Cost-Volume-Profit Relationships

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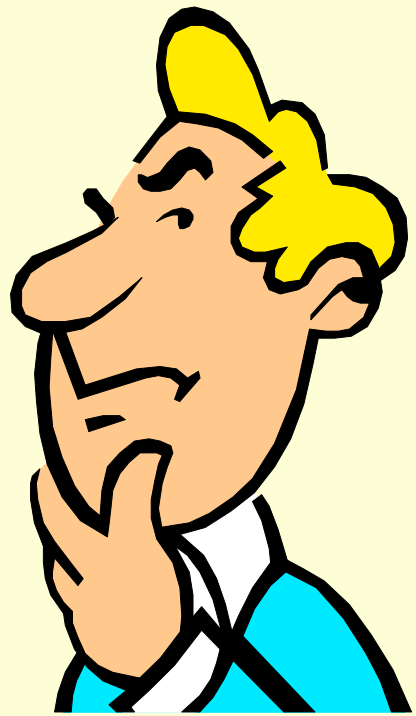
Assumptions of CVP Analysis

1. Selling price is constant.
2. Costs are linear.
3. In multi-product companies, the sales mix is constant.
4. In manufacturing companies, inventories do not change (units produced = units sold).



Cost-Volume-Profit Assumptions and Terminology

1. Changes in the level of revenues and costs arise only because of changes in the number of product (or service) units produced and sold.

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2. Total costs can be divided into a fixed component and a component that is variable with respect to the level of output.

Cost-Volume-Profit Assumptions and Terminology

3. When graphed, the behavior of total revenues and total costs is linear (straight-line) in relation to output units within the relevant range (and time period).

4. The unit selling price, unit variable costs, and fixed costs are known and constant.

Cost-Volume-Profit Assumptions and Terminology

5. The analysis either covers a single product or assumes that the sales mix when multiple products are sold will remain constant as the level of total units sold changes.
6. All revenues and costs can be added and compared without taking into account the time value of money.

Cost-Volume-Profit Assumptions and Terminology

Operating income
= Total revenues from operations
– Cost of goods sold and operating costs (excluding income taxes)

Net income = Operating income – Income taxes

Essentials of Cost-Volume-Profit (CVP) Analysis Example

Assume that the Pants Shop can purchase pants for $32 from a local factory; other variable costs amount to $10 per unit.

The local factory allows the Pants Shop to return all unsold pants and receive a full $32 refund per pair of pants within one year.

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The average selling price per pair of pants is $70 and total fixed costs amount to $84,000.

Essentials of Cost-Volume-Profit (CVP) Analysis Example

How much revenue will the business receive if 2,500 units are sold?

2,500 × $70 = $175,000

How much variable costs will the business incur?

2,500 × $42 = $105,000

$175,000 – 105,000 – 84,000 = ($14,000)

Essentials of Cost-Volume-Profit (CVP) Analysis Example

What is the contribution margin per unit?

$70 – $42 = $28 contribution margin per unit

What is the total contribution margin when 2,500 pairs of pants are sold?

2,500 × $28 = $70,000

Essentials of Cost-Volume-Profit (CVP) Analysis Example

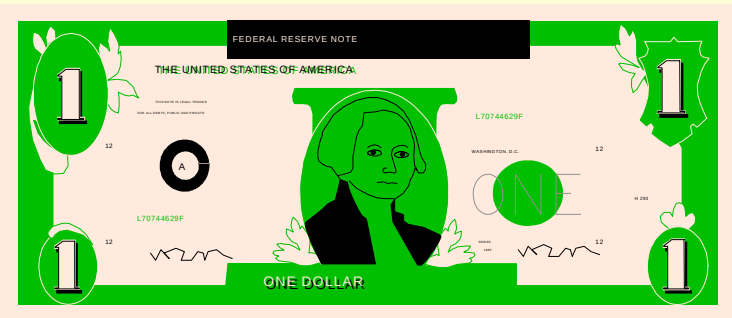
Contribution margin percentage (contribution margin ratio) is the contribution margin per unit divided by the selling price.

What is the contribution margin percentage?

$28 ÷ $70 = 40%

Essentials of Cost-Volume-Profit (CVP) Analysis Example

If the business sells 3,000 pairs of pants, revenues will be $210,000 and contribution margin would equal 40% × $210,000 = $84,000.



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The Basics of Cost-Volume-Profit (CVP) Analysis

WIND BICYCLE CO.
Contribution Income Statement
For the Month of June

	Total	Per Unit
Sales (500 bikes)	$ 250,000	$ 500
Less: variable expenses	150,000	300
Contribution margin	100,000	$ 200
Less: fixed expenses	80,000	
Net operating income	$ 20,000	

Contribution Margin (CM) is the amount remaining from sales revenue after variable expenses have been deducted.

