TURKISH AVIATION ACADEMY

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Operations & Logistics Management in Air Transportation

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Air Transportation Management

M.Sc. Program

Air Transportation Systems and Infrastructure

Strategic Planning

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OPERATİONS AND FİNANCE

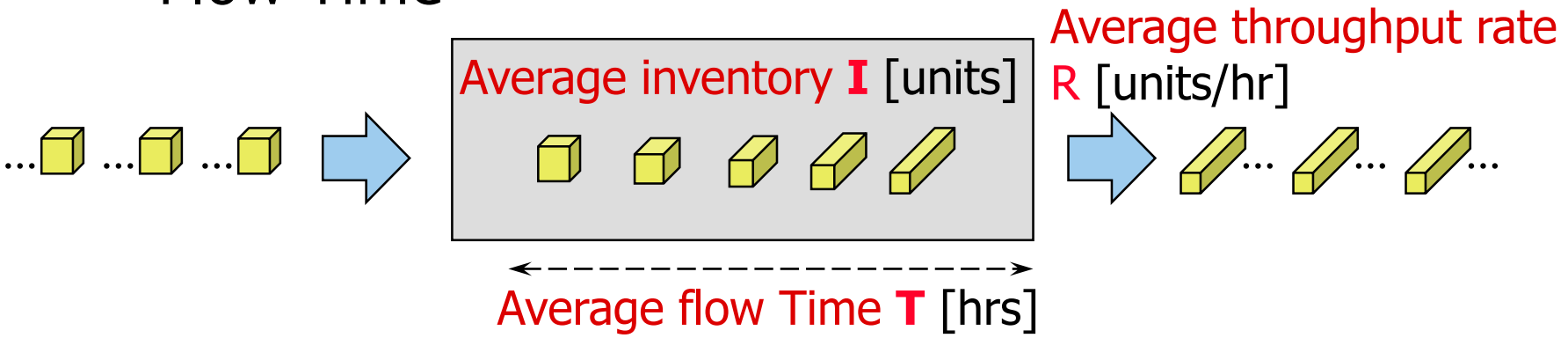
RECALL: PC INDUSTRY 2005

	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



$$\text{Inventory (Average)} = \text{Throughput rate (Average)} \times \text{Flow time (Average)}$$

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

FOUR DİFFERENT WAYS TO COUNT İNVENTORY

- **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 CALCULATİONS

- Days-of-supply is the "T" in I = R x 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 CALCULATİONS

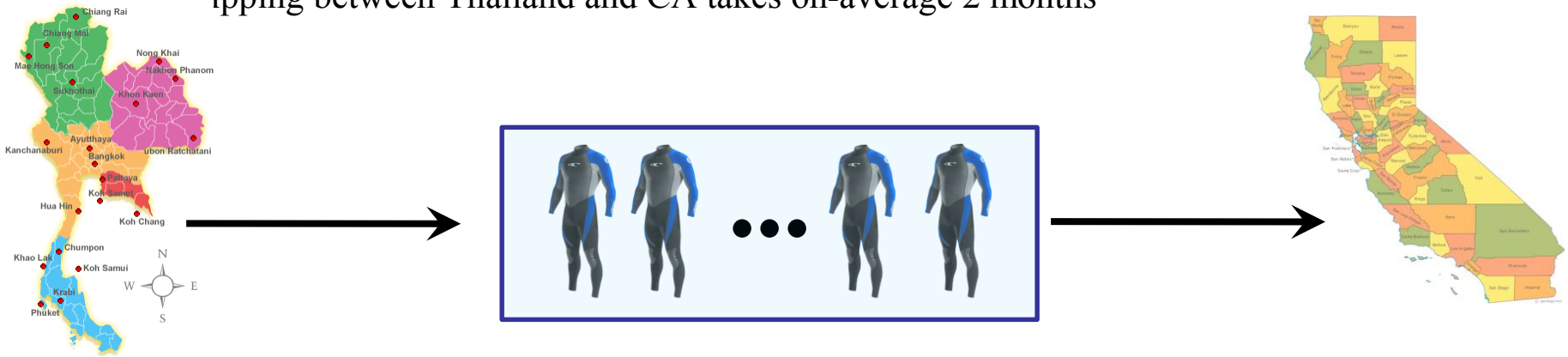
- Inventory Turns = 1 / T = R / I

- 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!

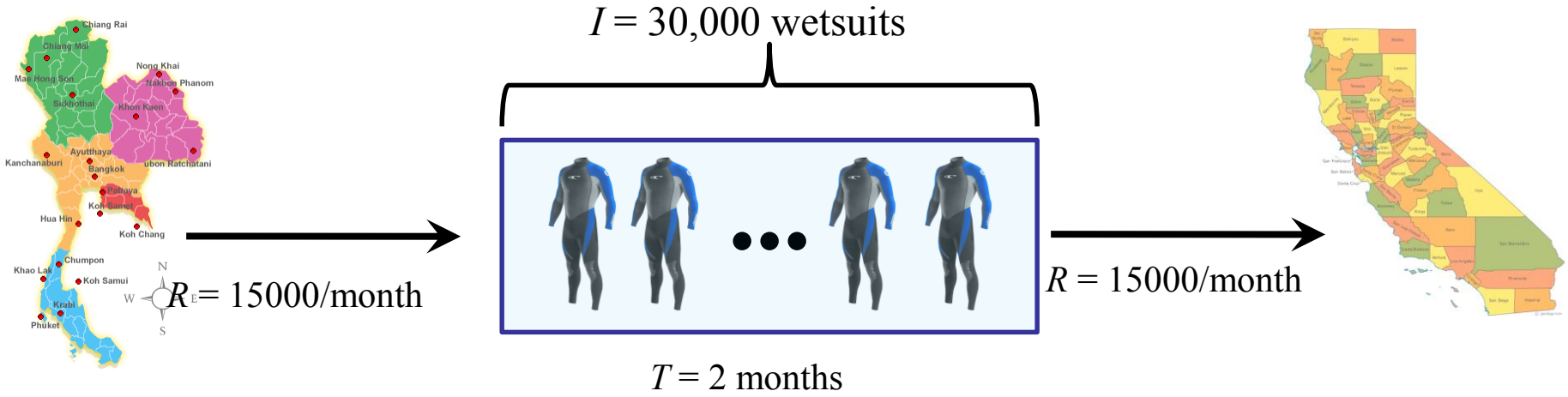
A LITTLE'S LAW APPLICATION: IN-TRANSIT INVENTORY

- 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, $T = 2$
  - $I = R$ x T = 15,000 x 2 = 30,000 units are in-transit on average



Annual turns:

R = 15000 x 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 = $1/T$ = 1 / (1/6) = 6

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

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

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

- COGS = Cost of Goods Sold = Flow Rate
  - The Flow Rate is not 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

- *COGS = Cost of Goods Sold = Flow Rate*
  - The Flow Rate is not 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

