TOPIC 3 PLANNING AND DECSION MAKING TECHNIQUES

COST VOLUME PROFIT (CVP) ANALYSIS OR BREAK-EVEN POINTS (BEP) ANALYSIS FOR SINGLE AND MULTIPLE PRODUCTS UNDER CONDITIONS OF UNCERTAINTY

Main uses of CVP analysis

Cost-volume-profit analysis is a forecasting concept that can be used in a variety of pricing situations. These include:

a) **To evaluate indirect costs (fixed costs).** Many indirect costs are fixed or semi variable. And therefore the principles of CVP analysis can be used in indirect cost analysis. As overall volume increases, indirect cost rates typically decline because fixed costs are spread over an increasing production volume.

b) **To evaluate item price in price analysis.** CVP analysis assumes that total cost is composed of fixed and variable elements. This assumption can be used to explain price changes as well as cost changes. As the volume being acquired increases unit costs decline. As unit costs decline, the vendor can reduce prices and same make the same profit per unit.

c) **To evaluate direct costs in pricing new contracts.** Quantity differences will often affect direct costs -- particularly direct material cost. Direct material requirements often include a fixed component for development or production operation set-up. As that direct cost is spread over an increasing volume unit costs should decline.

d) To evaluate direct costs in pricing contract changes. How will an increase in contract effort increase contract price? Some costs will increase others will not. The concepts of cost-volume-profit analysis can be an invaluable aid in considering the effect of the change on contract price (Lucey. T 2003; Strathmore 1992; Garrison R.H & Norren E.W. 2000)

4.1 Assumptions Of Cost volume profit Analysis

1) Production units equal sales units' within the relevant range
2) Selling price and variable costs per unit remains constant within the relevant range
3) Total fixed costs remain constant or unchanged within the relevant range.
4) Total variable costs vary directly proportional to the output within the relevant range
5) Total costs and total revenue functions have been reliably determined and are linear functions of the output within the relevant range.

6) The analysis either relates to one product only or a constant production/sales mix for multiple products within the relevant range.
7) Sales and expenses relationships are valid only within the relevant range.
8) All costs can be accurately divided into fixed and variable components within the relevant range. This means that mixed costs can be decomposed into fixed and variable elements.
9) Productivity and technology remain unchanged within the relevant range. Assumes that there is no learning curves effects i.e. production methods, technology and efficiency remain constant within the relevant range
10) CVP analysis only applies within the relevant range. The relevant range is a band of activity or volume within which a given cost behaviour is defined or valid.
11) Prices of factors of production remain constant within the relevant range.
12) Assumes that profits are computed based on marginal or variable costing basis.
13) Volume is the only factor affecting revenues and costs within the relevant range.
14) The analysis applies only to a Short time period (Lucey. T 2003; Strathmore 1992; Garrison R.H & Norren E.W. 2000).

4.2 CVP ANALYSIS FOR ONE PRODUCT ONLY UNDER CERTAINITY ENVIRONMENT

We should note that a BEP is the point or level of activity [level of activity] where a company makes neither profits nor losses. I.e. a point where total revenue (TR) is equal to total cost (TC).

- The two approaches are used to determine the break even points (BEP) are::

1. **Graphical Method Or Graphics Analysis**
2. **Equations Method Or Algebraic Analysis**

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Equation method

Let S = unit selling price

V = unit variable costs

Q = total units sold [produced] F = total fixed cost

At the BEP TR=TC

TR = SQ.....1

TC = TVC +TFC.....2

Equate equation 1 and 2

SQ = VQ + F SQ-

VQ = F [S-V]Q = F

BEP IN UNITS $Q = \frac{F}{(S-V)} = \frac{TOTAL.FIXED.COSTS}{UNIT.CONTRIBUTION.MARGIN}$ **.....**

Equation 3

S-V represents contribution margin per unit or unit contribution margin

BEP in sales value = BEP in units * unit selling price
.....equation 4

Alternatively

BEP in sales value = $\frac{TOTALFIXEDCOSTS}{CONTRIBUTIONMARGINRATIO[CMR]}$ **.....**

equation 5

Contribution margin ratio [CMR] is also called profit volume ratio [P/V ratio] or contribution sales ratio [C/S ratio]

