

- <u>Assumptions</u>
  - Known annual demand, constant demand rate
  - No uncertainty (in demand)

# True or False?

The motivation of the EOQ model is to match the demand with the right quantity of supply.

False.

EOQ model is to find the optimal order frequency, which makes a balance between minimizing holding cost and setup cost.

# Economic Order Quantity

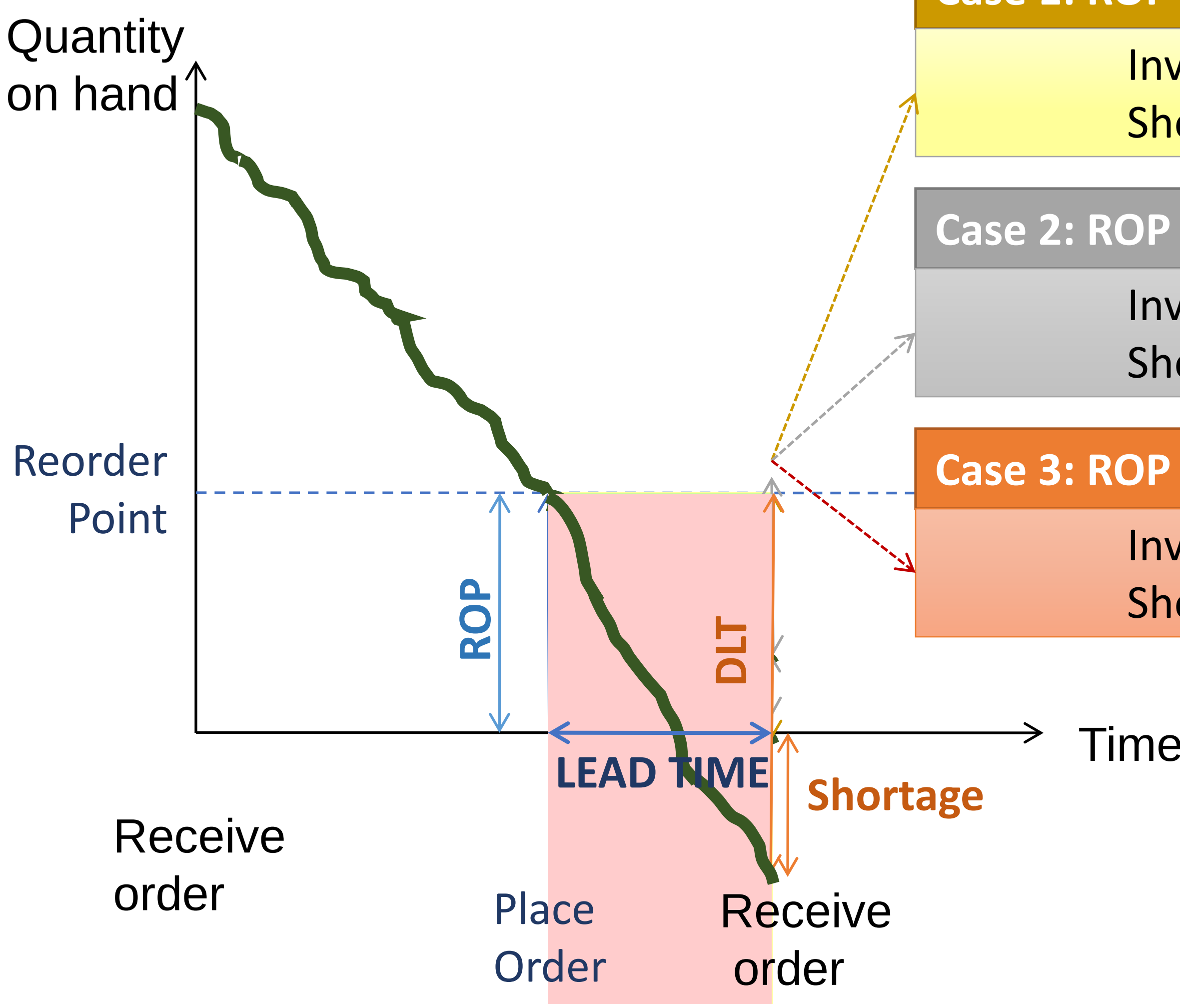
$$\text{Total Cost} = TC(Q) = \frac{Q}{2}H + \frac{D}{Q}S$$

