Operations management & Finance

Professor David Gillen (University of British Columbia) & Professor Benny Mantin (University of Waterloo)

Istanbul Technical University

Air Transportation Management

M.Sc. Program

Logistic Management in Air Transport

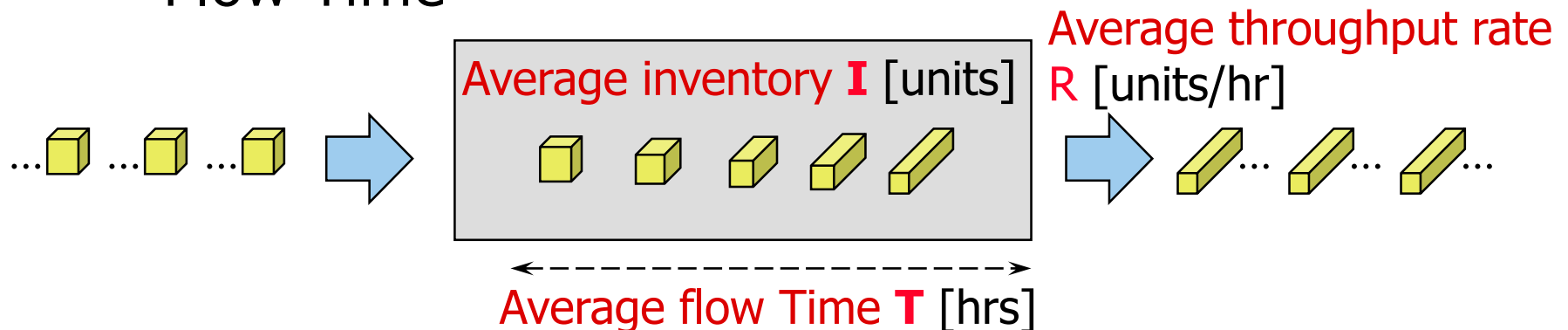**Module 4**

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OPERATIONS AND FINANCE

RECALL: PC INDUSTRY 2005

	Dell	IBM	Apple	HP
Revenue (billion $)	55.9	91.1	13.9	88.7
Net income (billion $)	3.6	8.0	1.6	3.7
Number of employees	65,200	341,750	14,800	150,000
Revenue per employee	$ 857,000	$ 270,000	$ 940,000	$ 591,000
Income per employee	$ 55,000	$ 23,000	$ 108,000	$ 25,000
Days of inventory	4.6	19	6.1	38

Source: COMPUSTAT database, finance.yahoo.com

LITTLE'S LAW

- Establishes a relationship between Average Inventory, Average Throughput Rate and Average Flow Time

Average inventory **I** [units]

Average throughput rate R [units/hr]

Average flow Time **T** [hrs]

Inventory = Throughput rate × Flow time
(Average)   (Average)   (Average)

- For an entering unit, time in system is high
  - if inventory is high
  - or, if throughput rate is low

FOUR DIFFERENT WAYS TO COUNT INVENTORY

- **In terms of flow units (The " I " in $I = R$ x T)**
  - Number of wetsuits, patients, tons of wheat, semiconductor chips, etc.
  - Useful when the focus is on one particular flow unit.

- **In terms of \$s (The " I " in $I = R$ x T)**
  - The \$ value of inventory
  - This is an intuitive measure of a firm's total inventory.
  - Useful for a diverse product mix

- **In terms of days-of-supply (**The "T" in $I = R$ x T)
  - The average number of days a unit spends in the system.
  - Also, the number of days inventory would last at the average flow rate if no replenishments arrive.

- **In terms of *turns*: (1/T)**
  - The number of times the average amount of inventory exits the system.

DAYS-OF-SUPPLY CALCULATIONS

- Days-of-supply is the "T" in $I = R \times T$

- Days-of-supply = I / R = Inventory / Average daily flow rate

- Can also be measured in different time lengths
  - Weeks-of-supply = Inventory / Average weekly flow rate
  - Months-of-supply = Inventory / Average monthly flow rate
  - Years-of-supply = Inventory / Average yearly flow rate

Keep units consistent!

Inventory turns calculations

- Inventory Turns = 1 / T = R / I

- Different measures of turns:
  - Yearly turns = Average annual flow rate / Inventory
  - Monthly turns = Average monthly flow rate / Inventory
  - Weekly turns = Average weekly flow rate / Inventory
  - Daily turns = Average daily flow rate / Inventory

  Keep units consistent!

A Little's Law application: In-transit inventory

- O'Neill, based in California (CA), buys wetsuits from a supplier in Thailand:
  - Each month they order on-average 15,000 wetsuits
  - Each month they receive on-average 15,000 wetsuits
  - Shipping between Thailand and CA takes on-average 2 months

What is the Annual Turn over-rate?
What is the Monthly Turn over-rate?

- O'Neill, based in California (CA), buys wetsuits from a supplier in Thailand:
  - Each month they order on-average 15,000 wetsuits, $R = 15,000$
  - Shipping between Thailand and CA takes on-average 2 months, $T = 2$
  - $I = R \times T = 15,000 \times 2 = 30,000$ units are in-transit on average

$I = 30,000$ wetsuits

$R = 15000$/month

$T = 2$ months
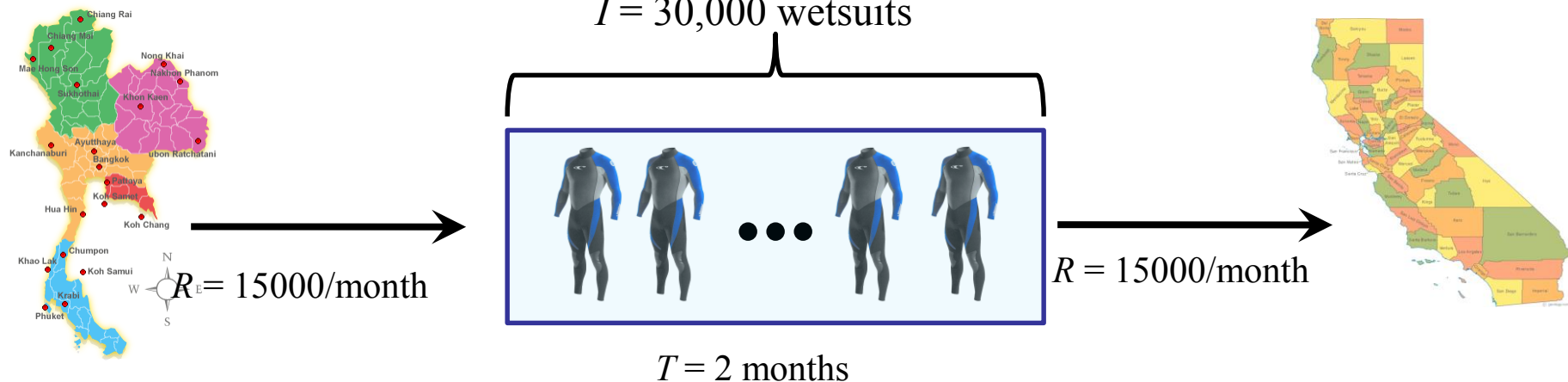
$R = 15000$/month

Annual turns:

$R = 15000 \times 12 = 180,000$ per year
$I = 30,000$
$T = 2$ months $= 1/6$ year
Annual Turns $= R / I = 180,000 / 30,000 = 6$
Annual Turns $= I/T = 1 / (1/6) = 6$

Monthly Turns $= R / I = 15,000 / 30,000 = 0.5$ turns / month
Monthly Turns $= I/T = 1 / 2 = 0.5$ turns/month

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TURNS AND DAYS-OF-SUPPLY AT WALMART IN 2010*

All figures in $Million from 2010 balance sheet and income statement

Walmart

I = Inventory = $33,160

R = COGS = $304,657

- COGS = Cost of Goods Sold = Flow Rate
  - The Flow Rate is <u>not</u> Sales (which was $405,046) because inventory is measured in the cost to purchase goods, not in the sales revenue that may be earned from the goods.
  - Note: Some companies use the term "Cost of sales" to mean COGS

- Calculate the Annual turns.
- Calculate the days-of-supply.

