

Chapter

# 5

## Break-even analysis (CVP analysis)

## 5.1 Introduction

**Cost-volume-profit (CVP) analysis** looks at how profit changes when there are changes in variable costs, sales price, fixed costs and quantity.

It is a good example of 'what if?' analysis and it in particular looks at sales minus variable costs which is known as **contribution**. It allows management to understand the level of sales needed to cover all costs of a project and what level of sales is needed start making profits.

To break even would mean an organisation would be earning no profit and no loss.

$$\text{Sales revenue} = \text{All variable and fixed cost}$$

Main assumptions in this model are that selling price, fixed costs and variable costs are constant.

## 5.2 Formulae to learn

**Contribution per unit** = sales price per unit less variable cost per unit

$$\text{Break-even volume} = \frac{\text{Fixed overhead}}{\text{Contribution per unit}}$$

The number of units you would need to sell in order to earn enough contribution to cover the fixed overhead e.g. the number of units sold where the contribution would equal the fixed overhead.

### The contribution to sales ratio (C/S ratio)

The contribution to sales (or C/S) ratio (also called the profit-volume or P/V ratio) would calculate how much contribution a product would earn for every £1 of sales generated, expressed as a decimal or percentage. For example a 0.4 or 40% C/S ratio, would mean 40 pence of contribution is earned for every £1 of sales generated.

$$\text{C/S ratio} = \frac{\text{Contribution per unit}}{\text{Sales price per unit}}$$

$$\text{C/S ratio} = \frac{\text{Total contribution}}{\text{Total sales revenue}}$$

**Break-even revenue**

The sales revenue earned that would give no profit and no loss. It can be calculated by multiplying the break-even volume (above) by the products selling price, or alternatively by using the following formulae.

$$= \frac{\text{Fixed overhead}}{\text{C/S ratio}}$$

**Margin of safety**

Measures the sensitivity of the budgeted sales volume compared with the break-even sales volume. The difference between the level of sales activity achieved and the level of sales activity required to break-even in absolute or percentage terms.

**Margin of safety (units)** = Budgeted sales volume less Break-even sales volume

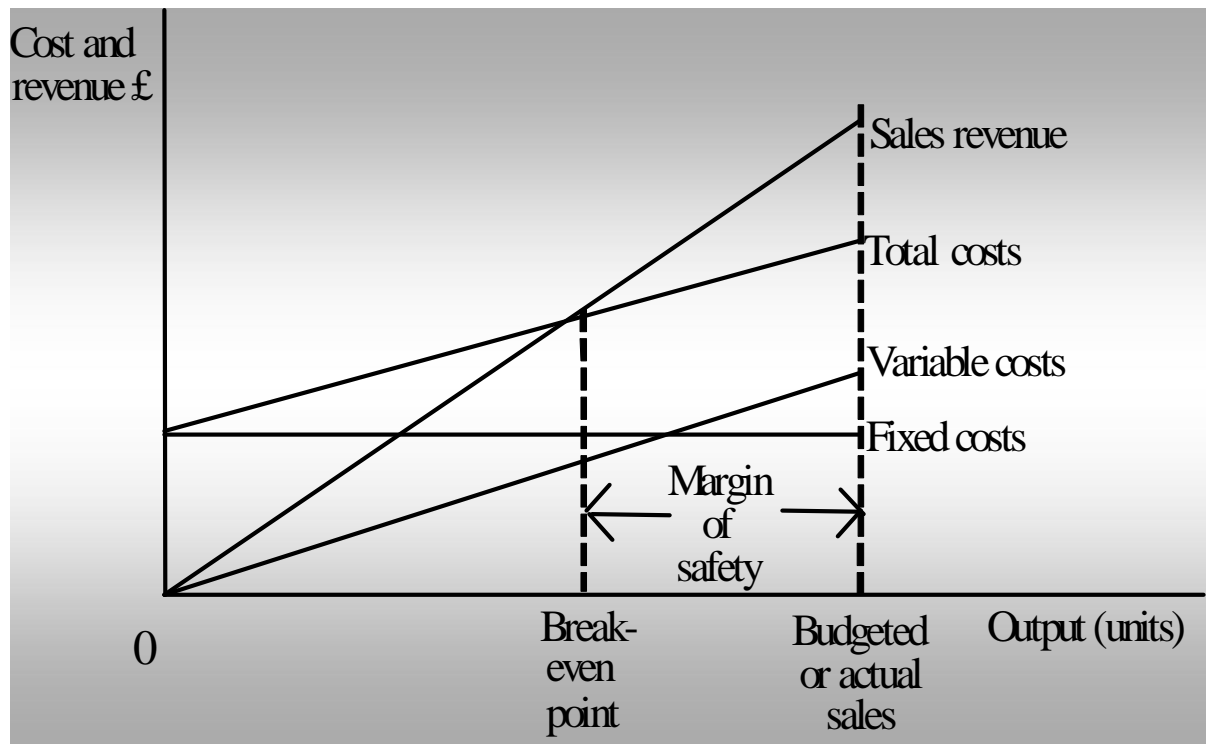
**Margin of safety (%)** =  $\frac{\text{Budgeted sales less Break-even sales volume}}{\text{Budgeted sales volume}} \times 100$