The Basics of Cost-Volume-Profit (CVP) Analysis

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CM goes to cover fixed expenses.

The Basics of Cost-Volume-Profit (CVP) Analysis

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Less: fixed expenses	80,000	
Net operating income	$ 20,000	

After covering fixed costs, any remaining CM contributes to income.

The Contribution Approach

For each additional unit Wind sells, $200 more in contribution margin will help to cover fixed expenses and profit.

	Total	Per Unit
Sales (500 bikes)	$250,000	$ 500
Less: variable expenses	150,000	300
Contribution margin	$100,000	$ 200
Less: fixed expenses	80,000	
Net operating income	$ 20,000	

The Contribution Approach

Each month Wind must generate at least $80,000 in total CM to break even.

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	Total	Per Unit
Sales (500 bikes)	$250,000	$ 500
Less: variable expenses	150,000	300
Contribution margin	$100,000	$ 200
Less: fixed expenses	80,000	
Net operating income	$ 20,000	

The Contribution Approach

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If Wind sells 400 units in a month, it will be operating at the break-even point.

WIND BICYCLE CO.
Contribution Income Statement
For the Month of June

	Total	Per Unit
Sales (400 bikes)	$ 200,000	$ 500
Less: variable expenses	120,000	300
Contribution margin	80,000	$ 200
Less: fixed expenses	80,000	
Net operating income	$ 0	

The Contribution Approach

If Wind sells one more bike (401 bikes), net operating income will increase by $200.

WIND BICYCLE CO.
Contribution Income Statement
For the Month of June

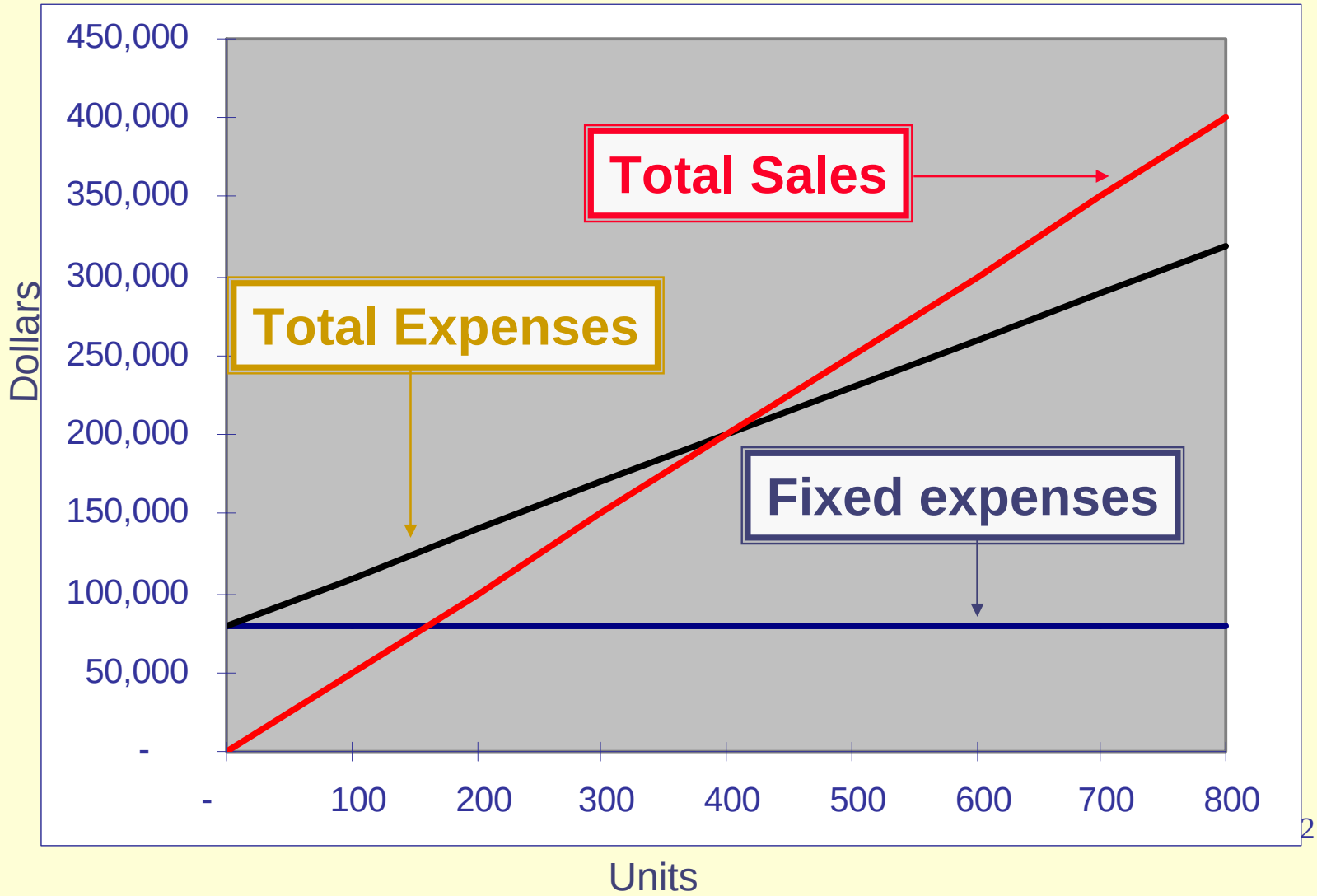
	Total	Per Unit
Sales (401 bikes)	$ 200,500	$ 500
Less: variable expenses	120,300	300
Contribution margin	80,200	$ 200
Less: fixed expenses	80,000	
Net operating income	$ 200	