* All figures in $Million from 2010 balance sheet and income statement

R = COGS = $304,657 /yr

I = Inventory = $33,160

- *COGS = Cost of Goods Sold = Flow Rate*
  - The Flow Rate is <u>not</u> Sales (which was $405,046) because inventory is measured in the cost to purchase goods, not in the sales revenue that may be earned from the goods.
  - Note: Some companies use the term "Cost of sales" to mean COGS

- Annual turns = $304,657 / $33,160 = 9.19 turns/year

- Average Daily throughput = $304,657 / 365 = $834.6 /day
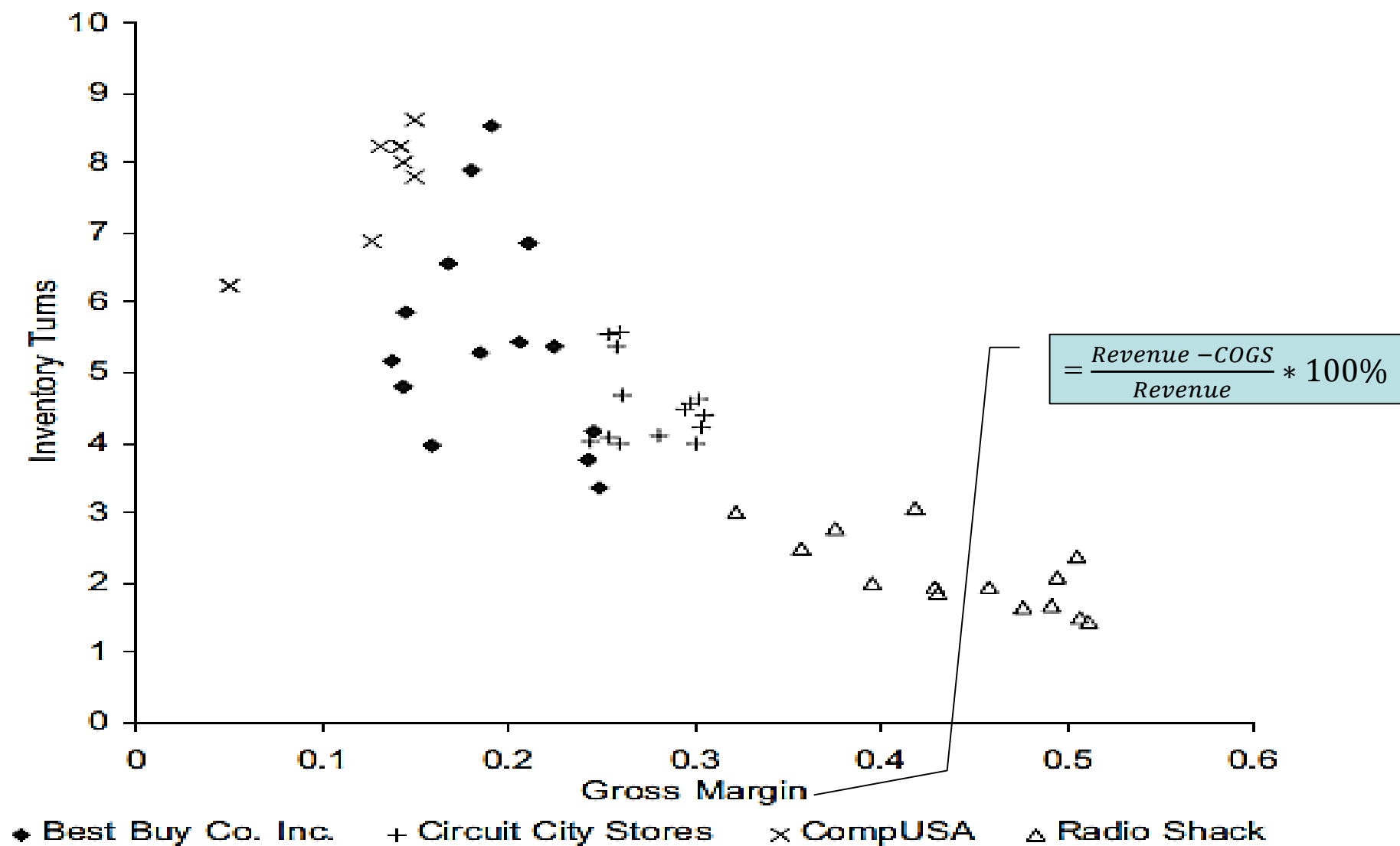- Days-of-supply = $33,160 / $ 834.6 = 39.7 days

WALMART'S TURNS CHANGE FROM YEAR TO YEAR
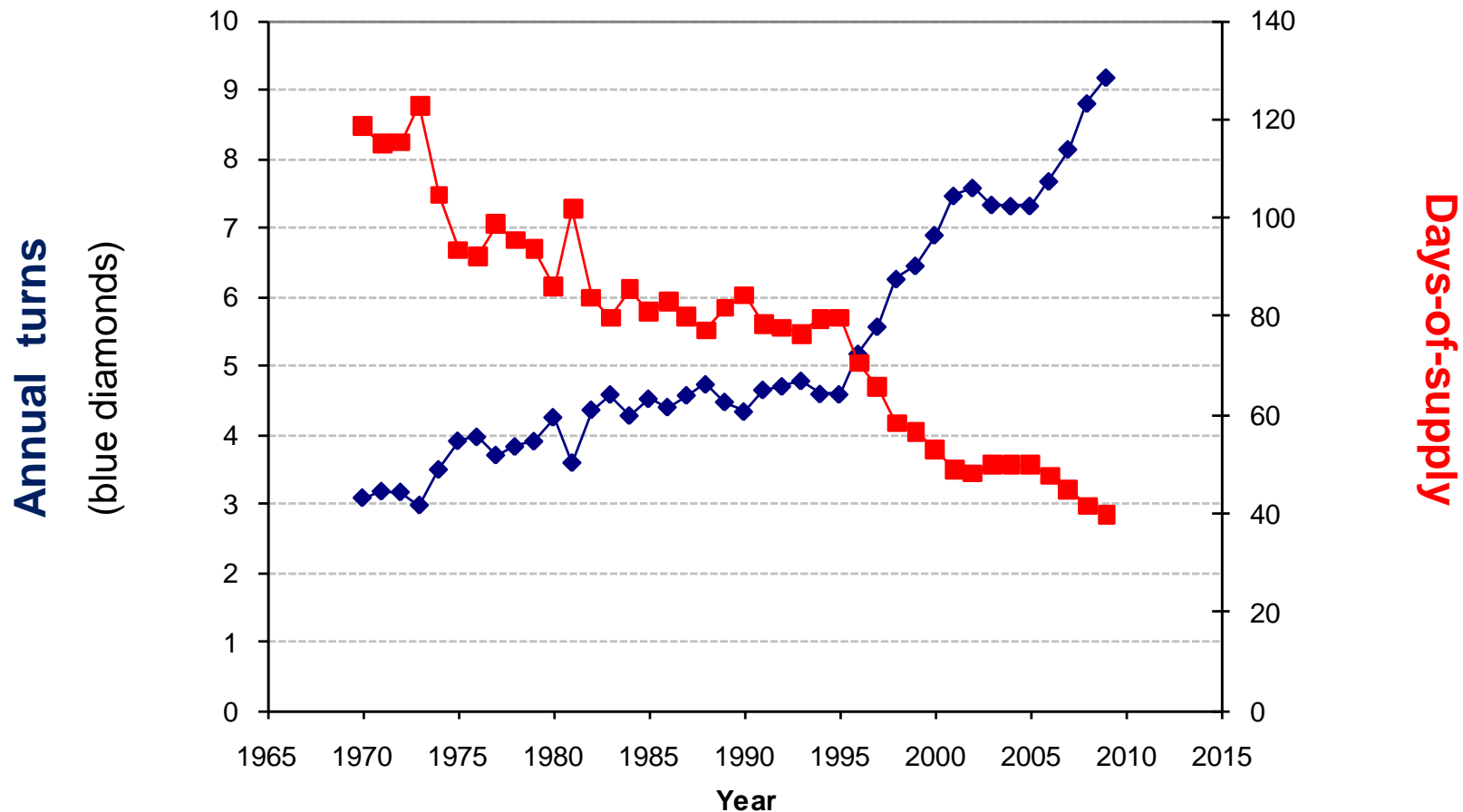
* Annual turns decreased slightly since 2010

Figure 1 Plot of Annual Inventory Turns vs. Annual Gross Margin for Four Consumer Electronics Retailers for the Years 1987–2000

$$= \frac{Revenue - COGS}{Revenue} * 100\%$$

◆ Best Buy Co. Inc.   + Circuit City Stores   × CompUSA   △ Radio Shack

Source: Gaur, Fisher, Raman 2005

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INVENTORY TURNS AND GROSS MARGINS