**Number of units sold to achieve a target profit**

$$= \frac{\text{Fixed cost} + \text{Target profit}}{\text{Contribution per unit}}$$

## Break-even charts

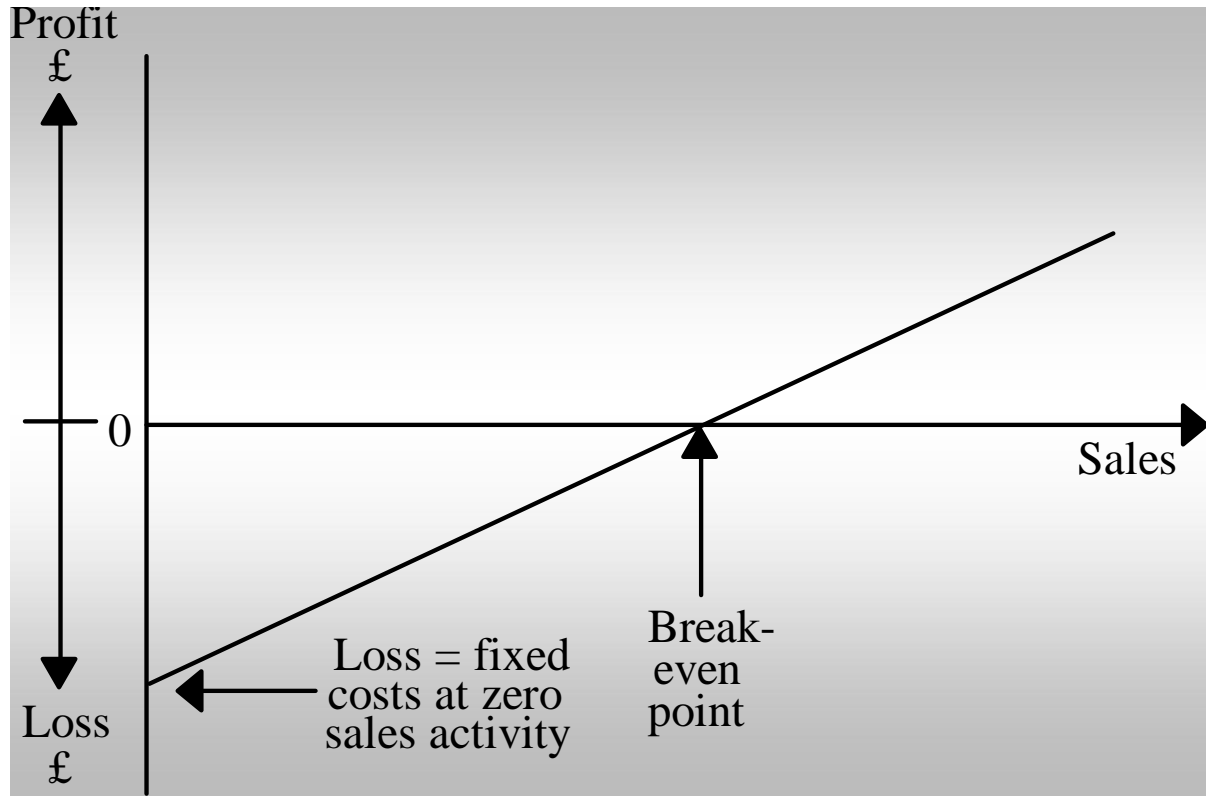
Indicates graphically profit and losses at different levels of sales volume achieved.