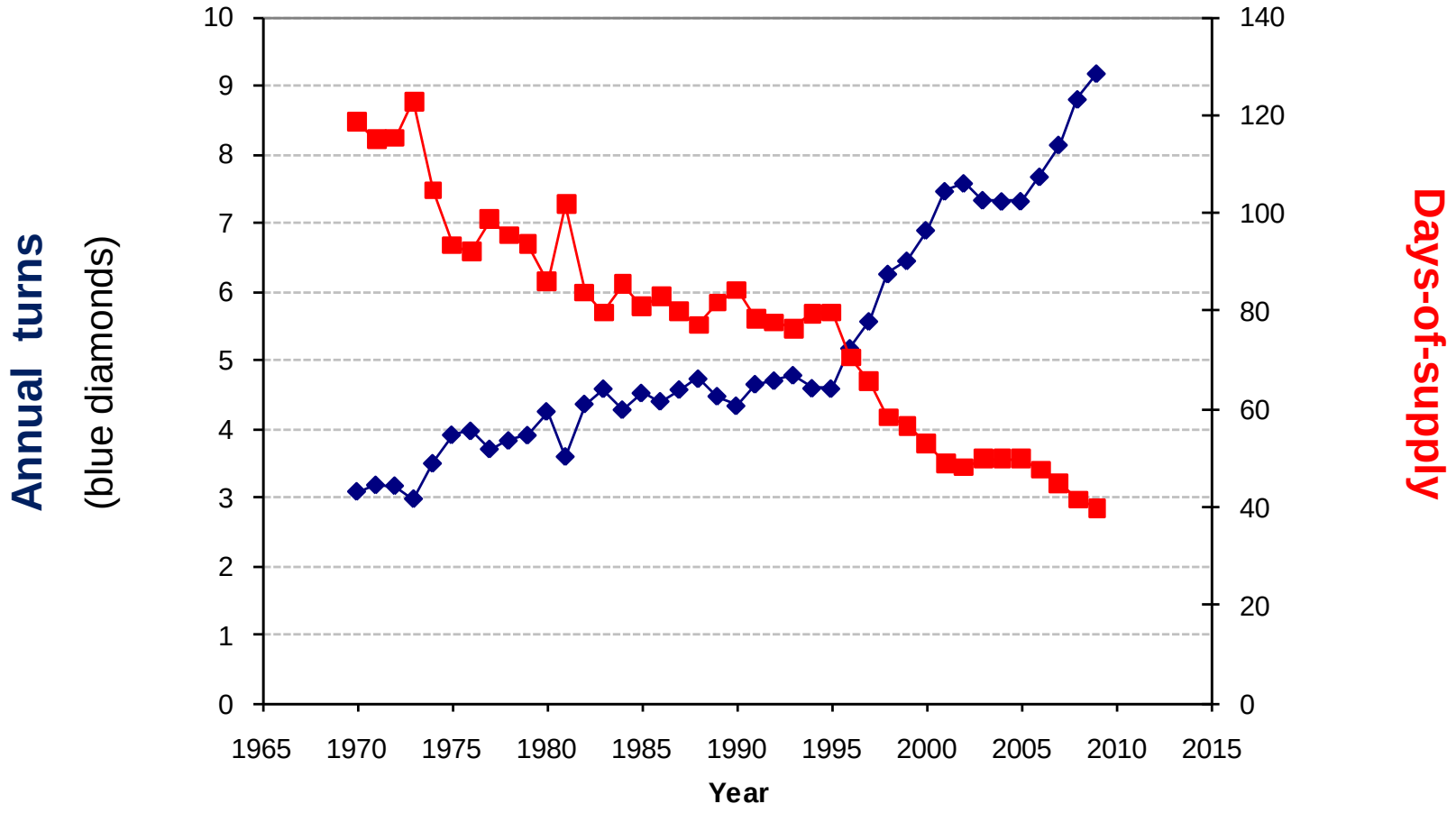
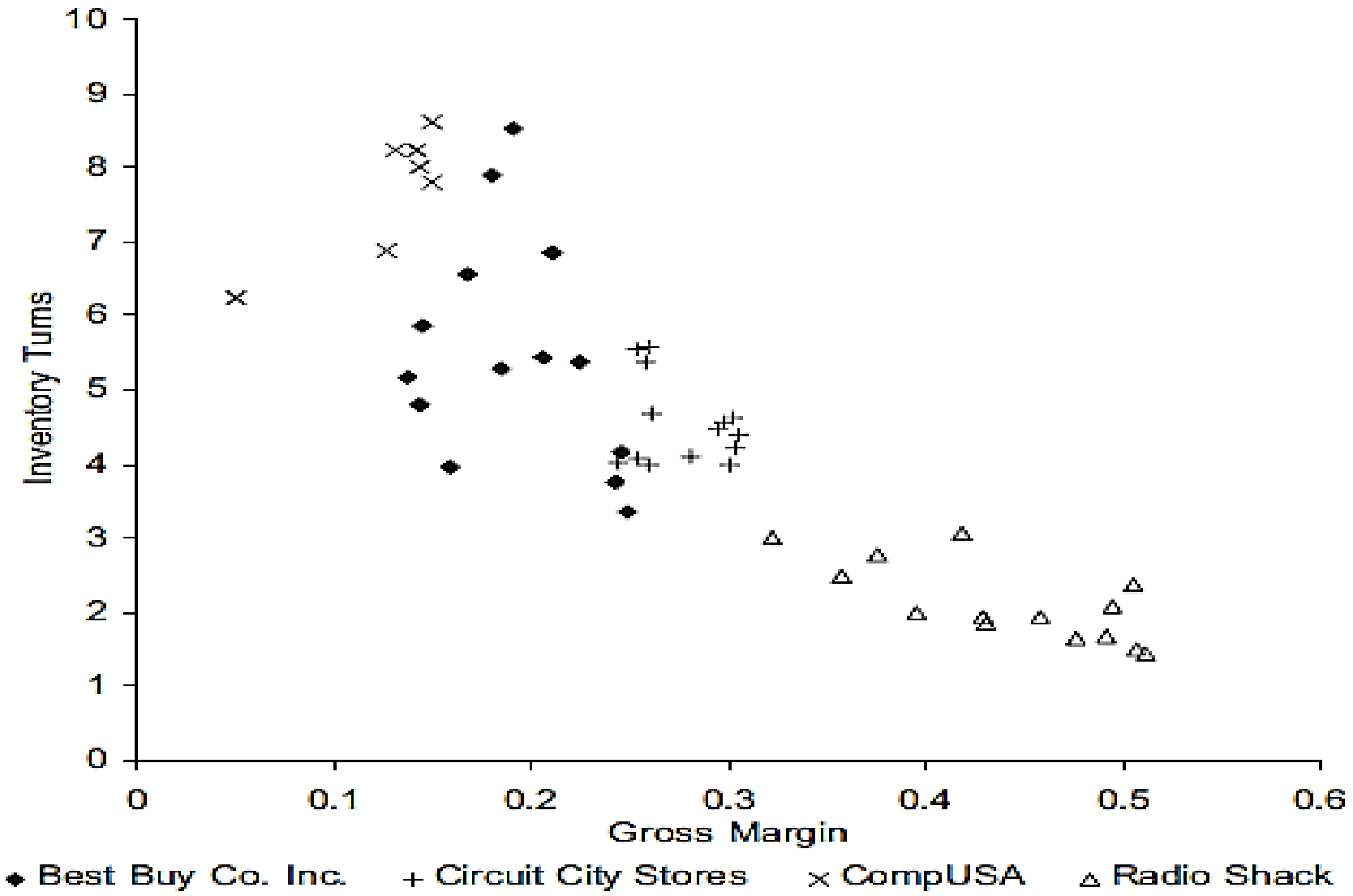


Figure 1 **Plot of Annual Inventory Turns vs. Annual Gross Margin for Four Consumer Electronics Retailers for the Years 1987–2000**



Source: Gaur, Fisher, Raman 2005

INVENTORY TURNS AND GROSS MARGİNS

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 HOLDİNG 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 HOLDİNG 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

$$\text{Inventory holding cost per turn} = \text{Annual inventory holding costs x Flow Time}$$

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

INVENTORY HOLDİNG COST PER UNİT

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

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

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

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

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

SOLUTİON

Calculate the annual inventory holding cost

Annual Inventory Holding costs= COGI*holding rate
= 1M * $100* 0.3 = $30 M

Average Inventory holding cost per turn
= Annual Inventory cost *Flow time
= Annual Inventory cost/ turnover rate
= $30 M /6 = $5 M per turn

Average Inventory holding cost per unit
= Average inventory holding cost per turn / Average inventory
= $5 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