Retail segment	Examples	Annual Inventory Turns	Gross margin
Apparel and accessory	Ann Taylor, GAP	4.57	37%
Catalog, mail-order	Spiegel ,Lands End	8.60	39%
Department stores	Sears, JCPenney	3.87	34%
Drug and proprietary stores	Rite Aid, CVS	5.26	28%
Food stores	Albertson's, Safeway	10.78	26%
Hobby, toy/game stores	Toys R Us	2.99	35%
Home furniture/equipment	Bed Bath & Beyond, Linens N' Things	5.44	40%
Jewlery	Tiffany	1.68	42%
Radio, TV, consumer electronics	Best Buy, Circuit City, CompUSA	4.10	31%
Variety stores	Kmart, Walmart, Target	4.45	29%

INVENTORY HOLDING RATE

Annual Inventory Holding rate is the percentage of cost allocated by the company to represent cost involved in holding 1 unit of inventory in storage for 1 year

Annual Inventory Holding Cost = Cost of Goods in Inventory * inventory holding rate

Category	Cost (and range) as a Percent of Inventory Value
Housing costs (building rent or depreciation, operating **costs, taxes, insurance)**	6% (3 - 10%)
Material handling costs (equipment lease or depreciation, power, operating cost)	3% (1 - 3.5%)
Labor cost	3% (3 - 5%)
Investment costs (borrowing costs, taxes, and insurance on inventory)	11% (6 - 24%)
Pilferage, space, and obsolescence	3% (2 - 5%)
Overall carrying cost	26%

ANNUAL INVENTORY HOLDING COST

Annual inventory holding cost is the holding cost (storage cost) of the average inventory for one year.

Inventory (I) is the average units in transit in the process. This is an instantaneous value that will be maintained on average whether over a month or a year or a decade (assuming average flow rates do not change)

Cost of goods in inventory (COGI) = Average Inventory* Unit Cost

Annual inventory holding cost = COGI * annual inventory holding rate

If I want to calculate the annual inventory holding cost I am done, I do not need to account for the time it stays in inventory since on average I am keeping the same level of inventory throughout the year

INVENTORY HOLDING COST PER TURN

In order to calculate the inventory holding cost per turn of inventory, I need to account for the average time this batch of inventory spent in the system

Inventory holding cost per turn = Annual inventory holding costs x Flow Time

$$= \frac{\text{Annual inventory holding costs}}{\text{Inventory turns}}$$

INVENTORY HOLDING COST PER UNIT

The per unit inventory cost is the average holding cost for 1 specific unit. This clearly depends on how long this unit spends in the system

$$\text{Inventory holding cost per unit} = \frac{\text{Annual inventory holding costs}}{\text{Average Inventory}} \times \text{Flow Time}$$

$$= \frac{\text{Annual inventory holding costs}}{\text{Inventory turns} \times \text{Average Inventory}}$$

$$= \frac{\text{Inventory holding costs per turn}}{\text{Average Inventory}}$$

EXAMPLE

- Average annual inventory = 1 M units/ year
- One unit costs 100$ and it sells for 170 dollars
- Annual inventory holding costs rate=30%
- Inventory turns=6

a) Calculate the annual inventory cost.
b) Calculate the Inventory holding costs per turn
c) Calculate the inventory holding cost per unit

SOLUTION

Calculate the annual inventory holding cost

Annual Inventory Holding costs= COGI*holding rate
$$= 1M * \$100 * 0.3 = \$30 \text{ M}$$
Average Inventory holding cost per turn
$$= \text{Annual Inventory cost } *\text{Flow time}$$
$$= \text{Annual Inventory cost} / \text{turnover rate}$$
$$= \$30 \text{ M} / 6 = \$5 \text{ M per turn}$$
Average Inventory holding cost per unit
$$= \text{Average inventory holding cost per turn} / \text{Average inventory}$$
$$= \$5 \text{ M} / 1M = \$5$$

ANOTHER EXAMPLE

- The following figures are taken from the 2003 financial statements of McDonald's and Wendy's. Figures are in million dollars.

	McDonald's	Wendy's
Inventory	$ 129.4	$ 54.4
Revenue	$ 17,140.5	$ 3,148.9
COGS	$ 11,943.7	$ 1,534.6
Gross Profit	$ 5,196.8	$ 1,513.4

- In 2003, what were McDonald's Inventory turns? What were Wendy's inventory turns?

- Suppose it costs both McDonald's and Wendy's $3 (COGS) per their value meal offerings, each sold at the same price $4. Assume a 30% annual holding cost for both. On average, how much does McDonald's save in inventory cost per value meal compared to Wendy's.

ANOTHER EXAMPLE

	McDonald's	**Wendy's**
Inventory	$ 129.4	$ 54.4
Revenue	$ 17,140.5	$ 3,148.9
COGS	$ 11,943.7	$ 1,534.6
Gross Profit	$ 5,196.8	$ 1,513.4

- How to calculate inventory turns?
    - It is the COGS/Inventory
    - Hence, IT_M=11,943.7/129.4=92.3
    - And, IT_W=1,534.6/54.4=28.2

ANOTHER EXAMPLE

	McDonald's	Wendy's
Inventory	$ 129.4	$ 54.4
Revenue	$ 17,140.5	$ 3,148.9
COGS	$ 11,943.7	$ 1,534.6
Gross Profit	$ 5,196.8	$ 1,513.4

- Unit cost is $3, selling price is $4. Holding cost rate is 30%. We are required to find the holding cost per unit.

- Recall that we need to multiply this rate by the unit cost and then multiply by the average inventory to obtain the annual holding cost

	McDonald's	Wendy's
Annual holding cost	($129.4/$3)*$3*0.3 =$ 38.82	($54.4/$3)*3*0.3 = $16.32
Annual turns	92.3	28.2
Per turn	$0.42	$ 0.578
Per unit	$0.00975	$ 0.0319
% per unit	0.32%	1.06%

ANOTHER EXAMPLE

- If we stock one unit that costs $3 for the entire year, the holding cost incurred is

$$\$3 * 0.3 = \$0.9$$

- But each unit does not spent the entire year in stock….

- For M: $3*0.3*(1/92.3)=$0.0097
- For W: $3*0.3*(1/28.2)=$0.0319

The process handles a flow of 100 customers/ hr.
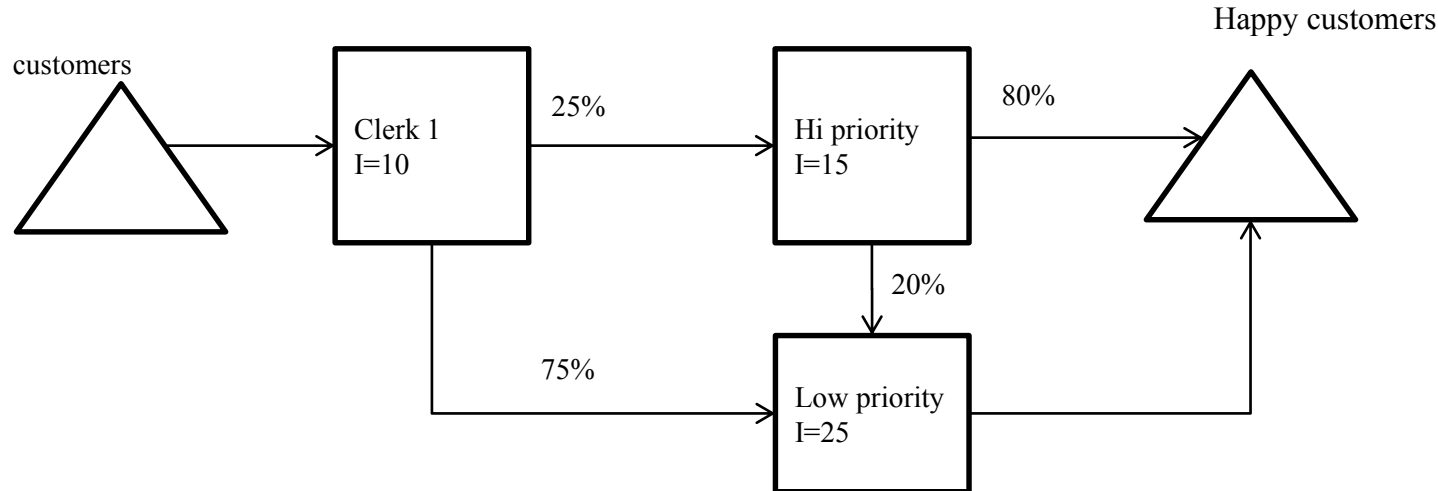
There are more low than hi priority customers waiting. Is the process well designed? What are the flow time (by average and by type) ?

