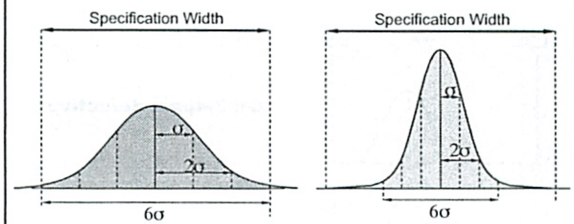
4/26

Announcements

1. Retailer game material is posted, report due Monday, May 3
2. This week recitations + office hours: How to operate the retailer game
3. Last assignment is Due last class (simulation report)

Process Capability



$c_p = \dfrac{\text{Specification Width}}{\text{Process Width } \boxed{6\sigma}} = 1$ $\qquad$ $c_p = \dfrac{\text{Specification Width}}{\text{Process Width } \boxed{6\sigma}} = 2$

Sigma Measure = 3 x Capability

T chart is 3σ
– since 6σ is 6 on each side

Why 6σ?

99% Good (3.8 Sigma)		99.99966% Good (6 Sigma)
20,000 lost articles of mail per hour	→	Seven articles lost per hour
Unsafe drinking water for almost 15 minutes each day	→	One unsafe minute every seven months
5,000 incorrect surgical operations per week	→	1.7 incorrect operations per week
Two short or long landings at most major airports each day	→	One short or long landing every five years
200,000 wrong drug prescriptions each year	→	68 wrong prescriptions per year
No electricity for almost seven hours each month	→	One hour without electricity every 34 years

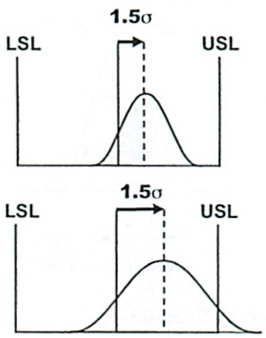
6σ and Dependent Components

- Consider a product made of 100 components
- Assume a defect rate of 1% on each component
- The defect rate on the product is:

(3.8σ) $P(\text{defect}) = 1 - (0.99)^{100} = 63\%$!

(6σ) $P(\text{defect}) = 1 - (0.9999996)^{100} = 3.4\text{ppm}$!

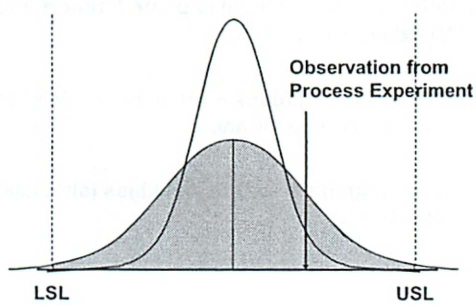
Robustness To Process Shift



6σ: 3.4ppm defective

3σ: 7% defective

Learning Rate/Continuous Improvement



Why 6σ?

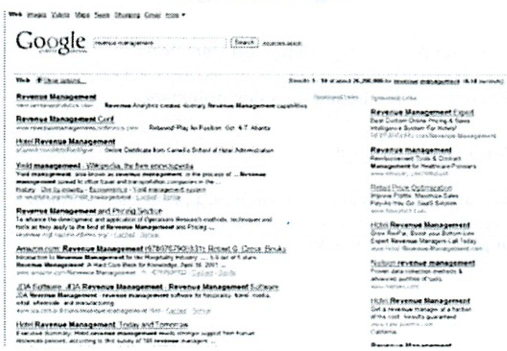
- Large Volume or Costly Defects
- Connected Components
- Robustness to Process Shift
- Tolerance Buildup
- Easier to Learn Process Improvements

Break.Com

- Supply chain in the online advertising industry. What is Break.com's value proposition ?
- What challenges does Break.com face in managing its display advertising contracts?
- How should Break.com price contracts with different customers?
- Challenges and risks associated with revenue management in the online display advertising industry

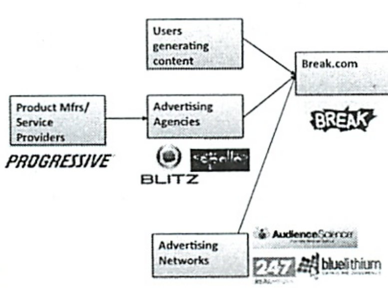
* Some of the slides were adapted from Professor Guillaume Roels

Search Ads



Display Ads

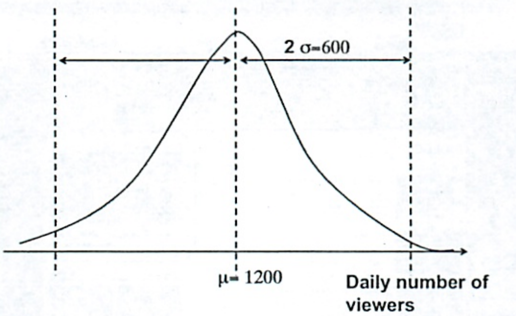
Break.Com's Supply/Value Chain



Display Contract Management

How many contracts to accept?

Stochastic Supply



Contracting/Pricing Practices

- Contract Acceptance/Rejection Decisions:

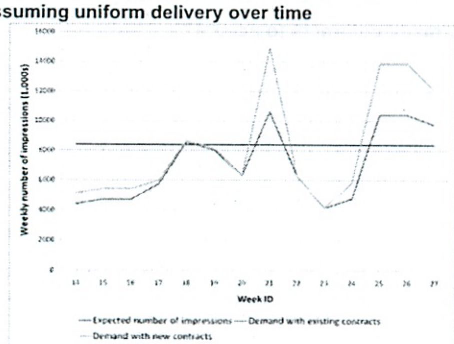
  Price threshold based on sales objective

- Ad Delivery Method:

  Uniform Ad Delivery over Time (e.g., request 2 million impressions over 4 weeks → deliver .5 million impressions per week)

Supply and Demand

Assuming uniform delivery over time



Improvement Opportunities

Challenges and Tradeoffs

- Short-Term Revenue vs. Long-Term Brand Dilution
  - Customers' Perspective

    "Punch-the-monkey" ads on ESPN.com

    "There are literally ads everywhere, ... I do not go to ESPN.com anymore." (http://www.somerandomdude.net/blog/opinion/sorry-state-of-online-advertising/, January 2007)
  - Advertisers' Perspective

    Under-delivery penalty?

    Uniform allocation?

Challenges and Opportunities

- Transparency

  In August 2000, Amazon was discovered to charge higher prices to its most loyal customers

- Behavioral Marketing and Privacy Issues

Break.com - Wrap-Up

- Matching supply and demand in the face of stochastic supply
- Pricing should account for opportunity cost
- Short-term revenue maximization vs. long-term customer loyalty; importance of aligning operational and business decision with long-term strategy

Retailer game this weekend
- Report due Tue
- markups + RM

← not that involved

Sim report due last class

Now shift to customer-side
- revenue management, etc

6σ

Collect data

Make random dist

$\cancel{\sigma = \frac{\text{capability}}{3}}$

Concentrate errors
- reduce var

Have less defects

Goal is less defects

$$\text{capability} = \frac{\text{spec width}}{\text{process width of } 6\sigma}$$

$\sigma = 3 \cdot \text{capability}$

(2)

Control vs capability

much
same
consistant

to spec

$\uparrow \sigma$ means # errors decrease greatly (exponentially)
multiple

$3\sigma = 99\%$
$6\sigma = 99.99966\%$ big impact

Especially w/ lots of components (100)

P(defect in entire product)

$= 1-(.99)^{100} = 27\%$

$= 1-(.9999966)^{100} = 3.4$ parts per million

Also ~~change~~ when in control - more wiggle room in spec width

Easier to see assignable causes
~~Larger~~
Also changes company culture

(3) Companies have lots of cost

Depends on industry

Don't have to do 6σ, could do 5.5σ

7σ

6σ means 6σ on each side of mean

Break.com

- online advertising
- search and display
- (I don't think Prof Fully gets this)
  (coming from ops perspective)
- kinda like supply chain
  - value chain
- Break.com actively currates
  - focused
- allows sware words
- buy videos from users

Contracts on # of impressions

9

Network effect

What contracts should it make?

Uncertanity if underdeliver ~~ad~~ viewers promised

Exclusive details

Page Views are inventory

Ad network if have not sold that inventory is random

~~Clan~~ Game / Example

- Just home page
- ~~$~~ 6.50 = CPM
- Under delivery = 10% = .65

  ~~Amt less that ad networks~~
  loss of goodwill
- over delivery & cost for not selling = 6.5 - .3 = 6.2

  .3: revenue from ad network

  6.2: lost revenue

5

Newsvendor

crit ix $\dfrac{6.2}{6.2+.6} = .91$

So $k = 1.35$ from table

Quarter $\sim N(13 \cdot 7 \cdot 1200, \sqrt{13 \cdot 7} \cdot \cancel{1200}\ 300)$

$\mu_{quarter}$ $\sigma_{quarter}$

$Q^* = \mu_{quarter} + 1.35\, \sigma_{quarter}$

ads to sell

daily mean is 1200

σ 300

Factor in growth

Sub target audience

linear programming from DND

Can't take CPM as given also

(6)

Their policy

- price threshhold based on sales objectives
  - can sell any price above this
  - can target pitch towards this
- Spread ads in uniformed way
  - So can calculate per week

Challenges in Industry

Short term revenue vs long-term ~~brad~~ brand dilution

~~Many~~ - many cos failed in begining

- Google shows this

Tracking / understanding user behavior

Transparency

Newspapers dying out?