| | |
|---|---|
| **D** | Annual Demand Rate |
| **S** | Order or Setup Cost |
| **H** | Annual Holding Cost |

$$Q_{OPT} = \sqrt{\frac{2SD}{H}}$$

$$TC_{OPT} = \sqrt{2SDH}$$

# Demand During Lead Time: Uncertain




**Case 1: ROP = DLT**

Inventory = 0
Shortage = 0

**Case 2: ROP > DLT**

Inventory = ROP – DLT
Shortage = 0

**Case 3: ROP < DLT**

Inventory = 0
Shortage = DLT - ROP

DLT = Demand during the Lead Time

# ROP and Normal Demand

Suppose weekly demand has a normal distribution: $N(m, \sigma^2)$

Suppose lead time is *k* weeks.

Then, DLT has normal distribution $N(m_{LT}, \sigma_{LT}{}^2)$
with mean $m_{LT} = k \cdot m$ and standard deviation $\sigma_{LT} = \sqrt{k} \cdot \sigma$

Given ROP, CSL is

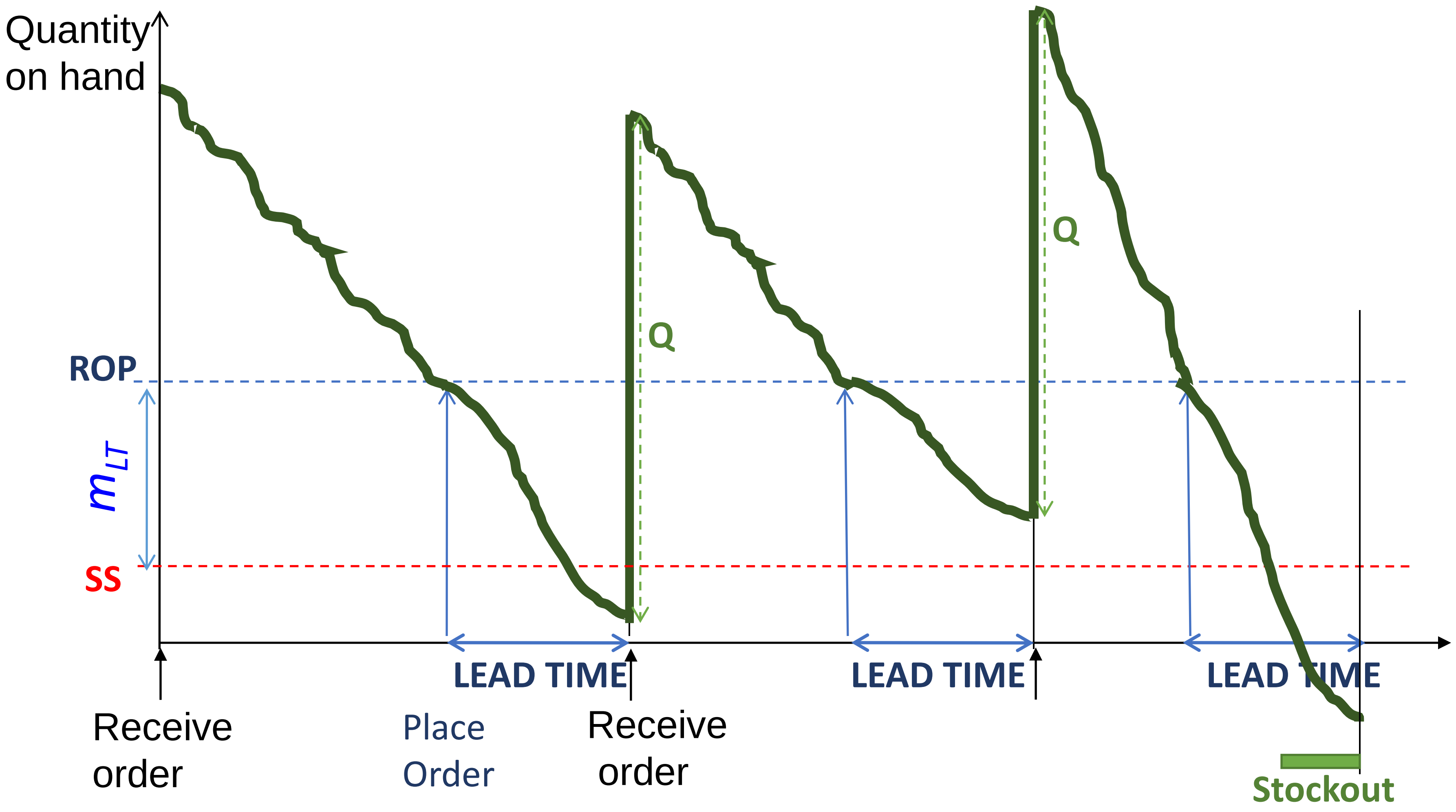
$$P[DLT \le ROP] = P[N(0,1) \le z] = normsdist\ (z)$$ where $z = \dfrac{ROP - m_{LT}}{\sigma_{LT}}$