CVP Relationships in Graphic Form

Viewing CVP relationships in a graph is often helpful. Consider the following information for Wind Co.:

	Income 300 units	Income 400 units	Income 500 units
Sales	$ 150,000	$ 200,000	$ 250,000
Less: variable expenses	90,000	120,000	150,000
Contribution margin	$ 60,000	$ 80,000	$ 100,000
Less: fixed expenses	80,000	80,000	80,000
Net operating income	$ (20,000)	$ -	$ 20,000

CVP Graph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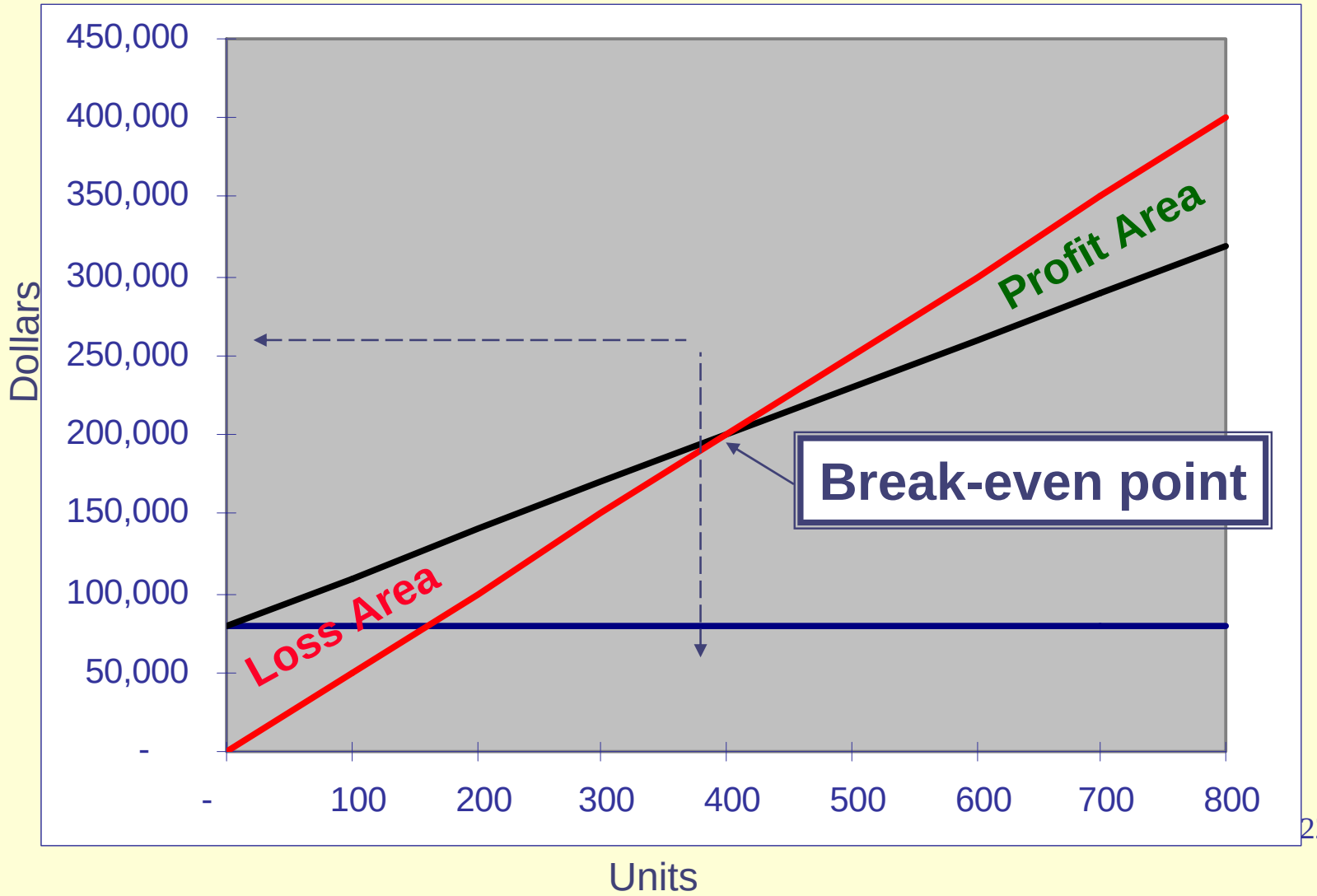
CVP Graph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Dollars
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500
600
700
800
Units
Profit Area
Loss Area
Break-even point