Unbundeling

Differentiate

Subscription to track

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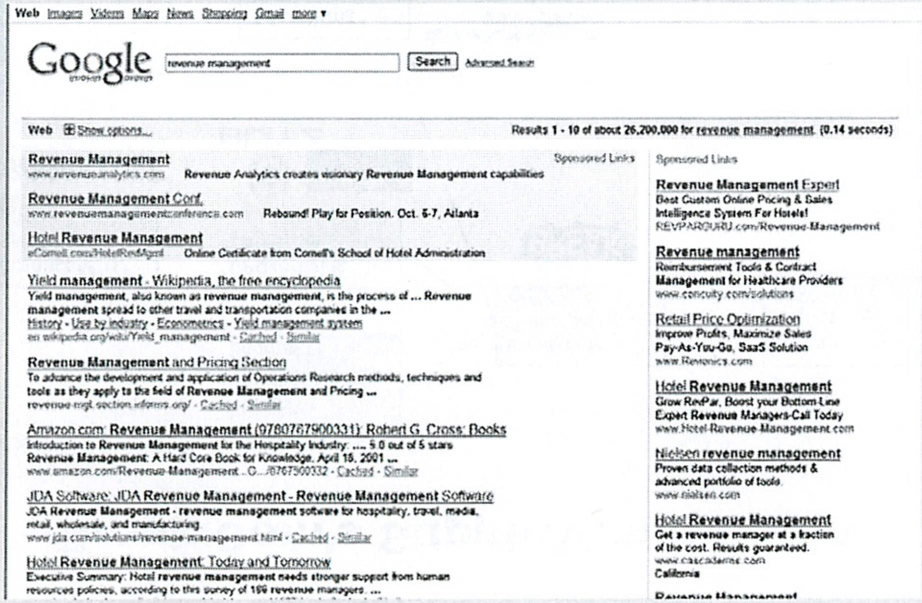

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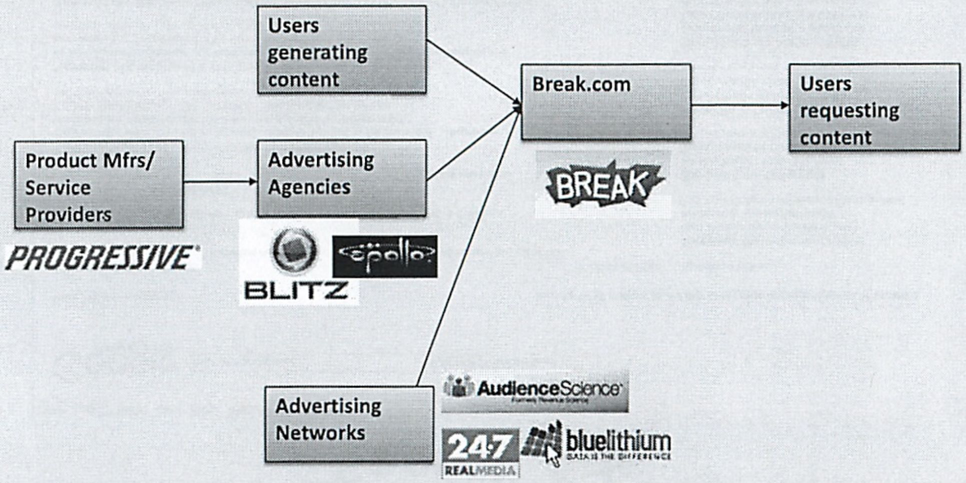

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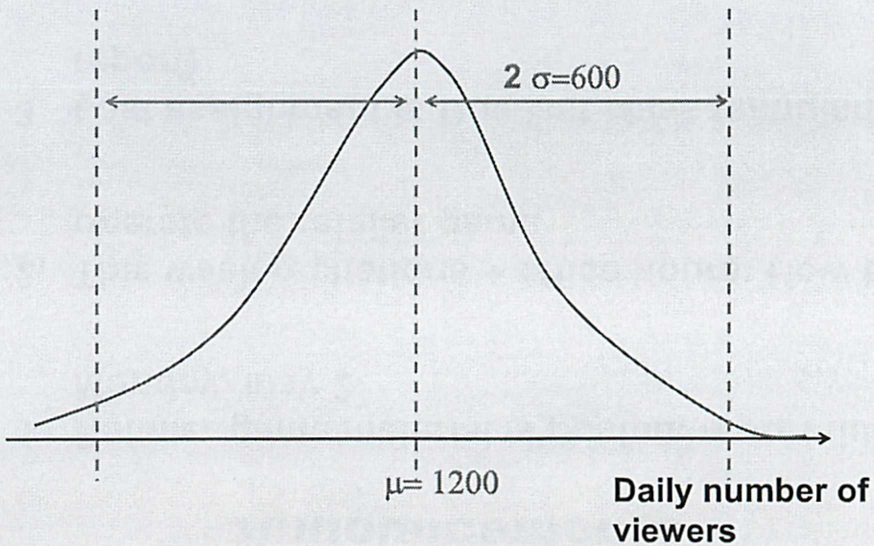

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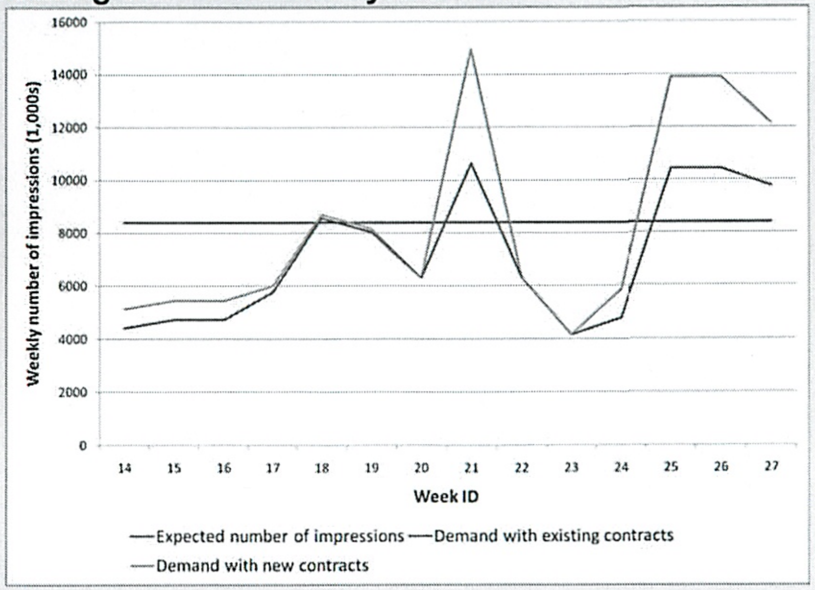

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    "ESPN has decided to shun lower priced and sometimes questionably relevant network advertising" (March 2008, http://www.webguild.org/2008/03/espn-shuns-cheap-ads.php)
  - Advertisers' Perspective

    Under-delivery penalty?

    Uniform allocation?

Challenges and Opportunities

- Transparency

  In August 2000, Amazon was discovered to charge higher prices to its most loyal customers

  [Comments on DVDTalk.com]

  "Amazon is over in my book"

  "I will never buy another thing from those guys!"

  "Amazon is suck." (sic)

  "This was a pure and simple test. This was not dynamic pricing. We don't do that and have no plans ever to do that." (Bill Curry, Amazon spokesman)
- Behavioral Marketing and Privacy Issues

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15.761

4/28

Retailer game up
Seed fri
due Tue report

Coordination to ↓ Risk

- sharing revenue
- risk

Case: Blockbuster vs Video Valt

Ind Store	Blockbuster
- personal exp	- inexperienced
- family-owned	- new releases
- classic	- DVD
- VHS	- more inventory
- more stockouts	- sell other stuff
- buy inventory	- revenue share

- loyalty w/ cards
- can both exist?

(2)

(people don't really understand their biz models!)
"Netflix has 1 big dist center for pooling

Netflix: you pay + never watch

Other parts of the world

Question is how much to order

- Newsvendor for Ind store
- Assuming 3 month life span, can rent 1x/day
- unit price $40
- rental fee $4/day
- Salvage vale $6

- Find MR vs MC breakpoint
  for the q-th copy

$$12 \text{ weeks} \cdot 7 \text{ days} \cdot \$4/\text{day} \cdot P(D \geq q) \geq 40 - 6$$

only if demand
is higher than
q ordered

I don't need to divide by day — total cost

③

$$P(D \geq q) = \frac{40-6}{(12 \cdot 7 \cdot 4) + (40-6)}$$

↑ choose where MR = MC

↑ note its $1 - P(D \leq q)$

$$1 - \frac{336}{34 + 336}$$

---- (prof all confused)

(I would do in retail days)

$= 91\%$

↑ Order to satisfy 91% of cust

9% stockout rate

Block Buster

50% rev share

\$7 upfront fee

$U = 12 \cdot 7 \cdot 2$

$O = 7 - 6$

$$P(D \leq q) = \frac{168}{169} - 99.4\%$$

9

So Blockbuster has less stockouts

Can rev sharing be bad?

1. Sharing info bad sometimes?
   (I am not very protective of this)
   Studios can maximize $ from them

2. Not sharing late fees?
   - So marked upfront fee down

3. Reducing risk to retailer
   - Shared risk

(I think reduces risk all around
   - Prof and some MBAs unsure)

4. Increase in inventory
   -

5. Need to actually track
   - Disney sued Blockbuster

6. Loss of bargining power to retailer

7. Whats the agreement?

(5)

What happen

It ↑ BB's market share

Vertically Integrate firm

- 2 players are in same firm
- Demand ~ uniform [0, 100]

C = 20

price = 100

Newsvendor approach - MR = MC

MR = 100
↑ qth unit

↙ dropped k to "normalize"

$$P(D \geq q) = 100\left(\frac{100\cancel{k} - q}{100k}\right) = 100 - q$$

↑ demand uniform, not normal

(6)

