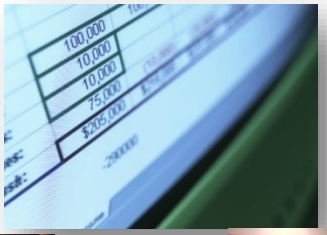


Differential Analysis: The Key to Decision Making

Chapter 13

Learning Objectives

- Identify relevant and irrelevant costs and benefits in a decision.
- Prepare an analysis showing whether a special order should be accepted.
- Prepare an analysis showing whether a product line or other business segment should be dropped or retained.
- Prepare a make or buy (outsourcing) analysis.
- Determine the most profitable use of a constrained resource and the value of obtaining more of the constrained resource (limiting factors).
- Prepare an analysis showing whether joint products should be sold at the split-off point or processed further (sell or process further).

Differential Cost Approaches

Using the ***differential cost approach*** is desirable for two reasons:

1. Only rarely will enough information be available to prepare detailed income statements for both alternatives.
2. Mingling irrelevant costs with relevant costs may cause confusion and distract attention away from the information that is really critical.

1. Avoid a wrong assumption that "All variable costs are relevant and all fixed costs are irrelevant." for example, we might think the variable marketing costs as irrelevant costs for the special order if no additional marketing efforts are needed.
2. Be aware that unit-fixed-cost data (which is prevalent under the financial accounting framework) can potentially mislead managers.

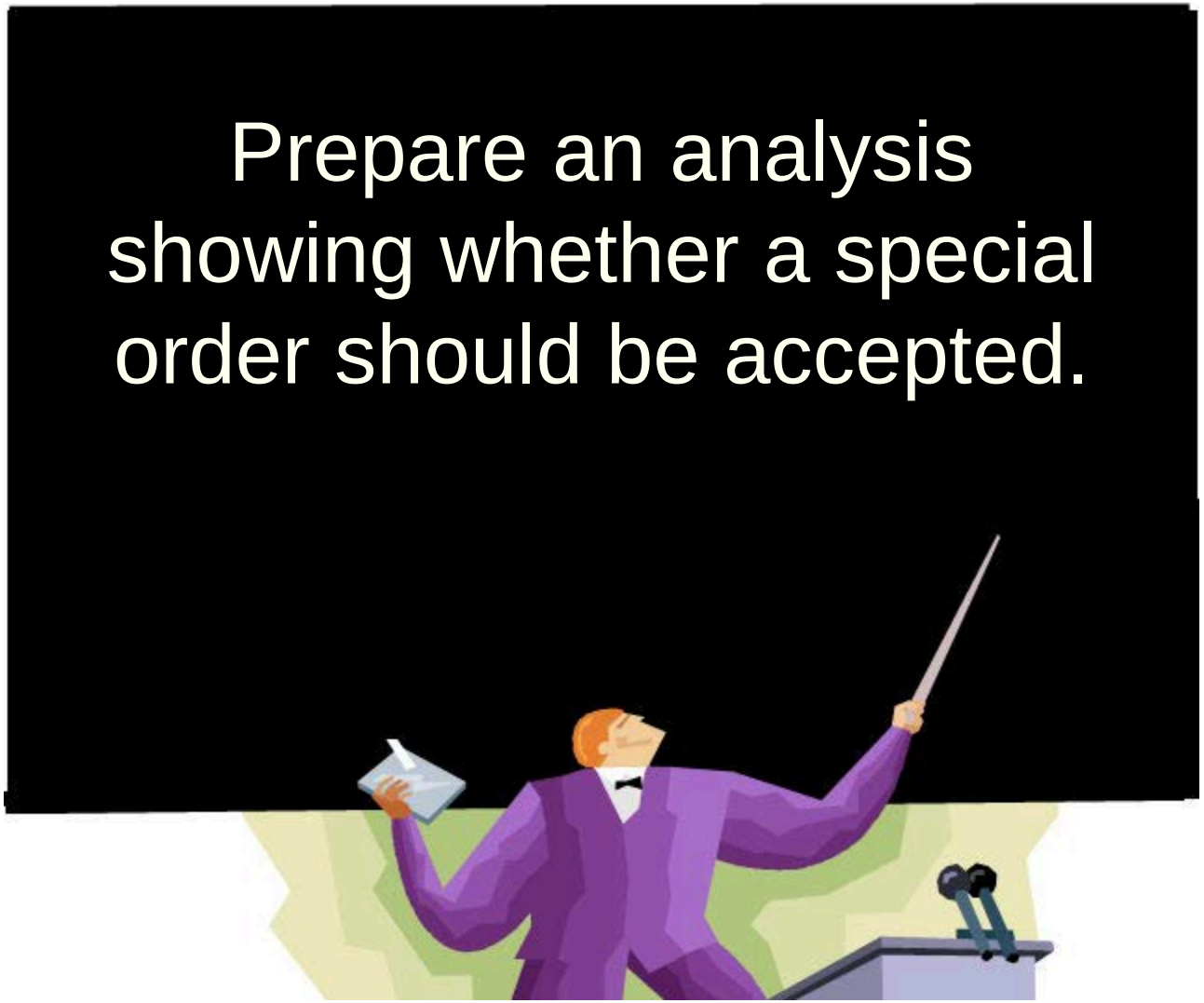
Short-Term Special Decisions

- Special sales orders
- Discontinuing products, departments, and stores
- Limiting factors: capacity constraint
- Outsourcing (make or buy)
- Selling as is or processing further

"Short-term" helps to define the fixed costs which we assume to be constant in a short period.

- **Over a long enough time horizon, any cost could change.**

Learning Objective 2



Special order decisions

A special order is a one-time order that is not considered part of the company's normal ongoing business.

Surf Gear manufactures towels. The plant has a production capacity of 48,000 towels per month. Current monthly production & sale is 30,000 towels. The expected results for the coming month: (note: fixed cost is averaged over the units)

		Without the Special Order		
		30,000		
		Units to be Sold		
		Per Unit		Total
		(1)		(2) = (1) x 30,000
6	Revenues	$20.00		$600,000
7	Variable costs:			
8	Manufacturing	7.50		225,000
9	Marketing	5.00		150,000
10	Total variable costs	12.50		375,000
11	Contribution margin	7.50		225,000
12	Fixed costs:			
13	Manufacturing	4.50		135,000
14	Marketing	2.00		60,000
15	Total fixed costs	6.50		195,000
16	Operating income	$ 1.00		$ 30,000
17				

Due to workers' strike at its existing towel supplier, Azelia, a luxury hotel chain has offered to buy 5,000 towels from Surf Gear at $11 per unit

Additional assumptions:

- No marketing costs for this order;
- No long-run or strategic implication

Special Order decision

Pay attention to the marketing costs (fixed and variable)
-- variable marketing costs are irrelevant because there is no additional marketing efforts made for this special order.

