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Engineering Economics: Break-even Analysis

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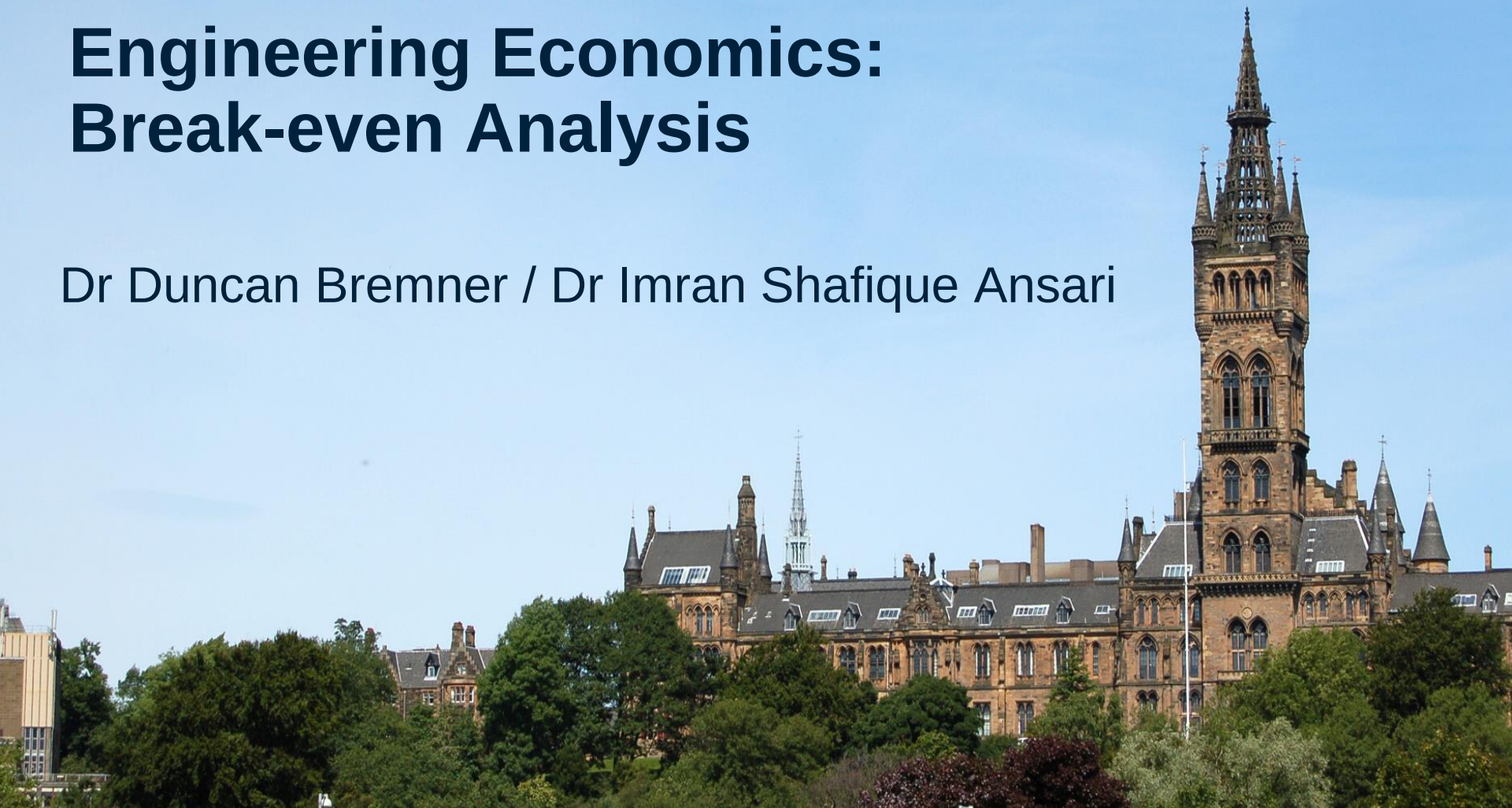