Contribution margin ratio [CMR] $= \frac{(S - V)}{S} = \frac{(UNIT.CONTIBUTION)}{UNIT.SELLING.PRICE}$

...equation 6

Or

CMR $= \frac{(SQ - VQ)}{SQ} = \frac{(TR - TVC)}{TR}$

$= \frac{(Total.contribution)}{TR}$ **.....equation 6**

BEP in sales value = $\frac{(TFC)}{(C/S..ratio)}$ ..... same as equation 5

Where c/s ratio = Total contribution ..... Equation 6
Total sales

BEP in sales value $= \frac{TFC*.UNIT.SELLING.PRICE}{CONTRIBUTION.MARGIN.PER.UNIT}$ ***.....***

Equation 7

Margin of safety

- The margin of safety indicates by how sales may decrease before a company starts incurring losses.Margin of safety is the amount by which the actual output of sales may fall short of the budget sales value without incurring losses.
- It measures the amount of risk that a company might make a loss if it fails to achieve the target.It is usually expressed as a percentage of the budgeted sales value.

A high margin of safety implies a high profit expectation even if the budget is not achieved hence the higher margin of safety the better for the company.

$$\textbf{MOS} = \left[\frac{(Expeceted.sales - BEP.sales)}{Expected.sale}\right] * 100\% \quad \textbf{..... Equation 8}$$

(Lucey. T 2003; Strathmore 1992; Garrison R.H & Norren E.W. 2000)

4.2.1 TARGETED PROFIT:

Let **X**: Number of units to be sold/produced so as to earn the target profit

Y: be target profit before tax. **Z:** be the target profit

after tax. **T:** be the corporate tax rate

M: Sales value required to achieve the profit target.

4.2.1.1 TARGETED PROFIT BEFORE TAX

$$\textbf{Number of units [X]} = \left|\frac{TFC + Y}{S - V}\right| \textbf{..... .....Equation 9}$$

$$\textbf{Sales value [M]} = \left|\frac{TFC + Y}{CMR}\right| \textbf{..... Equation 10}$$

$$\textbf{Contribution margin ratio [CMR]} = \frac{(S - V)}{S} = \frac{(UNIT.CONTIBUTION)}{UNIT.SELLING.PRICE}$$

4.2.1.2 TARGETED PROFIT AFTER TAX:

$$\textbf{Number of units [X]} = \frac{(TFC) + \left(\frac{Z}{1-T}\right)}{|S - V|} \quad \textbf{..... .....Equation 11}$$

$$\textbf{Sales value [M]} = \frac{(TFC)+\left(\frac{Z}{1-T}\right)}{[CMR]} \quad \textbf{..... Equation 12}$$

CVP Analysis For Multiple Products Certainty Environment

We can now extend the CVP analysis for a single product to handle more realistic situations where a firm produce and sale more than one product. The main objective of the company is to produce a mixture that maximizes total contribution.

4.2.2 Equations for a multiple products CVP Analysis

Total BEP in units (x)

$$\textbf{x=} \frac{TFC}{Average.Contribution..M\arg in(ACM)} \textbf{.....equation 13}$$

$$\text{ACM} = \sum_{T\ 1}^{N} \propto_t [S_t - V_t] \quad \text{.....}$$

.....equation 14

=

Where

T: = product under consideration
N; = total number of products
$\propto_t$ =Sales mix ratio in units for product t St= Unit selling price for product t
Vt = Unit variable cost for product t

Total BEP in sales value (m)

$$\textbf{M =} \frac{TFC}{Contribution.M\arg in.Ratio(CMR)} \textbf{ .. ..equation 15}$$

$$\textbf{CMR =} \frac{(TR-TVC)}{TR}$$

$$\textbf{CMR =} \frac{(Total.Contribution)}{Total.\text{Re}\,venue} \textbf{.....equation 16}$$