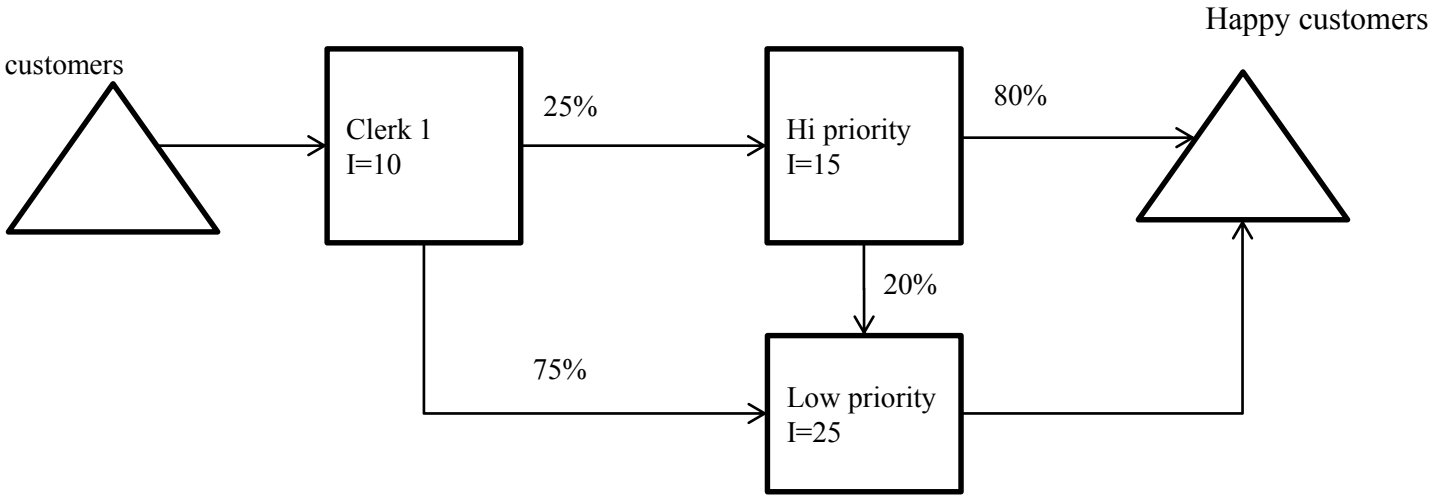
$$\$3 * 0.3 = \$0.9$$

- 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

ONE MORE EXAMPLE

The process handles a flow of 100 customers/ hr.
What is the average flow time?



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
1-Hi: 75% spend 24.75 min
} => 30 min

ECONOMİC 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)

ECONOMİC 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).

PAUL DOWNS CABINETMAKERS

Paul Downs started making furniture in 1986, in a small shop in Manayunk. Over the years we have outgrown 4 other shops and we now operate a 20,000 sf shop (see below) in Bridgeport, PA.

Much of our work is residential, but we also do a lot of office furniture, including desks and conference tables. We complete 125 commissions per year, consisting of about 500 separate pieces of furniture.

Production facility

- Machines valued about $350k, depreciation $60k p.a.
- Overall facility is utilized at 100% right now

Show rooms and factory: $150k for rent

Indirect costs: marketing ($100k, $180k management, $60k finish)

Inventory: $50,000 WIP and $20,000 raw material

Suppliers need to be paid 1 month before receiving the wood.

PAUL DOWNS

CABINETMAKERS

Work force

12 cabinet makers each working about (220 days @8h/day)

Make $20 per hour

A worker needs about 40h per unit of furniture (work-cell) as labor content

Spend about 15% of time on set-ups (build fixtures / program machines)

Labor utilization around 90% (idle time resulting from waiting)

End Product

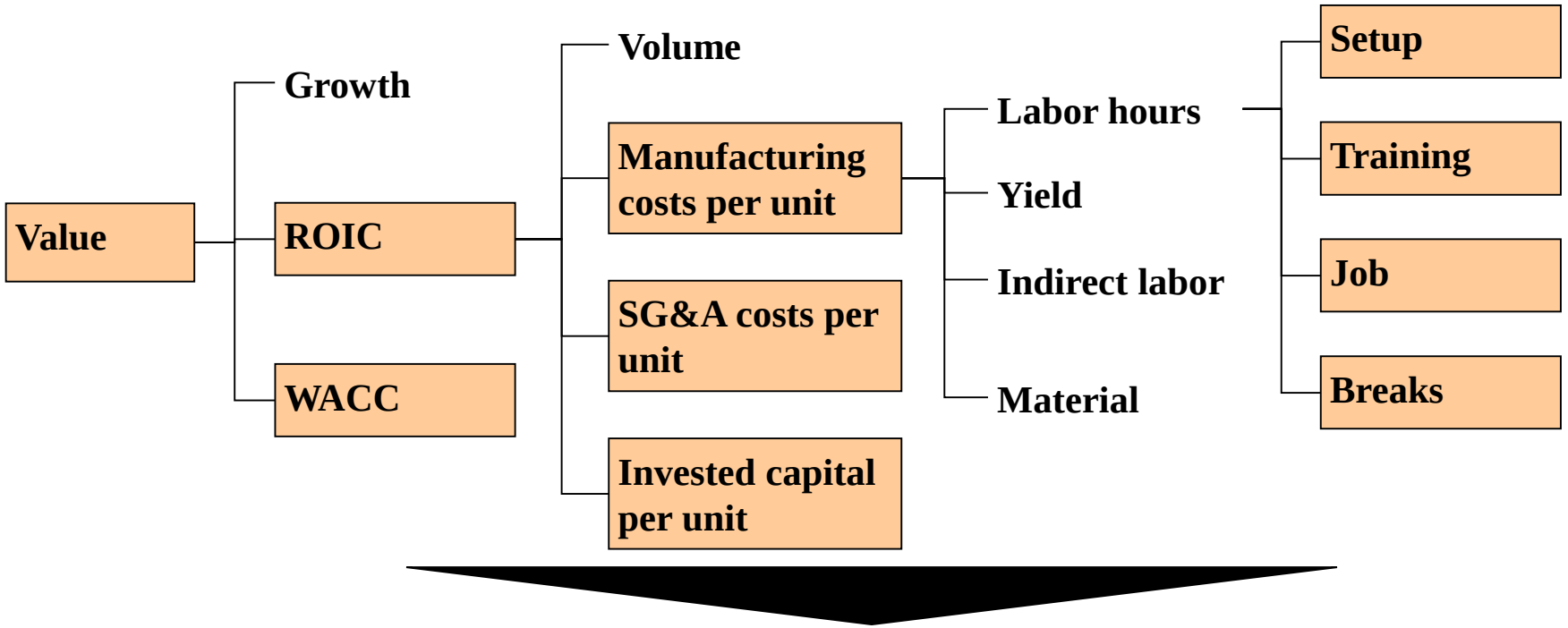
Average price is $3000 per unit

Requires 30kg of wood (wood costs about $10 per kg) before scrap

25% scrap

Customer pays 50% down and gets her furniture 3 months later

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

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 capacity constrained (i.e. has high demand), everything that creates additional capacity is powerful