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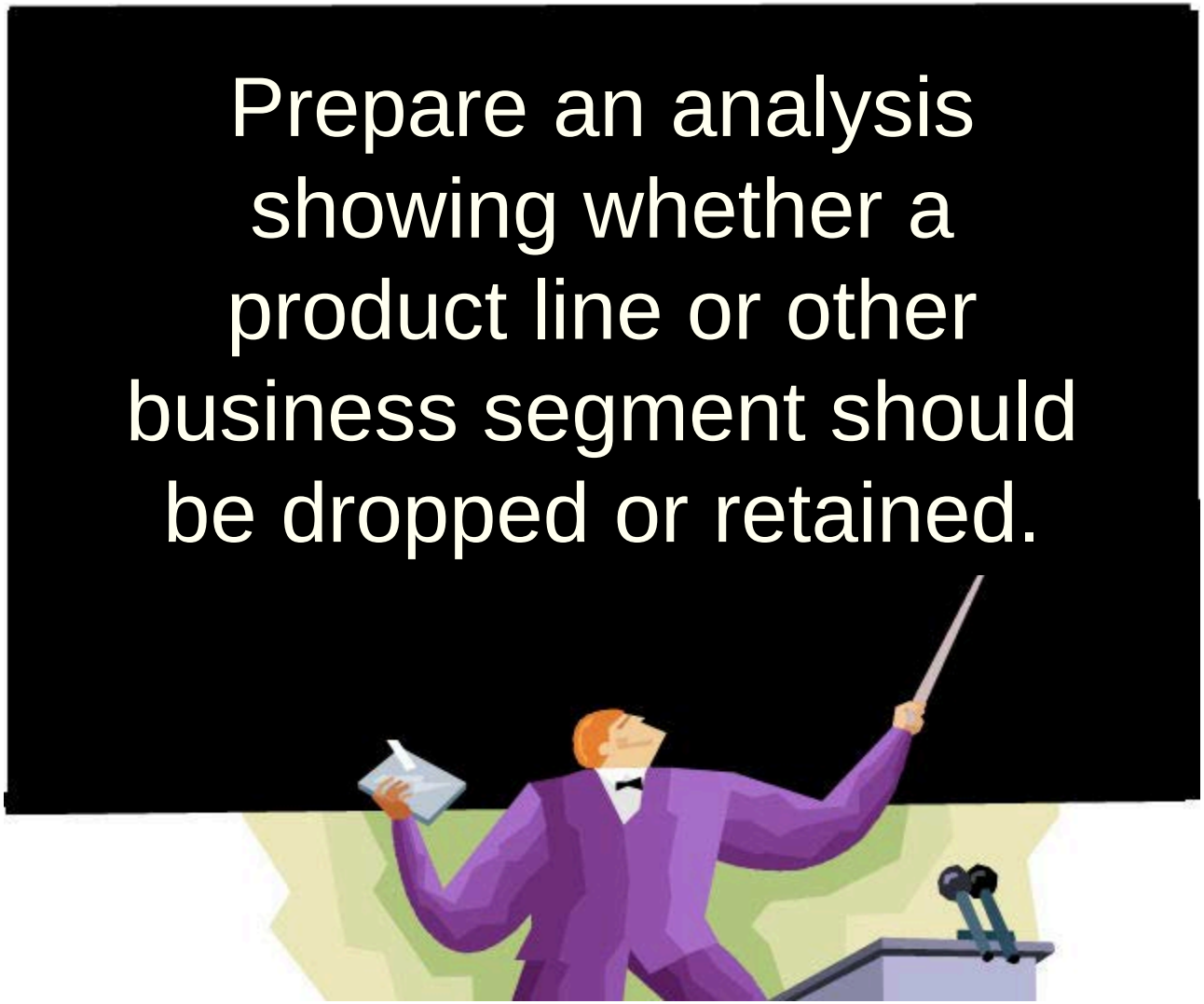
	A	B	C	D	E	F	G	H
1		Without the Special Order				With the Special Order		Difference: Relevant Amounts
2		30,000				35,000		for the
3		Units to be Sold				Units to be Sold		5,000
4		Per Unit		Total		Total		Units Special Order
5		(1)		(2) = (1) x 30,000		(3)		(4) = (3) – (2)
6	Revenues	$20.00		$600,000		$655,000		$55,000[a]
7	Variable costs:							
8	Manufacturing	7.50		225,000		262,500		37,500[b]
9	Marketing	5.00		150,000		150,000		0[c]
10	Total variable costs	12.50		375,000		412,500		37,500
11	Contribution margin	7.50		225,000		242,500		17,500
12	Fixed costs:							
13	Manufacturing	4.50		135,000		135,000		0[d]
14	Marketing	2.00		60,000		60,000		0[d]
15	Total fixed costs	6.50		195,000		195,000		0
16	Operating income	$ 1.00		$ 30,000		$ 47,500		$17,500
17								
18	[a]5,000 units x $11.00 per unit = $55,000.							
19	[b]5,000 units x $7.50 per unit = $37,500.							
20	[c]No variable marketing costs would be incurred for the 5,000-unit one-time-only special order.							
21	[d]Fixed manufacturing costs and fixed marketing costs would be unaffected by the special order.							

Special order decisions

- Is it possible for the fixed manufacturing cost to be a relevant cost?
  - What if Surf Gear needs to run three shifts of 16,000 towels per shift to achieve full capacity of 48,000 towels.
  - That is, in this case the fixed cost is actually a step-variable cost.
- Relax the assumption of "no long-term implication"
  - In what situation the company might reject the order even if the analysis shows a positive CM?
  - In what situation the company might accept the order even if the analysis shows a negative CM?

Learning Objective 3



Adding/Dropping Segments

Lovell is considering discontinuing this product line:

Digital Watches		
Sales		$ 500,000
Less: variable expenses		
Variable manufacturing costs	$ 120,000	
Variable shipping costs	5,000	
Commissions	75,000	200,000
Contribution margin		$ 300,000
Less: fixed expenses		
General factory overhead	$ 60,000	
Salary of line manager	90,000	
Depreciation of equipment	10,000	
Advertising - direct	100,000	
Rent - factory space	80,000	
General admin. expenses	30,000	370,000
Net operating loss		$ (70,000)

Adding/Dropping Segments

An investigation has revealed that the fixed general factory overhead and fixed general administrative expenses will not be affected by dropping the digital watch line. The fixed general factory overhead and general administrative expenses assigned to this product would be reallocated to other product lines.

The equipment used to manufacture digital watches has no resale value or alternative use.

A Contribution Margin Approach

Contribution Margin Solution

Contribution margin lost if digital watches are dropped		$ (300,000)
Less fixed costs that can be avoided		
Salary of the line manager	$ 90,000	
Advertising - direct	100,000	
Rent - factory space	80,000	270,000
Net disadvantage		$ (30,000)

Answer: should not drop

Discussion:

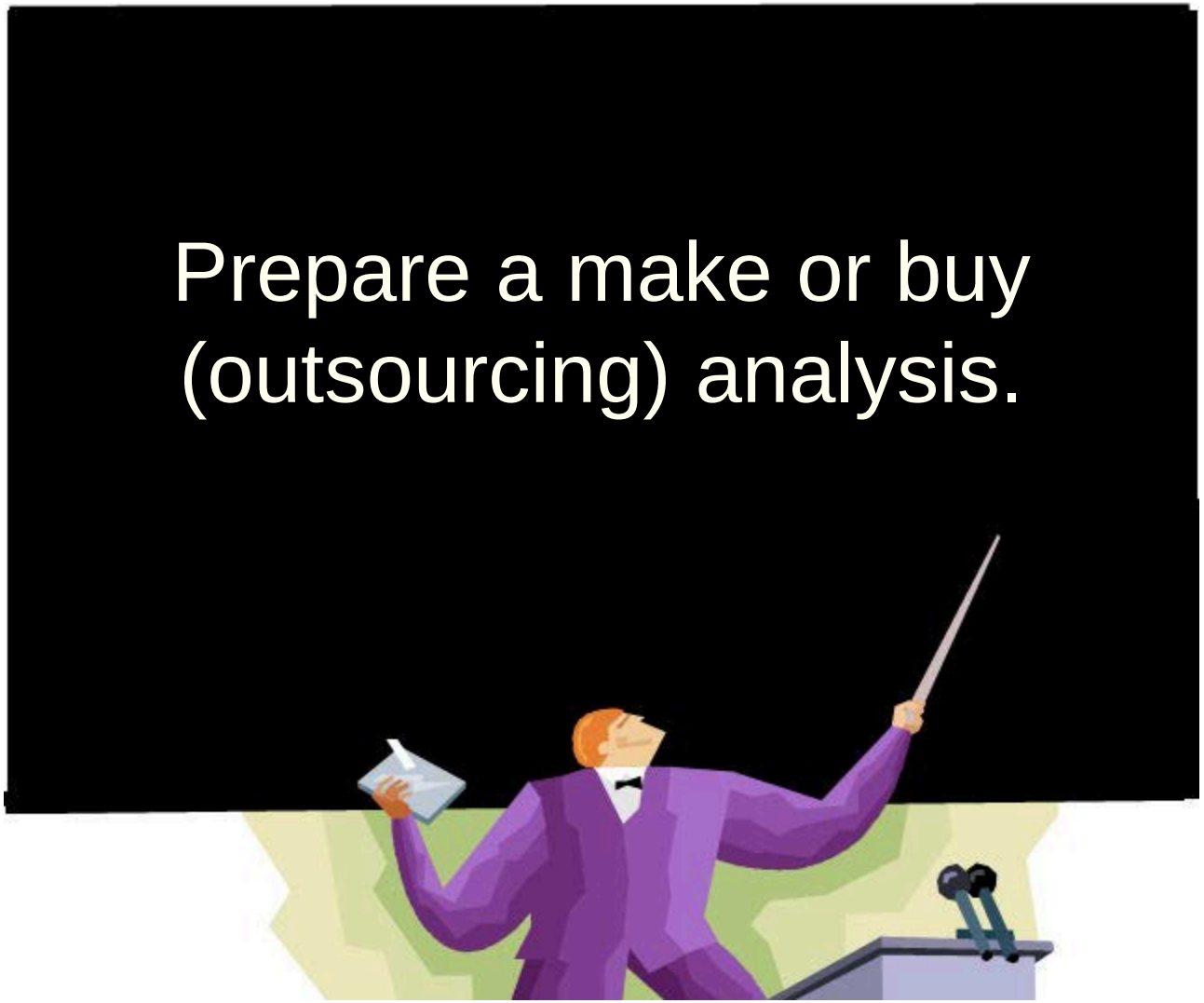
- How about the $10,000 depreciation?
- If this product line has an expected useful life of three years, why don't we consider a time horizon of three years? The answers only consider Year 1's data for the decision.

Discussion:

If resale value is not zero and the decision of add/drop must be made in year 1 (at the beginning):

- when resale value is non-zero, the depreciation is a cost that can be avoided (why?) since we will consider the proceeds from the sale of equipment.
- We need to consider the total effects over the WHOLE useful life. It cannot be determined by only Year 1's data.
- the length of the useful life matters for the decision (i.e., might not be a "short-term" decision)
- See my illustration (an additional file used for calculation in the class)

Learning Objective 4



Vertical Integration- Advantages & Disadvantage

Advantages:

Smoother flow of parts and materials

Better quality control

Realize profits

Disadvantages:

Companies may fail to take advantage of suppliers who can create economies of scale advantage by pooling demand from numerous companies.

Cost structure consists of higher percentage of fixed cost.

The Make or Buy Decision: An Example

- Essex Company manufactures part 4A that is used in one of its products.
- The unit product cost of this part is:

Direct materials	**$ 9**
Direct labor	**5**
Variable overhead	**1**
Depreciation of special equip.	**3**
Supervisor's salary	**2**
General factory overhead	**10**
Unit product cost	**$ 30**

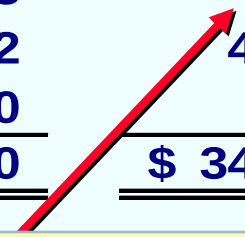
The Make or Buy Decision

- The special equipment used to manufacture part 4A has no resale value.
- The total amount of general factory overhead, which is allocated on the basis of direct labor hours, would be unaffected by this decision.
- The $30 unit product cost is based on 20,000 parts produced each year.
- An outside supplier has offered to provide the 20,000 parts at a cost of $25 per part.

Should we accept the supplier's offer?

The Make or Buy Decision

	Cost Per Unit	Cost of 20,000 Units	
		Make	Buy
Outside purchase price	$ 25		$ 500,000
Direct materials (20,000 units)	$ 9	180,000	
Direct labor	5	100,000	
Variable overhead	1	20,000	
Depreciation of equip.	3	-	
Supervisor's salary	2	40,000	
General factory overhead	10	-	
Total cost	$ 30	$ 340,000	$ 500,000



The depreciation of the special equipment represents a sunk cost. The equipment has no resale value, thus its cost and associated depreciation are irrelevant to the decision.

The Make or Buy Decision

Answer: Essex should continue to make the part.

	Cost Per Unit	Cost of 20,000 Units	
		Make	Buy
Outside purchase price	$ 25		$ 500,000
Direct materials (20,000 units)	$ 9	180,000	
Direct labor	5	100,000	
Variable overhead	1	20,000	
Depreciation of equip.	3	-	
Supervisor's salary	2	40,000	
General factory overhead	10	-	
Total cost	$ 30	$ 340,000	$ 500,000

The **avoidable costs:** direct materials, direct labor, variable overhead, and the supervisor's salary.

Unavoidable costs: General factory overhead which is allocated to this product.

Learning Objective 5

Determine the most profitable use of a constrained resource and the value of obtaining more of the constrained resource

(Limiting factors).

An Example

Ensign Company produces two products and the data are shown below:

	Product 1	Product 2
Selling price per unit	$ 60	$ 50
Less variable expenses per unit	36	35
Contribution margin per unit	$ 24	$ 15
Current demand per week (units)	2,000	2,200
Contribution margin ratio	40%	30%
Processing time required on machine A1 per unit	1.00 min.	0.50 min.

An Example

- **Machine A1 is the constrained resource and is being used at 100% of its capacity.**
- **There is excess capacity on all other machines.**
- **Machine A1 has a capacity of 2,400 minutes per week.**

Should Ensign focus its efforts on Product 1 or Product 2?

Quick Check ✓

How many units of each product can be processed through Machine A1 in one minute?

	Product 1	Product 2
a.	1 unit	0.5 unit
b.	1 unit	2.0 units
c.	2 units	1.0 unit
d.	2 units	0.5 unit

Quick Check ✓

How many units of each product can be processed through Machine A1 in one minute?

	Product 1	Product 2
a.	1 unit	0.5 unit
b.	**1 unit**	**2.0 units**
c.	2 units	1.0 unit
d.	2 units	0.5 unit

Quick Check ✓

How to generates more profit for the company, using one minute of machine A1 to process Product 1 or using one minute of machine A1 to process Product 2?

a. Product 1

b. Product 2

c. They both would generate the same profit.

d. Cannot be determined.

24

Quick Check ✓

With one minute of machine A1, we could make 1 unit of Product 1, with a contribution margin of $24, or 2 units of Product 2, each with a contribution margin of $15.