Given CSL, *ROP* satisfying $\mathrm{CSL} = P[DLT \le \mathrm{ROP}]$ is

$\mathrm{ROP} = m_{LT} + z \cdot \sigma_{LT}$ where *z*=*normsinv*(CSL)

Safety Stock (SS)

# ROP and SS



Quantity on hand
ROP
$m_{LT}$
SS
Q
Q
LEAD TIME
LEAD TIME
LEAD TIME
Receive order
Place Order
Receive order
Stockout

# Average Inventory

| If the firm pays for inventory "in stock" | If the firm pays for inventory "in stock" and "on route" |
| --- | --- |
| Average Inventory = Q/2 + SS | Average Inventory = Q/2 + SS + $m_{LT}$<br>Pipeline Inventory |

↑ "Default" case in this course
(when there is no other explanation)

# Order Size for Fixed-Time-Period Model

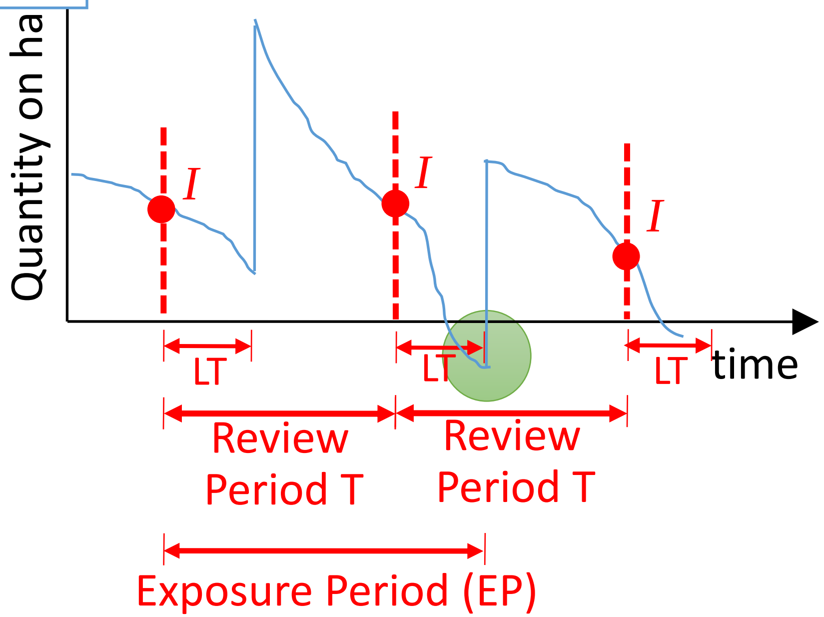
Assume Normal demand uncertainty

Given Cycle service level (CSL), we can find z = normsinv(CSL)

$\sigma_{LT+T}$ Standard deviation of demand during the **exposure period**

**Target Level or Target "Inventory Position"**
**= (LT + T) * D + $z\sigma_{LT+T}$**

**Order Quantity**
**= Target Level - I**




| | |
|---|---|
| **I** | Current inventory |
| **T** | Review Period (time between reviews) |
| **EP** | **Exposure Period** (= LT+T) |

# Practice problems

1. Kristen believes they are currently holding too much inventory for some ingredients, and she decides to optimize the inventory policy for whole wheat flour first using what she just learned from the Operations Analytics course. Kristen and her roommate bake cookies 7 days a week all year round. They get deliveries of flour from Flour Foods Co. each Friday and pay for the food upon delivery. They must place orders on Monday to ensure the Friday delivery (i.e., order lead time is 4 days). Kristen has observed that weekly demand for whole wheat flour is normally distributed with a mean of 66 lbs and a standard deviation of 6.6 lbs. Because she is a regular customer, Flour Foods Co. waives delivery charges. However, each package of flour is 10 lbs (i.e., order size must be multiples of 10 lbs).