Since the process handles a flow of 100 customers/ hr and on average there are 10 customers at the clerk, then due to Little's law
$T=I/R = 10/100=0.1hr=6$ minutes.
Hi priority handles 25 customers/hr => $T=15/25=0.6hr=36min$
Low priority handles 75+5 customers/hr => $25/80=0.3125=18.75min$
1-Hi: 20% spend 42 min
1-Hi-Low: 5% spend 60.75 min ⎱=> 30 min
1-Hi: 75% spend 24.75 min

ECONOMIC VALUE

- The objective of most incorporated organizations is to create economic value

- If money invested, then a return is expected to exceed other form of investment (such as savings account)

- Economic value is crated when the return on invested capital (ROIC) exceeds the (weighted average) cost of capital (WACC):

    Economic value created
    = Invested Capital * (ROIC – WACC)

Economic Value

- How do you create economic value?

- How do operational performance measures affect bottom line measures?

- What performance measure should we track?

- To that end, we introduce the ROIC tree (or KPI tree).

Creating ROIC (Value, KPI) Trees
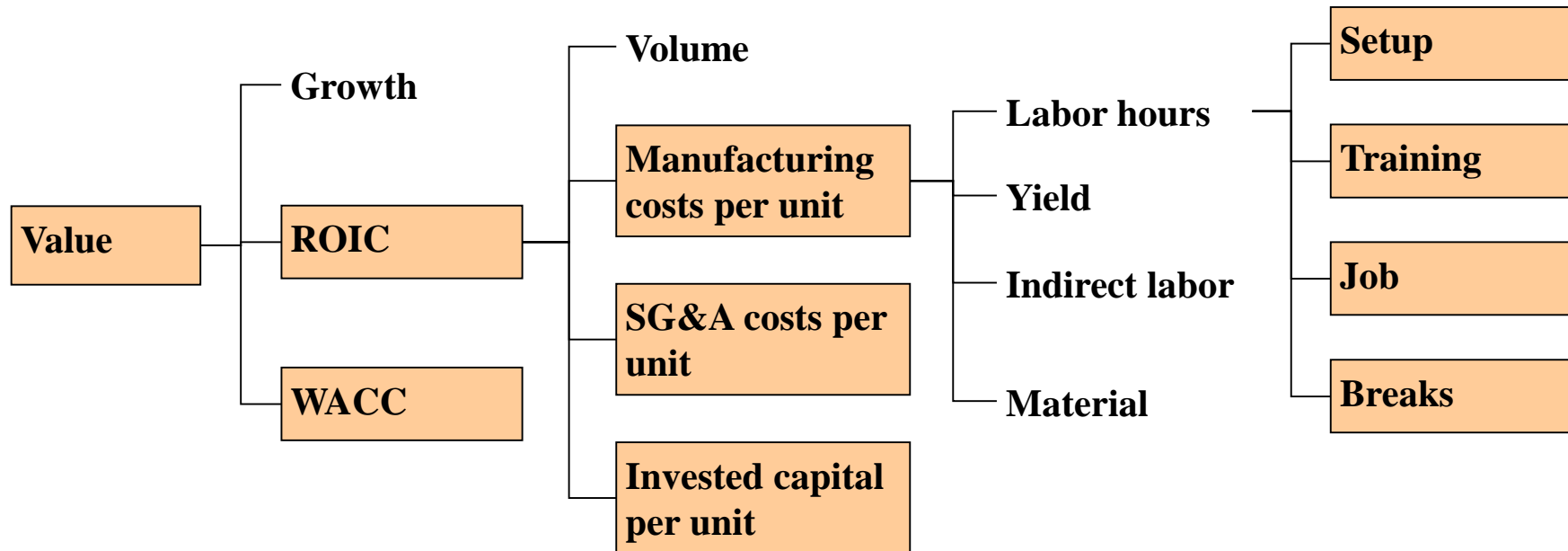
Develop value trees

- Link financial measures to potential value drivers in operations
- In operations, performance typically focuses on ROIC
- Develop several versions as there is no "right answer"
- Explore multiple sub-trees

- If the manager is interested in improving the ROIC by 5%, what should he be looking at?

$$ROIC = \frac{Return}{Invested\ Capital}$$

- With a little manipulation:

$$ROIC = \frac{Return}{Revenue} \times \frac{Revenue}{Invested\ Capital}$$

This is the company's margin

This is the company's capital turns

- Also known as DuPont model.

- So, to increase ROIC,
  - Increase margins
  - Turn assets faster
- Not much of an advice, so let's drill further:

Return = Revenue – Fixed Costs

– Flow Rate **X variable costs**

- Keep in mind that Revenue = Flow rate X price

$$\frac{Return}{Revenue} = \frac{Revenue - Fixed\ costs - Flow\ rate\ X\ Variable\ costs}{Revenue}$$

$$= 1 - \frac{Fixed\ costs}{Flow\ rate\ X\ Price} - \frac{Flow\ rate\ X\ Variable\ costs}{Flow\ rate\ X\ Price}$$

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- Similarly, we have that

$$\frac{Revenue}{Invested\ capital} = \frac{Flow\ rate\ X\ Price}{Invested\ capital}$$

- Putting it all together:

$$ROIC = \frac{Return}{Revenue} \times \frac{Revenue}{Invested\ Capital}$$

$$= \left[1 - \frac{Fixed\ costs}{Flow\ rate\ X\ Price} - \frac{Variable\ costs}{Price}\right] X \frac{Flow\ rate\ X\ Price}{Invested\ capital}$$