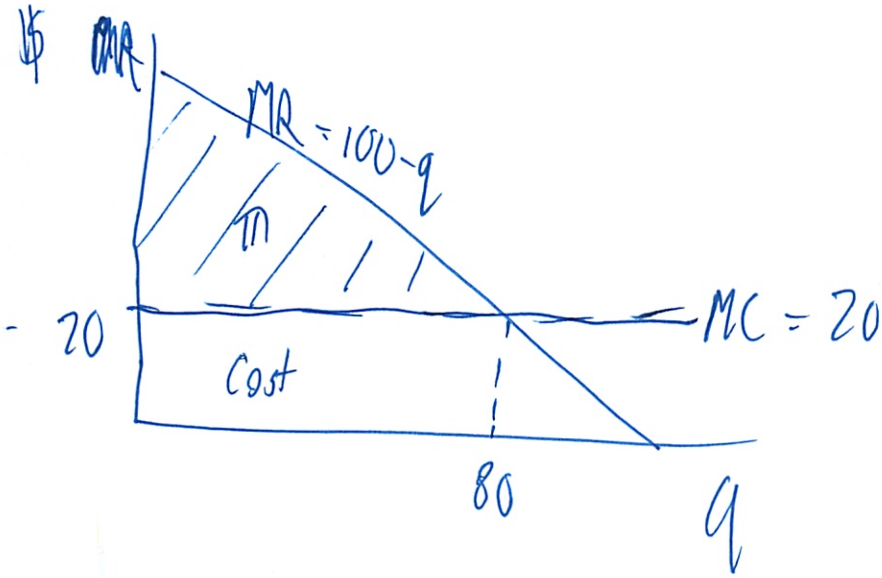
$MC = 20$

function of q

$MR = MC(q)$

$100 - q = 20$

$q = 80$



$$= \frac{80 \cdot 80}{2} = 3.2 \text{ million}$$

Firm cares about everything - wants optimal solution

2 players

Wholesale cost = 60

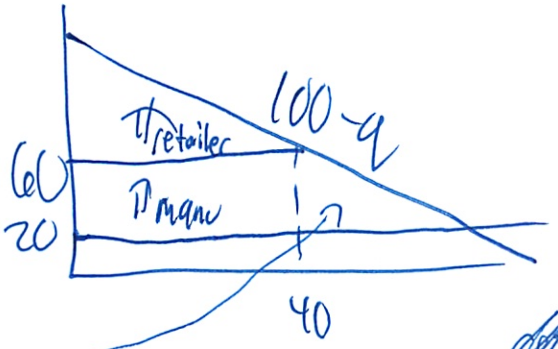
retailers perspective

$MR(q) = 100 - q$

$MC(q) = 60$

7

So now $q = 40$



Total profit lower

$\pi_{retailer} = \frac{40 \cdot 40}{2} = 800k$

$\pi_{manf} = 40 \cdot 40 = 1.6$

2.4 mill

$ on table

Lots of lit on contract theory

(I should study)

* Get contract to split little triangle

8

Now w/ rev share \$10 upfront ~~50% rev share~~

$MR = \frac{100-q}{2}$

$MC = 10$

$MR(q) = MC(q)$

$q^* = 80$

↑ just like 1 firm integrated!

But what are each's profits?

~~Find 2 best 2 is~~ Also

62.5% share

7.5 upfront

gives 80 q as well

See table!

- lots of diff contracts

Look for incentives for both

- proposed π must be larger

Could also do buy-back

quantity discount

(9)

Lots of incentive issues

Risk

Capabilities

(last part of class was cool - nice celebration)

15.761 Retail Game

4/28

- discount
- look at old data for strategy
- set up in advanced

60 2000 units

54 weekly - 15 units

48

36

25

Run 5 times ? w/ same base

5 strategies

Historical data a good

What is the question?

15 items - all similar

- combine

- when price drops how does demand spike?
  - % wise
  - relative demand same

2 Graph

Price vs Sales

- No

Demand vs day

Sales voltale even w/o price 0

Does not help

- in week where prices change ~~be~~ % sales

That varies a lot too!

? Seems like it does nothing

When sales fall below threshhold

- Not using hint?

? Don't dump slowly

When goes below 20% threshhod ~~w/ ...~~

to 48?

15.761 Littlefield Meeting

4/18

How forcast demand
- just go through

We decided all this

Say if good

Divide work - I'll do factory

late
Sat afternoon

4/28

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4. Pros and cons of revenue sharing for studios and retailers?
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Video Vault Vs. Blockbuster

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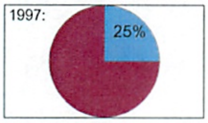
Revenue Sharing Pros and Cons

Retailers	Studios

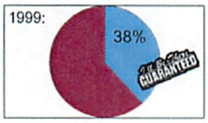
Before and After Revenue Sharing

Blockbuster market share

- Before revenue sharing (pre 1998):
  - Rentals shrinking, sales declines, 20% of surveyed customers can't find what they want.



- After revenue sharing (1998+):
  - Blockbuster negotiated revenue sharing deals with all the studios.
  - Begins the "Go home happy" campaign:
  - Total industry profit increased by about 7% (Mortimer 2003)

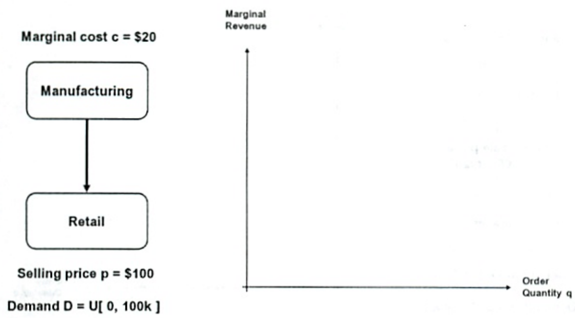


Vertically Integrated Firm

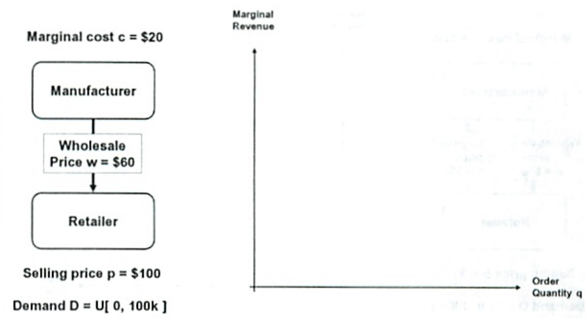
- Estimated total market demand D for product with 3 month life cycle sold at p = $100 retail price is uniform between 0 and 100,000 units
- No salvage value
- Firm owns both retail channel and manufacturing capacity, marginal cost (production + distribution) is c = $20, manufacturing lead-time >3 months

Optimal order quantity q? Expected profit?

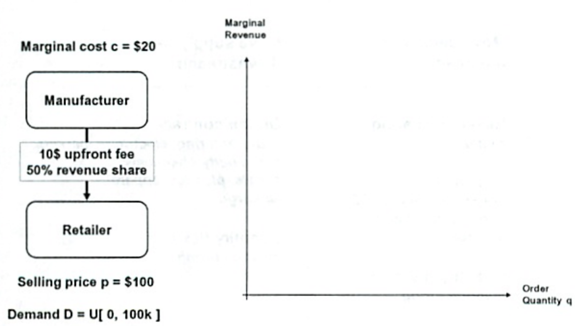
Marginal Revenue Analysis



Two Firm Supply Chain



Revenue Sharing Contract



Revenue Sharing Profit Allocation

Retailer revenue share	20%	30%	40%	50%	60%	70%	80%
Upfront fee	4	6	8	10	12	14	16
Order quantity	80,000	80,000	80,000	80,000	80,000	80,000	80,000
Retailer E[profits]	640,000	960,000	1,280,000	1,600,000	1,920,000	2,240,000	2,560,000
Manufacturer E[profits]	2,560,000	2,240,000	1,920,000	1,600,000	1,280,000	960,000	640,000
Total E[profits]	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000

What do you observe?

Buy-Back Contract

Marginal cost c = \$20

Manufacturer

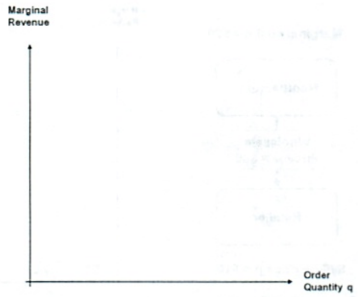
Wholesale price w = \$60

Buy-back price b = \$50

Retailer

Selling price p = \$100

Demand D = U[0, 100k]



Quantity Discount Contract

Marginal cost c = \$20

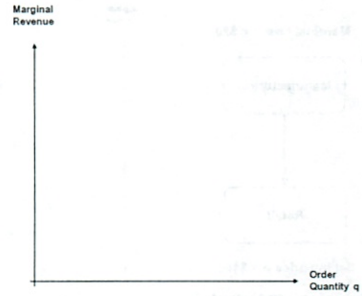
Manufacturer

Wholesale price w(q) = 60 – q/2000

Retailer

Selling price p = \$100

Demand D = U[0, 100k]



Supply Risk Example: Semiconductor Industry

- Setting:
  - Capital-intensive, with new foundries requiring \$3B investment, rapid technological progress
  - Huge swings in demand, profitability and available capacity
- No management of supply risk:
  - Buyer purchase from spot market after observing demand
  - Suppliers bear all risks of idle capacity, so they under-invest...
- More typically buyers (Dell, TI, Motorola and AMD) of commodity chips combine spot market purchases and long-term contracts with suppliers (Xilinx and Infineon):
  - Quantity flexibility contract: long-term contract covers several months and monthly deliveries are between some floor *M* and some ceiling *M + K* (*K* provides flexibility)
  - Option contract: buyer purchases options before demand is observed at p_o per option, then possibly exercises each option after observing demand at price p_e

Contract Summary

Move demand risk upstream:	Move supply risk downstream:
Revenue sharing *rental* Buy-back *books, cosmetics, CDs, agricultural chemicals, electronics* Quantity discount *manufacturing*	Option contract *manufacturing, electricity markets, commodity chemicals, metals, plastics, apparel, air cargo* Quantity flexibility *manufacturing*

Wrap Up

1. With wrong incentives the supply chain can perform sub-optimally (= how to share risk?)

2. Risk sharing (incentive alignment) maximize size of pie (= supply chain coordination)

3. Skillful contracting lets us do this while remaining cognizant of incentives

4. Many ‘contracts’: must calibrate carefully (there are many feasibility issues)

15.761 Retailer 5/2

at Michaels

When sales below 20%

< 30% 1st day of value

Seems to be no pattern

Is the data supposed to be good time to cut price

Go to 48

20% of what

What model from class

- GQN - no queue
- Newsvendor -
- Periodic restocking

Customer visit
- no visit data

Just shows us imp
- not even where to lower prices

2

Oh try it out

- So we click save or markdown

Michael wanted 20% off - 80%

Say 65% ~~[illegible]~~ of sales at full price cut to 20%

and 65% of sales new price cut to 40%

<u>Ran</u>

Actually had a ton of inventory left

Purpose is <u>max. revenue</u>

But is this high prices up front?