Some basic revision of product costs

Price: What a company sells a product for

Cost: what a company buys components for

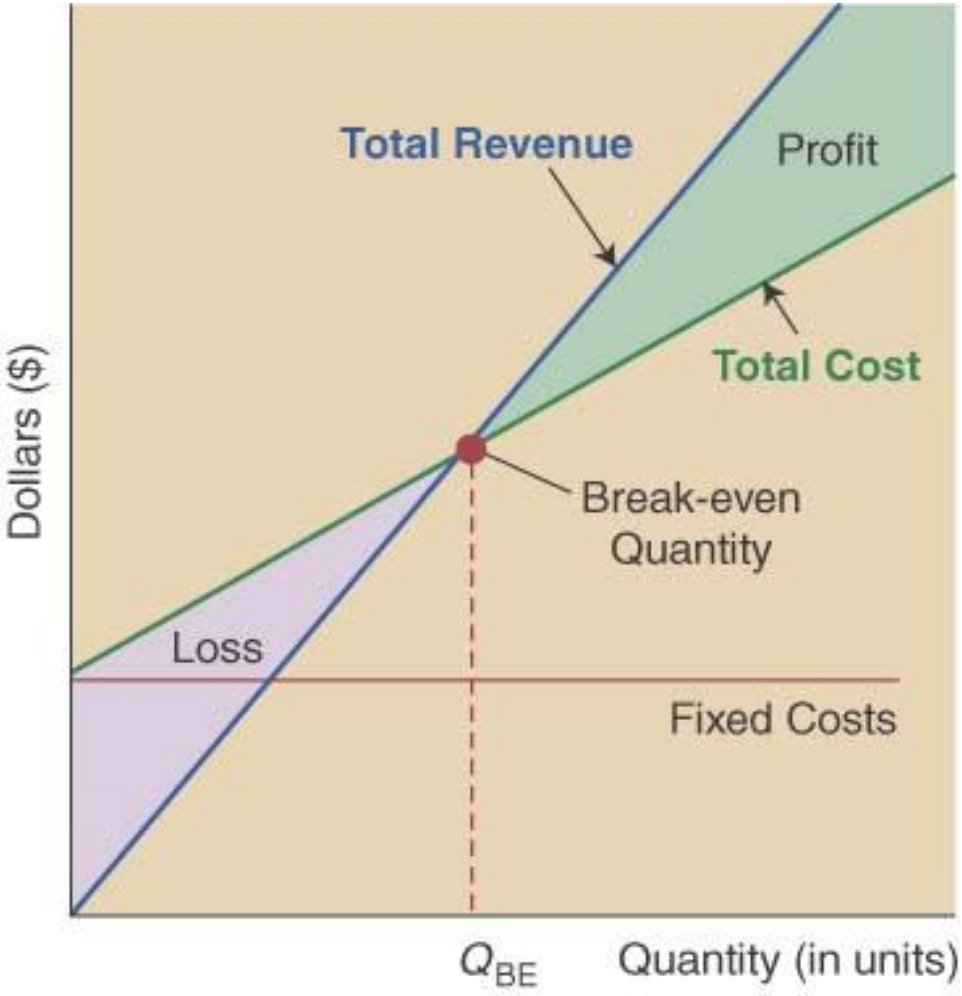
Fixed costs: costs to a company that are not dependent on volume

Variable costs: Costs to a company that ARE dependent on volume

Contribution of a product: Selling Price – Variable costs

Break-Even Analysis

- **Compute quantity of goods that must be sold to break-even**
- **Compute total revenue at an assumed selling price**
- **Compute fixed cost and variable cost for several quantities**
- **Plot the total revenue line and the total cost line**
- **Intersection is break-even**
- **Sensitivity analysis can be done to examine changes in all of the assumptions made**



Break-even Point of Production

The level of output at which total costs equal total revenue

Total Costs = Total Revenue

<u>No</u> profit or Loss occurs

Methods of Calculating

There are 3 different ways to calculate the break-even point:

Break-Even Formula

Table Method

Graphical Method

Break-even Formula

Contribution per unit

Is the selling price of a product minus variable costs per unit.

$$\text{Break-even level of output} = \frac{\text{Fixed Cost}}{\text{Contribution per unit}}$$

***Note:** The formula method produces exact answers so it is likely to be more accurate* than the graphing method.*

***but is it really??**

Break-even Formula Example

Fixed costs = $200,000

Contribution per unit = $50

What is the Break-even level of output?

$$\text{Break-even level of output} = \frac{\text{Fixed Cost}}{\text{Contribution per unit}}$$

200,000 / 50 = 4000 units

Break-Even Analysis

Total cost = fixed costs + variable costs (quantity):

$$TC = F + (VC)Q$$

Revenue = selling price (quantity)

$$R = (SP)Q$$

Break-even point is where total costs = revenue:

$$TC = R \quad or \quad F + (VC)Q = (SP)Q$$

$$or \quad Q = \frac{F}{SP - VC}$$

A firm estimates that the fixed cost of producing a line of footwear is $52,000 with a $9 variable cost for each pair produced. They want to know:

If each pair sells for $25, how many pairs must they sell to break-even?

If they sell 4000 pairs at $25 each, how much money will they make?

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Example Solved

Break-even point:

$$Q = \frac{F}{SP - VC} = \frac{\$52{,}000}{\$25 - \$9} = 3{,}250 \ pairs$$

Profit = total revenue – total costs

$$P = (SP)Q - (F + (VC)Q)$$

$$= (\$25)4{,}000 - (\$52{,}000 + (\$9)4{,}000)$$

$$= \$12{,}000$$

Table Method

The table method uses a table to arrange data so the break-even point can be easily identified.

Table Method Example

Data for a hamburger stand:

$500 for booth rental per day (fixed costs)
$1 hamburger cost and labor to make the hamburger (variable costs)
$2 sales price for hamburger (price)

Qty Sold	Fixed Cost	Variable Cost	Total Cost	Revenue (price X qty)	Profit/Loss
0	$500	$0	$500	0	($500)
100	$500	$100	$600	$200	($400)
200	$500	$200	$700	$400	($300)
300	$500	$300	$800	$600	($200)
400	$500	$400	$900	$800	($100)
500	**$500**	**$500**	**$1000**	**$1000**	**$0**
600	$500	$600	$1100	$1200	$100
700	$500	$700	$1200	$1400	$200

Break-even production is 500 hamburgers per day.