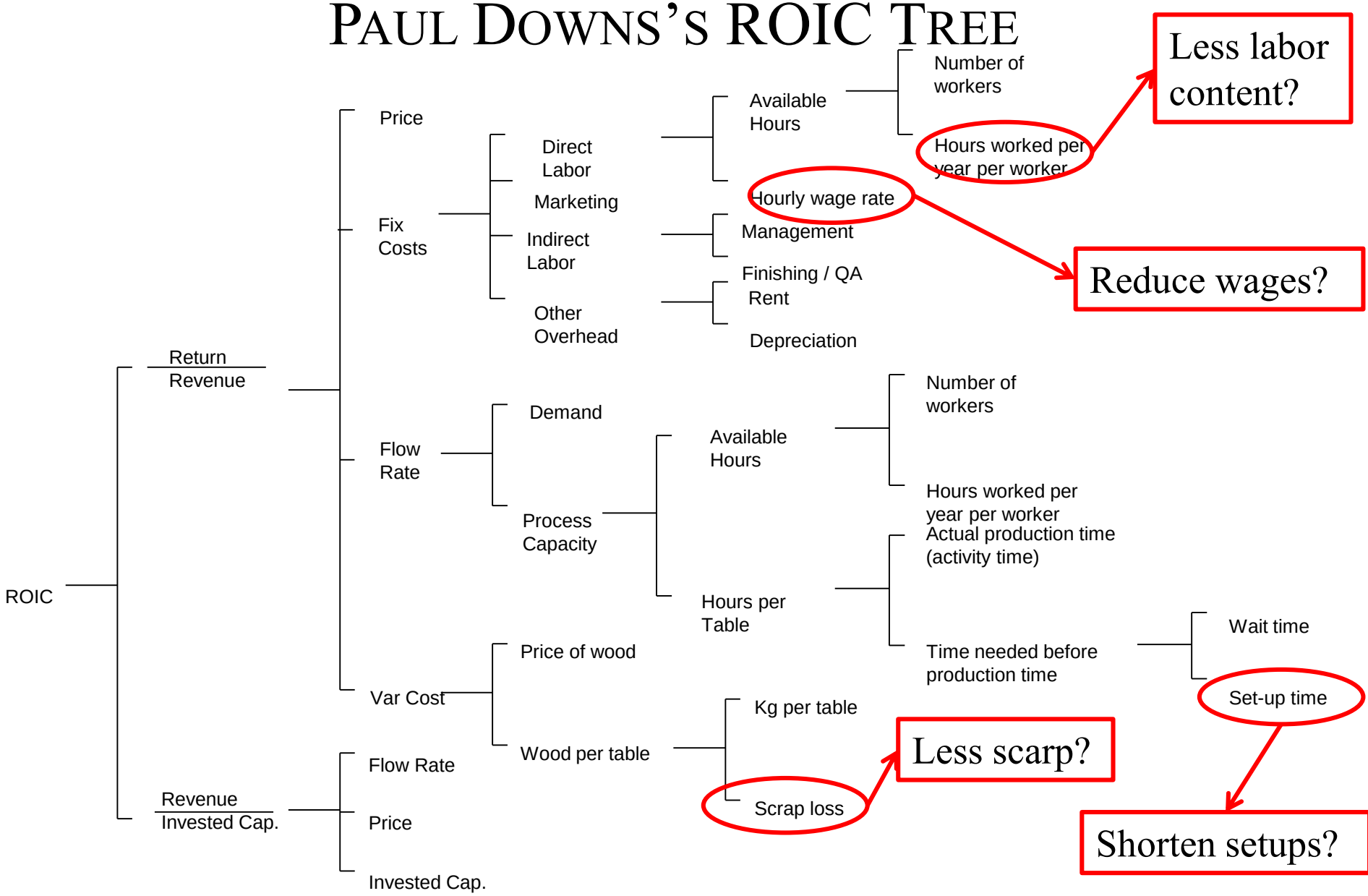
- utilization / downtime
- production yields
- set-up time / other improvement of overall equipment effectiveness (OEE)

-If operation currently is demand constrained (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

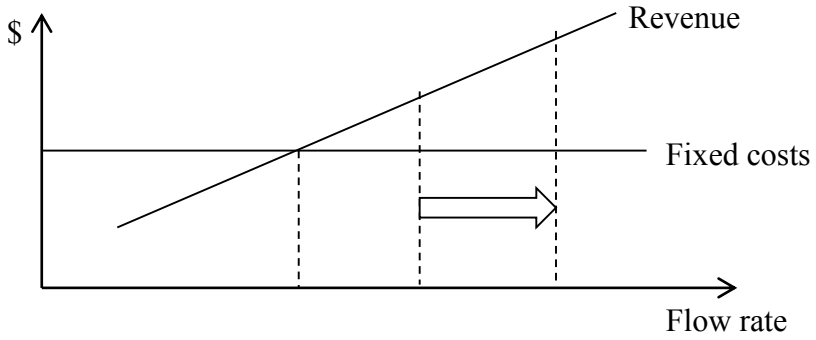
Paul Downs's ROIC Tree



IMPROVE ROIC

Change	Impact on ROIC
Reduce wages by $1/hr (from $20)	5.4%
Reduce setups by 5% points (from 15%)	18.8%
Reduce rent by $10k/yr	2.5%
Reduce labor content by 2 hr/table	14.7%
Reduce scrap rate by 5%	1.5%

Higher flow rates can have big impact on ROIC:



Setup:
- Driver of margins
- Influence Sales per year => Asset turns

Assumed:
- Sufficient demand
- 5% reduction is feasible

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

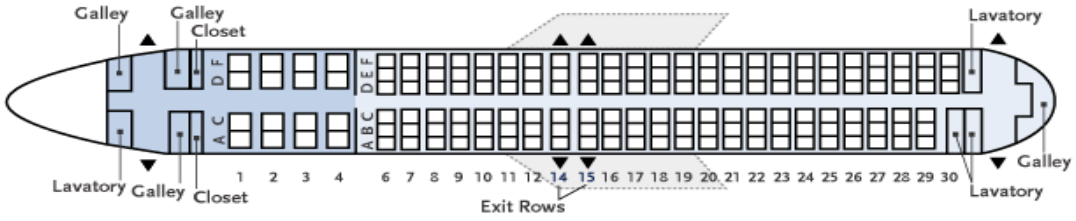
Revenue passenger miles: 120*2378=285,360 revenue passenger miles

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

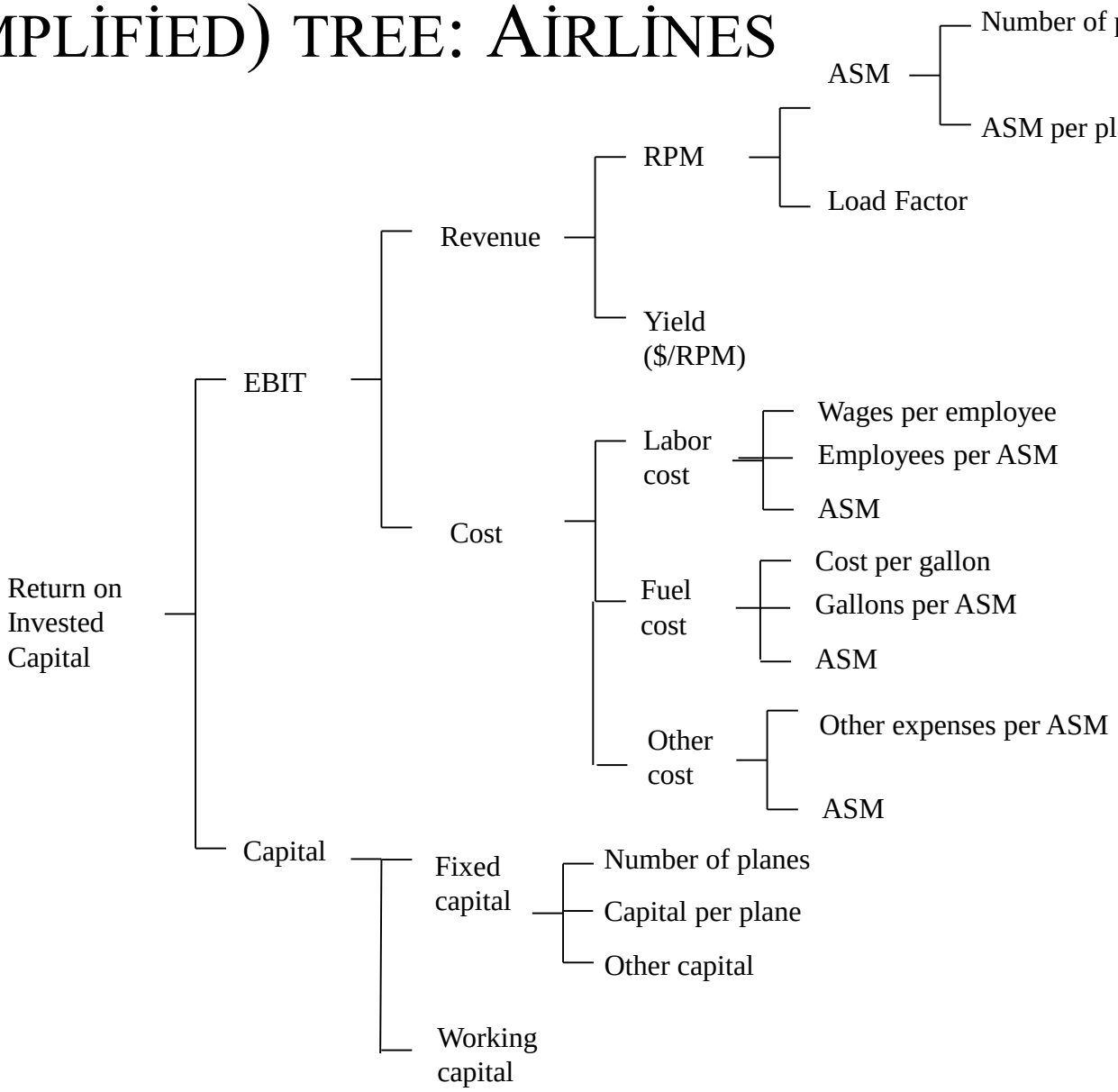
Yield: revenue per revenue passenger mile=120*200/285,360=0.08 $/RPM