- Where sales revenue is greater than total cost it means that profits are being generated.
- Where sales revenue is less than total cost it means that losses are being incurred.
- Where sales revenue equals total costs (intersection of the sales revenue line and total costs line) it means that no profit or loss is occurring. This is the break-even point.
- Variable costs vary directly with output, as more output is produced then more variable costs are incurred.
- Fixed costs do not vary with output and are constant for a range of output produced. They are incurred even when there is no output at the beginning of production. This is because they are costs that must be incurred to support manufacture such as machinery or a warehouse.
- The total costs line is a representation of the combined variable and fixed costs. This is why at nil output it has a cost which represents fixed costs, and then as output increases the total cost line varies with it and in parallel with the variable cost line.
- The margin of safety is the extra amount of sales that is expected to be generated when the budget or actual sales is compared to the break even level of sales.

### Profit volume charts

A variation of a break-even chart, indicating graphically the relationship between profit and losses at different levels of sales volume achieved.



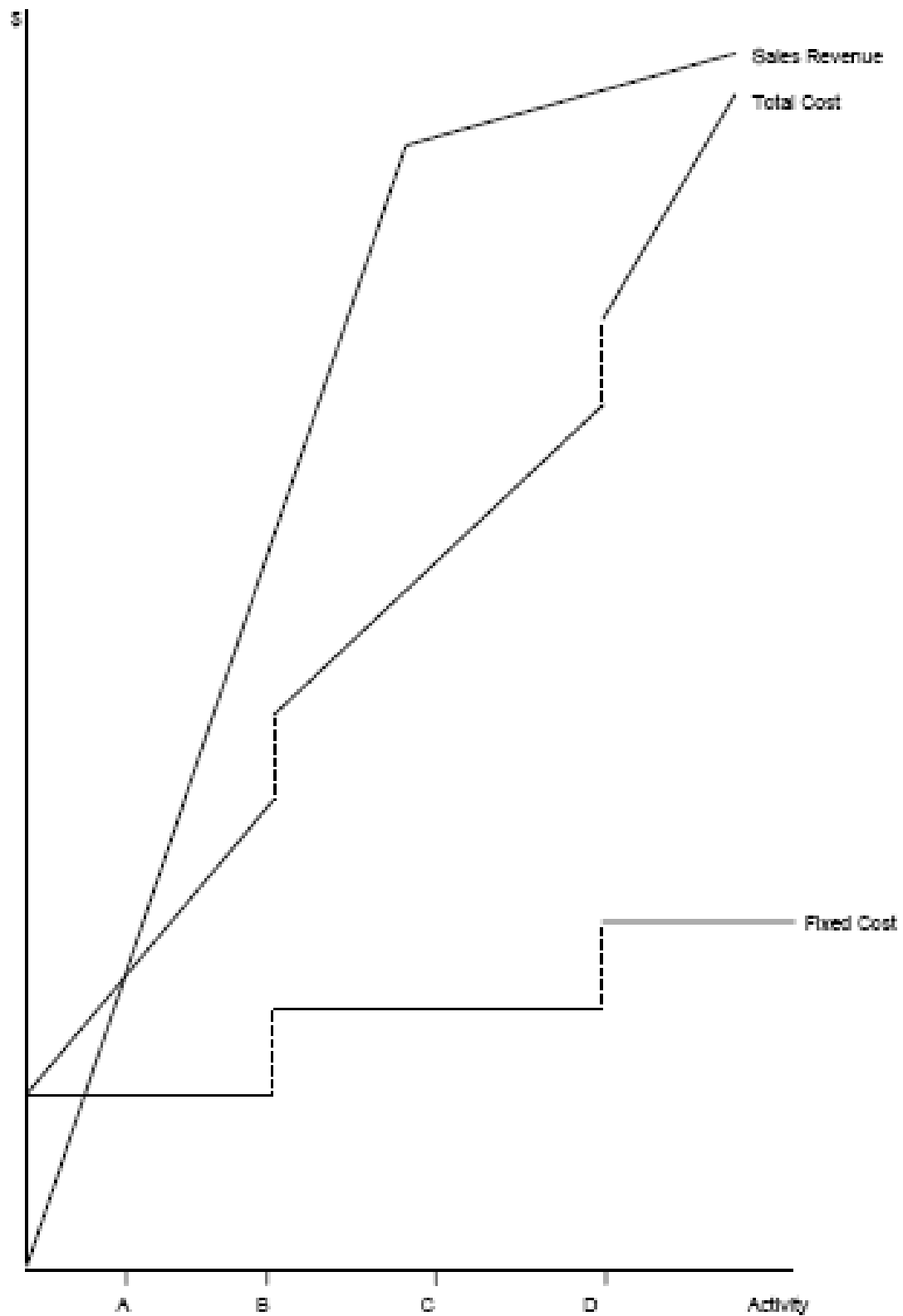
The profit volume chart is a summarisation of the break even chart, whereby the line represents total profit (sales less all costs). When the line rises above the horizontal axis it means that production is beginning to yield a profit, before this point it means that production is yielding a loss. The break even point where no profit or loss is being made is where this profit line intersected the horizontal axis.