Contribution Margin Ratio

The contribution margin **ratio** is:

$$\text{CM Ratio} = \frac{\text{Total CM}}{\text{Total sales}}$$

Contribution Margin (CM)

For Wind Bicycle Co. the ratio is:

$$\frac{\$\ 80{,}000}{\$200{,}000} = 40\%$$

Contribution Margin Ratio

Or, in terms of **units**, the contribution margin **ratio** is:

$$\text{CM Ratio} = \frac{\text{Unit CM}}{\text{Unit selling price}}$$

For Wind Bicycle Co. the ratio is:

$$\frac{\$200}{\$500} = 40\%$$

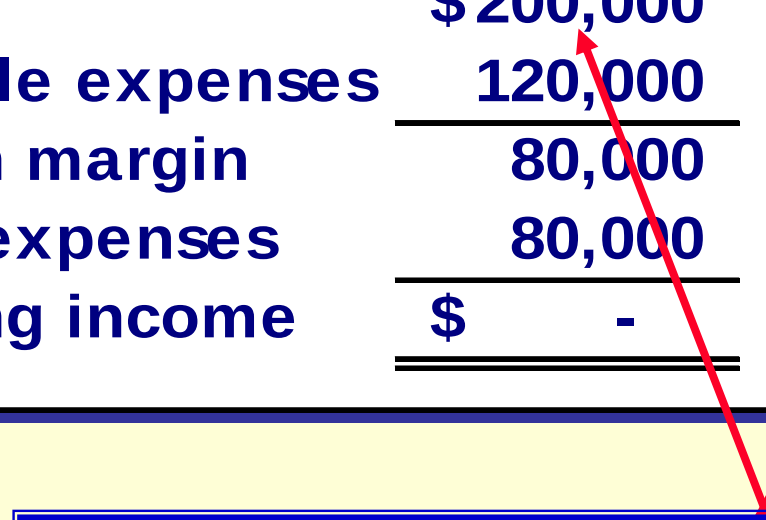
Contribution Margin Ratio

At Wind, each $1.00 increase in sales revenue results in a total contribution margin increase of 40¢.

If sales increase by $50,000, what will be the increase in total contribution margin?

Contribution Margin Ratio

	400 Bikes	500 Bikes
Sales	$200,000	$250,000
Less: variable expenses	120,000	150,000
Contribution margin	80,000	100,000
Less: fixed expenses	80,000	80,000
Net operating income	$ -	$ 20,000



A $50,000 increase in sales revenue

Contribution Margin Ratio

	400 Bikes	500 Bikes
Sales	$200,000	$250,000
Less: variable expenses	120,000	150,000
Contribution margin	80,000	100,000
Less: fixed expenses	80,000	80,000
Net operating income	$ -	$ 20,000

A $50,000 increase in sales revenue results in a $20,000 increase in CM. ($50,000 × 40% = $20,000)

Quick Check ✓

Coffee Klatch is an espresso stand in a downtown office building. The average selling price of a cup of coffee is $1.49 and the average variable expense per cup is $0.36. The average fixed expense per month is $1,300. 2,100 cups are sold each month on average.

What is the CM Ratio for Coffee Klatch?

a. 1.319

b. 0.758

c. 0.242

d. 4.139

Quick Check ✓

Coffee Klatch is an espresso stand in a downtown office building. The average selling price of a cup of coffee is $1.49 and the average variable expense per cup is $0.36. The average fixed expense per month is $1,300. 2,100 cups are sold each month on average.

What is the

a. 1.319

b. 0.758

c. 0.242

d. 4.139

$$\text{CM Ratio} = \frac{\text{Unit contribution margin}}{\text{Unit selling price}}$$

$$= \frac{(\$1.49 - \$0.36)}{\$1.49}$$

$$= \frac{\$1.13}{\$1.49} = 0.758$$

Changes in Fixed Costs and Sales Volume

Wind is currently selling 500 bikes per month. The company's sales manager believes that an increase of $10,000 in the monthly advertising budget would increase bike sales to 540 units.

Should we authorize the requested increase in the advertising budget?