Graphical Method

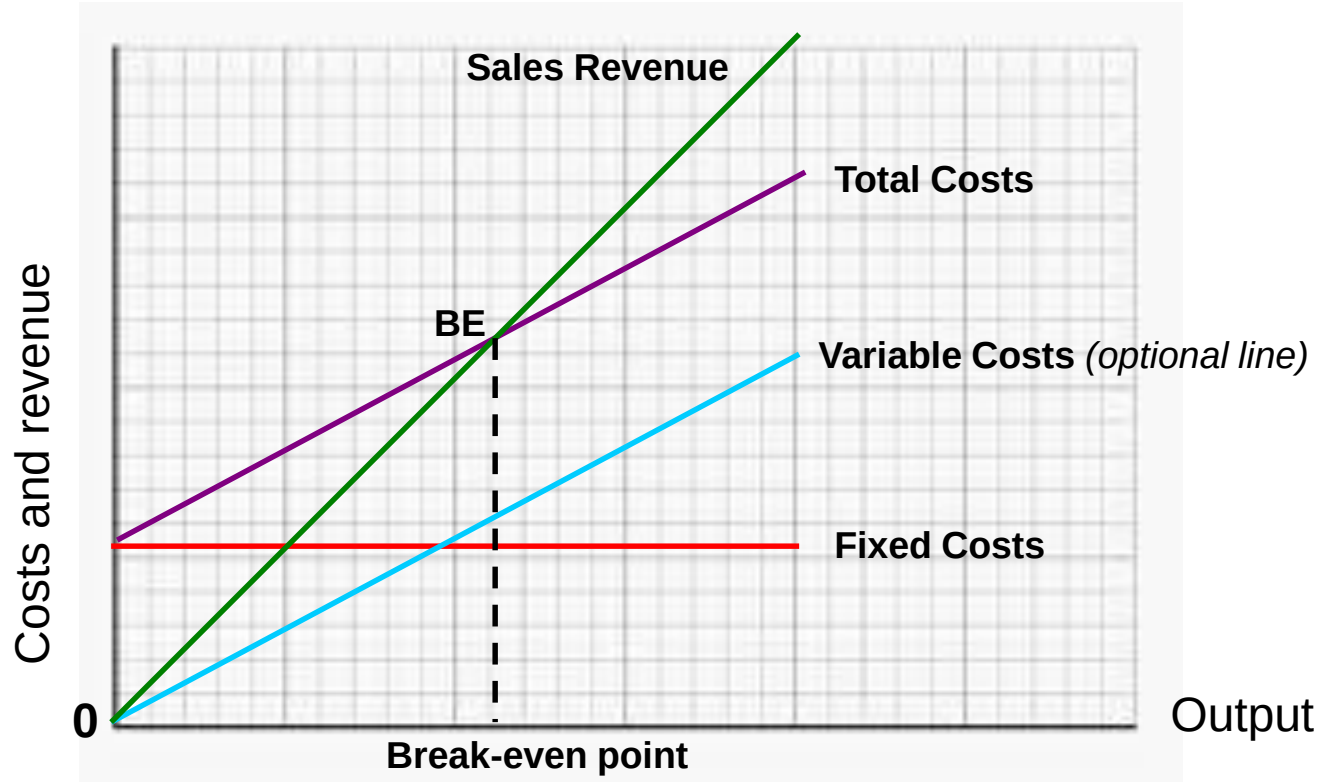
The break-even graph shows 3 pieces of information:

Fixed costs

Total costs (fixed costs + variable costs)

Sales revenue (selling price * units sold)