### Assumptions

1. Single product or single mix of products
2. Fixed cost, variable cost and selling price are constant
3. The level of production will equal the level of sales

### Example 5.1 – (CIMA P2 Nov 07)

Diagram showing costs and revenues over a range of activity levels



**You are required to interpret the diagram and explain how it illustrates issues that the operational managers should consider when making decisions. (Note: your answer must include explanations of the Sales Revenue, Total Cost and Fixed Cost lines, and the significance of each of the activity levels labelled A, B, C, D).**

### **Example 5.2**

Z-Boxes sell for £299 and their variable production cost is £99. The research and development, and fixed production overheads for the year are £1.2 million.

- a) Calculate the break-even level of sales volume and revenue?**
- b) Calculate the break-even revenue using C/S ratio?**
- c) The budget revenue is £2.99 million; calculate the margin of safety in units and as a percentage?**
- d) Produce a break-even chart and profit-volume chart using the information above?**
- e) How many Z-Boxes must be sold to achieve £500,000 profit**

## 5.2 Multiple product scenarios

Break-even analysis can also be used to work out either a break-even volume or revenue, given a multiple product scenario. This is achieved using the ÷average contribution per unitø or ÷average C/S ratio per unitø for all products together.

**This calculation will only work providing the sales mix remains constant.** Change the mix and the C/S ratio or contribution per unit of the mix of the products will change; hence you would need to again work out the break-even volume or revenue.

### Example 5.3

Me ole cock spaniel plc makes 3 products, details as follows:

	Apples (£)	Pears (£)	Cockneys (£)
Selling price	60	80	40
Variable cost	(20)	(30)	(20)
Contribution	40	50	20
Sales (units)	2,000	3,000	5,000

Fixed overhead for the year £800,000

**Calculate the break-even level of sales?**

### Example 5.4 – (CIMA P2 May 07)

A company provides a number of different services to its customers from a single office. The fixed costs of the office, including staff costs, are absorbed into the company's service costs using an absorption rate of \$25 per consulting hour based on a budgeted activity level of 100,000 hours each period.

Fee income and variable costs are different depending on the services provided, but the average contribution to sales ratio is 35%.

**Calculate the breakeven fee income?**



## Key summary of chapter

**Cost-volume-profit (CVP)** analysis looks at how profit changes when there are changes in variable costs, sales price, fixed costs and quantity.