ROIC Tree
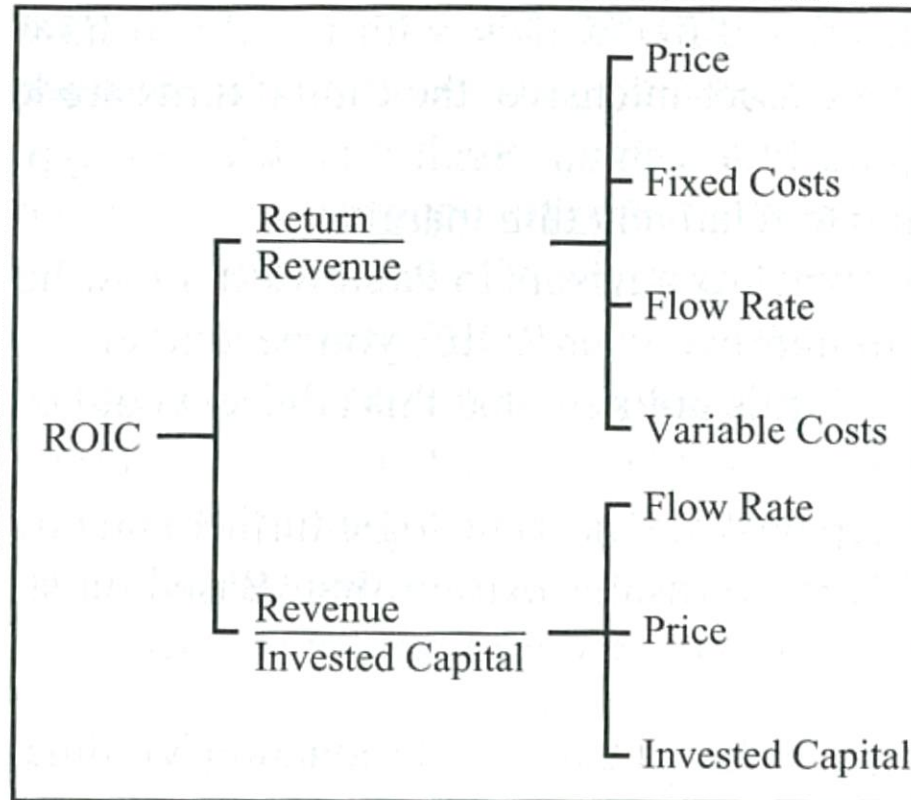
ROIC TREE
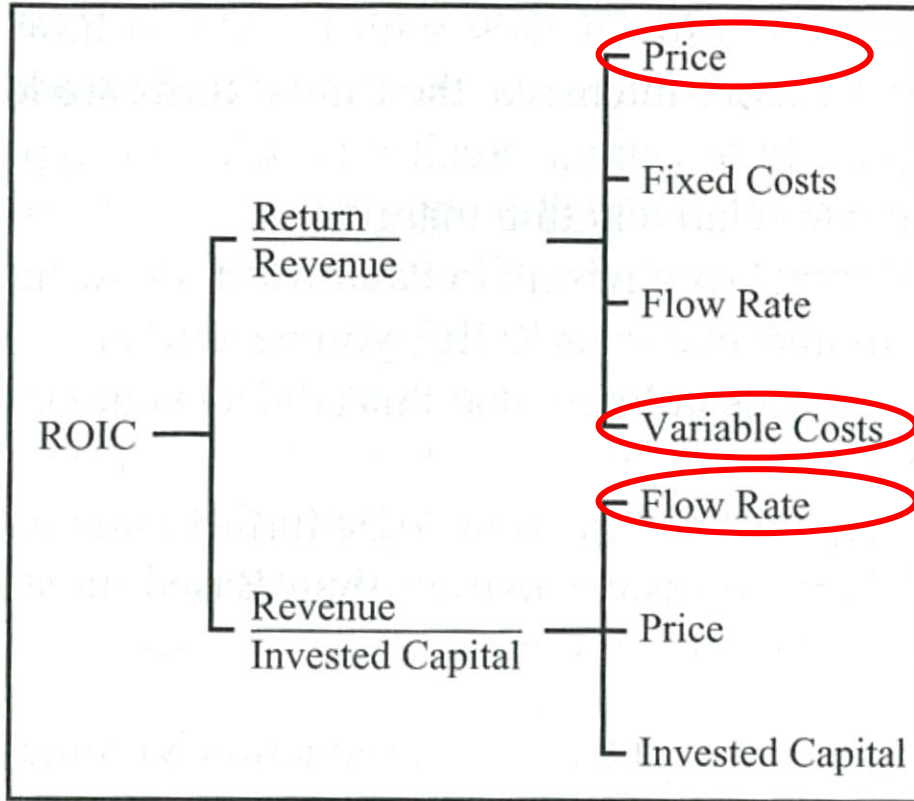
Assume fixed; beyond operational decision
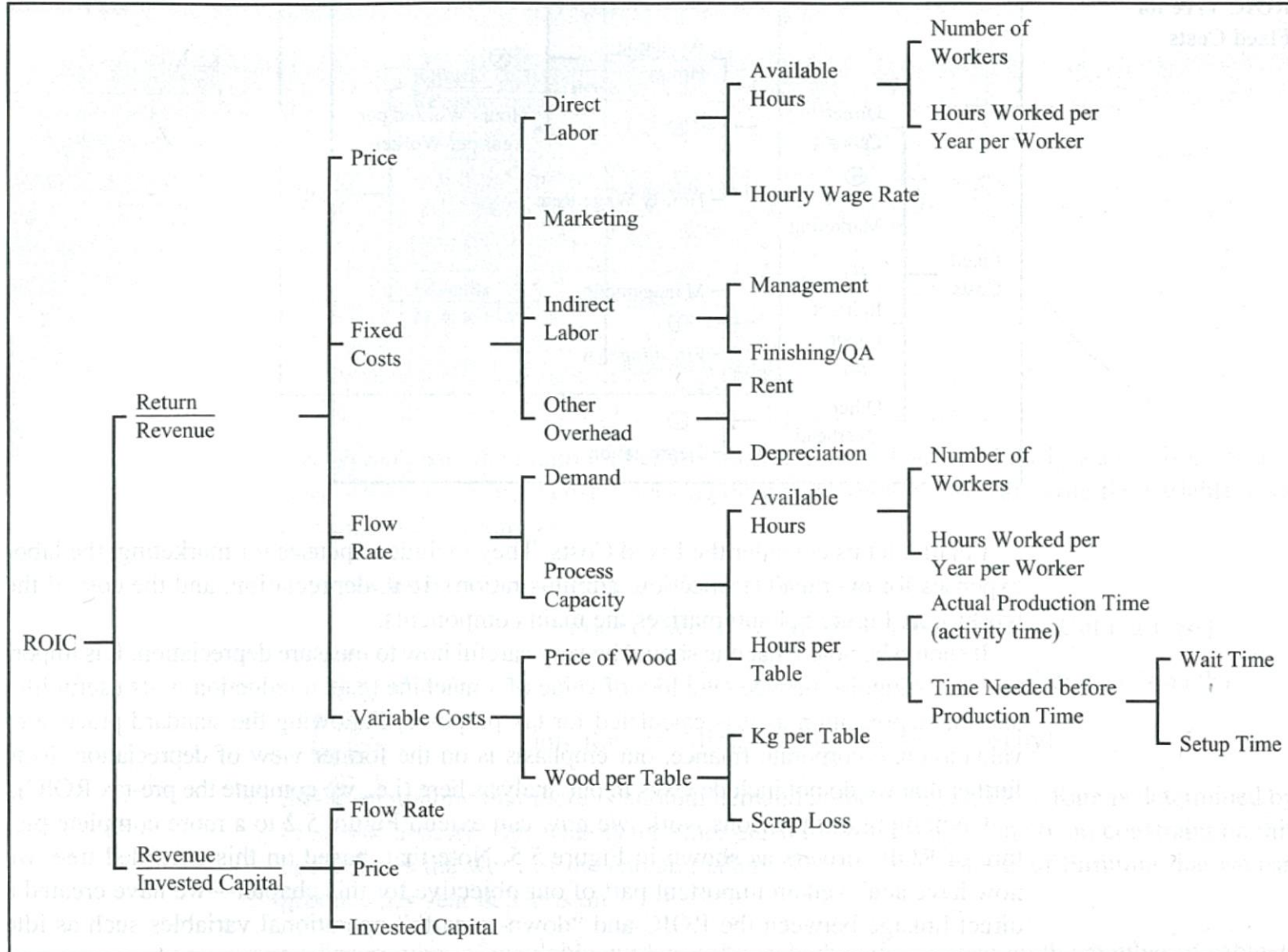
Driven by material:
Variable cost = Price of raw material
    X (rm in final good + processing loss)

Flow rate = min {Demand, Process Capacity}
The capacity depends on:
- # of available worker hours
- The time a worker needs for a piece of end unit = waiting, setting, actual work

IMPROVE ROIC

Many ways:

- Cut wages

- Change design to reduce work required

- Reduce waiting time (for machine)

- Reduce setup times

- Change payment terms (with suppliers)

- Etc.

Which one worth pursuing?!

Basic intuition: changes to one of the leaves will have rather small changes to the root of the tree…

ROIC TREE: IMPROVE ROIC

Less labor content?

Reduce wages?

Less scrap?

Shorten setups?
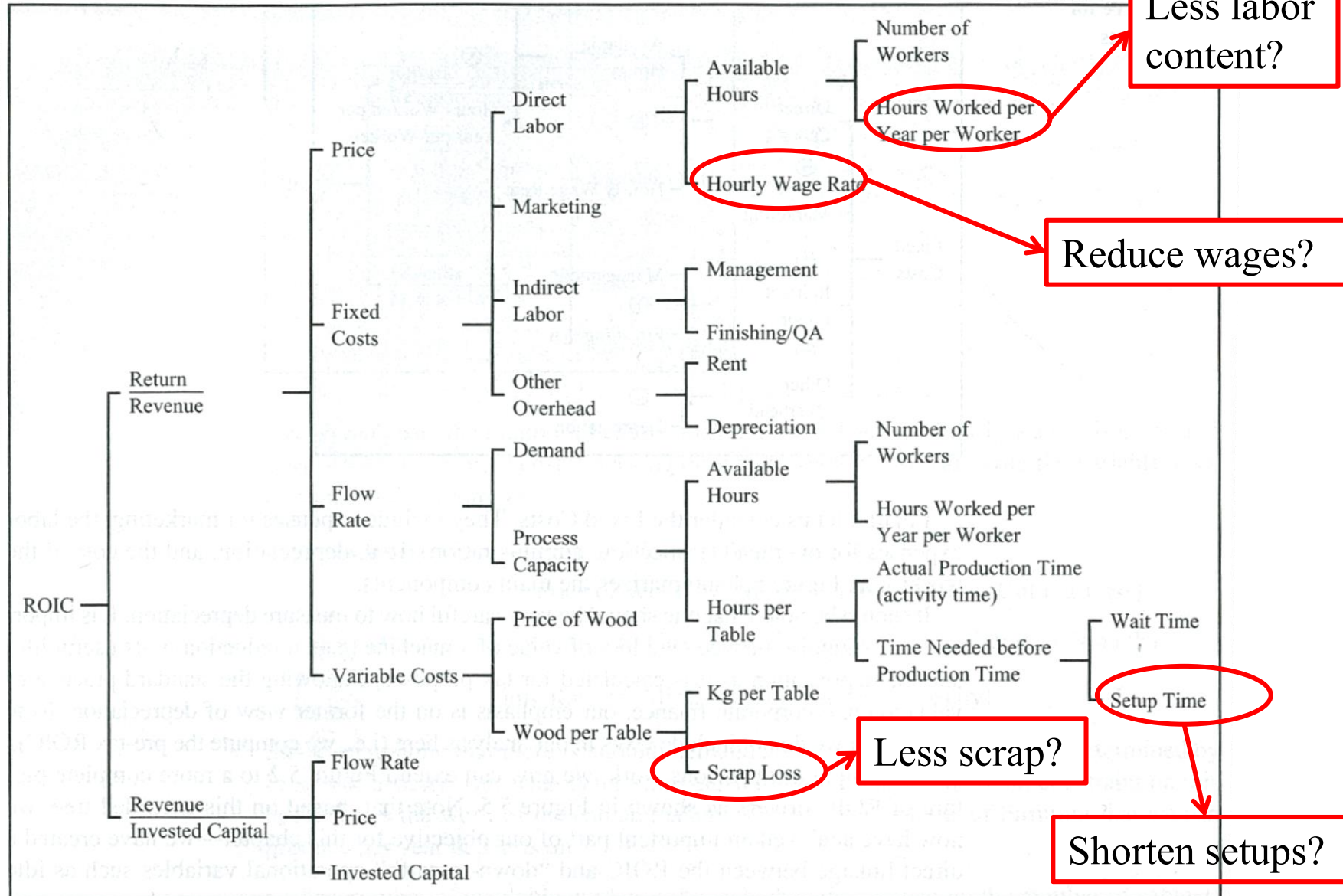
Improve ROIC: Value Drivers