Graphical Method Example



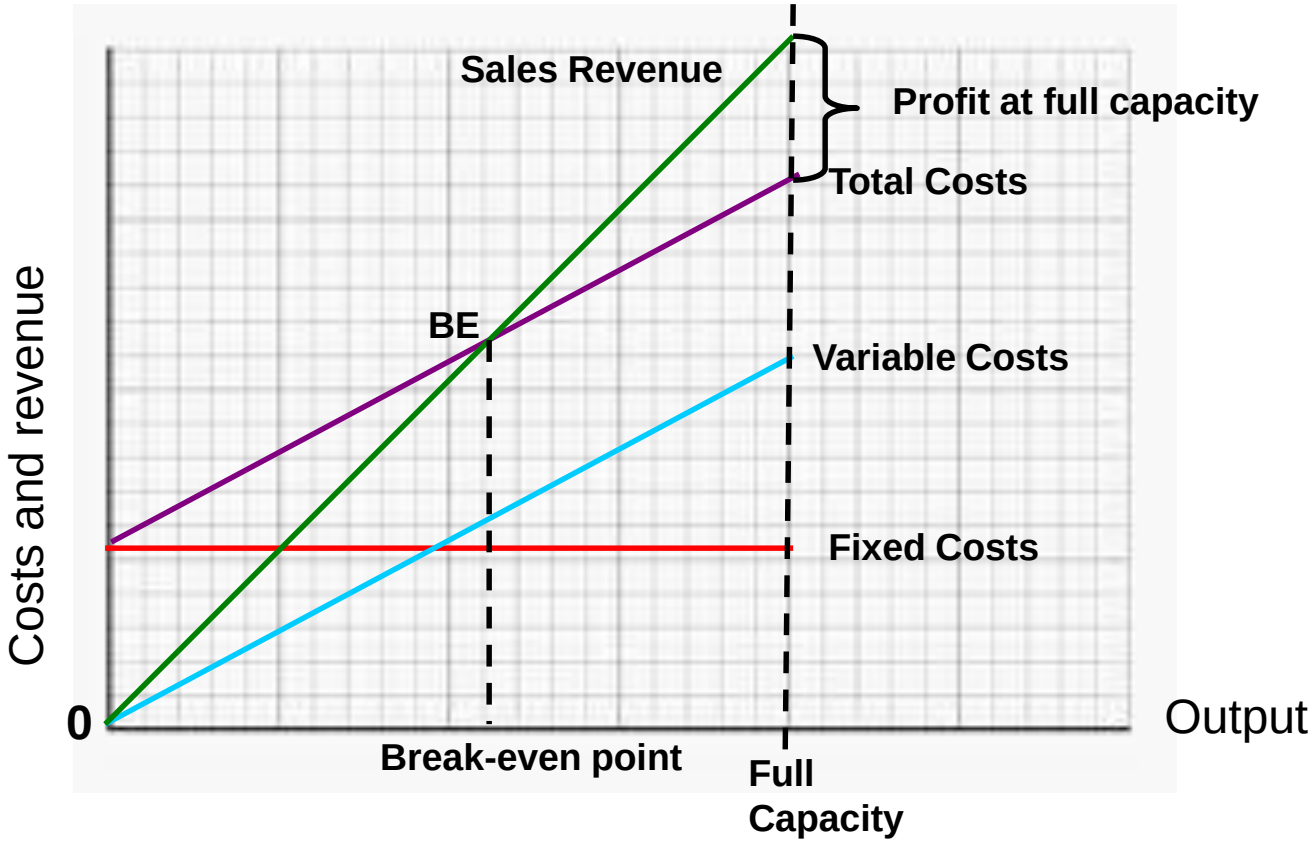
Fixed Costs Horizontal line showing fixed costs are constant at all production levels

Variable Costs Starts at 0 (if no goods produced, no variable costs) and increases at a constant rate (qty X variable cost per unit)

Total Costs Begins at the fixed cost line and follows the same slope as the variable costs

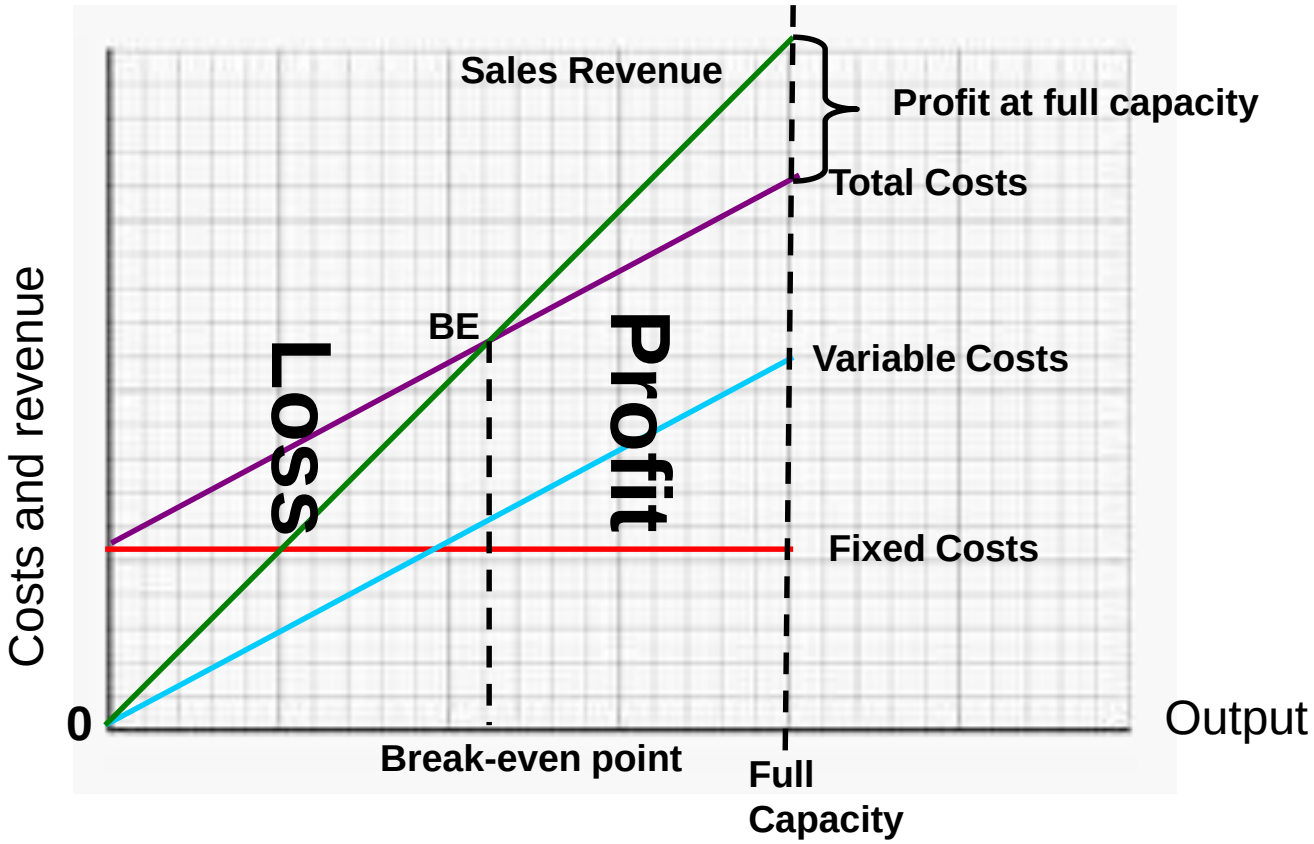
Sales Revenue Begins at zero as if no sales made and it increases at a constant rate (total revenue=qty X price)