## Formulae to learn

**Contribution per unit** = sales price per unit less variable cost per unit

**Break-even volume** = 
$$\frac{\text{Fixed overhead}}{\text{Contribution per unit}}$$

**The contribution to sales ratio (C/S ratio)**

**C/S ratio** = 
$$\frac{\text{Contribution per unit}}{\text{Sales price per unit}}$$

**C/S ratio** = 
$$\frac{\text{Total contribution}}{\text{Total sales revenue}}$$

**Break-even revenue**

= 
$$\frac{\text{Fixed overhead}}{\text{C/S ratio}}$$

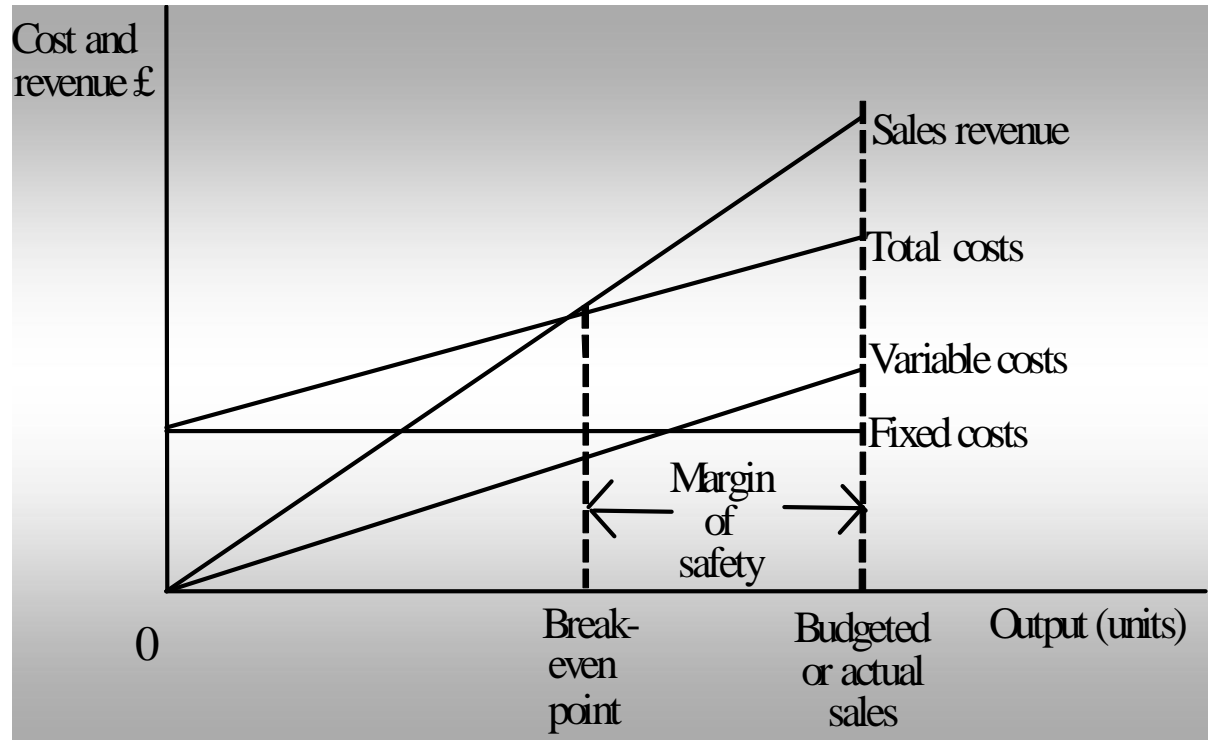
**Margin of safety (units)** = Budgeted sales volume less Break-even sales volume

**Margin of safety (%)** = 
$$\frac{\text{Budgeted sales less Break-even sales volume}}{\text{Budgeted sales volume}} \times 100$$