Changes in Fixed Costs and Sales Volume

$80,000 + $10,000 advertising = $90,000

	Current Sales (500 bikes)	Projected Sales (540 bikes)
Sales	$ 250,000	$ 270,000
Less: variable expenses	150,000	162,000
Contribution margin	100,000	108,000
Less: fixed expenses	80,000	90,000
Net operating income	$ 20,000	$ 18,000

Sales increased by $20,000, but net operating income **decreased** by $2,000.

Changes in Fixed Costs and Sales Volume

The Shortcut Solution

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Increase in CM (40 units X $200)	$	8,000
Increase in advertising expenses		10,000
Decrease in net operating income	$	(2,000)

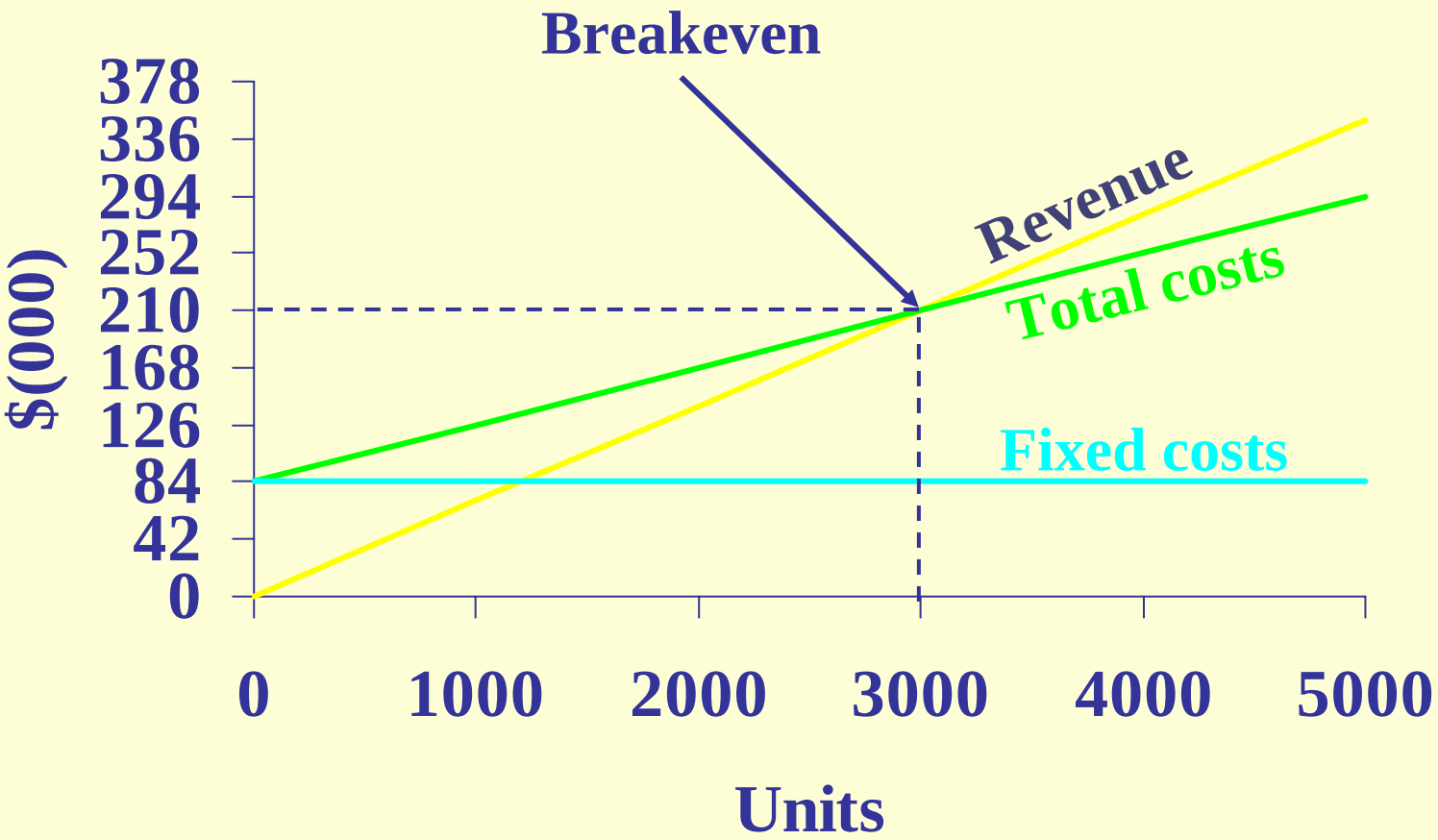
The answer in no.

Break-Even Analysis

Break-even analysis can be approached in three ways:

1. Graphical analysis.
2. Equation method.
3. Contribution margin method.

Graph Method



Equation Method

Profits = Sales – (Variable expenses + Fixed expenses)

OR

Sales = Variable expenses + Fixed expenses + Profits

At the break-even point profits equal zero.