Alternatively:

$$\textbf{Overall contribution margin ration} = \frac{\sum_{i=1}^{n}\left[Q_i\left(S_i - V_i\right)\right]}{\sum_{i=1}^{n} S_i Q_i} = \frac{(TR - TVC)}{TR}$$

..Equation17

Where:
n= number of different products
Q_i= estimated sales volume for the i^{th} product
S_i= unit selling price for the i^{th} product
V_i= unit variable cost for the i^{th} product

4.2.3 Targeted Profit For Multiple Products:

Let **X**: Number of units to be sold/produced so as to earn the target profit

Y: be target profit before tax. **Z:** be the target profit

after tax. **T:** be the corporate tax rate

M: Sales value required to achieve the profit target.

4.2.3.1 TARGETED PROFIT BEFORE TAX

$$\textbf{Number of units [X]} = \frac{TFC + Y}{ACM} \quad \textbf{.....equation 18}$$

$$\textbf{Sales value [M]} = \frac{TFC + Y}{CMR} \quad \textbf{.....equation 19}$$

4.2.3.2 TARGETED PROFIT AFTER TAX:

Number of units (x)

$$X = \frac{(TFC) + \left(\frac{Z}{1-T}\right)}{[ACM]} \quad \text{.....equation 20}$$

Sales value [M]

$$[M] = \frac{(TFC) + \left(\frac{Z}{1\_T}\right)}{|CMR|} \quad \text{.....equation 21}$$

8 The multi-product profit-volume graph – Step-by-step

In a multi-product environment, two lines must be shown on the profit-volume graph:
1 One straight line, where a constant mix between the products is assumed.
2 One bow shaped line, to see how the individual products contribute to profit rather than as a constant mix. It is assumed that the company sells its most profitable product first and then its next most profitable product, and so on.

Step 1: Calculate the C/S ratio of each product being sold, and rank the products in order of profitability (in other words, products are ranked in decreasing order based on the size of their C/S ratio with the highest C/S ratio product ranked first).

Step 2: Draw the graph, showing cumulative sales on the x-axis. The products are shown individually on a graph from left to right, in order of the size of their C/S ratio (and therefore based on the Step 1 ranking above). For example, if we assume 3 products X, Y and Z, then the following graph could be drawn, with 'V' representing the total sales. At an output of 0, the profit earned will amount to the company's fixed costs, represented by point k on the chart.

Step 3: Draw the line km, that represents the profit earned by product X – the slope of the line is determined by the contribution per unit earned on sales of that product.

Step 4: Draw the line mn, that represents the profit earned by product y, which has a lower contribution per unit than product X. The line nj is the profit earned by the least profitable product, product Z.

Step 5: Draw the line joining points k and j: it reflects the average profitability of the three products, and each point on that line represents the profit earned for the associated output, assuming that the three products are sold in the standard product mix, i.e. the mix implied in the construction of the chart. Accordingly, the indicated breakeven point only applies if the products are sold in the standard product mix.
It can also be seen that breakeven can also occur at lower levels of output, provided the proportions of the products are changed. For example, the point B where the line kmnj crosses the horizontal axis indicates a possible breakeven point.

Plotting products individually may present the following benefits in a decision making process:

- In order to improve overall profitability, it may be worth considering an increase in the sales of the product with the highest C/S ratio, even if it means as decrease in the least profitable product.
- It helps managers decide which products should be continued or abandoned.
- It also helps management focus on the price of products and whether some prices should be raised in order to improve the individual product's C/S ratio.
- Last, it clarifies what changes in selling prices and sales volumes will have on breakeven points and profits.

BJS Ltd produces and sells the following three products:
Product

	X	Y	Z
	Shs.	Shs.	Shs.
Selling price per unit	16	20	10
Variable cost per unit	5	15	7
Contribution per unit	11	5	3
Budgeted sales volume	50,000	10,000	100,000

The company expects the fixed costs to be shs. 450,000 for the coming year. Assume that sales arise throughout the year in a constant mix.
Required:

a. Calculate the weighted average C/S ratio for the products.
b. Calculate the break-even sales revenue required.
c. Calculate the margin of safety required.
d. Calculate the revenue required to achieve a target profit of shs. 900,000.
e. Draw a multi-product profit-volume chart assuming the budget is achieved.