$2 \times \$15 = \$30 > \$24$

b. Product 2

c. They both would generate the same profit.

d. Cannot be determined.

Utilization of a Constrained Resource

The key is the contribution margin per unit of the constrained resource.

		Product 1		Product 2	
Contribution margin per unit		$ 24		$ 15	
Time required to produce one unit	÷	1.00	min.	0.50	min.
Contribution margin per minute		$ 24		$ 30	

Ensign should emphasize Product 2 because it generates a contribution margin of $30 per minute of the constrained resource relative to $24 per minute for Product 1.

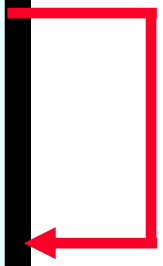
Meet market demand for product 2 first and then for product 1

Assume market demand for product 2 is 2,200 and is 2,000 for product 1.

Let's see how this plan would work.

Alloting Our Constrained Resource (Machine A1)

Weekly demand for Product 2		2,200	units
Time required per unit	×	0.50	min.
Total time required to make Product 2		1,100	min.
Total time available		2,400	min.
Time used to make Product 2		1,100	min.
Time available for Product 1		1,300	min.



Assume market demand for product 2 is 2,200 and is 2,000 for product 1.

Let's see how this plan would work.

Alloting Our Constrained Resource (Machine A1)

Weekly demand for Product 2		2,200	units
Time required per unit	×	0.50	min.
Total time required to make Product 2		1,100	min.
Total time available		2,400	min.
Time used to make Product 2		1,100	min.
Time available for Product 1		1,300	min.
Time required per unit	÷	1.00	min.
Production of Product 1		1,300	units

Assume market demand for product 2 is 2,200 and is 2,000 for product 1.

According to this plan, we will produce 2,200 units of Product 2 and 1,300 of Product 1. Our contribution margin looks like this.

	Product 1	Product 2
Production and sales (units)	1,300	2,200
Contribution margin per unit	$ 24	$ 15
Total contribution margin	$ 31,200	$ 33,000

The total contribution margin for Ensign is $64,200.

Quick Check ✓

	Chairs	*Tables*
Selling price per unit	$80	$400
Variable cost per unit	$30	$200
Board feet per unit	2	10
Monthly demand	600	100

The company's supplier of hardwood will only be able to supply 2,000 board feet this month. What plan would maximize profits?

a. 500 chairs and 100 tables

b. 600 chairs and 80 tables

c. 500 chairs and 80 tables

d. 600 chairs and 100 tables

Quick Check ✓

Selling price per uni
Variable cost per un
Board feet per unit
Monthly demand

	Chairs	*Tables*
Selling price	$ 80	$ 400
Variable cost	30	200
Contribution margin	$ 50	$ 200
Board feet	2	10
CM per board foot	$ 25	$ 20
Production of chairs	600	
Board feet required	1,200	
Board feet remaining	800	
Board feet per table	10	
Production of tables	80	

The company's supplie
be able to supply 2,00
What plan would maximize profits?

a. 500 chairs and 100 tables

b. 600 chairs and 80 tables

c. 500 chairs and 80 tables

d. 600 chairs and 100 tables

Quick Check ✓

As before, Colonial Heritage's supplier of hardwood will only be able to supply 2,000 board feet this month. Assume the company follows the plan we have proposed. Up to how much should Colonial Heritage be willing to pay *more than* the usual price to obtain more hardwood?

a. $40 above the usual price per board foot

b. $25 above the usual price per board foot

c. $20 above the usual price per board foot

d. Zero

Quick Check ✓

The additional wood would be used to make tables. In this use, each board foot of additional wood will allow the company to earn an additional $20 of contribution margin and profit.

obtain more hardwood?

a. $40 above the usual price per board foot

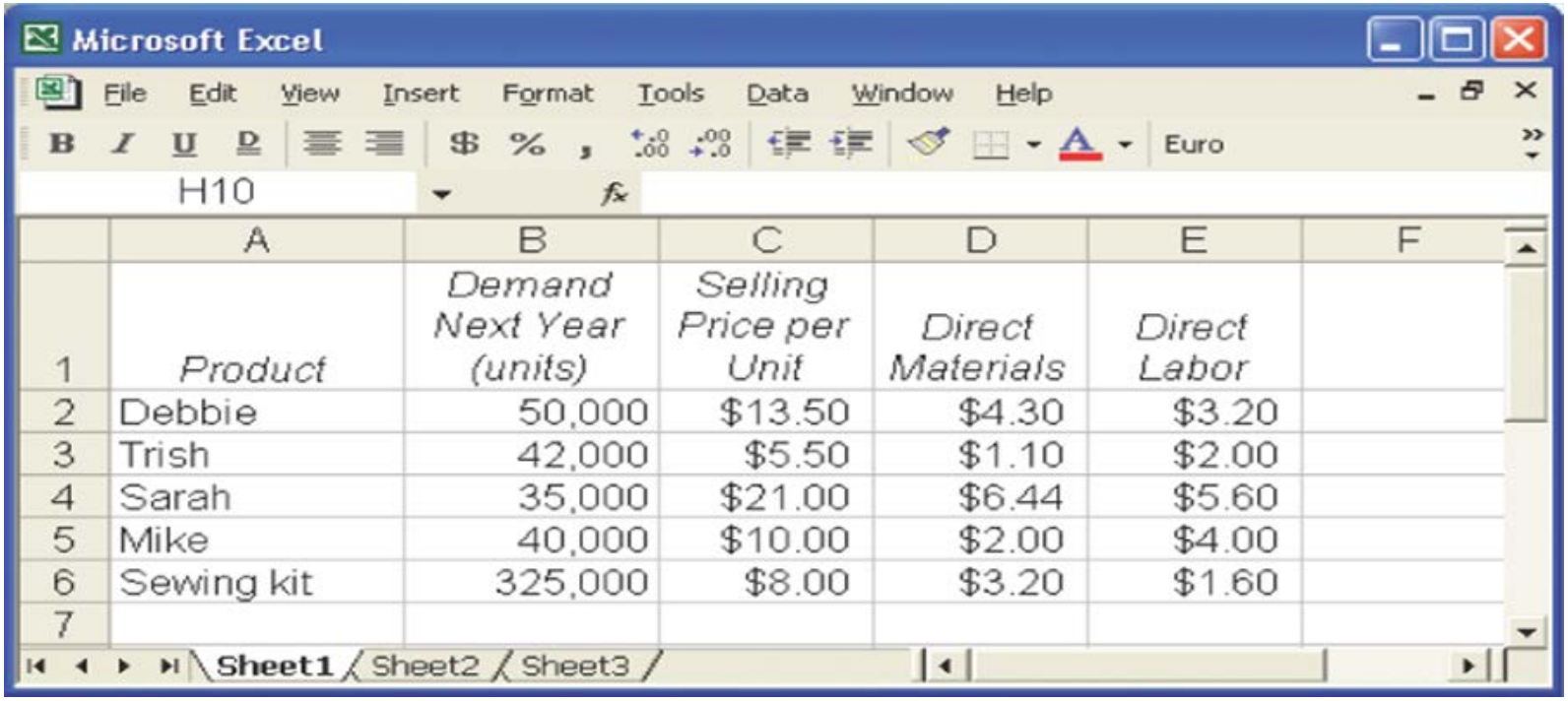
b. $25 above the usual price per board foot

c. $20 above the usual price per board foot

d. Zero

Note: the $20 above the regular price. So the price = (regular price +$20)

In-Class Exercise
P13-25 (Utilization of a Constrained Resources)



Microsoft Excel

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H10

	A	B	C	D	E	F
1	*Product*	*Demand Next Year (units)*	*Selling Price per Unit*	*Direct Materials*	*Direct Labor*	
2	Debbie	50,000	$13.50	$4.30	$3.20	
3	Trish	42,000	$5.50	$1.10	$2.00	
4	Sarah	35,000	$21.00	$6.44	$5.60	
5	Mike	40,000	$10.00	$2.00	$4.00	
6	Sewing kit	325,000	$8.00	$3.20	$1.60	
7						

Sheet1 Sheet2 Sheet3

1. How would you allocate the 130,000 direct labor hours of capacity to Walton Toy Company's various products?
2. How much are you willing to pay for additional capacity?