Graphical Method Example



The maximum profit is made when the maximum output is produced.

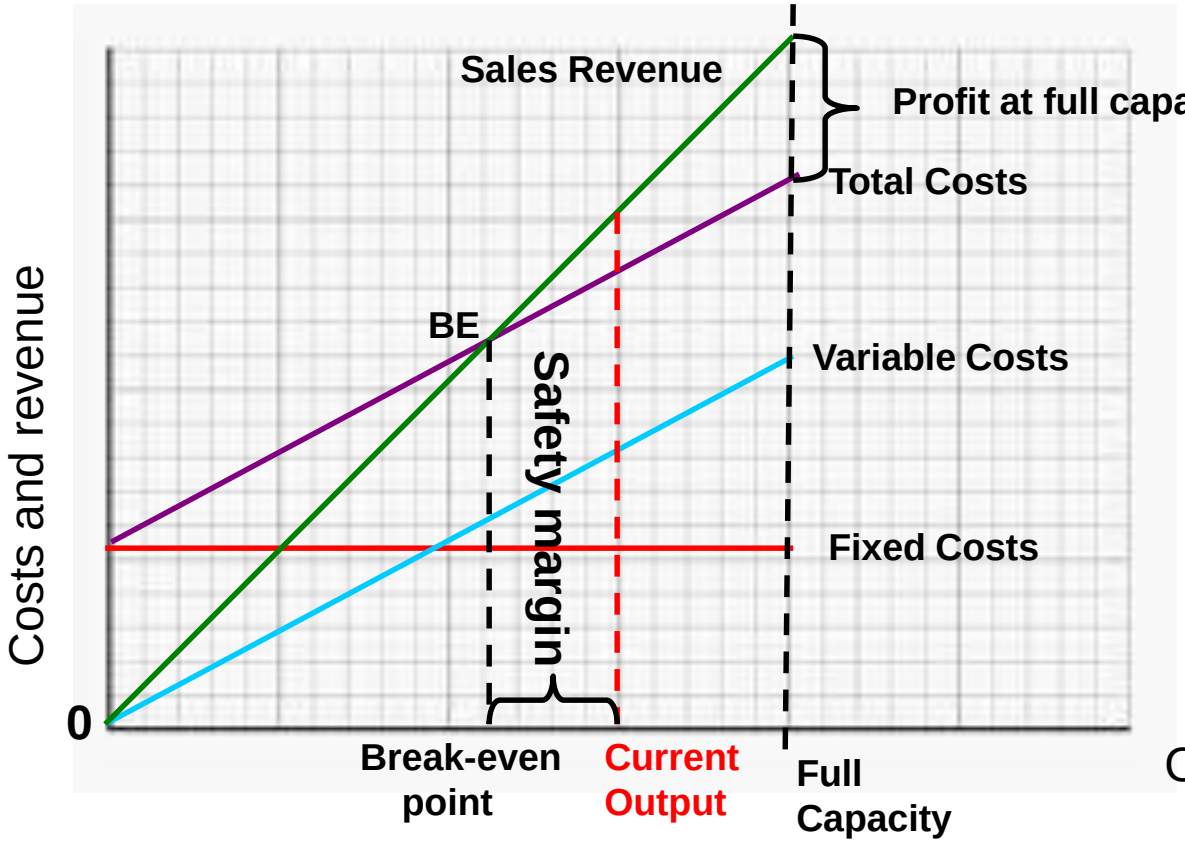
Profit vs Loss



Profits are to the right of the break-even point.