Value drivers are (operational / "little") variables in the ROIC tree that have a big impact on ROIC

Identify value drivers based on sensitivity analysis in Excel

Typical value drivers:

-If operation currently is <u>capacity constrained</u> (i.e. has high demand), everything
  that creates additional capacity is powerful
>> utilization / downtime
>> production yields
>> set-up time / other improvement of overall equipment effectiveness (OEE)

-If operation currently is <u>demand constrained</u> (i.e. has insufficient demand),
 everything that gets more $'s out of a customer is powerful
>> variety / customization
>> after-sales service / support => innovation

But: no general rule exists: your insight is needed

IMPROVE ROIC

- In a capacity constrained operations, reducing setups can go a long way:
  - It is a driver of margins
  - It influence sales per year => asset turns
- Assumed: Sufficient demand
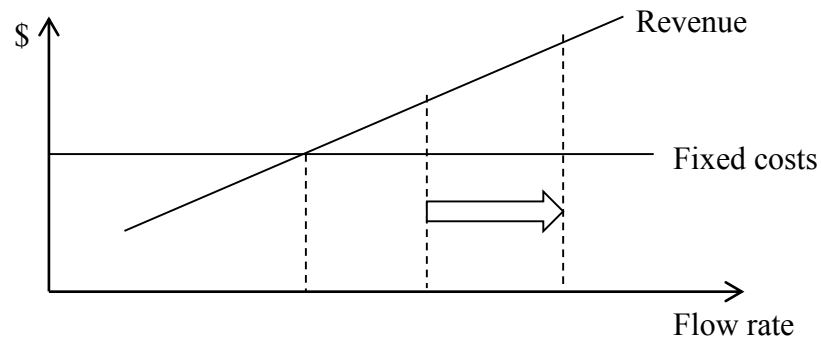
Airline Example: PHL to SEA on a Boeing 737-700

Distance: 2378 miles (nonstop)

Seats on airplane: 137

Available seat miles: 137*2378=325,786 seat miles

120 passengers are on the plane paying an average of $200 for their ticket

Revenue passenger miles: 120*2378=285,360 revenue passenger miles

Load factor: RPM/ASM=0.876 (percentage of seats sold)

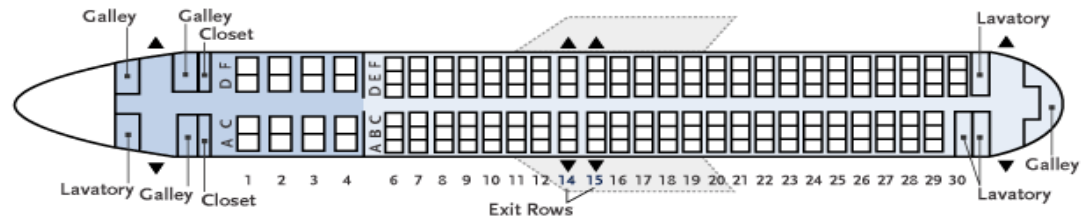Yield: revenue per revenue passenger mile=120*200/285,360=0.08 $/RPM

Main cost categories are
        Labor expenses
        Fuel expenses
        Landing fees
        SG&A

THY Example: to on an Airbus 321

Distance: _____ KM (nonstop)

Seats on airplane:

Available seat km: _____ * _____ = _____ seat km

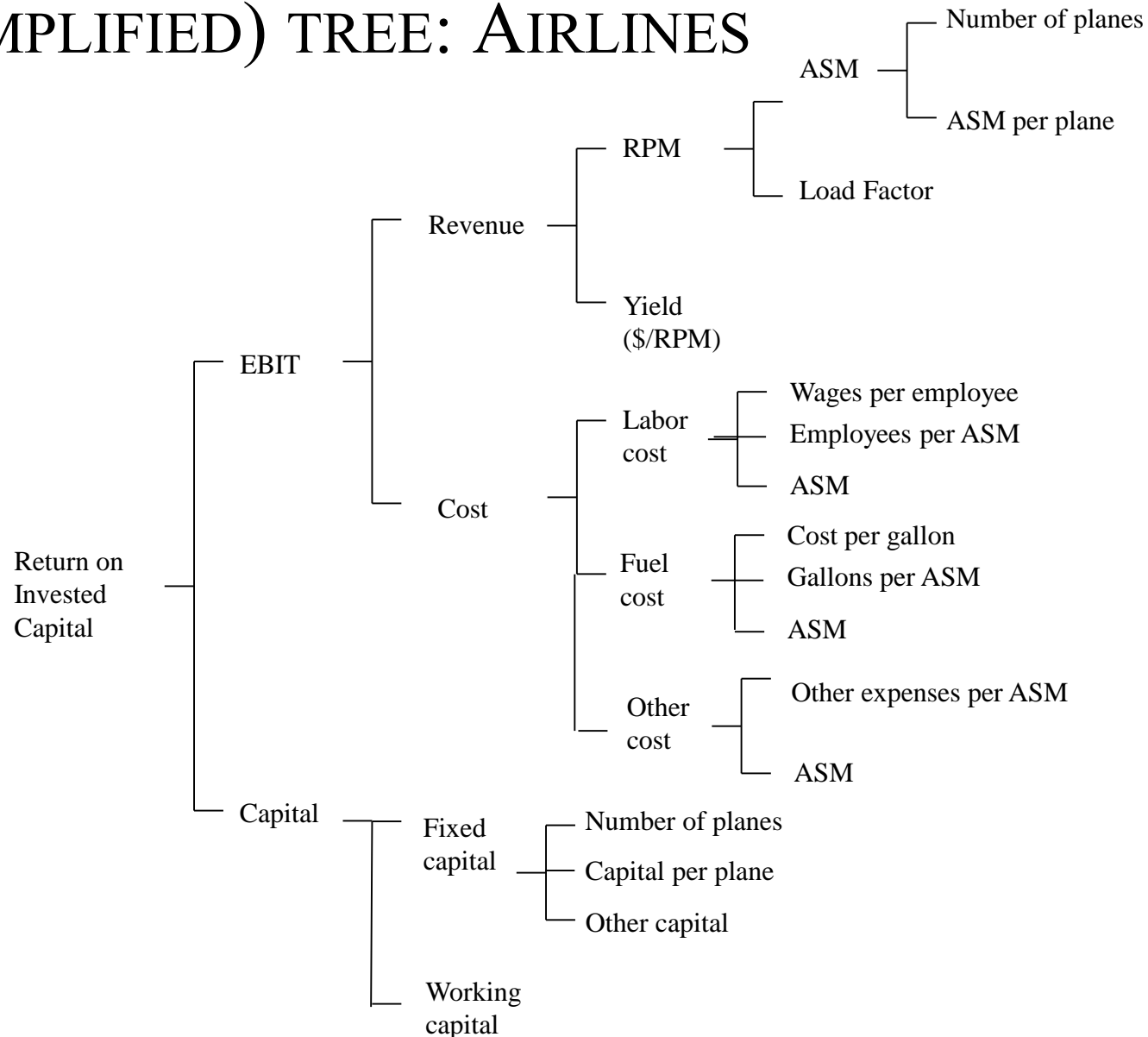_____ passengers are on the plane paying an average of $_____ for their ticket

Revenue passenger km: _____ * _____ = _____ revenue passenger km

Load factor: RPK/ASK=_____ (percentage of seats sold)

Yield: revenue per revenue passenger km=_____*_____/_____=_____ $/RPK

ROIC (SIMPLIFIED) TREE: AIRLINES

PRODUCTIVITY RATIOS

- $productivity = \dfrac{revenue}{cost}$

- $labor\ productivity = \dfrac{revenue}{labor\ cost}$

- Southwest's ratio was 40% higher than US's (pre 2001). Is it due to higher volume of passengers? Are the employees paid less? The ratio does not reveal this information.