40% ~~[illegible]~~ price - week 13 no matter what

~~[illegible]~~ Do price check

Smoother: 2 in a row at 65

3

Inv just looks linear

i Ignore week 13 rule

1.93%

Total diff 6%

Seed 2

Use same strategy

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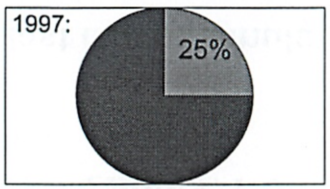

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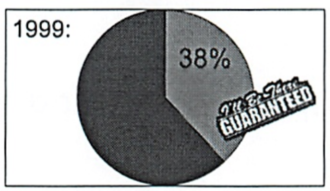

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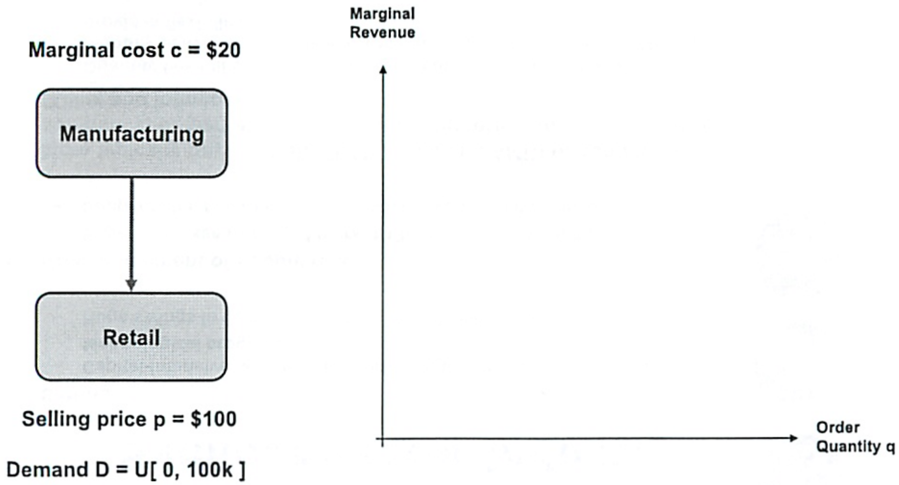
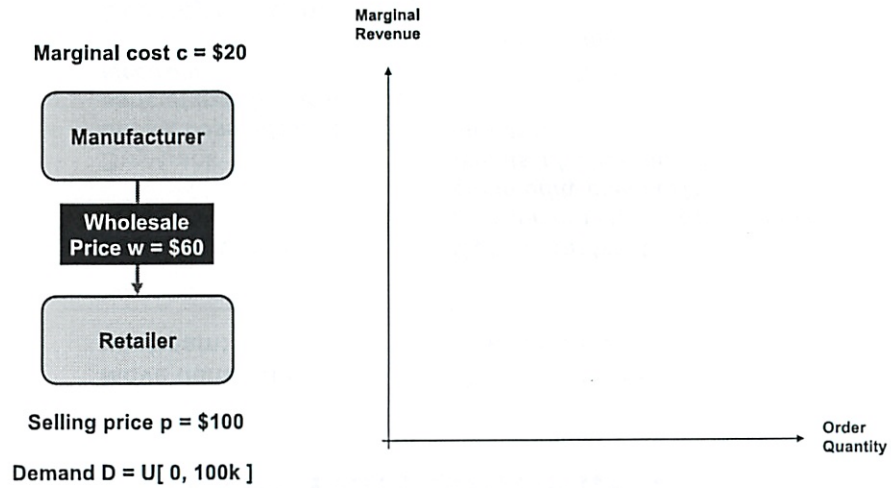
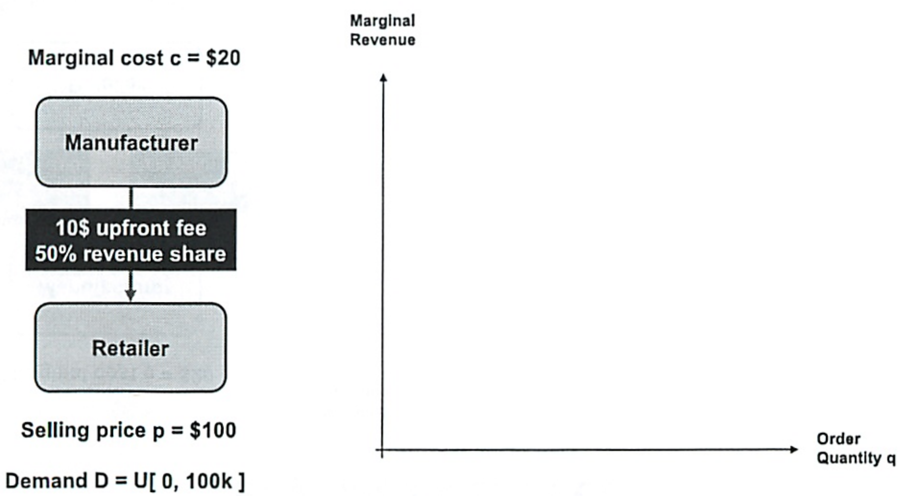


Two Firm Supply Chain



Revenue Sharing Contract



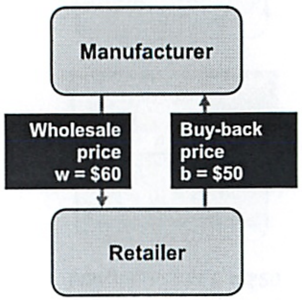
Revenue Sharing Profit Allocation

Retailer revenue share	20%	30%	40%	50%	60%	70%	80%
Upfront fee	4	6	8	10	12	14	16
Order quantity	80,000	80,000	80,000	80,000	80,000	80,000	80,000
Retailer E[profits]	640,000	960,000	1,280,000	1,600,000	1,920,000	2,240,000	2,560,000
Manufacturer E[profits]	2,560,000	2,240,000	1,920,000	1,600,000	1,280,000	960,000	640,000
Total E[profits]	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000

What do you observe?

Buy-Back Contract

Marginal cost c = $20



Selling price p = $100

Demand D = U[0, 100k]

Quantity Discount Contract

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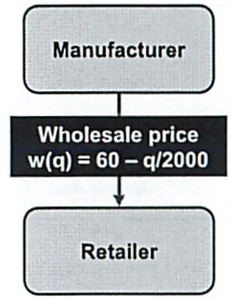

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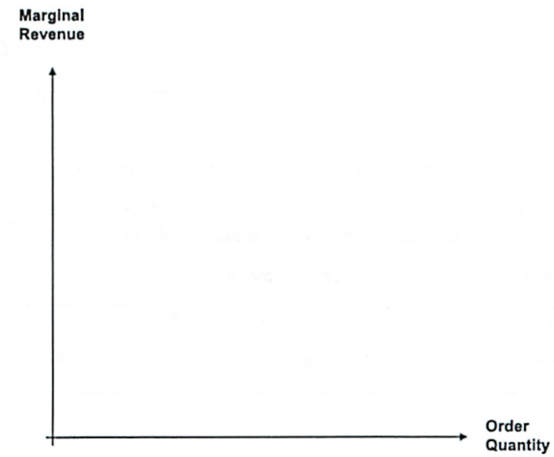

Supply Risk Example: Semiconductor Industry

- Setting:
  - Capital-intensive, with new foundries requiring $3B investment, rapid technological progress
  - Huge swings in demand, profitability and available capacity
- No management of supply risk:
  - Buyer purchase from spot market after observing demand
  - Suppliers bear all risks of idle capacity, so they under-invest...
- More typically buyers (Dell, TI, Motorola and AMD) of commodity chips combine spot market purchases and long-term contracts with suppliers (Xilinx and Infineon):
  - Quantity flexibility contract: long-term contract covers several months and monthly deliveries are between some floor M and some ceiling $M + K$ (K provides flexibility)
  - Option contract: buyer purchases options before demand is observed at p_0 per option, then possibly exercises each option after observing demand at price p_e

Contract Summary

Move demand risk upstream:	Move supply risk downstream:
Revenue sharing *rental*	**Option contract** *manufacturing, electricity markets, commodity chemicals, metals, plastics, apparel, air cargo*
Buy-back *books, cosmetics, CDs, agricultural chemicals, electronics*	**Quantity flexibility** *manufacturing*
Quantity discount *manufacturing*	

Wrap Up

1. With wrong incentives the supply chain can perform sub-optimally (= how to share risk?)

2. Risk sharing (incentive alignment) maximize size of pie (= supply chain coordination)

3. Skillful contracting lets us do this while remaining cognizant of incentives

4. Many ‘contracts’: must calibrate carefully (there are many feasibility issues)

RM 1

5/3

Revenue Management 1

1. What is RM?
2. Retailer Game Heuristics
3. Case Study: ZARA

What is Revenue Management?

The science of selling the right item to the right person (= at the right price)

Limited Capacity

Uncertain Demand

↓

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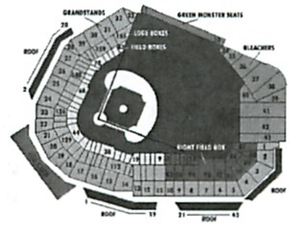

How Important Is RM?