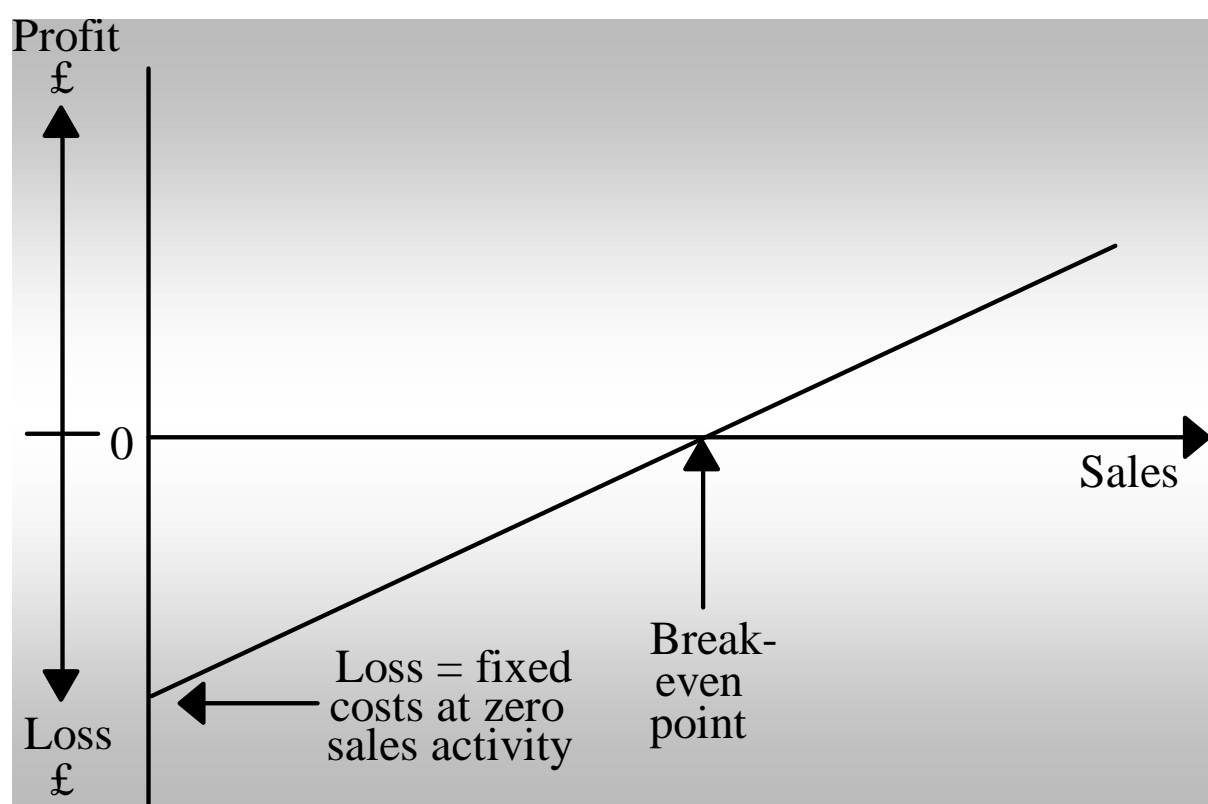
**Number of units sold to achieve a target profit**

= 
$$\frac{\text{Fixed cost} + \text{Target profit}}{\text{Contribution per unit}}$$

**Break-even chart**



**Profit volume chart**



## **Solutions to lecture examples**

## Chapter 5

### Example 5.1 – (CIMA P2 Nov 06)

#### Explanation of sales revenue line

The sales revenue line shows the amount of sales earned throughout the different level of activities. It can be seen that between zero and somewhere between activity B and C there is a constant rise or straight line increase in sales revenue. This means that the unit price charged is the same and volume sold has been increasing at a constant rate.

Beyond the point between B and C sales revenue increases at much slower rate, this indicates that selling price per unit is too high and in order to achieve previous rates of growth there has to be a reduction in unit price.

#### Explanation of the fixed cost line

A fixed cost is a cost which **cannot be easily identified or related to a cost per unit** or activity of any kind e.g. a cost which remains constant when the production of a good or service within the organisation rises or falls.

Fixed cost over the long-term will normally display the characteristics of stepped cost behaviour. That is the cost remains constant but only within a certain range of production. Once this range of production is exceeded the fixed cost will rise.

In the diagram we can see that the fixed cost line is stepped. Between the zero activity and up to activity level B fixed costs are constant. At zero activity fixed costs need to be spent such as machinery and buildings in order to manufacture products.

If we were to increase our level of activity beyond level B there needs to be an increase in fixed costs and then the costs are constant up to activity level D. There is another increase in fixed costs at activity D when looking beyond this point and then the costs are constant again.

These sudden stepped increases in fixed costs could be due to the factory reaching full capacity and then extra leasehold expenses will need to be incurred in order to obtain more buildings, if production is to increase or expand further.

Another example is supervisor's salaries, they could be paid fixed salaries, but supervision is limited to how many workers that can be supervised. Once the size of the workforce exceeds a certain range another supervisor will need to be employed.

### Explanation of total cost line

Total costs include both fixed costs and variable costs. Variable costs are costs **that can be easily identified or related to a cost per unit** or activity level of some kind e.g. a cost which rises or falls directly with the production/provision of a good or service within an organisation. Examples could include labour piece work schemes e.g. a factory worker that gets paid for each unit they make or the cost of material/components for the production or assembly of a product.

All variable cost starts from the origin of the graph indicating the cost is nil if the activity level is zero. Variable cost does not necessarily behave in a linear manner e.g. a constant amount incurred for each unit of activity. It can behave in a curvilinear (non-linear) manner as well, in which case the variable cost line would be curved not straight.