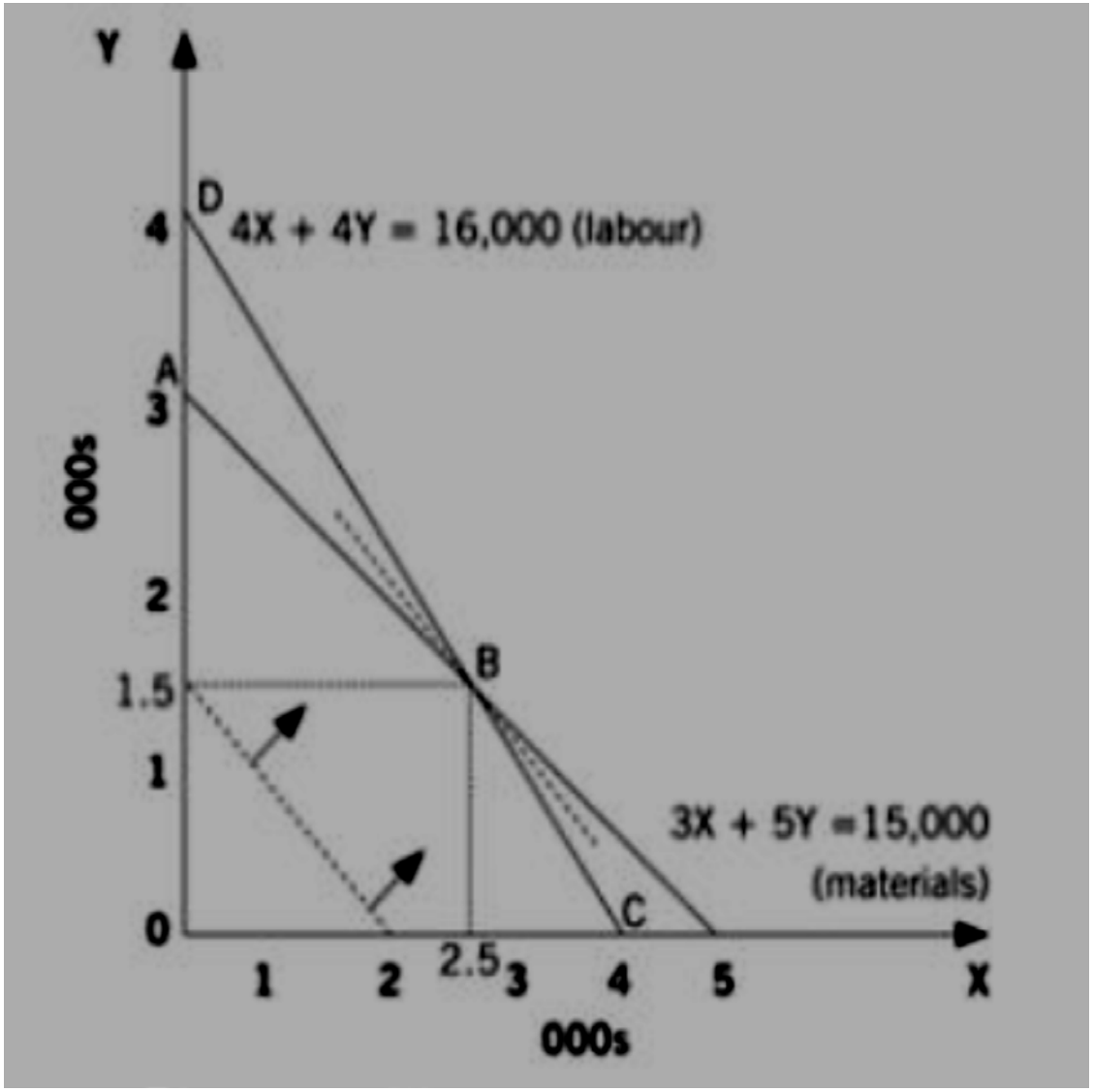
Multiple limiting factors

If there are multiple limiting factors, **linear programming approach** is used. We can no longer use the ranking of contribution per factor as for the cases where there is only one limiting factor.

Example:

Suppose a profit-seeking firm has two constraints: labor, limited to 16,000 hours, and materials, limited to 15,000kg. The firm manufactures and sells two products, X and Y. To make X, the firm uses 3kg of material and four hours of labor, whereas to make Y, the firm uses 5kg of material and four hours of labor. The contributions made by each product are $30 for X and $40 for Y. The cost of materials is normally $8 per kg, and the labor rate is $10 per hour.

Multiple limiting factors



The constraints:
(1) $3X + 5Y \leq 15{,}000$ &
(2) $4X + 4Y \leq 16{,}000$

The target: maximize C = 30X + 40Y

The graph shows that by pushing out the contribution margin function, the optimal solution will be at point B – the intersection of materials and labor constraints.
X=2,500 & Y=1,500