SAP

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ORACLE

ita software

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- US $23 billion revenue
  - A 0.2% increase in revenue?
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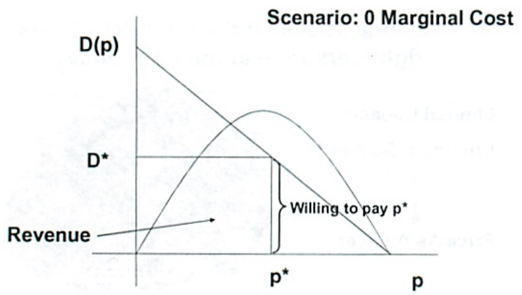
Selling to the right person: Econ 101



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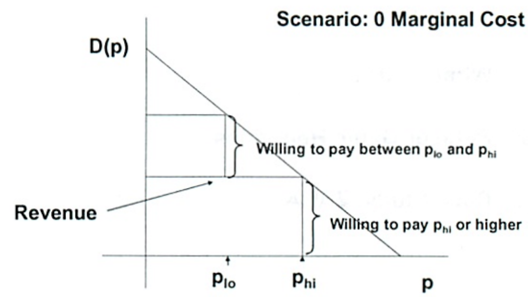

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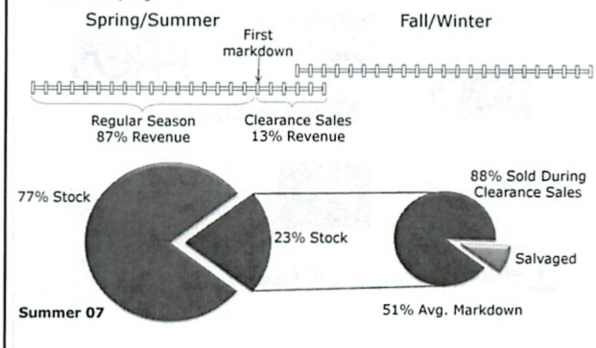
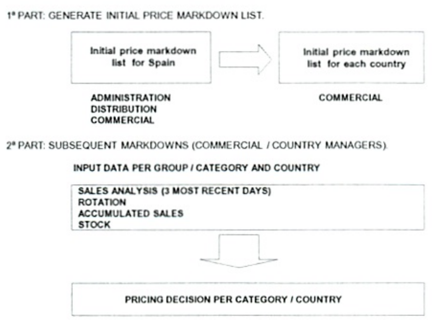
Clearance Sales at Zara

Two campaigns:



Legacy Pricing Process



Retailer Model

- Initial Stock: 2000 Units
  - Demand difficult to predict
  - No restocking
- Initial Price: $60
  - Can markdown - $54 (10%), $48 (20%), $36 (40%)
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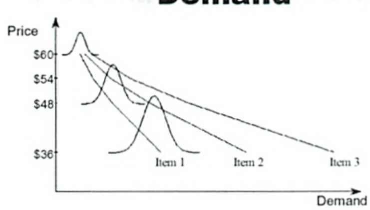
  - Salvage at $25

GOAL: Maximize revenues from the 2000 units

Demand



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- Figuring out what curve you face
  - Needs Historical Data
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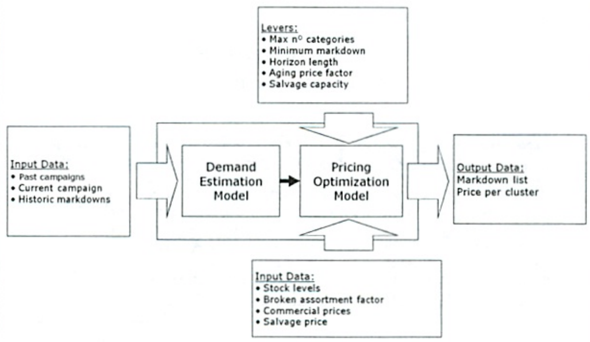
Sample Output

Back to Zara: New Pricing Process



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Model Output (for Women Blazer)

			5 weeks to go			4 weeks to go			3 weeks to go...		
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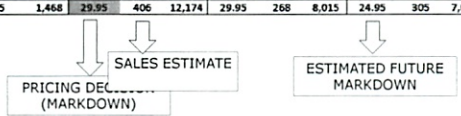
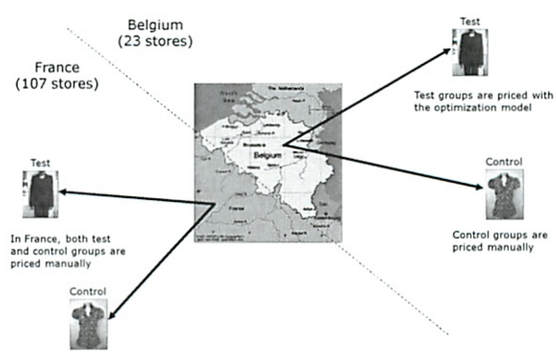
13900	59.95	4	49.95	0	11	49.95	0	9	39.95	0	10
12900	59.95	185	49.95	37	1,837	49.95	28	1,387	39.95	34	1,354
11900	59.95	793	49.95	198	9,894	49.95	138	6,887	39.95	169	6,767
9900	49.95	1,023	39.95	251	10,030	39.95	172	6,856	29.95	233	6,966
7990	39.95	1,468	29.95	406	12,174	29.95	268	8,015	24.95	305	7,612



Pilot Test Experiment Design



Pilot Test Results

Performance metric:

$$Y = \%\ \text{INCOME} = \frac{\text{CLEARANCE SALES REVENUE + SALVAGED}}{\text{INITIAL STOCK VALUED AT SEASON PRICES}}$$

Y performance	2006			2007			2008			Average 2008
	B	F	B-F	B	F	B-F	B	F	B-F	
Woman Blazer	35.3%	27.8%	7.5	38.8%	33.5%	5.3	39.1%	35.4%	3.7	
Basic Blazer	43.6%	37.4%	6.2	50.2%	45.2%	5.0	48.7%	46.4%	2.3	2.2
T.R.L. Trouser	47.6%	45.7%	1.9	45.5%	40.2%	5.3	40.1%	40.0%	0.0	
T-Shirt	42.8%	43.1%	-0.3	45.9%	43.2%	2.6	47.6%	44.9%	2.6	
Woman Trouser	36.5%	31.6%	4.9	51.3%	44.9%	6.5	36.6%	38.1%	-1.4	
Basic Trouser	56.3%	49.3%	7.0	48.9%	48.8%	0.1	40.6%	46.6%	-6.0	-2.5
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+4% or $47M
in additional profits

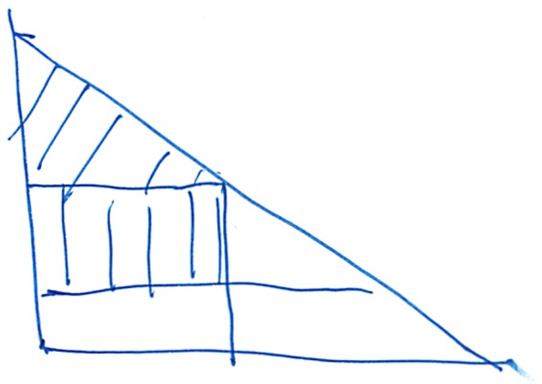
Revenue Management 1 Wrap-Up

1. Revenue Management = Limited inventory sold to the right customers.
2. Markdown management is a mode for such discrimination in retail
3. Scientific RM = $$

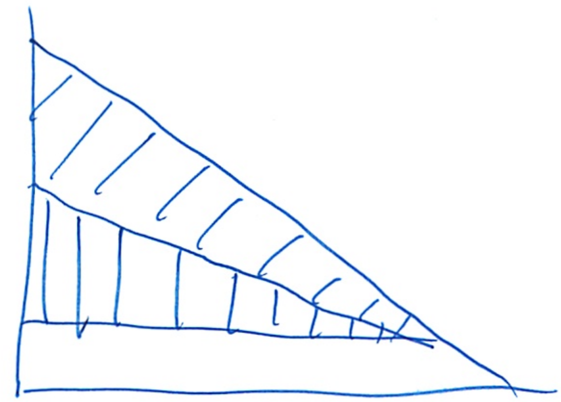
Marginal Revenue Analysis cont

Found advantage to profit sharing

Traditional



Rev Share



$10 upfront
50% rev share

Also Buy back

Same as

What is the difference b/w?

- who gets the $ when
- risk of manuf costs
- who covers shrinkage
  - buy back: retailer has more risk

2

- auditing / proof needed in rev share

Or quantity discount

Lots of risk in chips market

In general:

risk upstream	risk downstream
rev share	Options
buy back	quant flexible
quant discount	

Game theory / equilibrium kinda he is doing now

Trust

Even if it seems best for everyone

③

Revenue Management

Max revenue

Which products to sell to who at what price

Who is willing to pay more?

How can we get that?

* Science ~~to~~ of selling right item to right person at right price *

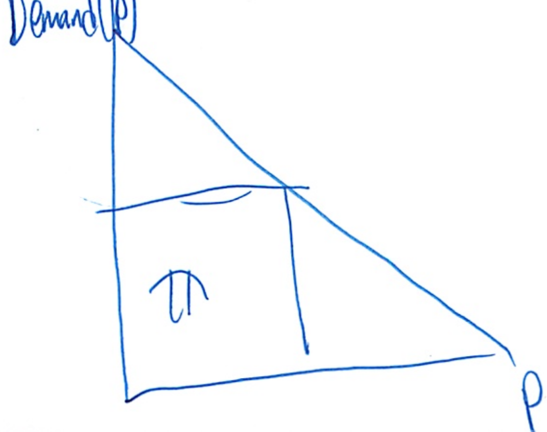
Uncertain demand + limited capacity

↓

Use price as a levor

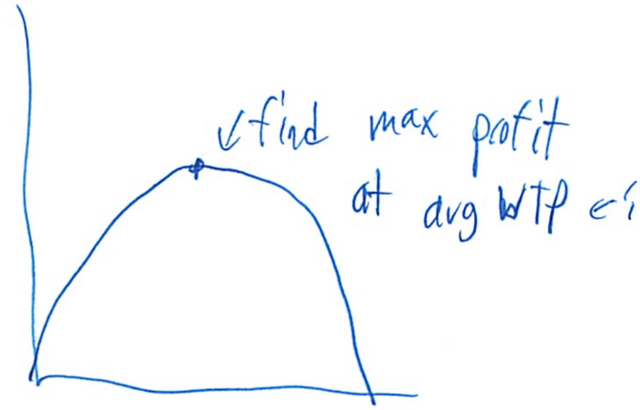
(prof + class not as developed of airline specific understanding)

Price vs demand graph



1 price

π



(4)

Improve by price discrimination

- charge people who are willing to pay a higher price more

~~WTP~~

WTP

Auctions are natural way to find WTP

(we talked about this more in 15.~~0~~567)

Not many things illegal

Some cust pushback - some reverted
- some pushed through

Markdowns - if you wait
- are less trendy

Risky - will cust not pay full price?

RM not cost management - already spent/committed cost

~~Space issue~~

How does Zara do sales?

- space issue
- doing a lot

(5)

? easier to cut price if have less inv
less inv to be scared of to sell at lower price

(? does that make sense ?)
More flexibility
More pricing decisions - lots of items
? Gap have more data so can do better forecasting ?