   - Suppose that on Monday, Oct 18, Kristen checked her whole wheat flour inventory and found that she had 83 lbs in stock. How much whole wheat flour should she order to maintain a 99% service level?

$D = 66$ lbs. per week

$\sigma = 6.6$ lbs. for weekly demand

$SL = 99\%$

$T = 1$ week

$LT = \frac{4}{7}$ week

$Iventory = 83$ lbs.

Thus:

$z = normsinv(SL) = 2.33$

$\sigma_{LT+T} = \sqrt{LT + T} \cdot \sigma = 8.27$

Target: $(LT + T) \cdot D + z\sigma_{LT+T} = 122.96$

Order Quantity: $Target - Inventory = 39.96$ lbs.

Therefore, Kristen should order 4 packages of flour to maintain a 99% service level.

# Practice Problems

2. Kristen also orders paper take-out bags with her logo printed on them. Daily demand for take-out bags is normally distributed with a mean of 50 bags and a standard deviation of 20 bags. Kristen places a new order for bags whenever she is running low. Kristen's printer (company) charges her \$15 per order for print setup independent of order size. Bags are printed in batches of 100, and priced at \$5 per batch (i.e., 5 cents each bag). It takes 5 days for an order to be printed and delivered. The only holding cost is the opportunity cost of capital, which is estimated to be 30% per year. Assume 360 days per year.

a) What is the optimal order quantity per order for Kristen?
b) On average, how often does Kristen need to order take-out bags? That is, if Kristen places an order once every X days, what is X?
c) If Kristen wants to make sure the bags do not run out with 99% probability during the order lead time, what is her optimal reorder point?

a.

$D = 0.5 \times 360$ batches per year

$S = \$15$

$C = \$5$

$I = 30\%$

Hence, $Q_{OPT} = \sqrt{\frac{2SD}{I \cdot C}} = 40$ batches.

b.

$X = \frac{Q}{D} = 80$ days

c.

$SL = 99\%$

$k = 5$ days

Average daily demand $m = 0.5$ batches

$\sigma = 0.2$ batches for daily demand

$m_{LT} = km = 2.5$ batches

$\sigma_{LT} = \sqrt{k} \cdot \sigma = 0.45$

$z = normsinv(SL) = 2.33$

Hence, to maintain a 99% service level, $ROP = m_{LT} + z\sigma_{LT} = 3.54$ batches.

# How much inventory should you hold?

- Trade-off #1: How much to order each time?

Inventory ordering costs (Economies of scale)

Inventory holding costs

Economic Order Quantity (EOQ) Model

- Trade-off #2: How much to hold each time?

Cost of running out

Cost of having excess inventory

Newsvendor Model

# What is the Best Service Level (SL*) ?

- Trade-off:

| | Inventory Holding Cost<br>(Overage Cost) | Loss of Revenue & Goodwill<br>(Underage Cost) |
|---|---|---|
| High<br>Service Level | High | Low |
| Low<br>Service Level | Low | High |

# How to Interpret $C_u$ and $C_o$?

$C_u$, $C_o$ are the unit opportunity costs.

You should compute $C_u$:

Suppose the actual demand D is larger than my current stock S. If I could return to the past and order one unit more, then it increases my profit (or reduces my cost) by $C_u$.

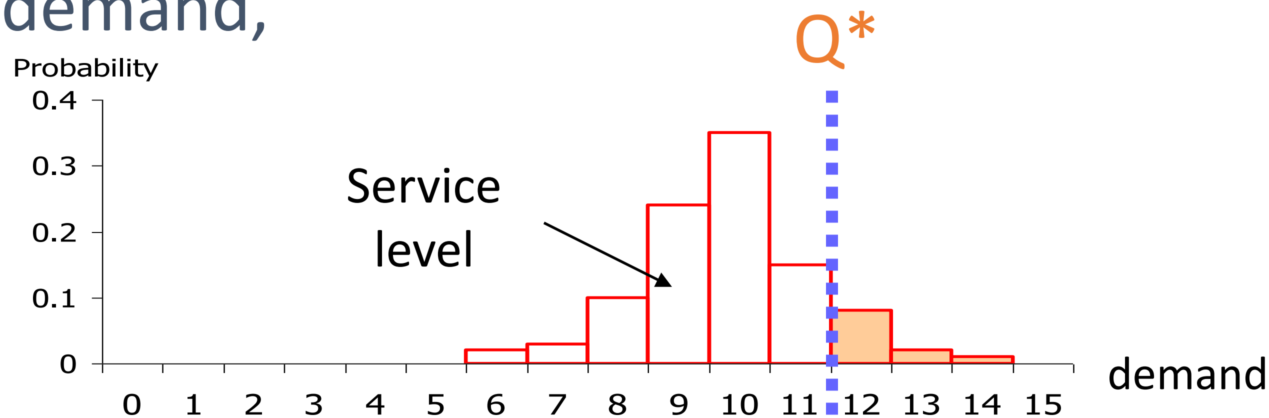
You should compute $C_o$:

Suppose the actual demand D is smaller than my current stock S. I could return to the past and order one unit less, then it increases my profit (or reduces my cost) by $C_o$.

# Newsvendor logic

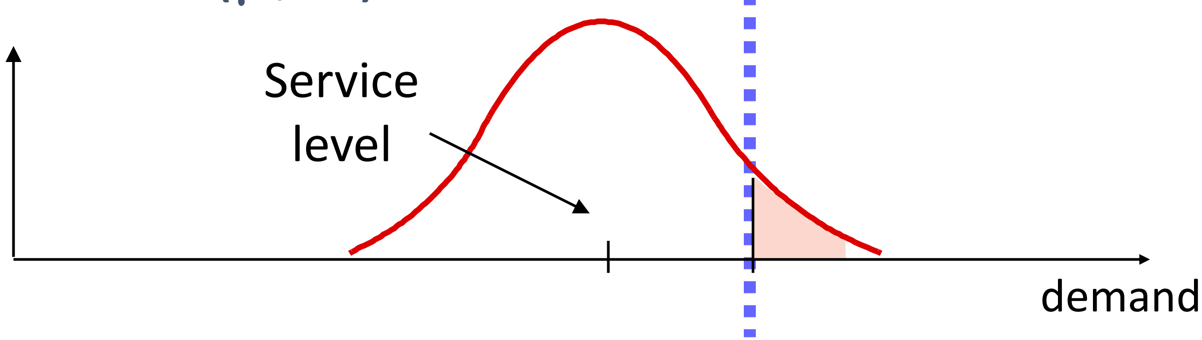
- With discrete demand,

$Q^*$ = smallest quantity such that $SL \geq C_u / (C_u+C_o)$




- With normal demand $N(\mu, \sigma)$

$Q^*$ = the quantity such that $SL = C_u / (C_u+C_o)$




Step 1: find z, $z = \text{NORMSINV}(C_u / (C_u+C_o))$, or use z table

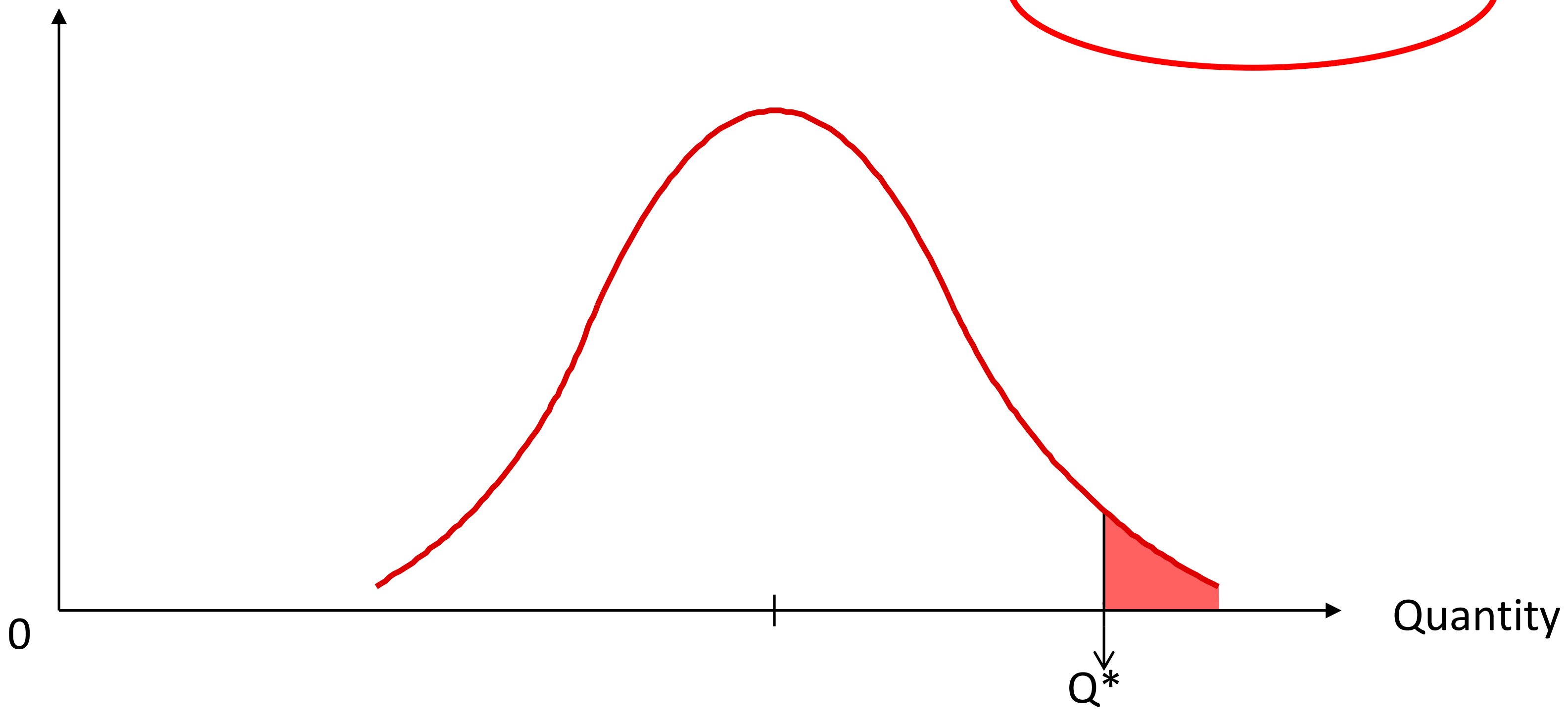
Step 2: compute $Q^*$, $Q^* = \mu + z\,\sigma$