- $productivity = \dfrac{revenue}{cost} = \underbrace{\dfrac{revenue}{Flow\ rate}}_{Yield} \cdot \underbrace{\dfrac{Flow\ rate}{Resource}}_{Efficiency} \cdot \underbrace{\dfrac{Resource}{cost}}_{Cost}$

- Applied to labor productivity:

- $labor\ prod. = \dfrac{revenue}{RPM} \cdot \dfrac{RPM}{ASM} \cdot \dfrac{ASM}{Employees} \cdot \dfrac{Employees}{cost}$

EXAMPLE: AIRLINES (2000)

$$labor\ prod = \frac{Revenue}{RPM} \cdot \frac{RPM}{ASM} \cdot \frac{ASM}{Employees} \cdot \frac{Employees}{Cost}$$

Airline	Operational yield ($/RPM)	Load factor	ASM/emp	# of emp/$m labor costs	Overall labor prod.
US	0.197	70	0.37	47.35	2.43
Southwest	0.135	69	0.53	67.01	3.31

USAir: 0.197 * 0.70 * 0.37 * 47.35 = 2.43
SW: 0.135 * 0.69 * 0.53 * 67.01 = 3.31
Note: There exists a $25k per year difference in wages (=(1/47.35-1/67.01)*4000)

Observations:

- US has a pricing power
- **A SW employee supports 50% more ASMs**
- SW were lower paid (but this has changed since then, now better paid…)

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WHAT IF

- What if US could pay SW paychecks?
  - 45,833 employees on payroll
  - 45,833 X ($21,120-$14,922)=**$284**,072,934

- What if US employees would achieve SW's productivity?
  - US: 17,212/45,833=0.37 ASM per employees
  - SW: 0.53 ASM per employees
  - With 0.53 ASM/emp, US would require only 17,212/0.53=32,475 employees
  - $21,120 X 13,358 = $282,120,960

- What if achieve productivity gain AFTER adjusting paycheck?
  - $14,922 X 13,358 = **$199**,382,076

WHAT IF

Strategic Trade-offs

Yield vs efficiency (2000)

Yield vs efficiency (2008)
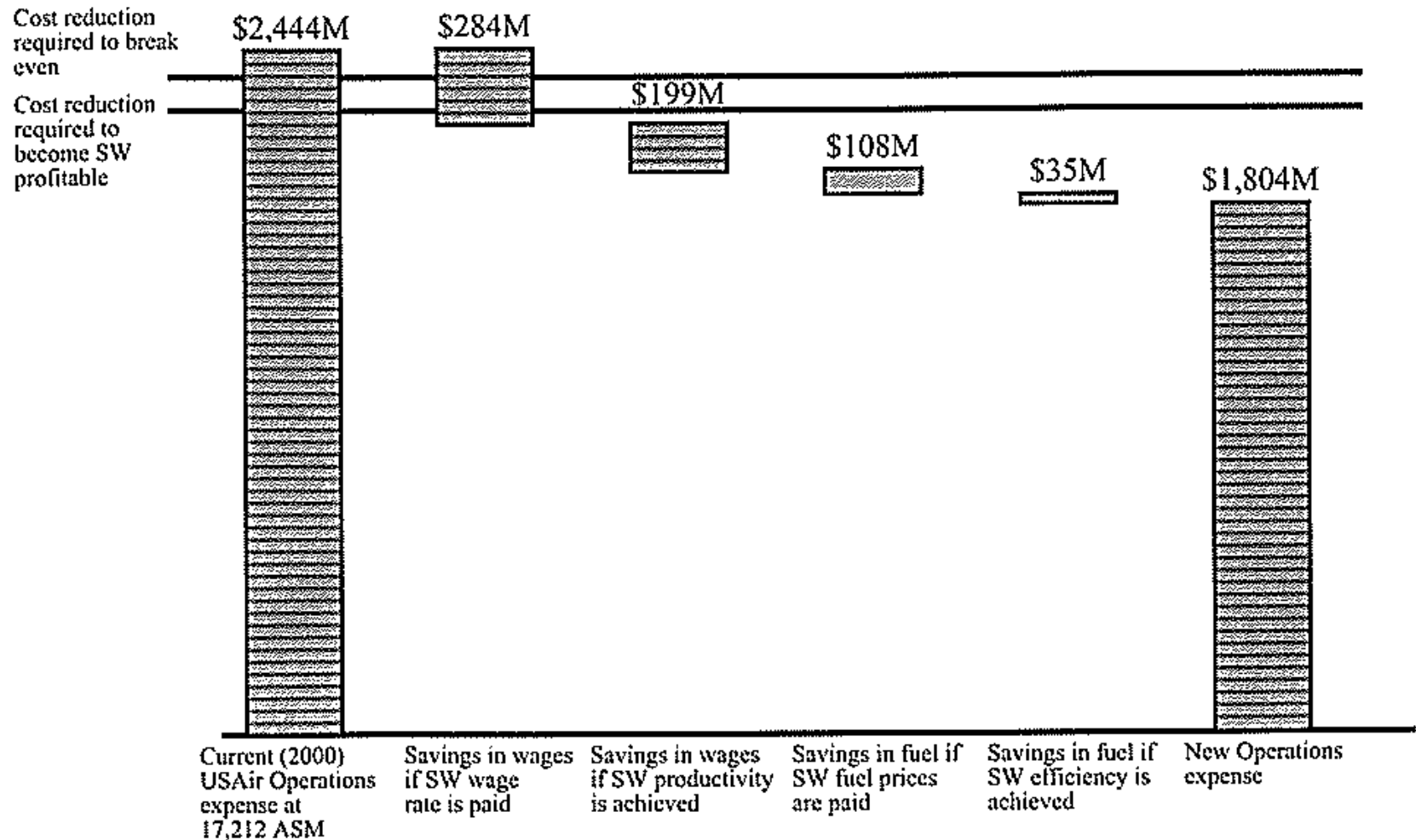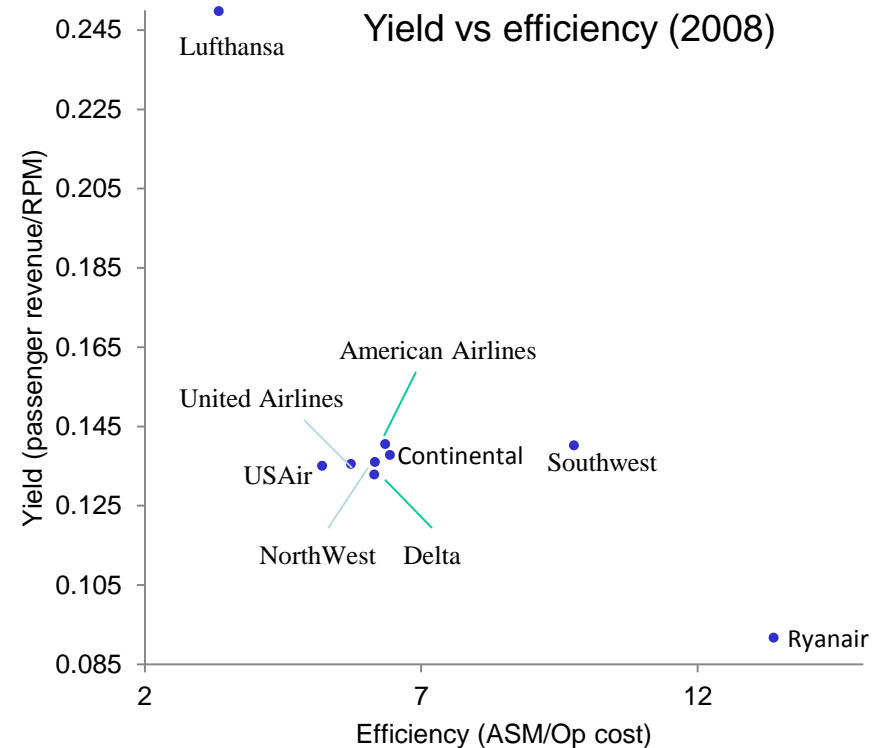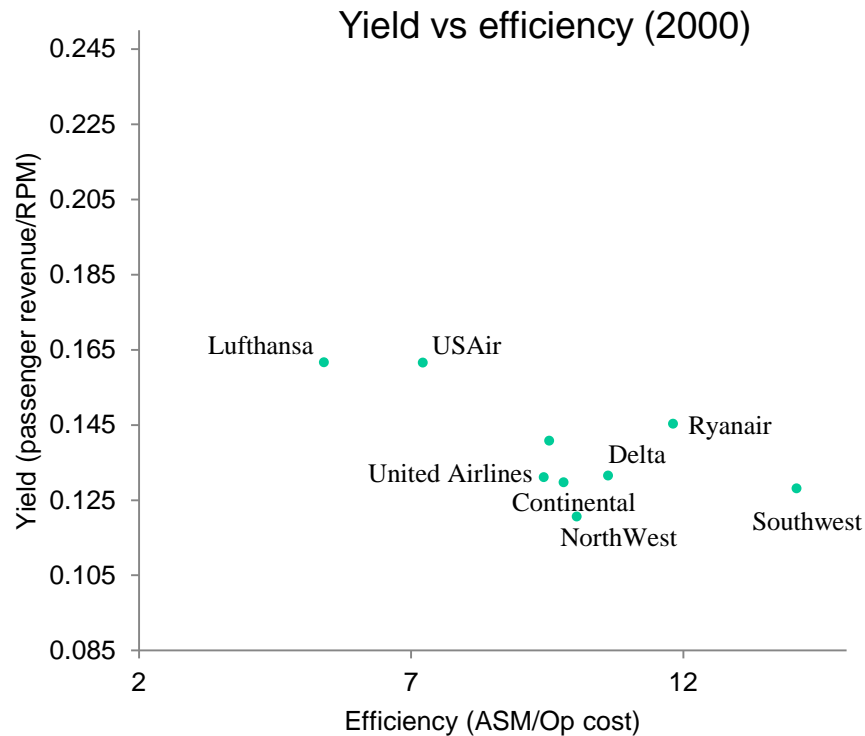
- No differentiation between the major US carriers
- Efficient frontier:
  Southwest introduced the high efficiency strategy in the US
  Ryanair has pushed this to the extreme in Europe following