- Do clearance by size
Markdowns brings more volume
~~Ma~~ - need more workers

Retailer game

- dont run out
[I disagree
- hard to figure out what discounting did
~~A~~ [What other students did]

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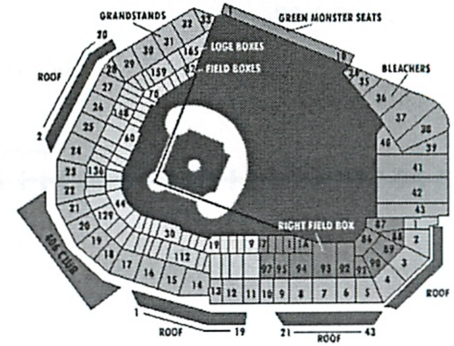

Solutions

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5/3

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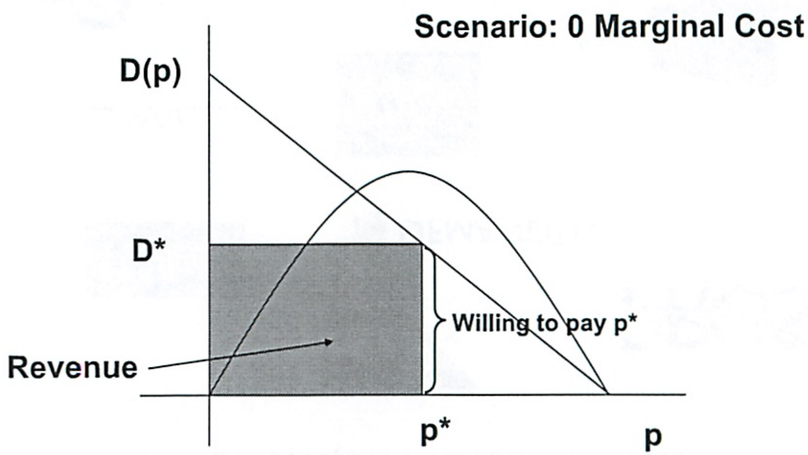

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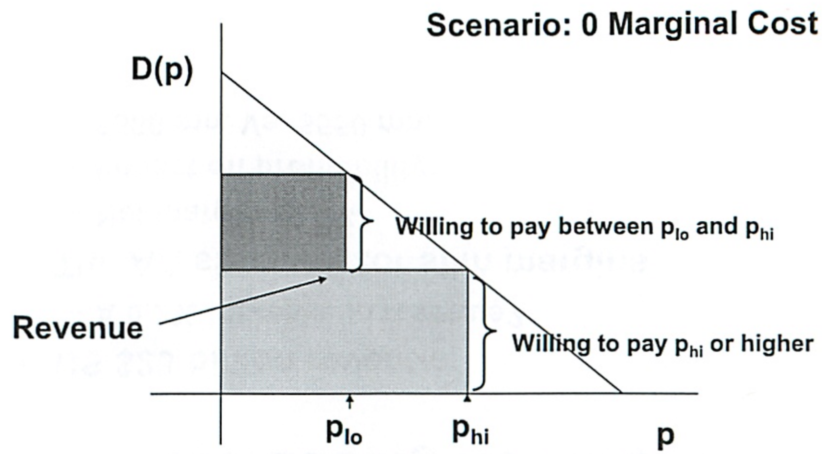

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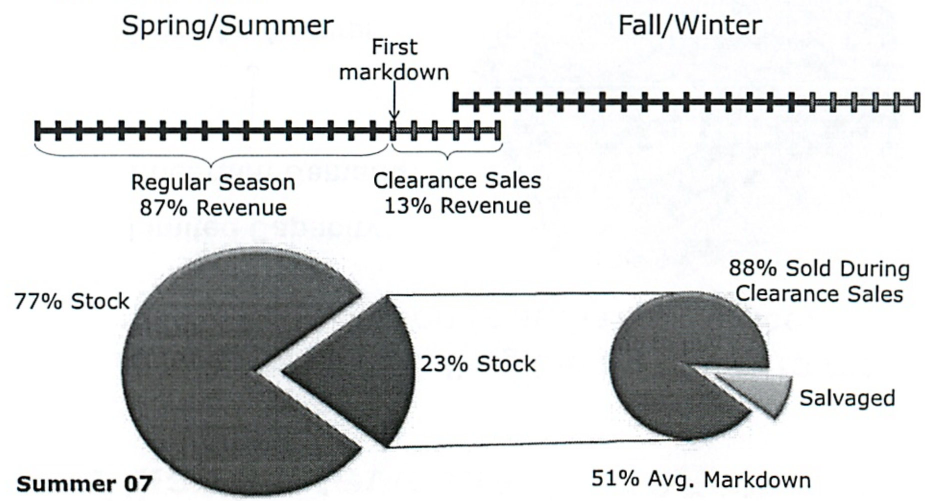

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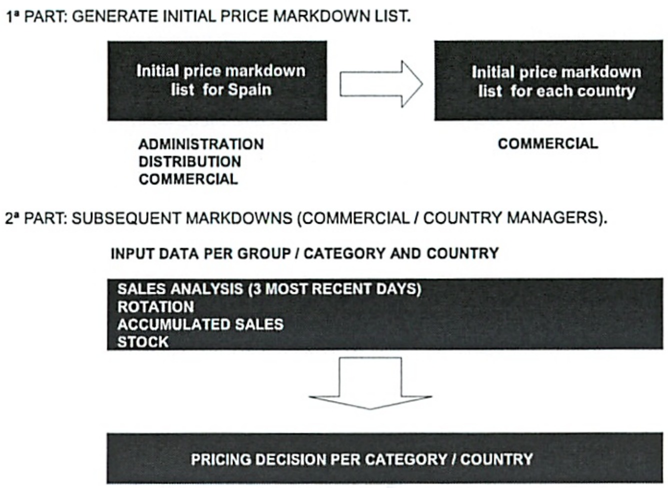

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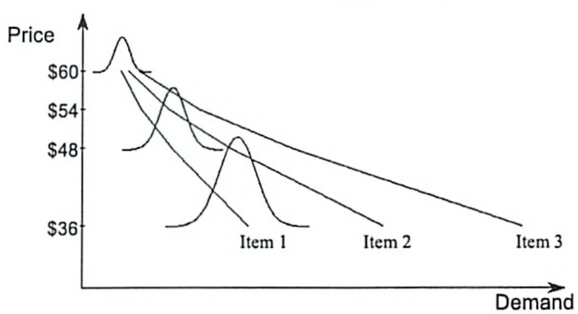

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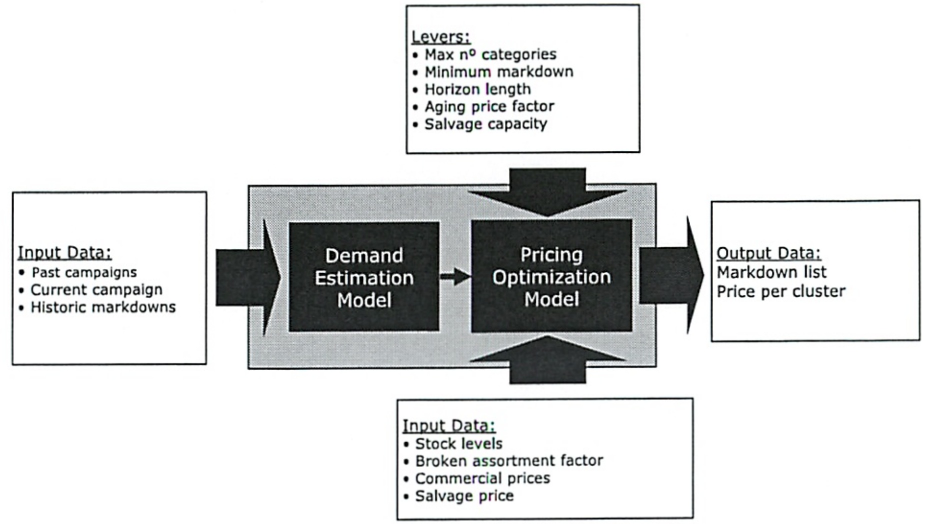

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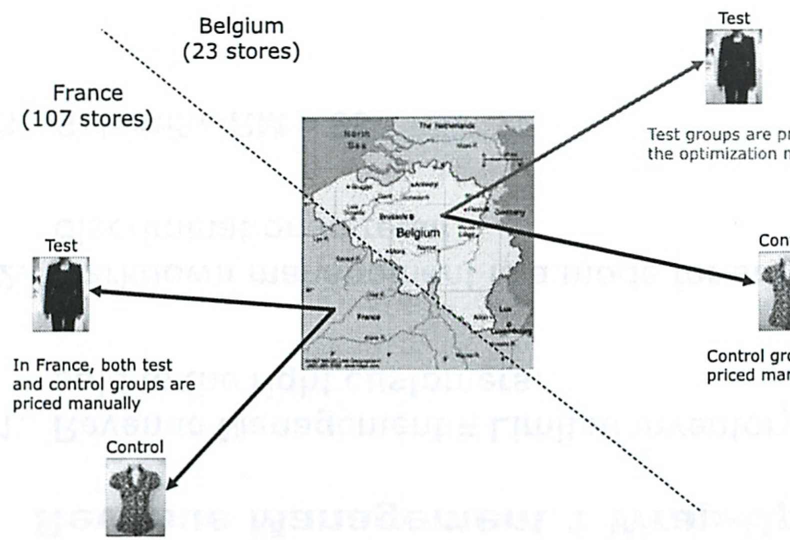
PRICING DEC... (MARKDOWN)

SALES ESTIMATE

ESTIMATED FUTURE MARKDOWN

Pilot Test Experiment Design



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3. **Scientific RM = $$**

RM2

5/5

Announcements

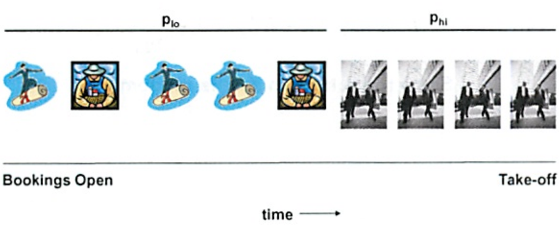
1. Recitations this week on RM
2. Simulation Report is due May 12 (last class)

Revenue Management (2)

1. How to design booking limits?
2. What about managing a network of routes?
3. Are there other application areas?

The 2-Fare Model

- Selling air tickets (Leisure and Business)



The 2-Fare Model: Data

P_lo = 200

P_hi = 310

100 seats

	D_lo	D_hi
Week 1	107	0
Week 2	109	35
Week 3	104	0
Week 4	91	0
Week 5	84	30
Week 6	110	30
Week 7	85	14
Week 8	110	14
Week 9	87	1
Week 10	111	24
Week 11	89	0
Week 12	129	50
Week 13	114	32
Week 14	109	27
Week 15	83	7
Week 16	87	43
Week 17	99	7
Week 18	83	18
Week 19	101	31
Week 20	90	18
Week 21	94	0
Week 22	75	35
Week 23	123	21
Week 24	80	22
Week 25	107	18
Week 26	107	48
Week 27	92	42
Week 28	117	0
Mean	**99**	**20**

Booking Limits/ Fare Protection

- Allow the sale of at most X leisure tickets
- New request for business class - accept
- New request for leisure class
  - How many leisure sold so far? (say 10)
  - Accept only if 10 < X
- Naïve Approach: Set....
  - X = C – Expected Business Demand

Littlewood's 2-Fare Model

- C seats
- Ample leisure demand $D_L >> C$
- Business demand uncertain D_B
- Leisure arrives before business
- What is booking limit with a crystal ball?
- What is booking limit otherwise?