Break-Even Analysis

Here is the information from Wind Bicycle Co.:

	Total	Per Unit	Percent
Sales (500 bikes)	$250,000	$ 500	100%
Less: variable expenses	150,000	300	60%
Contribution margin	$100,000	$ 200	40%
Less: fixed expenses	80,000		
Net operating income	$ 20,000		

Equation Method

We calculate the break-even point as follows:

Sales = Variable expenses + Fixed expenses + Profits

$500Q = $300Q + $80,000 + $0

Where:

Q = Number of bikes sold
$500 = Unit selling price
$300 = Unit variable expense
$80,000 = Total fixed expense

Equation Method

We calculate the break-even point as follows:

Sales = Variable expenses + Fixed expenses + Profits

$500Q = $300Q + $80,000 + $0
$200Q = $80,000
Q = $80,000 ÷ $200 per bike
Q = 400 bikes

Equation Method

We can also use the following equation to compute the break-even point in sales dollars.

Sales = Variable expenses + Fixed expenses + Profits

$$X = 0.60X + \$80,000 + \$0$$

Where:

X = Total sales dollars

0.60 = Variable expenses as a % of sales

$80,000 = Total fixed expenses

Equation Method

We can also use the following equation to compute the break-even point in sales dollars.

Sales = Variable expenses + Fixed expenses + Profits

$$X = 0.60X + \$80,000 + \$0$$
$$0.40X = \$80,000$$
$$X = \$80,000 \div 0.40$$
$$X = \$200,000$$

Contribution Margin Method

The contribution margin method is a variation of the equation method.

$$\text{Break-even point in units sold} = \frac{\text{Fixed expenses}}{\text{Unit contribution margin}}$$

$$\text{Break-even point in total sales dollars} = \frac{\text{Fixed expenses}}{\text{CM ratio}}$$

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Quick Check ✓

Coffee Klatch is an espresso stand in a downtown office building. The average selling price of a cup of coffee is $1.49 and the average variable expense per cup is $0.36. The average fixed expense per month is $1,300. 2,100 cups are sold each month on average.

What is the break-even sales in units?

a. 872 cups

b. 3,611 cups

c. 1,200 cups

d. 1,150 cups

Quick Check ✓

Coffee Klatch is an espresso stand in a downtown office building. The average selling price of a cup of coffee is $1.49 and the average v
average f
2,100 cup
What

a. 872

b. 3,611

c. 1,200

d. 1,150 cups

$$\text{Break-even} = \frac{\text{Fixed expenses}}{\text{Unit contribution margin}}$$

$$= \frac{\$1{,}300}{\$1.49 \text{ per cup} - \$0.36 \text{ per cup}}$$

$$= \frac{\$1{,}300}{\$1.13 \text{ per cup}}$$

$$= 1{,}150 \text{ cups}$$

Quick Check ✓

Coffee Klatch is an espresso stand in a downtown office building. The average selling price of a cup of coffee is $1.49 and the average variable expense per cup is $0.36. The average fixed expense per month is $1,300. 2,100 cups are sold each month on average.

What is the break-even sales in dollars?

a. $1,300

b. $1,715

c. $1,788

d. $3,129

Quick Check ✓

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What is the break-even sales in dollars?

a. $1,300

b. $1,715

c. $1,788

d. $3,129

$$\text{Break-even sales} = \frac{\text{Fixed expenses}}{\text{CM Ratio}}$$

$$= \frac{\$1,300}{0.758}$$

$$= \$1,715$$

Target Profit Analysis

Suppose Wind Co. wants to know how many bikes must be sold to earn a profit of $100,000.

We can use our CVP formula to determine the sales volume needed to achieve a target net profit figure.

The CVP Equation

Sales = Variable expenses + Fixed expenses + Profits

$500Q = $300Q + $80,000 + $100,000

$200Q = $180,000

Q = 900 bikes

The Contribution Margin Approach

We can determine the number of bikes that must be sold to earn a profit of $100,000 using the contribution margin approach.

$$\text{Unit sales to attain the target profit} = \frac{\text{Fixed expenses + Target profit}}{\text{Unit contribution margin}}$$

$$\frac{\$80{,}000 + \$100{,}000}{\$200 \text{ per bike}} = 900 \text{ bikes}$$

Quick Check ✓

Coffee Klatch is an espresso stand in a downtown office building. The average selling price of a cup of coffee is $1.49 and the average variable expense per cup is $0.36. The average fixed expense per month is $1,300.