In the newsvendor problem, suppose the demand distribution and the optimal stocking level Q* are as shown. How do you think $C_u$ and $C_o$ compare?

(a) $C_u < C_o$

(b) $C_u = C_o$

(c) $C_u > C_o$



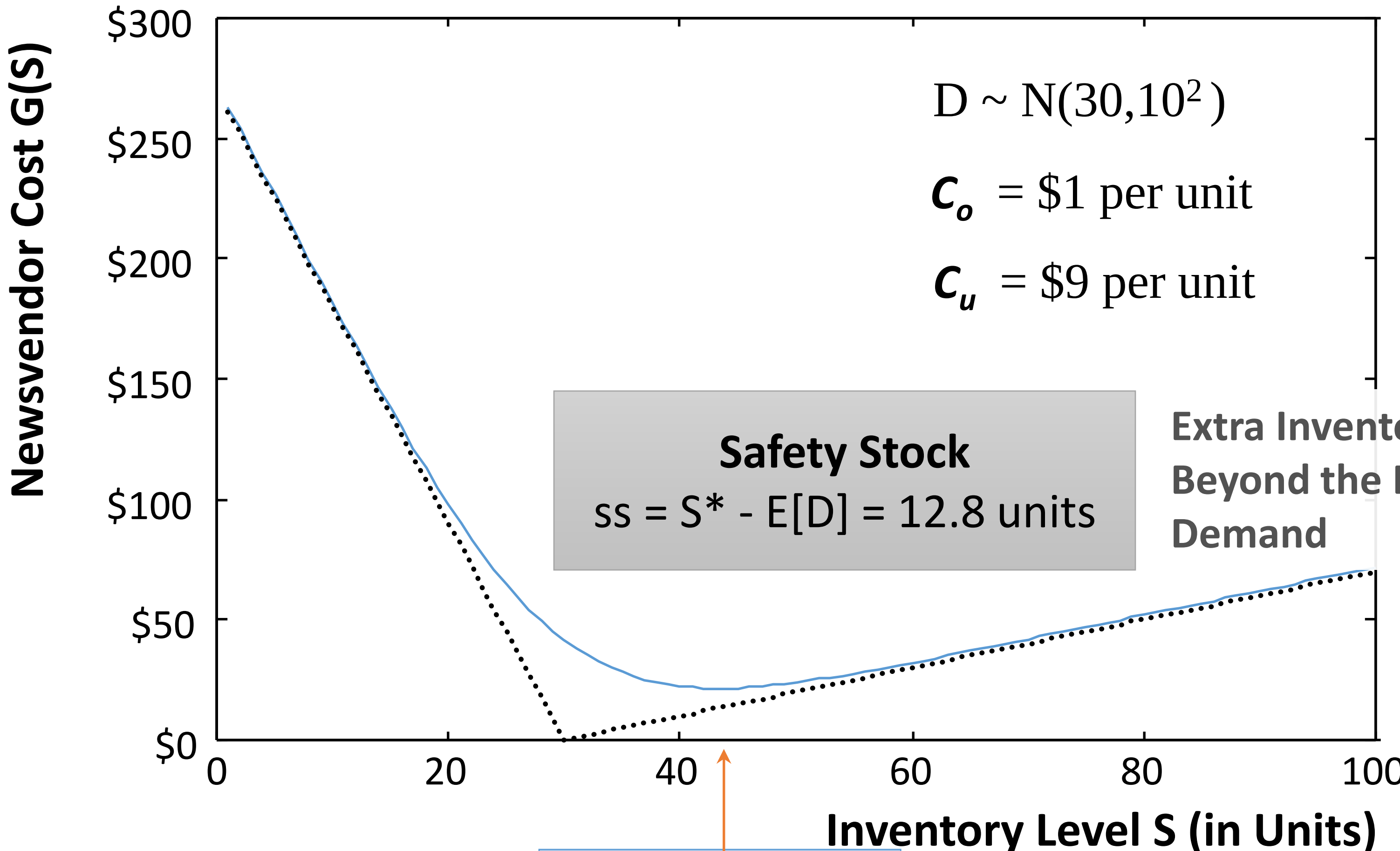
# Example 1: Newsvendor Model with Normal Demand