Main cost categories are

- Labor expenses
- Fuel expenses
- Landing fees
- SG&A



ROIC (SİMPLİFİED) TREE: AİRLİNES



PRODUCTİVİTY RATİOS

- $productivity = \frac{revenue}{cost}$
- $labor\ productivity = \frac{revenue}{labor\ cost}$
- 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.
- $productivity = \frac{revenue}{cost} = \underbrace{\frac{revenue}{Flow\ rate}}_{\text{Yield}} \cdot \underbrace{\frac{Flow\ rate}{Resource}}_{\text{Efficiency}} \cdot \underbrace{\frac{Resource}{cost}}_{\text{Cost}}$
- Applied to labor productivity:
- $labor\ prod. = \frac{revenue}{RPM} \cdot \frac{RPM}{ASM} \cdot \frac{ASM}{Employees} \cdot \frac{Employees}{cost}$

EXAMPLE: AİRLİNES (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)

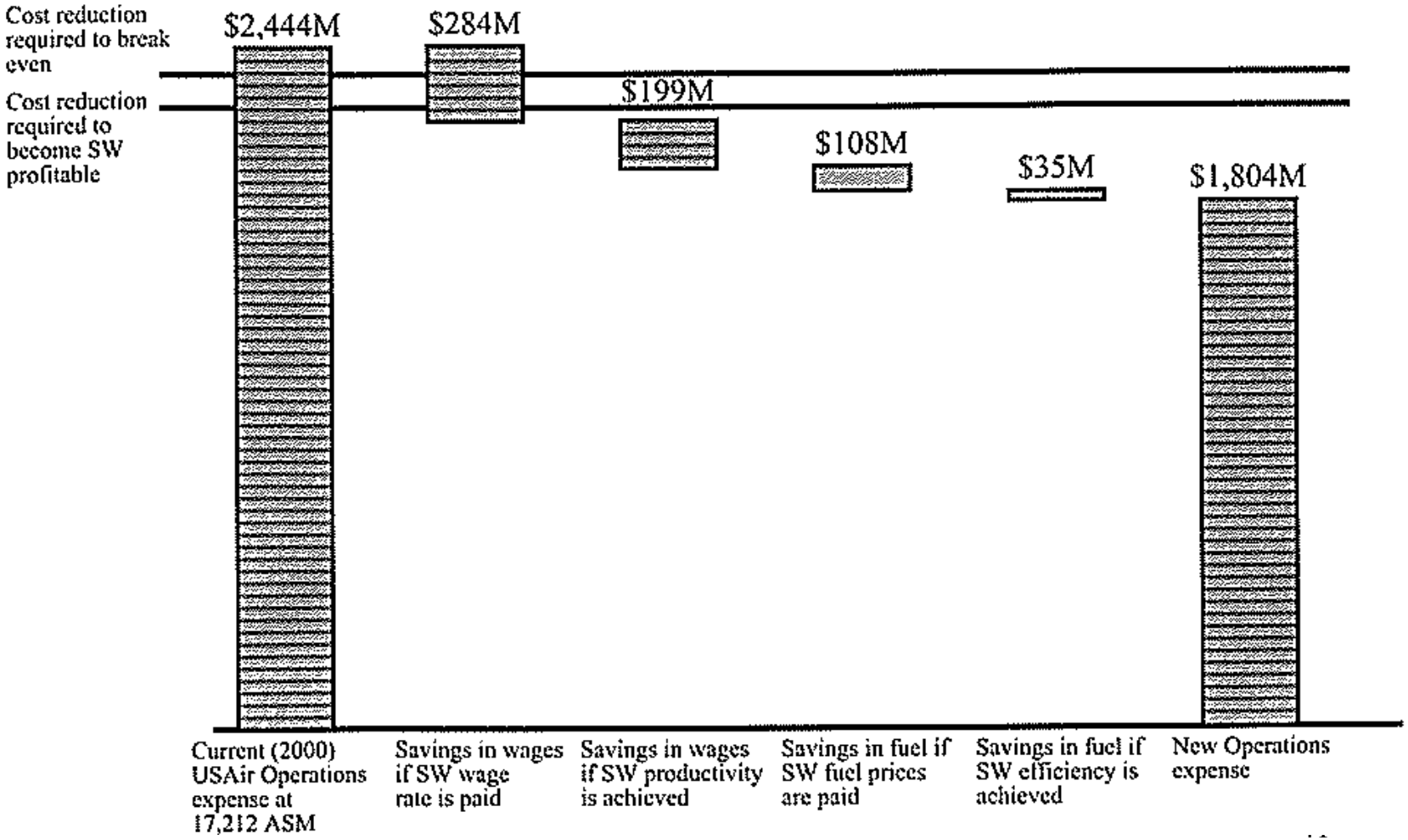
Observations:

- 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…)