How many cups of coffee would have to be sold to attain target profits of $2,500 per month?

a. 3,363 cups

b. 2,212 cups

c. 1,150 cups

d. 4,200 cups

Quick Check ✓

$$\text{Unit sales to attain target profit} = \frac{\text{Fixed expenses + Target profit}}{\text{Unit contribution margin}}$$

$$= \frac{\$1{,}300 + \$2{,}500}{\$1.49 - \$0.36}$$

$$= \frac{\$3{,}800}{\$1.13}$$

$$= 3{,}363 \text{ cups}$$

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a. 3,363 cups

b. 2,212 cups

c. 1,150 cups

d. 4,200 cups

The Margin of Safety

Excess of budgeted (or actual) sales over the break-even volume of sales. The amount by which sales can drop before losses begin to be incurred.

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Margin of safety = Total sales - Break-even sales

Let's calculate the margin of safety for Wind.

The Margin of Safety

Wind has a break-even point of $200,000. If actual sales are $250,000, the margin of safety is $50,000 or 100 bikes.

	Break-even sales 400 units	Actual sales 500 units
Sales	$ 200,000	$ 250,000
Less: variable expenses	120,000	150,000
Contribution margin	80,000	100,000
Less: fixed expenses	80,000	80,000
Net operating income	$ -	$ 20,000

The Margin of Safety

The margin of safety can be expressed as **20%** of sales.
($50,000 ÷ $250,000)

	Break-even sales 400 units	Actual sales 500 units
Sales	$ 200,000	$ 250,000
Less: variable expenses	120,000	150,000
Contribution margin	80,000	100,000
Less: fixed expenses	80,000	80,000
Net operating income	$ -	$ 20,000

Quick Check ✓

Coffee Klatch is an espresso stand in a downtown office building. The average selling price of a cup of coffee is $1.49 and the average variable expense per cup is $0.36. The average fixed expense per month is $1,300. 2,100 cups are sold each month on average.

What is the margin of safety?

a. 3,250 cups

b. 950 cups

c. 1,150 cups

d. 2,100 cups

Quick Check ✓

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Margin of safety = Total sales – Break-even sales
= 2,100 cups – 1,150 cups
= 950 cups

or

$$\text{Margin of safety percentage} = \frac{950 \text{ cups}}{2{,}100 \text{ cups}} = 45\%$$

a. 3,250 cups

b. 950 cups

c. 1,150 cups

d. 2,100 cups

Operating Leverage

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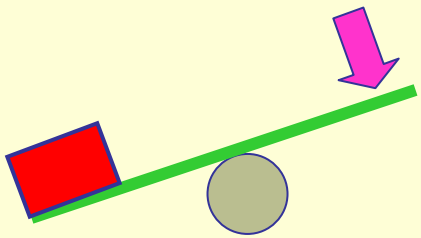
- A measure of how sensitive net operating income is to percentage changes in sales.
- With high leverage, a small percentage increase in sales can produce a much larger percentage increase in net operating income.

$$\text{Degree of operating leverage} = \frac{\text{Contribution margin}}{\text{Net operating income}}$$



Operating Leverage

	Actual sales 500 Bikes
Sales	$ 250,000
Less: variable expenses	150,000
Contribution margin	100,000
Less: fixed expenses	80,000
Net income	$ 20,000

$$\frac{\$100,000}{\$20,000} = 5$$

Operating Leverage

With a operating leverage of 5, if Wind increases its sales by 10%, net operating income would increase by 50%.

Percent increase in sales		**10%**
Degree of operating leverage	**×**	**5**
Percent increase in profits		**50%**

Here's the verification!

Operating Leverage

	Actual sales (500)	Increased sales (550)
Sales	$ 250,000	$ 275,000
Less variable expenses	150,000	165,000
Contribution margin	100,000	110,000
Less fixed expenses	80,000	80,000
Net operating income	$ 20,000	$ 30,000

10% increase in sales from $250,000 to $275,000 . . .

. . . results in a 50% increase in income from $20,000 to $30,000.

Quick Check ✓

Coffee Klatch is an espresso stand in a downtown office building. The average selling price of a cup of coffee is $1.49 and the average variable expense per cup is $0.36. The average fixed expense per month is $1,300. 2,100 cups are sold each month on average.

What is the operating leverage?

a. 2.21

b. 0.45

c. 0.34

d. 2.92

Quick Check ✓

Coffee
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2,100 cups
What is

a. 2.21
b. 0.45
c. 0.34
d. 2.92

	Actual sales 2,100 cups
Sales	$ 3,129
Less: Variable expenses	756
Contribution margin	2,373
Less: Fixed expenses	1,300
Net operating income	$ 1,073

$$\text{Operating leverage} = \frac{\text{Contribution margin}}{\text{Net operating income}}$$

$$= \frac{\$2,373}{\$1,073} = 2.21$$

Quick Check ✓

At Coffee Klatch the average selling price of a cup of coffee is $1.49, the average variable expense per cup is $0.36, and the average fixed expense per month is $1,300. 2,100 cups are sold each month on average.