- For the academic year 2020-2021, demand for HKU T-shirts is normally distributed with mean 1000 and standard deviation 200.
- Cost of shirts is $10.
- Selling price is $15.
- Unsold shirts can be sold off at $8 in the summer of 2021.
- How many shirts should the HKU bookstore buy for the 2020-2021 academic year?

| Mean demand | 1000 |
|---|---|
| STD of demand | 200 |

| | |
|---|---|
| $C_o$ | |
| $C_u$ | |

# Example 2: Newsvendor Model with Normal Demand




$D \sim N(30, 10^2)$

$c_o$ = \$1 per unit

$c_u$ = \$9 per unit

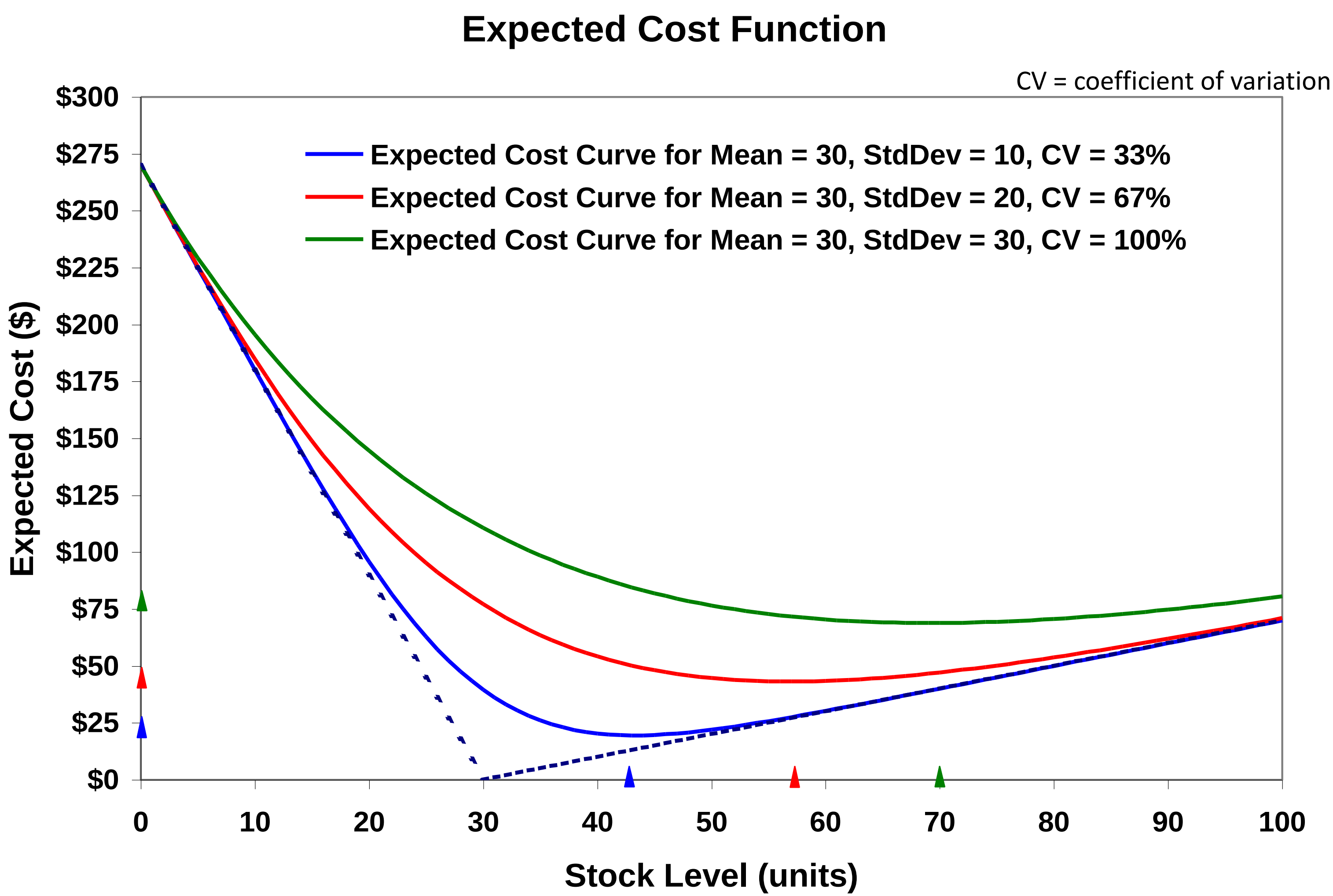
**Safety Stock**

ss = S* - E[D] = 12.8 units

**Extra Inventory Beyond the Expected Demand**

**S* = 42.8 units**

# Impact of Demand Variability



# Supply chain management

- Bullwhip effect
  - causes and ways to reduce the effect

- Supply chain coordination via contracts
  - Profit-sharing contract
  - Buyback contract

# Revenue management

Managing demand:

- Price-based RM
- Capacity-based RM

Applying newsvendor logic to:

- Reserving capacity
- Overbooking

## Traditional OM

- Production planning and scheduling
- Inventory management
- Warehouse & transportation

## Modern OM

- Today OM studies many kinds of business processes.
- OM concerns both *manufacturing* and *service* industries.


organising
manufacture
economies of scale
lean production
organise
effective utilization of resources
delivery
functioning
delegation of an entire operation ex warehouse functionings
infrastructure
resources
organizing
admin , resources , finance , hr , delivery
solving
customer service
organisation
effective
policies
function
continuous improvement
day to day
database management
customer
daily operations
organized
production
supply chain
coordination