In the diagram it can be seen that at activity zero total cost is equal to fixed costs. At this point there are no variable costs as there is no activity only fixed costs. Between activity levels zero and B we can see that total cost line is increasing at constant level. The constant increase is due to variable costs being incurred as a result of increasing activity.

Total costs increases in a stepped fashion at activity levels B and D because of the costs behaviour of fixed costs as mentioned previously. It can be seen that variable costs are increasing at the same constant rate within total costs up to activity level D, after this point it can be seen that the total costs line increases more steeply. This is due to increased variable costs per unit.

### Issues to consider when making decisions

At activity level A it can be seen from the diagram the sales revenue line intersects the total cost line indicating that this is the point when the company makes no loss or profit i.e. breakeven. Any activity beyond this point sales revenue will exceed total costs causing the company to make a profit, and anything below this activity, total costs will exceed sales revenue causing the company to make losses.

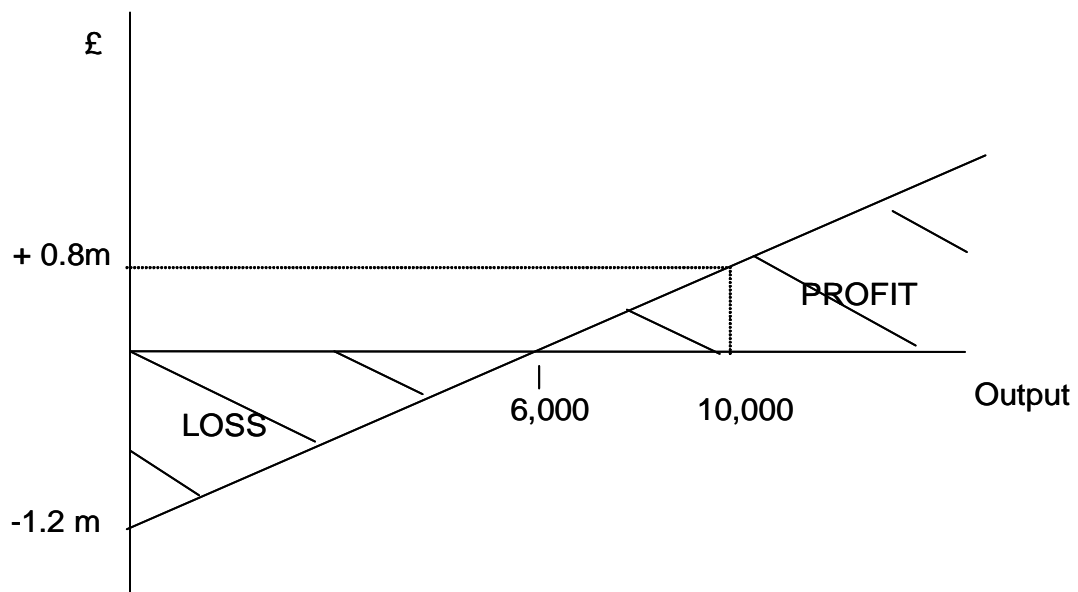
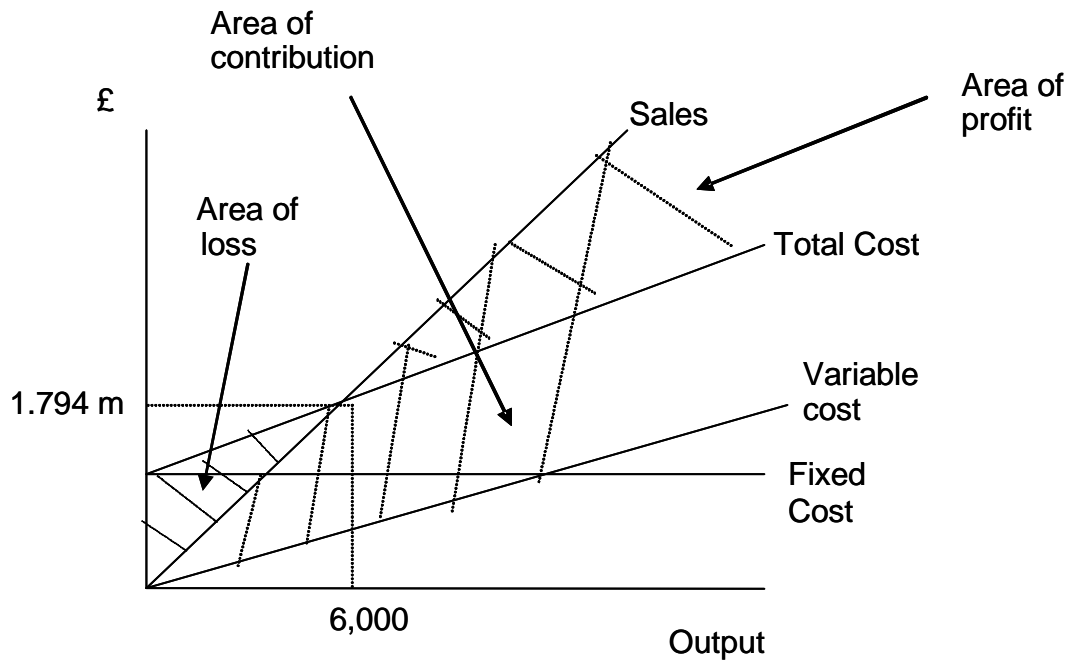
After activity level B fixed costs will increase sharply because of perhaps new investment required in the manufacturing process and profits will be reduced compared to just before activity level B. The operational managers need to consider whether the sales revenue forecast is likely to hold true, if not then profits can be reduced significantly as a result of this investment.