If sales increase by 20%, by how much should net operating income increase?

a. 30.0%

b. 20.0%

c. 22.1%

d. 44.2%

Quick Check ✓

At Coffee Klatch the average selling price of a cup of coffee is $1.49, the average variable expense per cup is $0.36, and the average fixed expense per month is $1,300. 2,100 cups are sold each month on average.

If sales increase by 20%, by how much should net operating income increase?

a. 30.0%

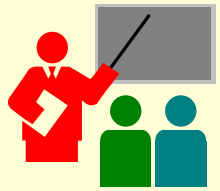
b. 20.0%

c. 22.1%

d. 44.2%

	Percent increase in sales	**20.0%**
×	**Degree of operating leverage**	**2.21**
	Percent increase in profit	**44.20%**

Teaching Note: Verify increase in profit



	Actual sales	*Increased sales*
	2,100 cups	*2,520 cups*
Sales	$ 3,129	$ 3,755
Less: Variable expenses	756	907
Contribution margin	2,373	2,848
Less: Fixed expenses	1,300	1,300
Net operating income	$ 1,073	$ 1,548
% change in sales		20.0%
% change in net operating income		44.2%

The Concept of Sales Mix

- Sales mix is the relative proportions in which a company's products are sold.
- Different products have different selling prices, cost structures, and contribution margins.

Let's assume Wind sells bikes and carts and see how we deal with break-even analysis.

Multi-product break-even analysis

Wind Bicycle Co. provides the following information:

	Bikes		Carts		Total	
Sales	$ 250,000	100%	$ 300,000	100%	$ 550,000	100.0%
Var. exp.	150,000	60%	135,000	45%	285,000	51.8%
Contrib. margin	$ 100,000	40%	$ 165,000	55%	265,000	48.2%
Fixed exp.					170,000	
Net operating income					$ 95,000	
Sales mix	$ 250,000	45%	$ 300,000	55%	$ 550,000	100.0%

$$\frac{\$265,000}{\$550,000} = 48.2\% \text{ (rounded)}$$

Multi-product break-even analysis

$$\text{Break-even sales} = \frac{\text{Fixed expenses}}{\text{CM Ratio}}$$

$$= \frac{\$170{,}000}{0.482}$$

$$= \$352{,}697$$

	Bikes		Carts		Total	
Sales	$ 158,714	100%	$ 193,983	100%	$ 352,697	100.0%
Var. exp.	95,228	60%	87,293	45%	182,521	51.8%
Contrib. margin	$ 63,485	40%	$ 106,691	55%	170,176	48.2%
Fixed exp.					170,000	
Net operating income					$ 176	
Sales mix	$ 158,714	45%	$ 193,983	55%	$ 352,697	100.0%

Rounding error

Explain CVP analysis in decision making and how sensitivity analysis helps managers cope with uncertainty.

Using CVP Analysis Example

Suppose the management anticipates selling 3,200 pairs of pants.

Management is considering an advertising campaign that would cost $10,000.

It is anticipated that the advertising will increase sales to 4,000 units.

Should the business advertise?

Using CVP Analysis Example

3,200 pairs of pants sold with no advertising:	
Contribution margin	$89,600
Fixed costs	84,000
Operating income	$ 5,600
4,000 pairs of pants sold with advertising:	
Contribution margin	$112,000
Fixed costs	94,000
Operating income	$ 18,000

Using CVP Analysis Example

Instead of advertising, management is considering reducing the selling price to $61 per pair of pants.

It is anticipated that this will increase sales to 4,500 units.

Should management decrease the selling price per pair of pants to $61?

Using CVP Analysis Example

3,200 pairs of pants sold with no change in the selling price:

Operating income = $5,600

4,500 pairs of pants sold at a reduced selling price:

Contribution margin: (4,500 × $19)	$85,500
Fixed costs	84,000
Operating income	$ 1,500

Sensitivity Analysis and Uncertainty Example

Assume that the Pants Shop can sell 4,000 pairs of pants.

Fixed costs are $84,000.

Contribution margin ratio is 40%.

At the present time the business cannot handle more than 3,500 pairs of pants.

Sensitivity Analysis and Uncertainty Example

To satisfy a demand for 4,000 pairs, management must acquire additional space for $6,000.

Should the additional space be acquired?

Revenues at breakeven with existing space are $84,000 ÷ .40 = $210,000.

Revenues at breakeven with additional space are $90,000 ÷ .40 = $225,000

Sensitivity Analysis and Uncertainty Example

Operating income at $245,000 revenues with existing space = ($245,000 × .40) – $84,000 = $14,000.

(3,500 pairs of pants × $28) – $84,000 = $14,000

Sensitivity Analysis and Uncertainty Example

Operating income at $280,000 revenues with additional space = ($280,000 × .40) – $90,000 = $22,000.

(4,000 pairs of pants × $28 contribution margin) – $90,000 = $22,000