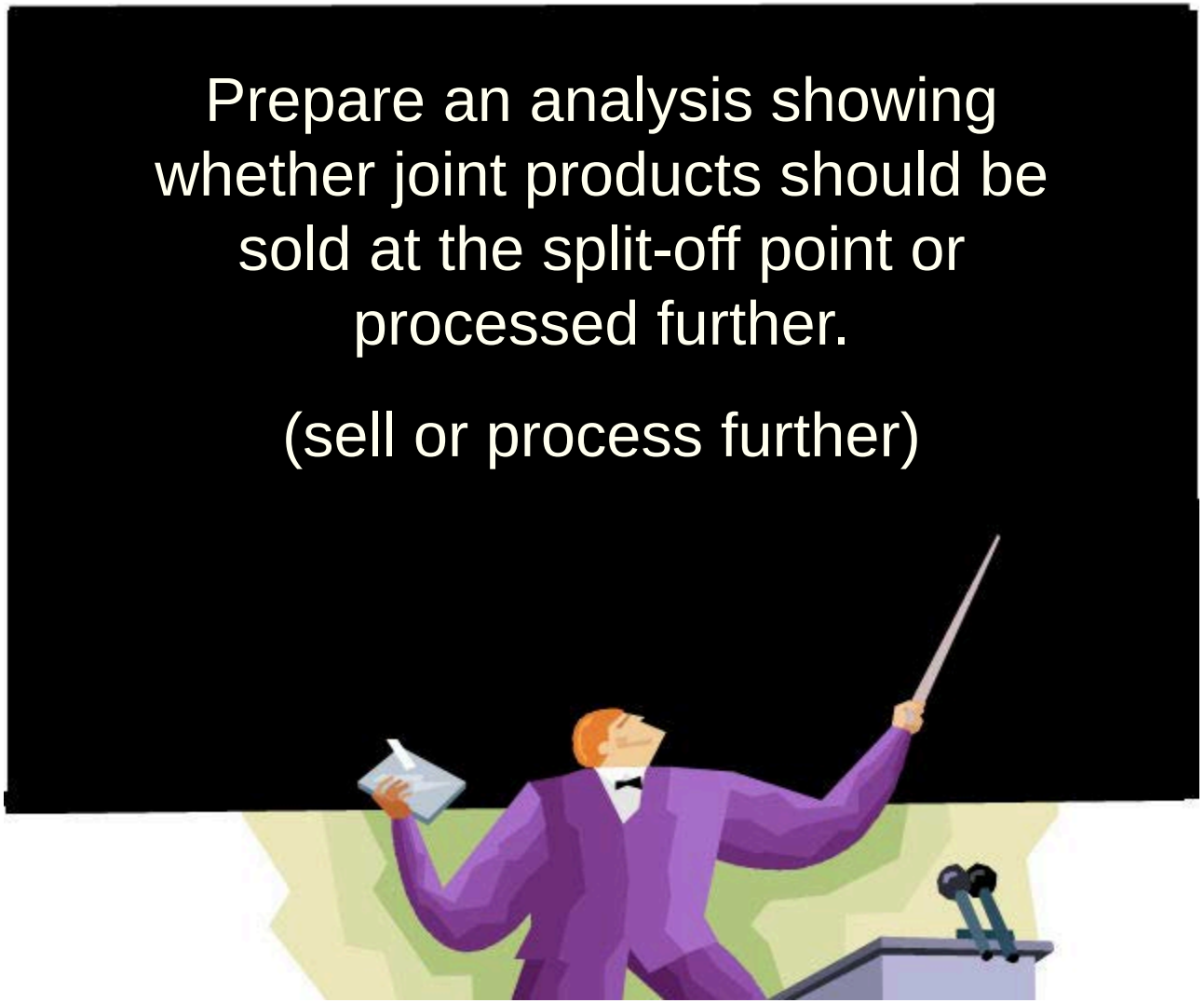
Data analytics exercise

- Solve the problem with multiple limiting factors in Excel worksheet.
- First step: install “Solver” add-in
- See the Excel data file on the Moodle
- Let’s find the solution for the following problem:

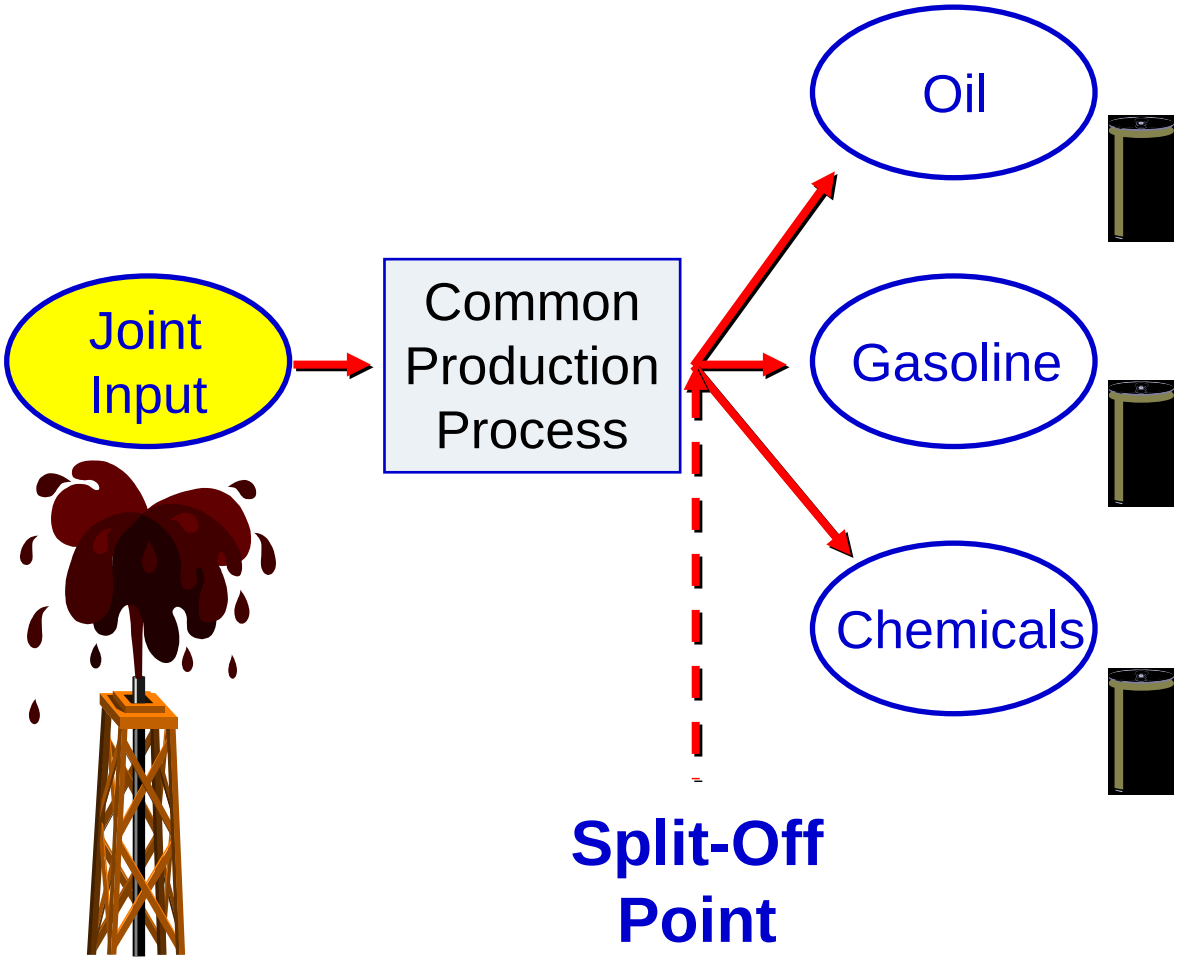
The target: maximize $C = 30X + 40Y$

The constraints:
(1) $3X + 5Y \leq 15{,}000$ & (2) $4X + 4Y \leq 16{,}000$

Learning Objective 6

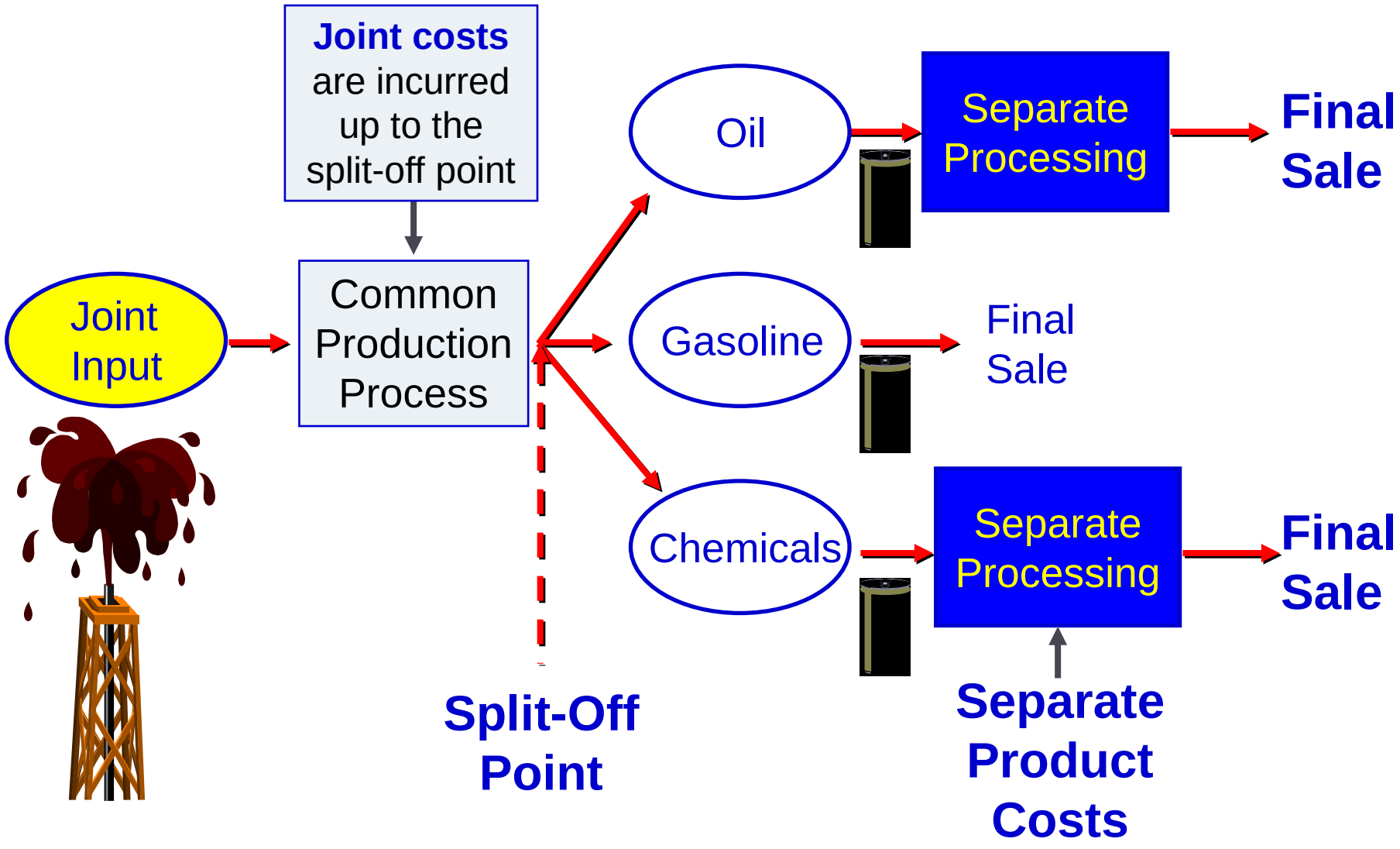


Joint Products



For example, in the petroleum refining industry, a large number of products are extracted from crude oil, including gasoline, jet fuel, home heating oil, lubricants, asphalt, and various organic chemicals.

Joint Products



Sell or Process Further

Joint costs are irrelevant in decisions regarding what to do with a product from the split-off point forward. Therefore, these costs should not be allocated to end products for decision-making purposes.

With respect to sell or process further decisions, it is profitable to continue processing a joint product after the split-off point so long as the incremental revenues from such processing exceeds the incremental processing costs incurred after the split-off point.

Sell or Process Further: An Example

- Sawmill, Inc. cuts logs from which unfinished lumber and sawdust are the immediate joint products.
- Unfinished lumber is sold “as is” or processed further into finished lumber.
- Sawdust can also be sold “as is” to gardening wholesalers or processed further into “pres-to-logs.”

Sell or Process Further

Data about Sawmill's joint products includes:

	Per Log	
	Lumber	Sawdust
Sales value at the split-off point	$ 140	$ 40
Sales value after further processing	270	50
Allocated joint product costs	96	24
Cost of further processing	50	20

Sell or Process Further

Analysis of Sell or Process Further	Per Log	
	Lumber	Sawdust
Sales value after further processing	$ 270	$ 50
Sales value at the split-off point	140	40
Incremental revenue	130	10
Cost of further processing		
Profit (loss) from further processing		

Sell or Process Further

Analysis of Sell or Process Further	Per Log	
	Lumber	Sawdust
Sales value after further processing	$ 270	$ 50
Sales value at the split-off point	140	40
Incremental revenue	130	10
Cost of further processing	50	20
Profit (loss) from further processing	$ 80	$ (10)

Key: the cost of **joint cost** BEFORE the split-off point ($96+24) is IRRELEVANT.

Lumber: to be processed further.
Sawdust: to be sold directly.

Discussion

Come-Clean Corp. produces Grit 337 which is a coarse cleaning powder with many industrial use. It costs $1.60 a pound to make, and it has a selling price of $2.00 a pound. Grit 337 can be further processed into Sparkle silver polish. A small portion of Grit 337 is further processed every year. The silver polish sells for $4.00 per jar. The further processing requires one-fourth pound of Grit 337 per jar of silver polish. The additional direct costs per jar are:

Other ingredients	$0.65
Direct labor	$1.48
Total direct cost	$2.13

Overhead costs associated with processing the silver polish are:

Variable MOH	25% of direct labor cost
Fixed MOH (per month):	
Production supervisor	$3,000
Depreciation of mixing equipment	$1,400

The production supervisor has no duties other than to oversee the production of Silver polish. The mixing equipment is special-purpose equipment and its resale value is zero.

Advertising costs for the silver polish total $4,000 per month. Variable selling costs associated with the silver polish are 7.5% of sales.

Discussion

Due to a recent decline in the demand for silver polish, the company is wondering whether to continue the production of silver polish.

Q1: what is incremental contribution Margin (CM) per jar from further processing of Grit 337 into silver polish

- How should we treat the $1.60 cost per pound to make Grit 337?
- Is the salary of supervisor is a relevant cost?
- How about the advertising costs and selling costs for silver polish?
- If the incremental CM >0, does it mean that we should continue processing silver polish? What factor to consider?

Discussion (answers to Q1)

The $1.60 cost per pound ($0.40 per 1/4 pound) required to produce the Grit 337 would not be relevant in this computation because it is incurred regardless of whether the Grit 337 is further processed into silver polish or sold outright.

Selling price of the silver polish, per jar	$4.00
Selling price of 1/4 pound of Grit 337 ($2.00 ÷ 4)	0.50
Incremental revenue per jar	$3.50

The incremental variable costs are:

Other ingredients	$0.65
Direct labor	1.48
Variable manufacturing overhead (25% × $1.48)	0.37
Variable selling costs (7.5% × $4)	0.30
Incremental variable cost per jar	$2.80

Therefore, the incremental contribution margin is $0.70 per jar ($3.50 – $2.80).

The fixed costs associated with further processing: (a) supervisor's salary; (b) advertising expenses, are not considered yet at this stage for the incremental CM.

Discussion (Q2)

Q2: what is the minimum number of jars of silver polish that must be sold each month to justify the continued processing?

- Why does the decision depend on the monthly demand?
- What are the monthly FIXED expenditures related to further processing?
- Again, the fixed monthly depreciation ($1,400) should be considered or not?

Discussion (Answers to Q2)

Production supervisor	$3,000
Advertising—direct	4,000
Avoidable fixed costs	$7,000

$$\frac{\text{Avoidable fixed costs}}{\text{Incremental CM per jar}} = \frac{\$7{,}000}{\$0.70 \text{ per jar}} = 10{,}000 \text{ jars per month}$$

In this question, "A small portion of Grit 337 is further processed every year" suggests that the mixing equipment is a sunk cost and is already there.