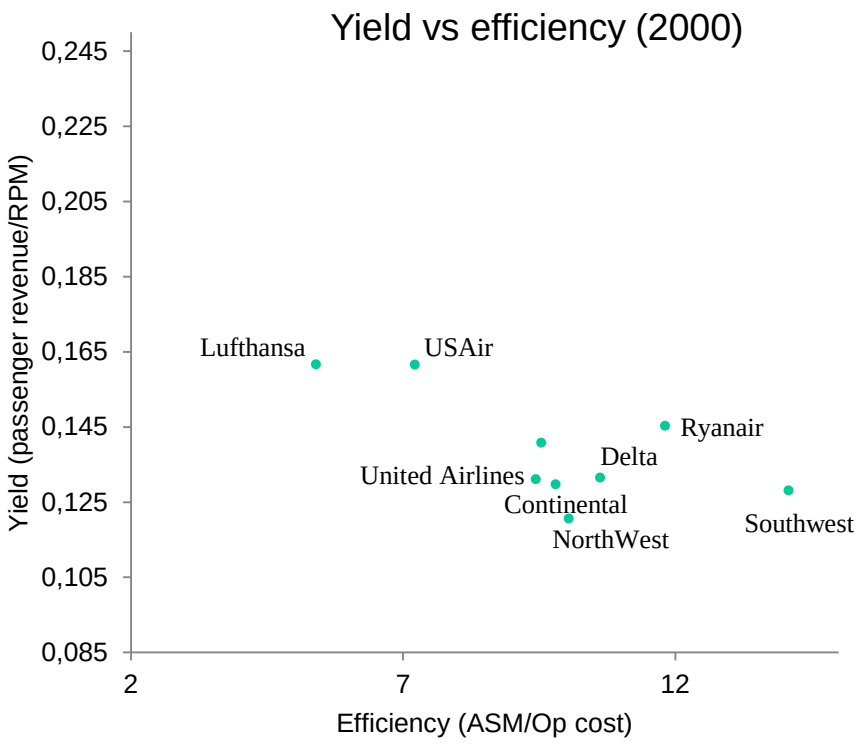
WHAT İF

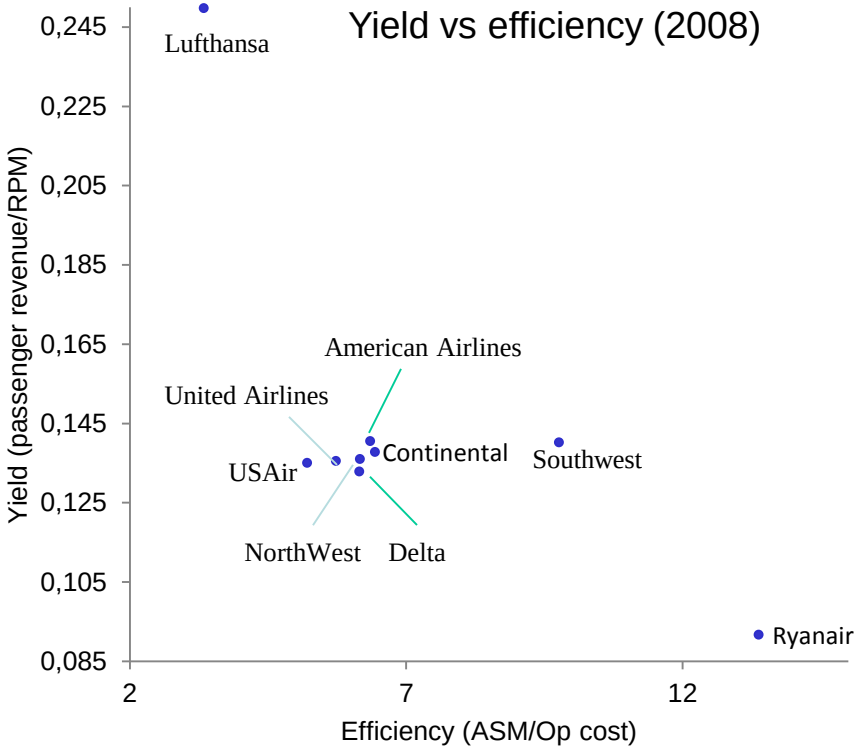
- What if US could pay SW paychecks?
  - 45,833 employees on payroll
  - 45,833 X ($21,120-$14,922)=**$284**,072,934
- What if US employees would achieve SW's productivity?
  - US: 17,212/45,833=0.37 ASM per employees
  - SW: 0.53 ASM per employees
  - With 0.53 ASM/emp, US would require only 17,212/0.53=32,475 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 İF


Cost reduction required to break even
Cost reduction required to become SW profitable
$2,444M
$284M
$199M
$108M
$35M
$1,804M
Current (2000) USAir Operations expense at 17,212 ASM
Savings in wages if SW wage rate is paid
Savings in wages if SW productivity is achieved
Savings in fuel if SW fuel prices are paid
Savings in fuel if SW efficiency is achieved
New Operations expense

Strategic Trade-offs





- 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

STRATEGİC TRADE-OFFS ACTİVİTY

- Pick two airlines and plot performance on at least two measures over the years, or
- Pick two points in time and plot all airlines

ADDİTİONAL SLİDES

CABİNETMAKER EXAMPLE

- Paul Downs started making furniture in 1986 in Pennsylvania. The business focuses on high-end furniture, and now has a facility of 33,000 sq-ft.
- The machines and processing equipment is valued at $350,000 which depreciates at $60,000 per year. The firm also spends $100,000 annually on marketing, $180,000 on management and admin. and $60,000 for a highly skilled worker who finishes furniture and conduct quality inspection.
- Two major types of inventory:
  - Raw material: $20,000, paid one month in advance
  - Work-in-process: $50,000

CABİNETMAKER EXAMPLE

- Paul employs 12 cabinetmakers. They work about 220 days in a year, 8 hours/day, and the typical wage is $20/hr.
- A typical furniture requires 40 hours. The work is organized in work cells. 15% of time is spent on building fixtures and setting up machines (such as programming). Expensive wood-working equipment is shared among the cells. Consequently, 10% of the time is spent in waiting.
- A typical piece requires about 30kg of wood + additional 25% due to scrap losses. Wood costs $10/kg
- A typical dinning table will sell for $3000 50% as down payment. Piece is delivered 3 months later. Paul is fully utilized.

- 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, Paul needs to either
  - 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

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

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

- Similarly, we have that

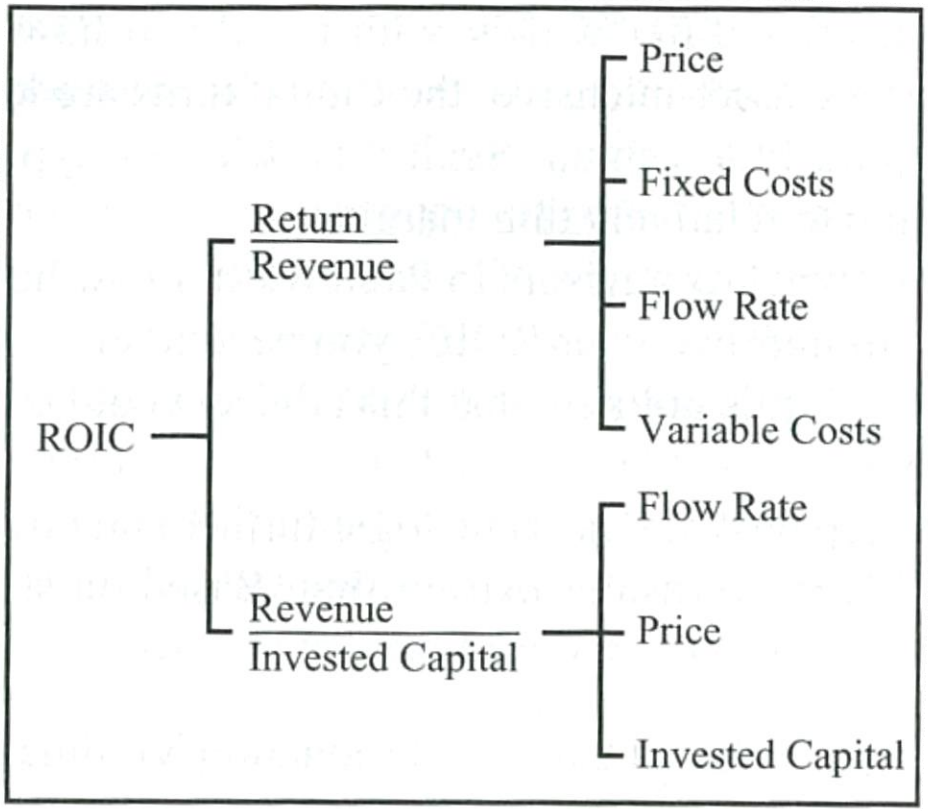
$$\frac{Revenue}{Invested\ capital} = \frac{Flow\ rate\ X\ Price}{Invested\ capital}$$

- Putting it all together:

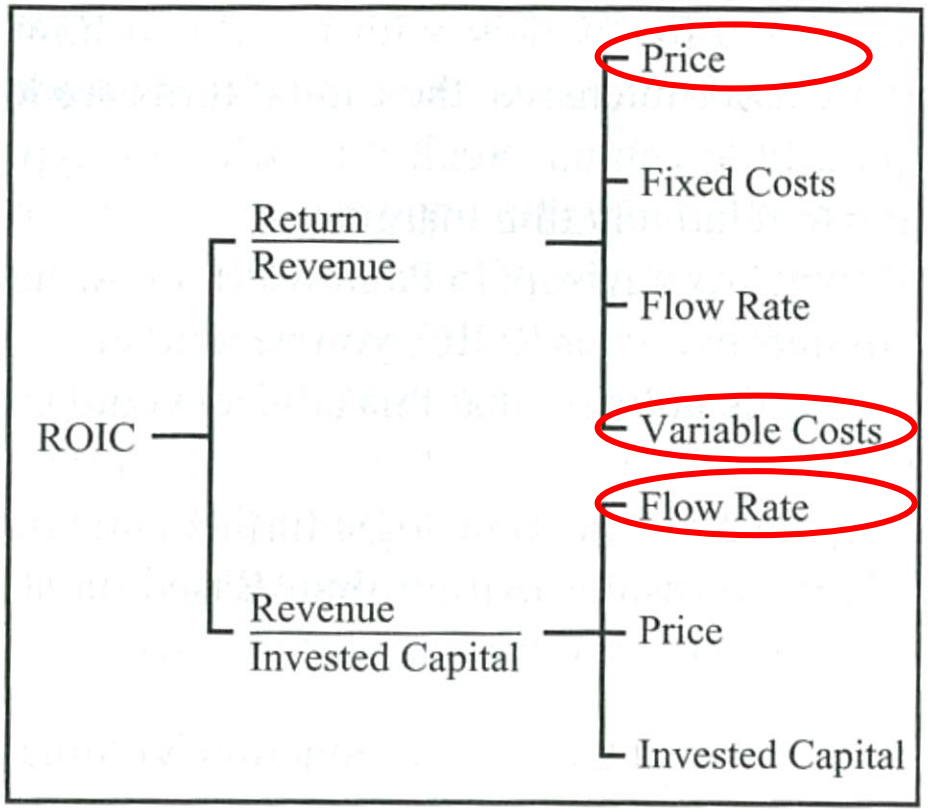
$$ROIC = \frac{Return}{Revenue} \times \frac{Revenue}{Invested\ Capital}$$