Losses are to the left of the break-even point.

Margin of Safety



If margin of safety is positive, production is above break even.

If margin of safety is negative, production is below break even.

Margin of safety is the amount by which the sales level exceeds the break-even level. If sales drop below this level, a loss will occur.

Additional Uses of Break-even Analysis

Marketing decision: The impact of price increases

This raises sales revenue line at all quantities – assuming that sales do not decline which may be unlikely.

Operations Management decision: Purchase of new equipment with lower variable costs

This lowers the variable cost line at each quantity level.

Choosing between two locations for a new factory with different fixed and variable costs.

Target Revenues & Profits

A modified break-even formula can be used to determine a target profit level.

$$\text{Target profit level of output} = \frac{\text{Fixed Costs + Target Profit}}{\text{Contribution per Unit}}$$

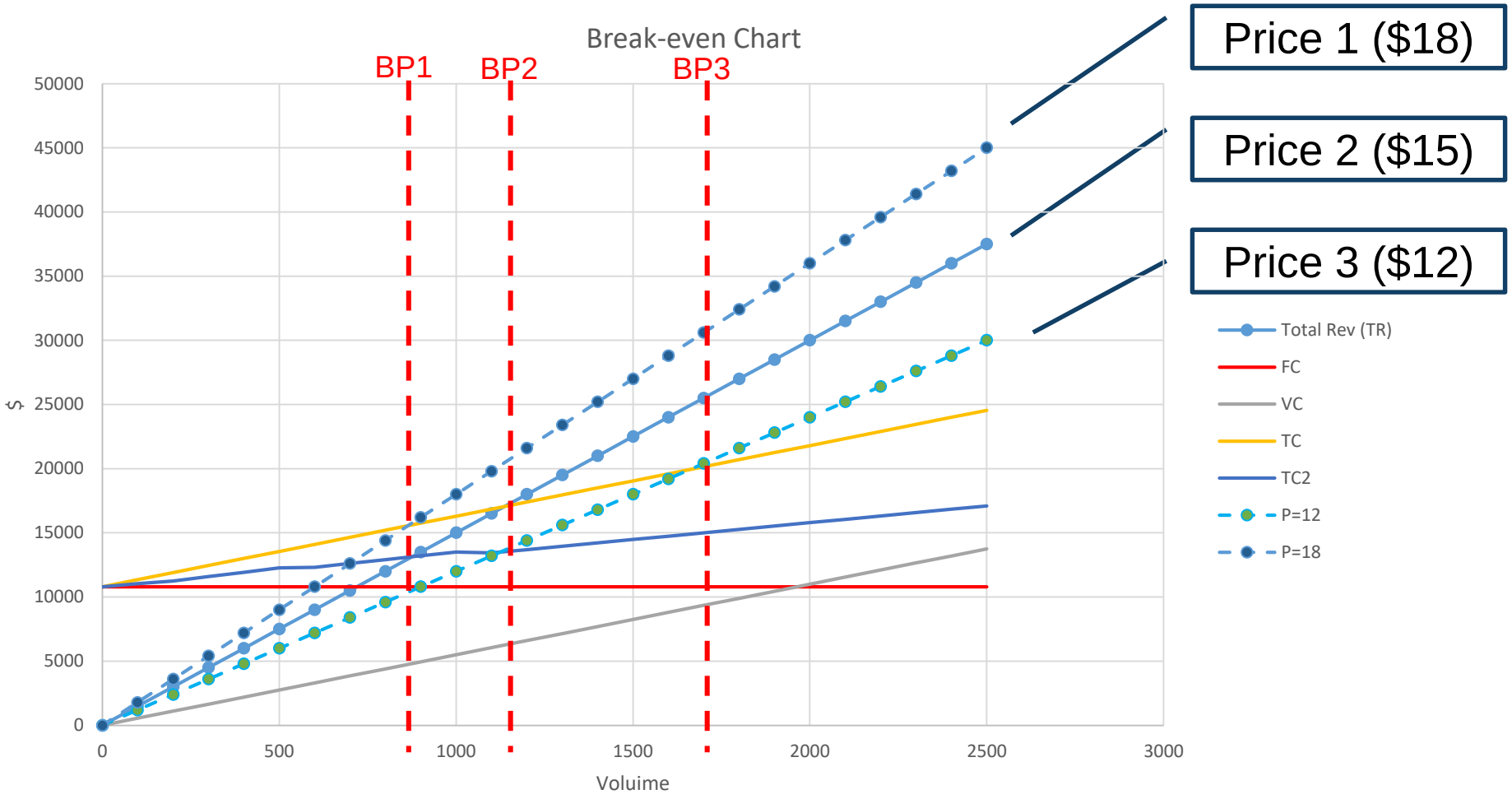
Target profit is $25,000

Fixed Costs are $200,000

Contribution per unit $50

$$4500 \text{ Units} = \frac{200{,}000 + 25{,}000}{50}$$

Using BEV to test Price Sensitivity



Break-even Revenue

Break-even Revenue is the amount of revenue needed to cover both fixed and variable costs so that the business breaks even.