customer satisfaction
tqm
company core
cost effective
functionality
controlling activities
results
bottlenecks
order
business
facility layout
lean management
manufacturing,
managing the process
product
operate
leadership
functional
daily working
convenience
co-ordination
people
accuracy
forecasting
plan
oee
processes
operations
kpi
execution
control
structure
best practices
manage
sop
bank
opex
cost
sales
continuity
foresight
discipline
ongoing
review
target
company
activities
decision making
organization
business management
efficiency, planning, strategy
process
accommodation
time
big business
facilities
network task
drive manufacturing readiness
drive
organize
quality
actions
management
healthcare
chain
action
flow
hr
efficiency
communication
value
inventory management
ahmad
decisions
effect output
integration
inventory
profit
t
activity
accountability
details
maintenance
growth
deliverables
administration
planning
lean
customers
lean six sigma
manager
cloud
capacity
efficient
productivity
sale
finance
automation
logistics
effectiveness
man power
controlling
day to day operations
connectivity
issue
team
manufacturing
operation
optimization
projects
manpower
fullfillment
factory
activity management
managing
overview
safety
orchestration
metrics
implementation
day to day activities
service
organised
seamless
lean manufacturing
improvement
designing and controlling the production process and business operations
operational excellence
labour productivity
operation management
supply

# Final Exam

- Time: Nov 29 10 AM-1PM
- Office Hours:
  - Prof Tian: Monday  office hour on syllabus
  - Prof Ouyang: Monday 4 – 5pm
  - By appointment
- A4 Formula sheet, one page, double sided, printed or handwritten.
- Good luck!