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

ROIC Tree


ROIC
Return / Revenue
Price
Fixed Costs
Flow Rate
Variable Costs
Revenue / Invested Capital
Flow Rate
Price
Invested Capital

ROIC Tree

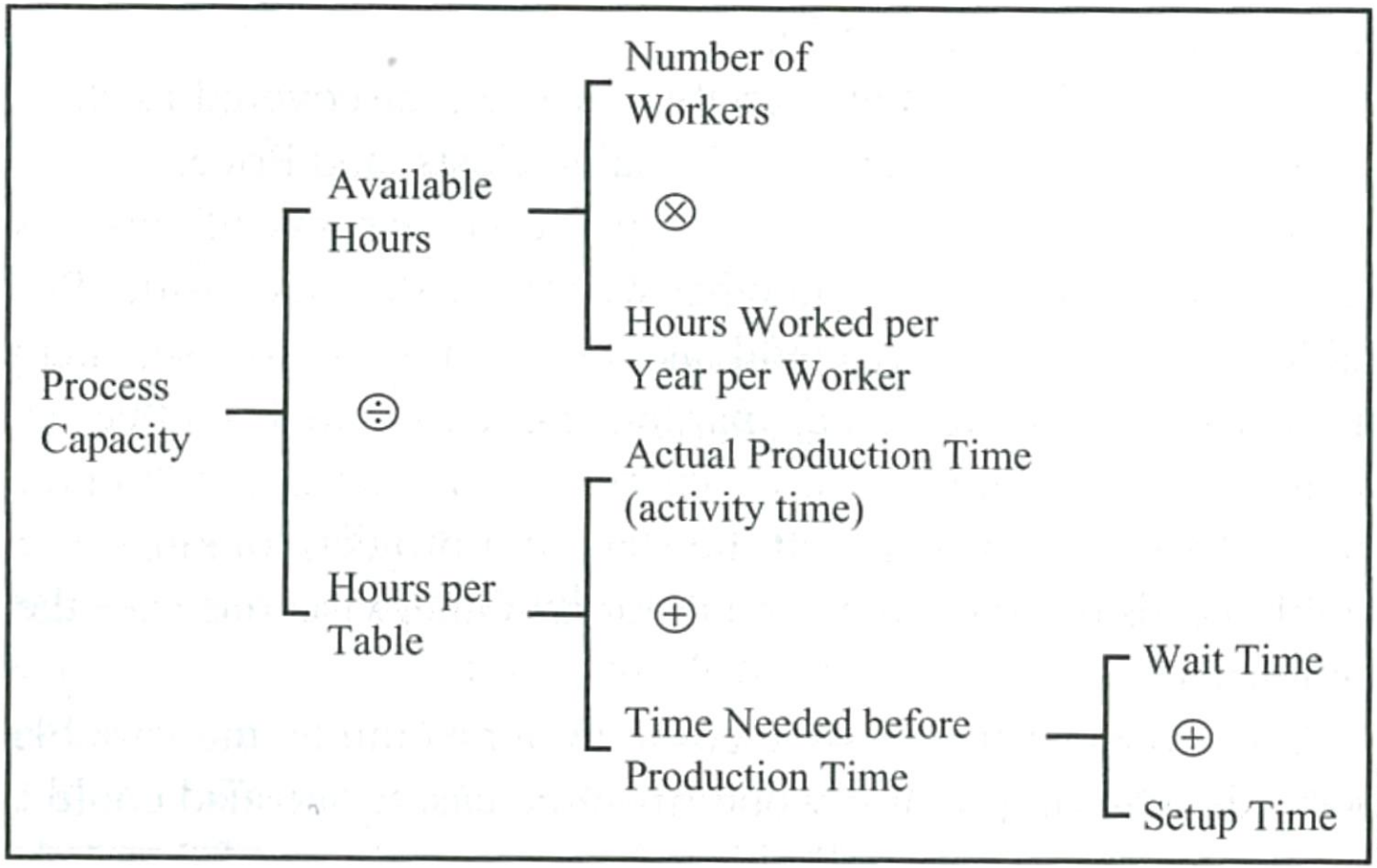


Assume fixed; beyond operational decision

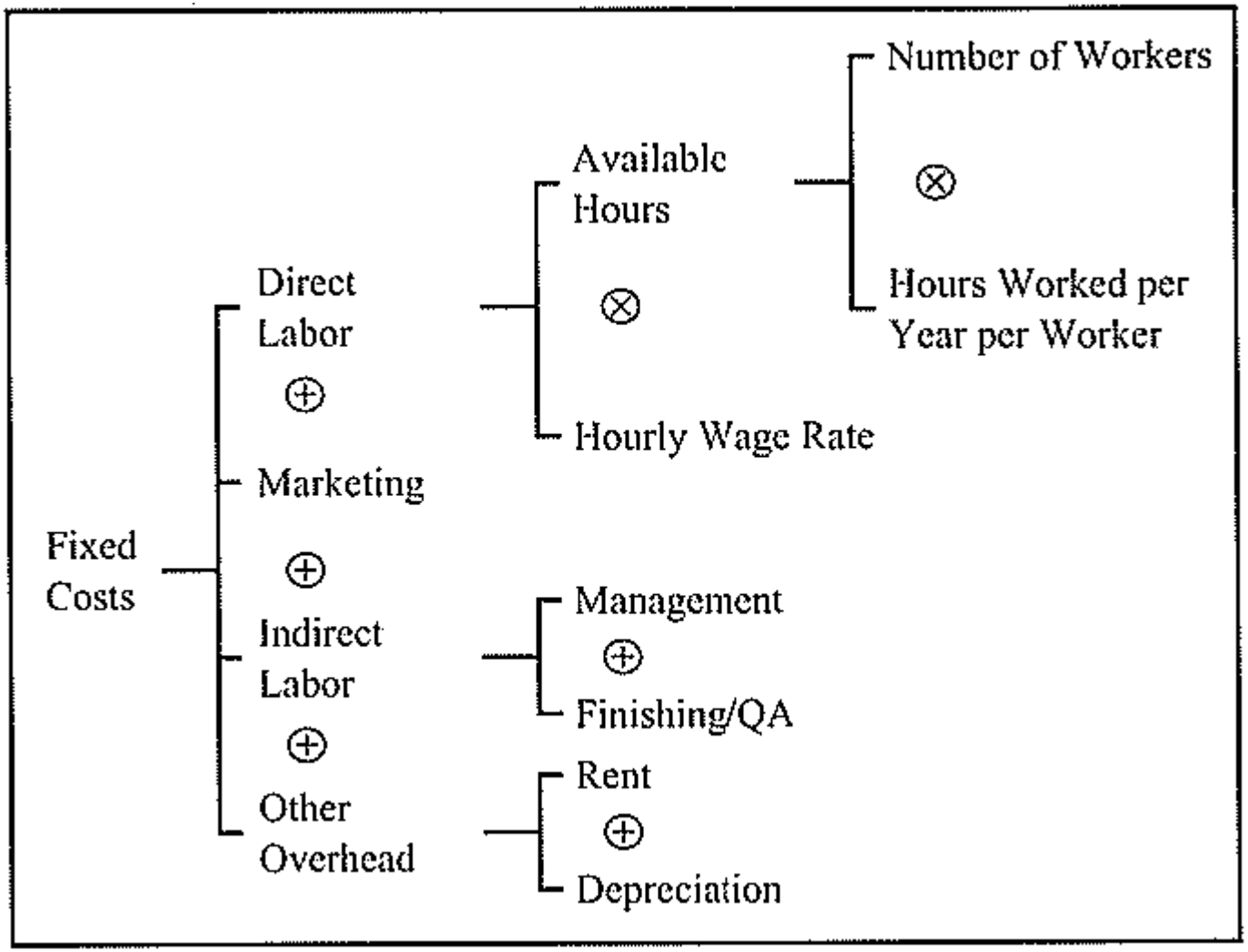
Driven by material:
Variable cost = Price of wood
X (wood in final table + cutting loss)