Between activity levels B and C the sales revenue line has a much higher gradient line than total costs and the company is earning greater profits as it increases its activity. Profits are maximised just before point C when beyond this point the sales revenue line is increasing at a slower rate when compared to total costs.

At activity level D there is another sharp increase in fixed costs and also variable costs are rising at steeper gradient to sales revenue. The operational manager should recommend to the company to continue to produce activity as long as the extra revenue is greater than the extra cost or variable cost.

### Example 5.2

- $1.2 \text{ million} / £200 = 6,000 \text{ units}$ ,  $6,000 \text{ units} \times £299 = £1,794,000$
- $£1.2 \text{ million} / 0.6689 = £1,793,990$
- $£2.99 \text{ million} / £299 = \text{budget volume } 10,000$  ( $10,000 - 6,000 = 4,000$  margin of safety) or ( $4,000 / 10,000 = 40\%$ )
- See charts below



e)  $(1.2\text{m} + 0.5\text{m}) / £200 = 8,500 \text{ units}$

### Example 5.3

Average contribution per unit

$$2,000 \times £40 = 80,000$$

$$3,000 \times £50 = 150,000$$

$$5,000 \times £20 = \underline{100,000}$$

$$\text{Total} \quad \underline{330,000} / 10,000 \text{ units} = £33 \text{ average contribution per unit}$$

$$\text{OR } 2/10 \times £40 + 3/10 \times £50 + 5/10 \times £20 = £33 \text{ average contribution per unit}$$

$$£800,000 / £33 \text{ per unit} = 24,242 \text{ units sold (in the mix 2:3:5)}$$

### Break-even revenue

$$\text{Apples } 2/10 \times 24,242 \text{ units sold} = 4,848 \times £60 = 290,880$$

$$\text{Pears } 3/10 \times 24,242 \text{ units sold} = 7,273 \times £80 = 581,840$$

$$\text{Cockneys } 5/10 \times 24,242 \text{ units sold} = \underline{12,121} \times £40 = \underline{484,840}$$

$$\underline{24,242} \quad \underline{1,357,560}$$

Alternative method would be to use the average C/S ratio

$$\text{Apples } 0.666 \times 0.2 = 0.133$$

$$\text{Pears } 0.625 \times 0.3 = 0.1875$$

$$\text{Cockneys } 0.500 \times 0.5 = \underline{0.25}$$

$$\underline{0.5705}$$

$$£800,000 / 0.5705 = £1,402,278 \text{ (close enough to £1,357,560 above!!!)}$$

### Example 5.4 – (CIMA P2 May 07)

A company provides a number of different services to its customers from a single office. The fixed costs of the office, including staff costs, are absorbed into the company's service costs using an absorption rate of \$25 per consulting hour based on a budgeted activity level of 100,000 hours each period.

Fee income and variable costs are different depending on the services provided, but the average contribution to sales ratio is 35%.

**Calculate the breakeven fee income.**

$$\text{Break-even revenue} = \text{Fixed overhead} / \text{C/S ratio}$$

$$\text{Therefore: } \$2,500,000 / 0.35 = \$7,142,857$$