$$\text{Break-even Revenue} = \frac{\text{Fixed Costs}}{1 - (\text{Variable cost} / \text{Price})}$$

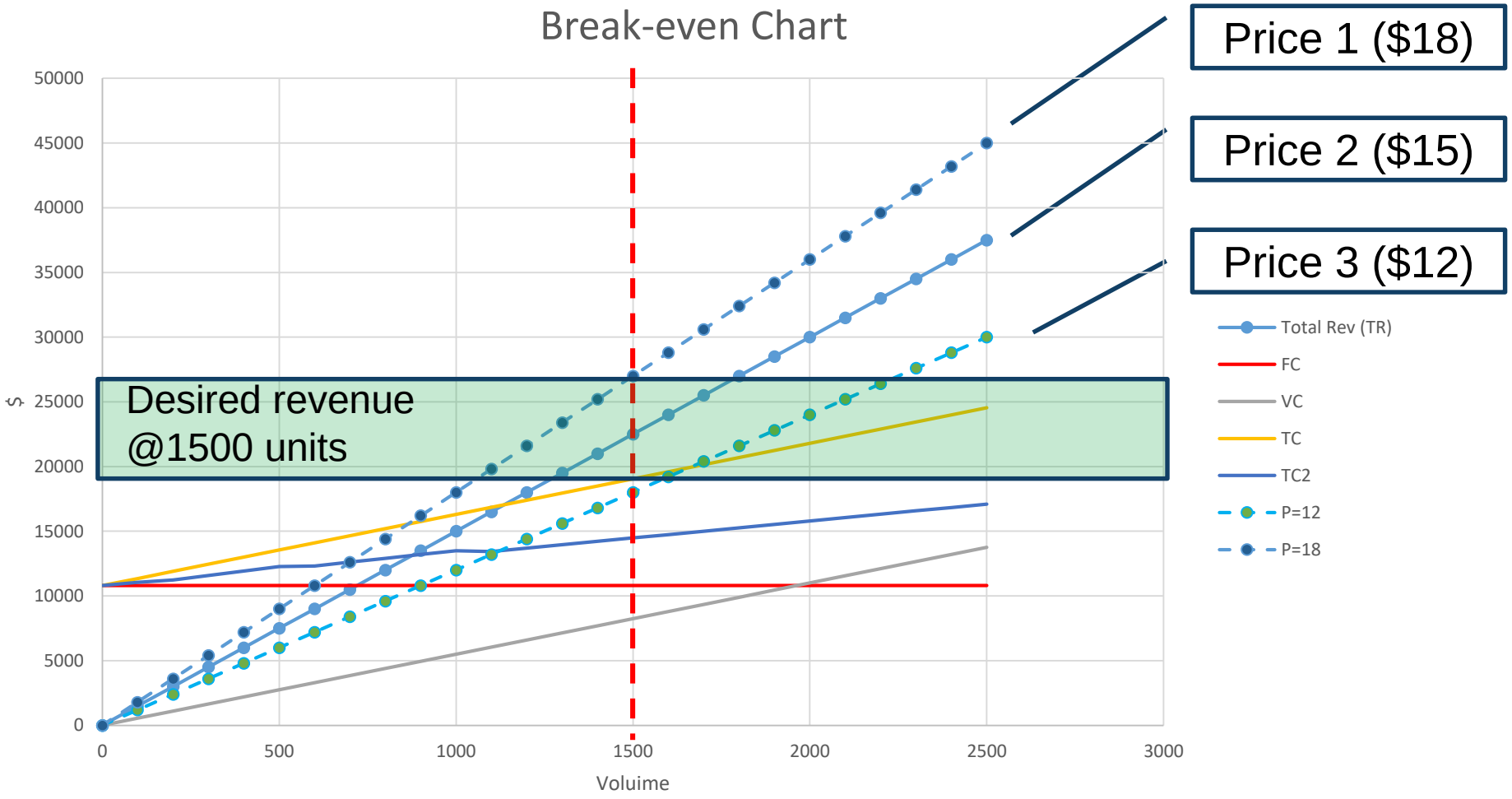
This is helpful in a service business.

Story: If the monthly fixed costs of a engineering consultancy are $60,000, engineers are paid $15 per hour, and clients are charged a price of $30 per hours, what is the break-even revenue?