Littlewood's Rule

- Consider selling the X+1st leisure seat
- Gain
  - $\$p_{lo}$
- Potential Loss
  - $\$p_{hi}$ - if we see demands for a business ticket > C – X (reserved capacity to business tickets)
- E[Potential Loss] = $p_{hi}\, P(D_B > C - X)$
- Net Expected Gain = $p_{lo} - p_{hi}\, P(D_B > C - X)$
- Sell if and only if $p_{lo} - p_{hi}\, P(D_B > C - X) \geq 0$

Littlewood Model

Set X* so that

$$P(D_B \leq C - X^*) = 1 - \frac{p_{\mathrm{lo}}}{p_{\mathrm{hi}}}$$

Same formula even if D_L is random!

Applied to Data

	D_lo	D_hi	Naive	Littlewood
Week 1	107	0	16000.00	17000.00
Week 2	109	35	22200.00	21650.00
Week 3	104	0	16000.00	17000.00
Week 4	91	0	16000.00	17000.00
Week 5	84	30	22200.00	21782.35
Week 6	110	30	22200.00	21650.00
Week 7	85	14	20194.69	21194.69
Week 8	110	14	20408.18	21408.18
Week 9	87	1	16219.29	17219.29
Week 10	111	24	22200.00	21650.00
Week 11	89	0	16000.00	17000.00
Week 12	129	50	22200.00	21650.00
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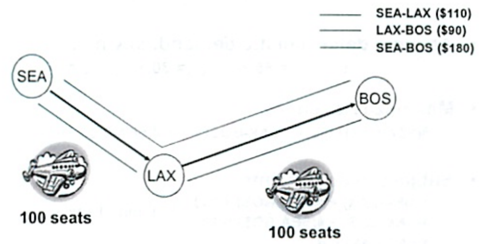
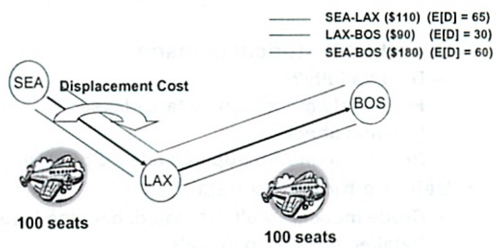
Capacity Management



- What is SEA-BOS seat inventory?

The Network Effect



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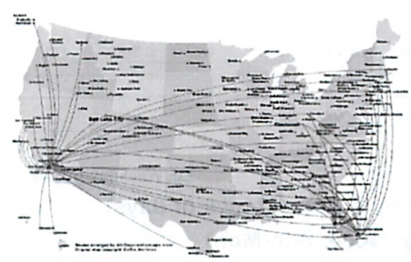

- What to do?

The Network Effect

- Assume deterministic demand, say mean:
  $d_{SEA\text{-}LAX} = 65$, $d_{LAX\text{-}BOS} = 30$, $d_{SEA\text{-}BOS} = 60$
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  #(SEA-LAX)110$ + #(LAX-BOS)90$ + #(SEA-BOS)180$
- Subject to constraints:

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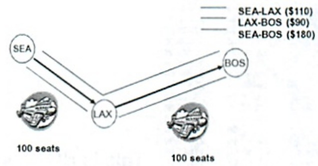
The Network Effect



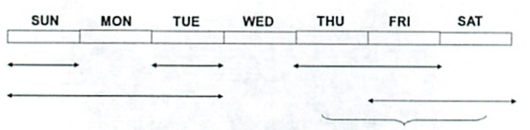
Max $110x1 + 90x2 + 180x3$

s.t. $x1 + x3 \le 100$
$x2 + x3 \le 100$
$0 \le x1 \le 65$
$0 \le x2 \le 30$
$0 \le x3 \le 60$

Solution:

$$\left.\begin{array}{l}x1^* = 40 \\ x2^* = 30 \\ x3^* = 60\end{array}\right\} \boxed{\text{Good proxy for 'Virtual Inventory'}}$$

Hotel Capacity Management



Eg. Weekday ($$) vs. Weekend ($)

- Itinerary = (price, block of days)
  - Eg: ($600, Sun-Mon)
- Seats = Room Capacity on Each Day
- Estimate demand for each block

Estimation And Forecasting

- Based on historical demand
  - Data Validity?
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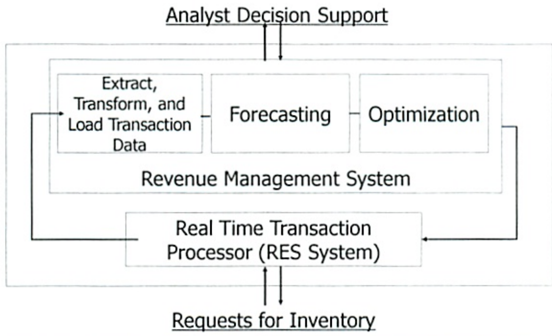
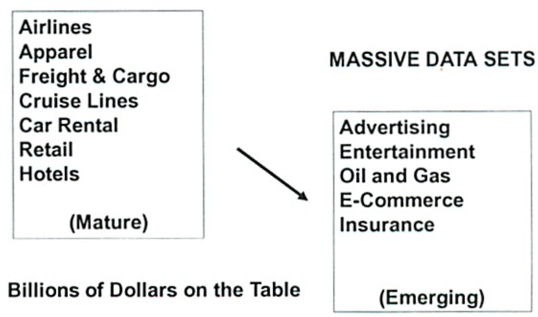


Legacy Systems

- Very complex software products
- Hard to bring about changes
- Training
- Understanding

Where is RM?



Revenue Management 1 Wrap-Up

1. Revenue Management = Limited inventory sold to the right customers
2. Markdown management is a mode for such discrimination in retail
3. Yield management = Hedging against high paying demand
4. Scientific RM = $$

Sim report due May 12

More detail of RM solution of Zara

Markdown Game

Goal Maximize Revene

15 weeks

Can markdown

No one tried Newsvendor approach

- One tried a NV technique
- but too conservitive

You have the quantity - need to maximize revenue

Can play w/ demand - Using pricing

But inventory is fixed

Can look at avg demand jmp

They got much closer demand jump

Oh compare avg sales old price to avg sales @ new price

(I was thinking demand spikes for week after drop - but jump is sustained)

② Their avg were much closer

Estimating demand at each price level

- makes demand estimation much more difficult

(Yeah should have read closer)

Another student said they expected demand decay

X_p = # of weeks item sold at that price

Season lenght $X_{60} + X_{54} + X_{48} + X_{36} \leq 15$

limited inv $\underbrace{98 X_{60}}_{\text{assume 98 sales/week at \$60}} + 128 X_{54} + 170 X_{48} + 275 X_{36} \leq 2000$

And solve for max revenue

But just looking at mean, not at st dev

$= \underbrace{60 \cdot 98 X_{60} + \cdots}_{\text{rev from sales}} + \underbrace{25 \cdot (200 - (98 X_{60} \cdots))}_{\text{rev from salvage}}$

$= (60-25) \cdot 98 X_{60} + (54-25) \cdot 128 \cdot X_{54} + \cdots + 25 \cdot 2000$

③ (It never runs down!! Decays when at same price!)

Run the Linear Programming Solution

1 week @ 60

14 weeks @ 48

So gap of ~0% or ~2% from optimal
- better than we did

(Nice model - should have thought of this, perhaps w/ 18.03)
(Really should think of this stuff on my own!)

Could reoptimize now every week
- ~~It~~ but bad if saw large deviation for mean
- goes faster down and can't get back

In solution he also used diff demand #
Oh used that item's 1st price
Some students saying relying on 1st data point
is not very safe - since large variation
Wait a few weeks to see a mean
Can see historical data how much var there is

(4)

Zara New pricing process

- model from MIT
- integer programming

input data

- past campeigns
- current camp.
- historical markdowns

levers

Max n° cut
min markdown
horizon length
aging price factor
salvage capacity

Gives price markdown table
Tested model in 1 country
Bundled similar items
4% more profits
But did it canabalize

(5)

Part 2 Airlines Yield Management

1. How to design booking limits
2. What about managing a network of routes?
3. Are there other application areas?

---

2 fares < low / high

2 cust < leasure - high price insensitivity - book ahead of time
biz - low - book before flight

Prices are fixed in this model

How many seats to save/protect for biz travelers?