Q: Let's assume that "production supervisor" is also already in place and cannot be fired. What is the answer to Q2?

Case analysis (Case #2)

- Case #2: Baldwin Bike

End of Chapter 13

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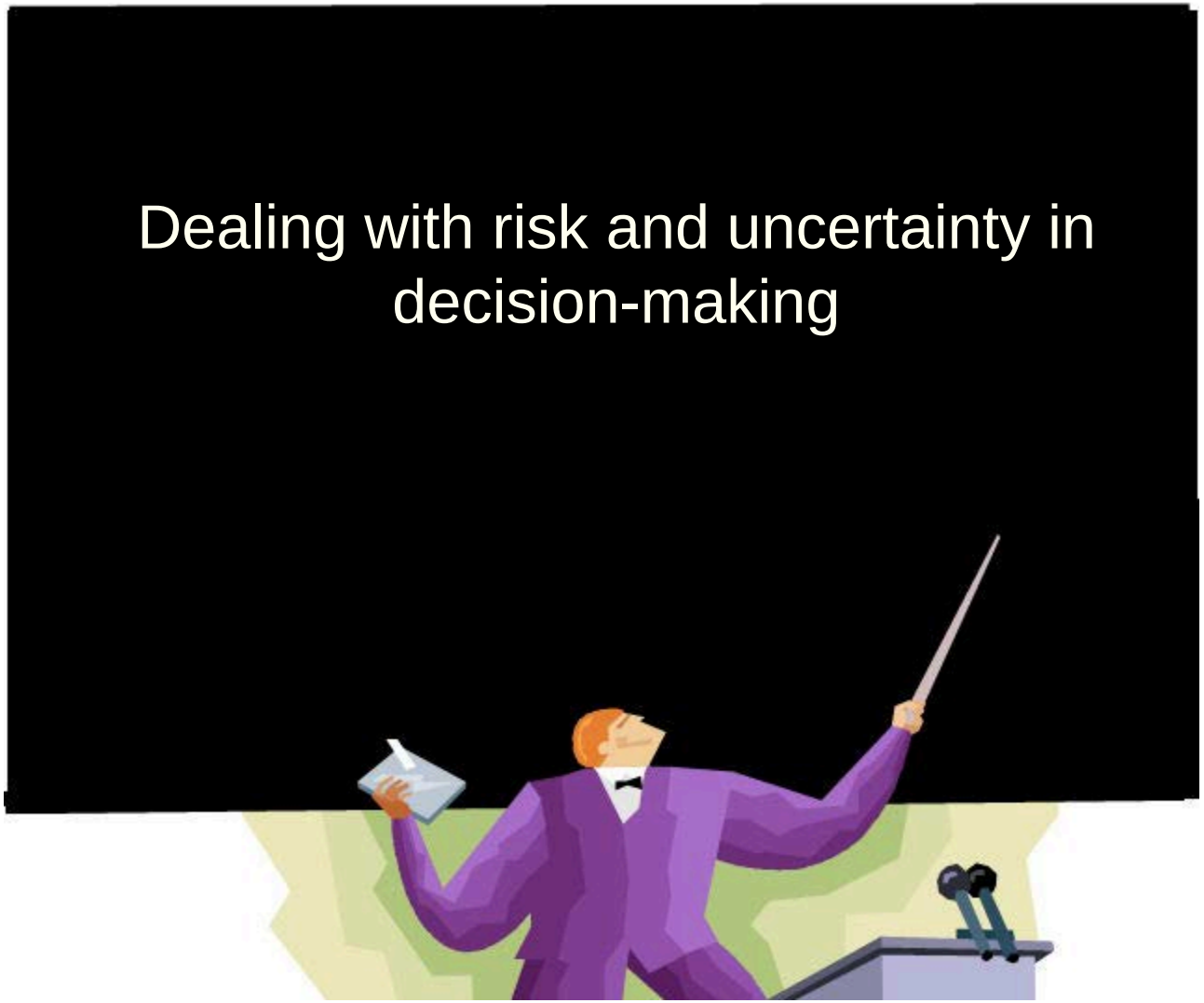

Risk and uncertainty

Risk: there are a number of possible outcomes and the probability of each outcome is known.

Uncertainty: there are a number of possible outcomes *but the probability of each outcome is NOT known*.

Attitudes to risk:

Risk seeker: a decision maker interested in the best outcomes no matter how small the chance that they may occur.

Risk neutral: a decision maker concerned with what will be the most likely outcome.

Risk averse: a decision maker who acts on the assumption that the worst outcome might occur.

Decision-making criteria

- The decision outcome resulting from the same information may vary from manager to manager as a result of their individual attitude towards the risk.
- We generally distinguish between individuals who are risk averse (dislike risk) and individuals who are risk seeking (content with risk).
- Similarly, the appropriate decision-making criteria used to make decisions are often determined by the individual's attitude to risk.

When probabilities are known for each outcome, we rely on "expected value" (for risk-neural people);
When probabilities are not available, there are still tools available for incorporating uncertainty into decision making.
Three decision-making criteria:

- Maximin.
- Maximax.
- Minimax regret.

Decision-making criteria

1. Maximin

This criteria is based upon a risk-averse (cautious) approach and bases the order decision upon maximizing the minimum payoff.

2. Maximax

This criteria is based upon a risk-seeking (optimistic) approach and bases the order decision upon maximizing the maximum payoff.

3. Minimax regret

This approach attempts to minimize the regret from making the wrong decision. We first identify the optimal decision for each of the possible situation and then calculate the regrets (i.e., the forgone benefits) for wrong decisions under each situation. The decision is then made on the basis of the lowest regret.

Example

An ice cream seller, when deciding how much ice cream to order (a small, medium, or large order), takes into consideration the weather forecast (cold, warm, or hot). There are nine possible combinations of order size and weather, and the payoffs for each are shown in the following table:

Order/weather	Cold	Warm	Hot
Small	$250	$200	$150
Medium	$200	$500	$300
Large	$100	$300	$750

The highest payoffs for each order size occur when the order size is most appropriate for the weather, i.e., small order/cold weather, medium order/warm weather, large order/hot weather. Otherwise, profits are lost from either unsold ice cream or lost potential sales.

Answers:

1. Maximin: order size= Medium;
2. Maximax: order size= Large;
3. How about minimax regrets?

Example

We need to construct the table of regrets:

Table of regrets: (for each weather outcome)

Order/weather	Cold	Warm	Hot
Small	$0	$300	$600
Medium	$50	$0	$450
Large	$150	$200	$0

Answers:

1. Minimax regrets: Large order

Exercise

Geoffrey Ramsbottom runs a kitchen that provides food for various canteens through a large organization. A particular salad is sold to the canteen for $10 and cost $8 to prepare. The payoff table is shown for the possible demand-supply combinations:

Supply/Demand	40	50	60	70
40	$80	$80	$80	$80
50	$0	$100	$100	$100
60	($80)	$20	$120	$120
70	($160)	($60)	$40	$140

Question: How many units to supply?

1. Maximin:
2. Maximax:
3. Minimax regrets:

Exercise

Table of regrets: (for each demand)

Supply/Demand	40	50	60	70
40	$0	$20	$40	$60
50	$80	$0	$20	$40
60	$160	$80	$0	$20
70	$240	$160	$80	$0

Maximum regret = $60 when Supply=40; $80 when S=50; $160 when S=60; $240 when S=70.

Question: How many units to supply?
Minimax regrets: Supply= 40