=> Choose clean strategies, especially for Lufthansa and Ryanair … and drive improvement towards the frontier and beyond

Note: all numbers are exchange rate adjusted

STRATEGIC TRADE-OFFS ACTIVITY

- Pick (at least) two years and choose two performance measures
  - The measures can be direct (such as ASM) or derived (such as ASM/employee)
  - The two performance measures should highlight a trade-off airline carriers consider
  - The two years should be somewhat far apart so changes over time can be demonstrated.

HERE IS AN EXAMPLE (FROM PREVIOUS YEARS)

Operational Yield vs ASM per Employee (2000)

Operational Yield vs ASM per Employee (2011)
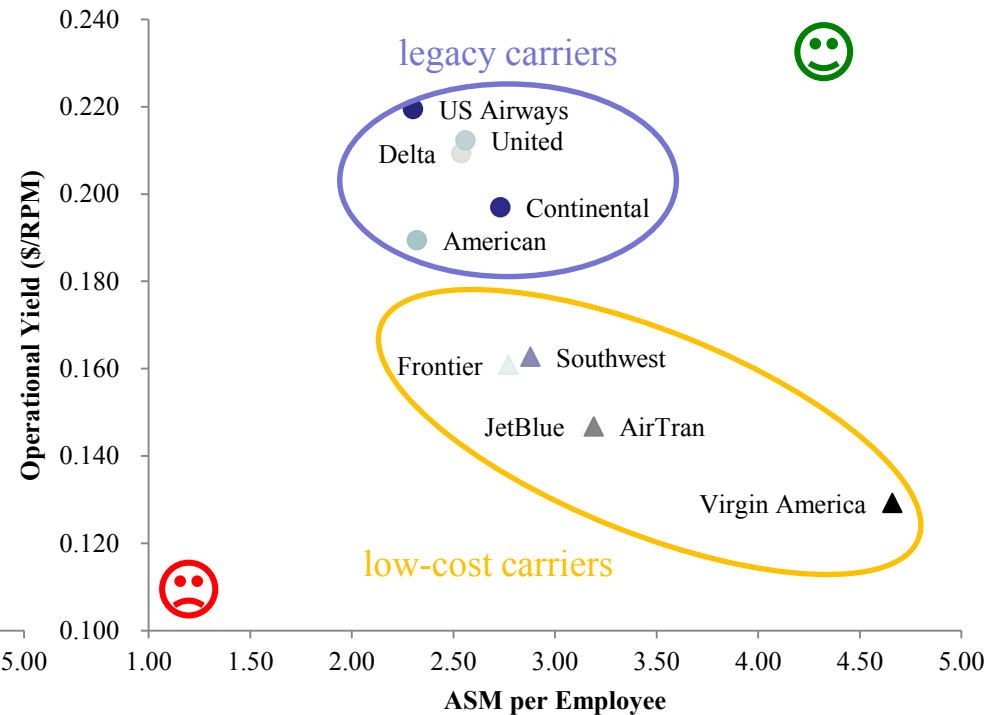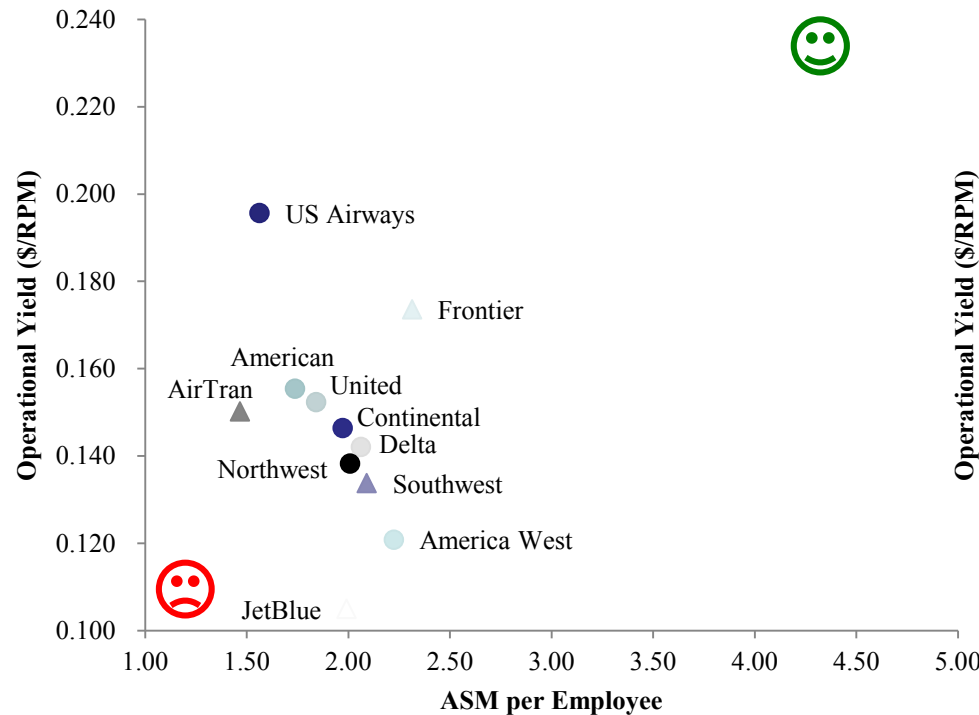
- No differentiation between legacy carriers and low cost carriers in 2000
- Big improvement from 2000 to 2011 for the whole industry
    - legacy and low cost carriers are clearly separated in terms of the operational yield
    - but in terms of efficiency, measured in ASM/employee, legacy carriers are only slightly worse than most of their competitors from the low-cost sector
  ⇨ **Irrespective of the year or the airline sector: To generate a high operational yield you need more personnel relatively to the available seat miles**