Once "sell out" of low price tickets - don't sell any more!
even if people willing to buy

Protecting ability to sell last-minute at higher price

Newsvendor Model:

Nieve - just save the mean (20 seats) each week

Allow sale of at most X leasure class tickets

6

~~All~~
Does not look at uncertainty
Or price

So what to set the booking limit at?
~~Box~~
Littlewood's Rule

- Consider selling $X+1^{th}$ seat
- What is p(over~~stock~~ save) p(under save)

- Gain \$ p_{lo}
- Loss \$ p_{hi}

So $E[\text{Loss}] = p_{hi} P(D_B > C-X)$

Net expected gain $p_{lo} - p_{hi} P(D_B > C-X)$

Sell if and only if $p_{lo} - p_{hi} P(D_B > C-X) \geq 0$

Set X^* so that

$$P(D_B \leq C-X^*) = 1 - \frac{p_{lo}}{p_{hi}}$$

Same formula even if D_L is random

7

~1% gain w/ this Littlewood model

So variability + prices

Only 2 fare classes

Static price

No cheating

No special weeks

seats fixed

O-D market

Competitors

~~[illegible]~~

Diff legs

- can arbitrage

How many seats to protect for multi-hop / connecting flights?

What is the displacement cost?

W/ 50 stops!

Don't really know how to solve accuratly

⑧

Get demand

$d_{SEA-LAX} = 65$

⋮ etc

Max revenue

$seats_{SEA-LAX} \cdot 75 + \ldots$ etc

Then constraints on limited seats

$seats_{SEA-LAX} + seats_{SEA-BOS} \leq 100$

and demand

$seats_{SEA-LAX} \leq d_{SEA-LAX}$

Let you know how many seats to save
w/ Linear Programming Solution

$seats_{SEA-LAX} = 40$

$seats_{LAX-BOS} = 30$

$seats_{SEA-BOS} = 60$

(9)

Forecast based on prior demand

Also misses varaibllity

Hotels

Same/similar

Conventions

Give large group a special rate?

etc

Same historical process issues

- shocks
- arbitage - breaking bariers
- valadility

Often systems propritary

Wrap-Up

Play w/ who gets the resourses

Price discrimination

Announcements

1. Recitations this week on RM
2. Simulation Report is due May 11 (last class)

Revenue Management (2)

1. How to design booking limits?
2. What about managing a network of routes?
3. Are there other application areas?

Solutions

The 2-Fare Model

- Selling air tickets (Leisure and Business)

p_{lo} p_{hi}

Bookings Open Take-off

time ⟶

The 2-Fare Model: Data

P_lo = 200

P_hi = 310

100 seats

	D_lo	D_hi
Week 1	107	0
Week 2	109	35
Week 3	104	0
Week 4	91	0
Week 5	84	30
Week 6	110	30
Week 7	85	14
Week 8	110	14
Week 9	87	1
Week 10	111	24
Week 11	89	0
Week 12	129	50
Week 13	114	32
Week 14	109	27
Week 15	83	7
Week 16	87	43
Week 17	99	7
Week 18	83	18
Week 19	101	31
Week 20	90	18
Week 21	94	0
Week 22	75	35
Week 23	123	21
Week 24	80	22
Week 25	107	18
Week 26	107	48
Week 27	92	42
Week 28	117	0
Mean	99	20

5/5

Booking Limits/ Fare Protection

- Allow the sale of at most X leisure tickets
- New request for business class - accept
- New request for leisure class
  - How many leisure sold so far? (say 10)
  - Accept only if 10 < X
- Naïve Approach: Set....
  - X = C – Expected Business Demand

Littlewood's 2-Fare Model

- C seats
- Ample leisure demand D_L >> C
- Business demand uncertain D_B
- Leisure arrives before business
- What is booking limit with a crystal ball?
- What is booking limit otherwise?

Littlewood's Rule

- Consider selling the X+1st leisure seat
- Gain
  - $\$p_{lo}$
- Potential Loss
  - $\$p_{hi}$ - if we see demands for a business ticket > C – X (reserved capacity to business tickets)
- E[Potential Loss] = $p_{hi} P(D_B > C - X)$
- Net Expected Gain = $p_{lo} - p_{hi} P(D_B > C - X)$
- Sell if and only if $p_{lo} - p_{hi} P(D_B > C - X) \geq 0$

Littlewood Model

Set X* so that

$$P(D_B \leq C - X^*) = 1 - \frac{p_{\text{lo}}}{p_{\text{hi}}}$$

Same formula even if D_L is random!

Applied to Data

	D_lo	D_hi	Naïve	Littlewood
Week 1	107	0	16000.00	17000.00
Week 2	109	35	22200.00	21650.00
Week 3	104	0	16000.00	17000.00
Week 4	91	0	16000.00	17000.00
Week 5	84	30	22200.00	21782.35
Week 6	110	30	22200.00	21650.00
Week 7	85	14	20194.69	21194.69
Week 8	110	14	20408.18	21408.18
Week 9	87	1	16219.29	17219.29
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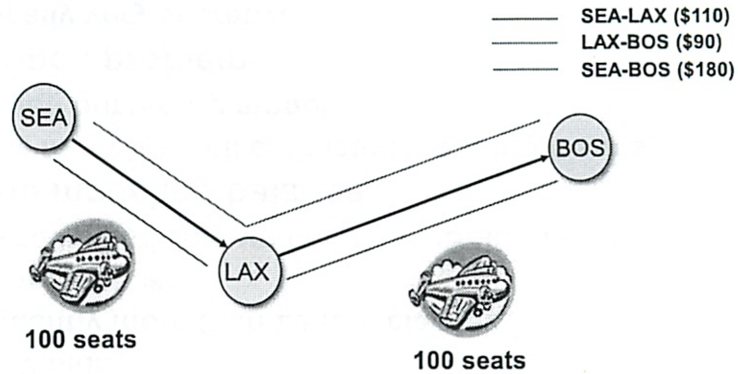
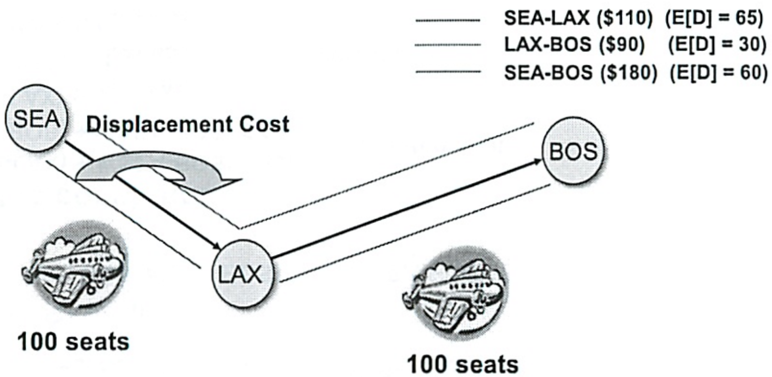


- What is SEA-BOS seat inventory?

The Network Effect



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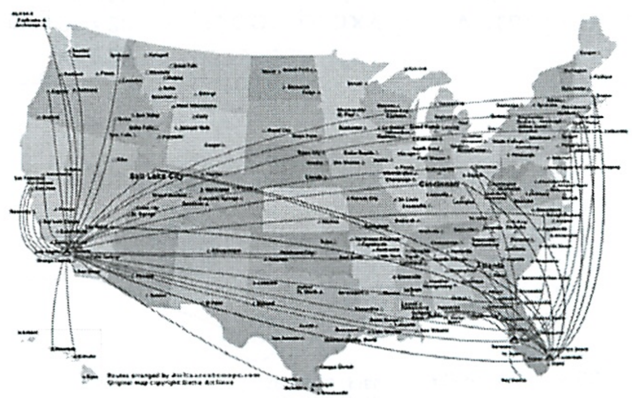

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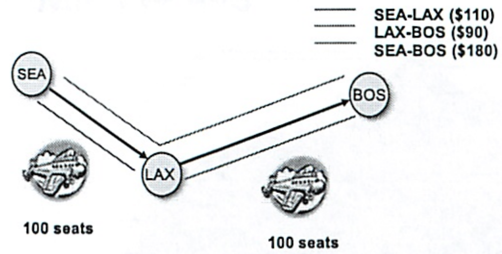

Max 110x1 + 90x2 +180x3

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Solution:

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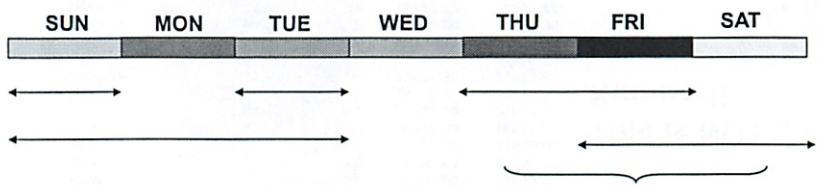
Hotel Capacity Management



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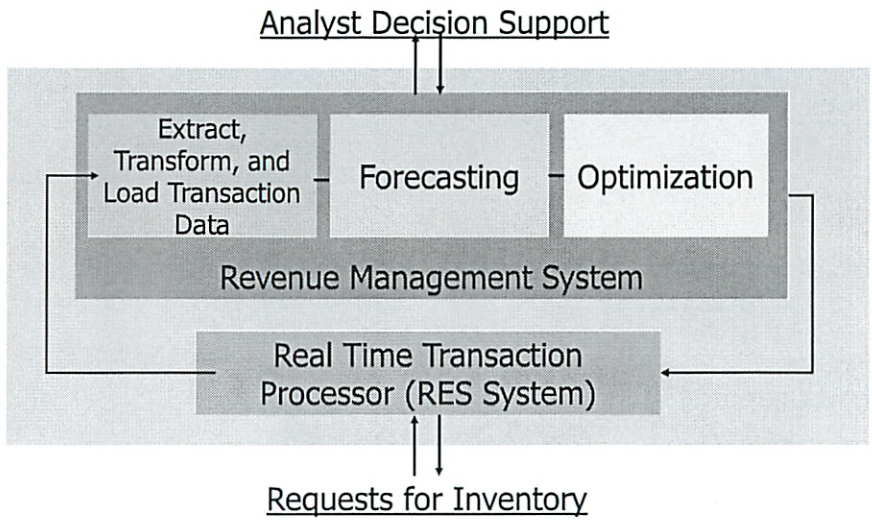

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- **Very complex software products**
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- **Training**
- **Understanding**

Where is RM?

Airlines
Apparel
Freight & Cargo
Cruise Lines
Car Rental
Retail
Hotels

(Mature)

MASSIVE DATA SETS

Advertising
Entertainment
Oil and Gas
E-Commerce
Insurance

(Emerging)

Billions of Dollars on the Table

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3. **Yield management = Hedging against high paying demand**
4. **Scientific RM = $$**