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

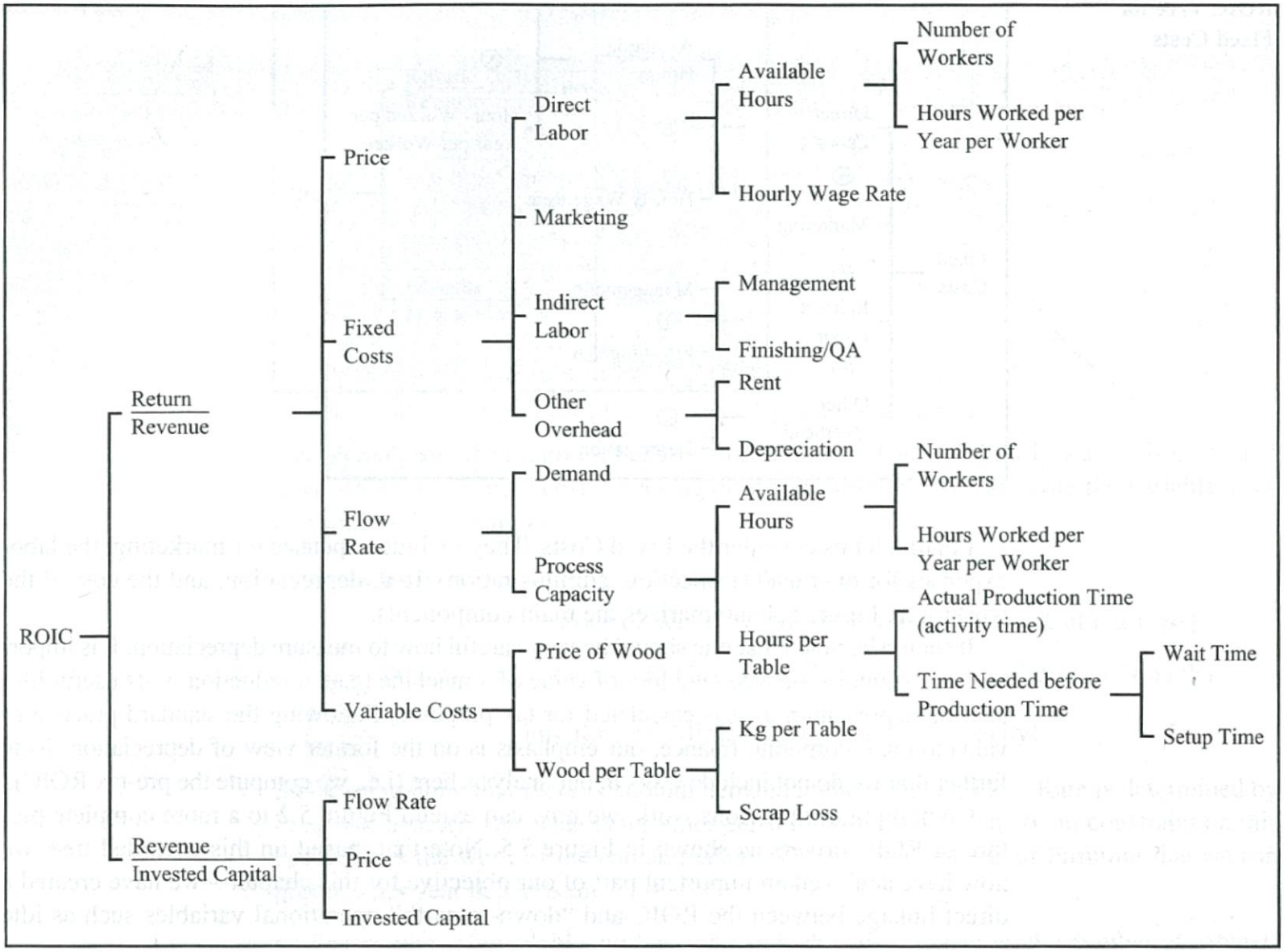
ROIC Tree: Process Capacity



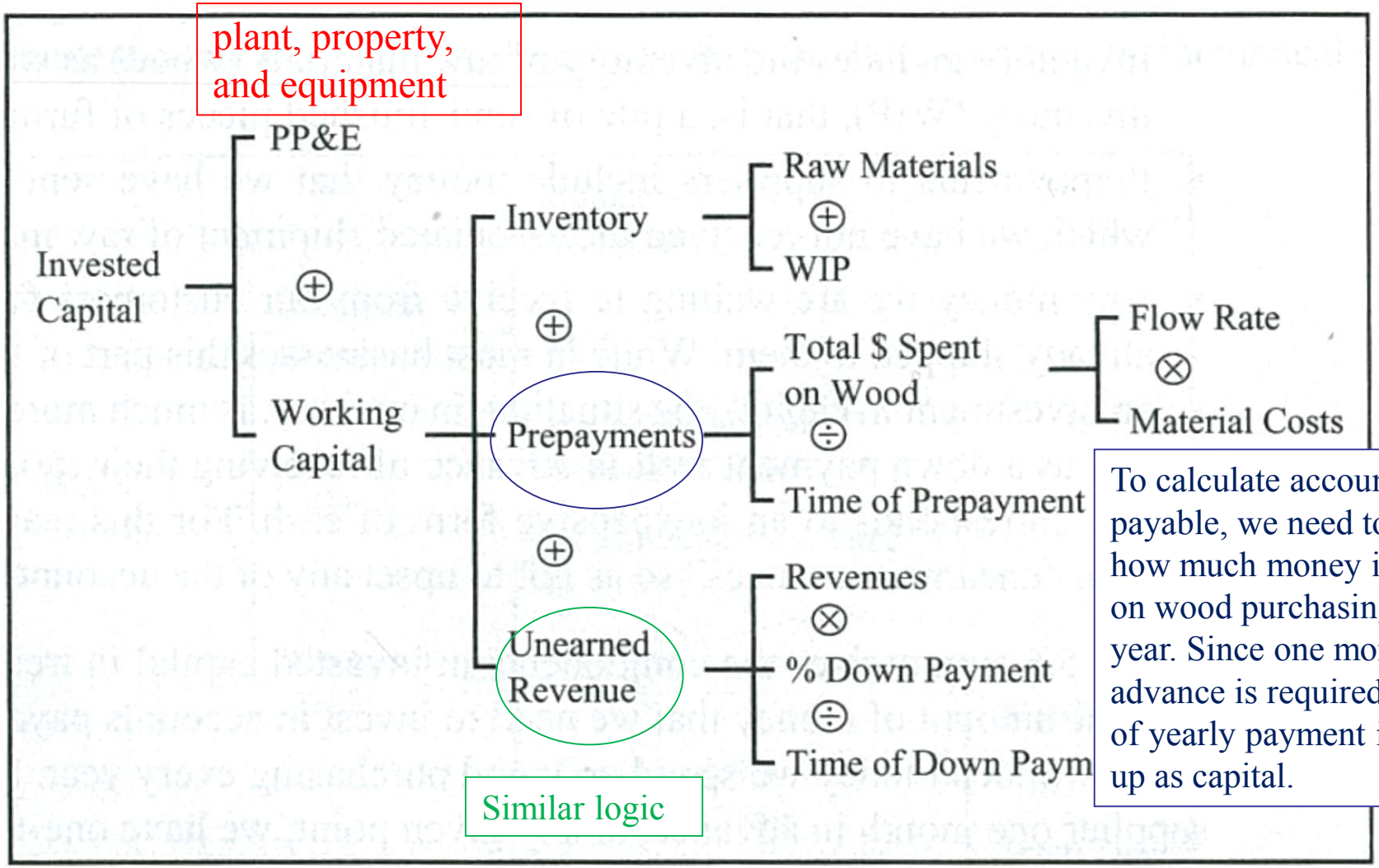
ROIC Tree: Fixed Costs



ROIC TREE: COMBİNİNG TOGETHER



ROIC Tree: Invested Capital



To calculate account payable, we need to find how much money is spent on wood purchasing every year. Since one month advance is required, 1/12 of yearly payment is tied up as capital.

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.

FIGURE 5.7 ROIC Tree in Excel