How many hours must they bill?

$$\frac{60{,}000}{1 - (15 / 30)} = \$120{,}000$$

Break Even Revenue



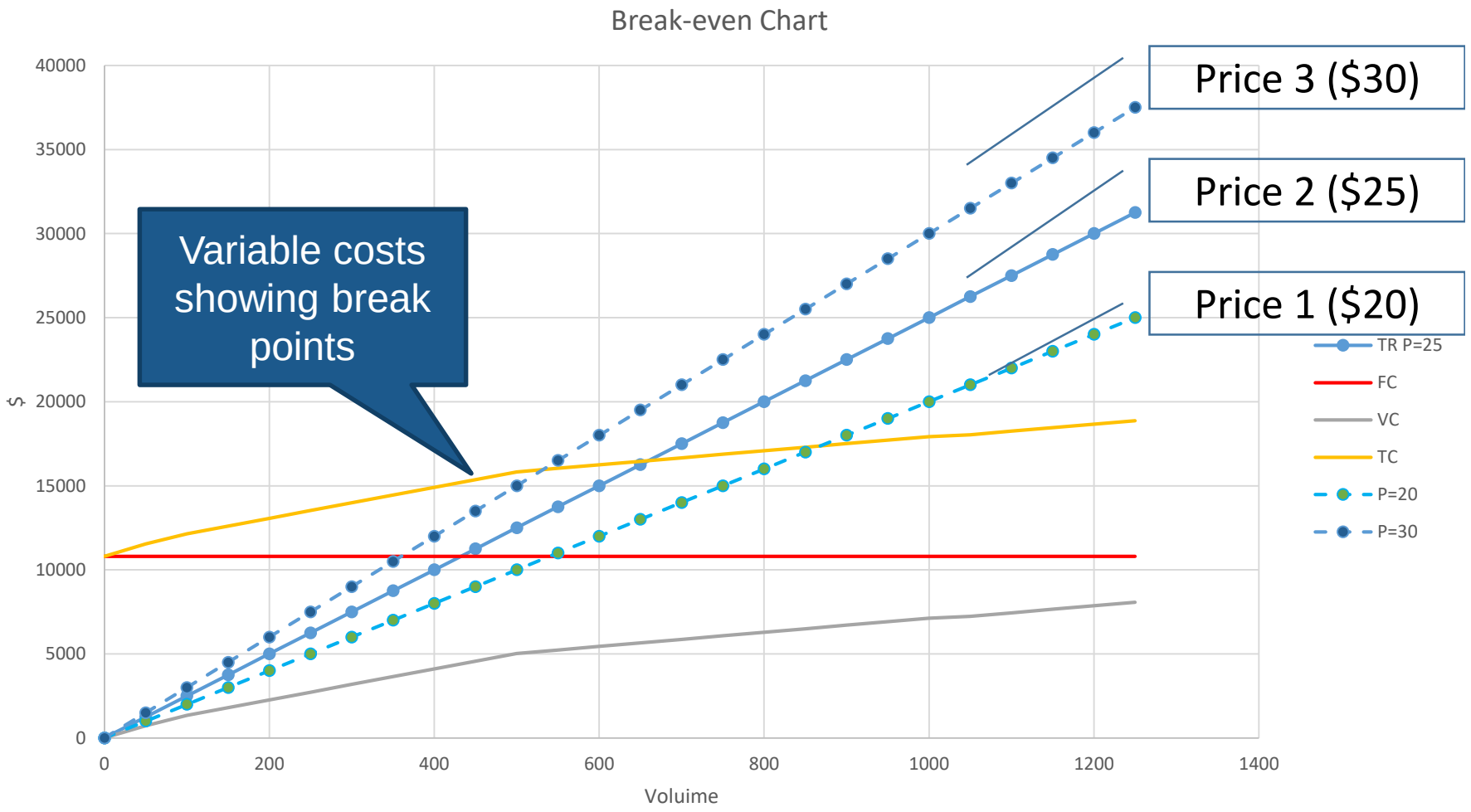
Why is Break-even Analysis Useful?

- **Charts are easy to construct and interpret**
- **Useful guidelines for break-even points, safety margins, profit/loss levels of different rates of output**
- **Comparisons can be made by constructing multiple charts**
- **The equation method produces an exact break-even quantity**
- **Break-even analysis can be used to assist managers in decision making such as location or new equipment purchases.**

Limitations of Break-even Analysis

- **Costs and revenues are not always represented by a straight line.**
- **Not all variable costs increase directly with output.**
- **Not all costs can be categorized into fixed or variable costs; some are semi-variable**
- **There is no allowance for stocking levels. It assumes all quantities produced will be sold.**
- **It is unlikely that fixed costs will not change at various output levels.**

Example 2 BEV analysis showing cost break points

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Thank you
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INSPIRING PEOPLE

Break-even calculation: A company is planning to establish a chain of movie theaters. It estimates that each new theater will cost approximately $1 Million. The theaters will hold 500 people and will have 4 showings each day with average ticket prices at $8. They estimate that concession sales will average $2 per patron. The variable costs in labor and material are estimated to be $6 per patron. They will be open 300 days each year. What must average occupancy be to break even?

Break Even Point

Total revenues = Total costs @ break-even point Q

Selling price*Q = Fixed cost + variable cost*Q

($8+$2)Q= $1,000,000 + $6*Q

Q = 166,667 patrons (28% occupancy)

What is the gross profit if they sell 300,000 tickets

Profit = Total Revenue – Total Costs

P = $10*300,000 – (1,000,000 + $6*300,000)

P = $200,000

If concessions average $.50/patron, what is break-even Q now? (sensitivity analysis)

($8.50)Q = 1,000,000 - $6*Q

Q = 400,000 patrons (67% occupancy)