A SINGLE PRODUCT CVP ANALYSIS UNDER THE ENVIRONMENT OF UNCERTAINTY.

The major limitation of the basic CVP analysis is the assumption that unit variable costs, unit sales price and Fixed Cost are constant and can be predicted with certainty. These factors however, are variable with expected values and Standard deviation that can only be estimated by the management (Lucey. T 2003; Strathmore 1992; Garrison R.H & Norren E.W. 2000)

There are various ways of dealing in uncertainty: These are:

1. Sensitivity Analysis (what if)
2. The point estimate of probability
3. Continuous probability distribution e.g. normal distribution
4. Margin of safety
5. Simulation Analysis **(Lucey. T 2003; Strathmore 1992; Garrison R.H & Norren E.W. 2000)**

Simulation Analysis

- Look at possible situation which might occur
- Best where all other methods fail (analytical technique e.g. CVP fails)
- Use random numbers to simulate
- Using your own example demonstrate how simulation can be used in CVP analysis (Lucey. T 2003; Strathmore 1992; Garrison R.H & Norren E.W. 2000).

Point estimate of probability (PEOP)

The approach requires a number of different values of each of the uncertain variable to be selected. Usually three values are selected. These are:

1. Worst possible outcome (WP)
2. Most likely outcome (ML)
3. Best possible outcome (BP)

For each of these 3 values, probability of occurrence is then estimated (Lucey. T 2003; Strathmore 1992; Garrison R.H & Norren E.W. 2000; Drury 2004).

Illustration

Assume that the management accountant of a company which make and sales products x has made following estimates

Sales demand

Condition	units	Probability
Worst possible [WP]	45,000	0.3
Most likely [ML]	50,000	0.6
Best possible [BP]	55,000	0.1

Unit Variable costs

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		Cash	Probability
Best possible	[BP]	Shs. 3.5	0.3
Most likely	[ML]	Shs.4.0	0.55
Worst possible	[WP]	Shs. 5.5	0.15

Fixed costs are estimated at Shs. 240,000 and the sales price Shs.10 per unit

Required:

a) Determine the expected profit

b) Compute the probability that the company was fail to break even.

c) If the company has a budgeted profit level of Shs. 60 000, what is the probability that the company will not achieve this target.

d) Coefficient of variation for the profits

Solution:

Profit [P] = (S-V) Q – F

E [P] = (S-E [V])*E [Q] – F

E (Q) = 45 000(0.3) + 50 000 (0.6) + 55 000(0.1) = 49 000(units)

E (V) =Shs.3.5(0.30) +Shs. 4 (0.55) +Shs. 5.5 (0.15) = Shs. 4.075

E (P) = [S-E (V)] (Q) – FC

Expected profit E [P] = (10-4.075) 49 000- 240 000 = Shs. 50,325

Alternatively: use a decision tree

	Demand	Probability of demand	VC per unit	Probability of VC	Joint probability	Contribution	profits	Weighted profits
	A	B	C	D	E=B*D	F=[10-C]*A	G=F-240,000	H =E*G
1			3.5	0.3	0.09	292,500	52,500	4,725.0
2	45,000	0.3	4	0.55	0.165	270,000	30,000	4,950.0
3			5.5	0.15	0.045	202,500	(37,500)	(1,687.5)
4								
5			3.5	0.3	0.18	325,000	85,000	15,300.0
6		0.6	4	0.55	0.33			

	50,000					300,000	60,000	19,800.0
7			5.5	0.15	0.09	225,000	(15,000)	(1,350.0)
8								
9			3.5	0.3	0.03	357,500	117,500	3,525.0
10	55,000	0.1	4	0.55	0.055	330,000	90,000	4,950.0
11			5.5	0.15	0.015	247,500	7,500	112.5
12							E[P]	50,325.0

B] Prob [P<0] = 0.045 + 0.09 = 0.135

C] Prob [P<60,000] = 1- (0.180+ 0.03 +0.33 + 0.055) = 0.405

D] Coefficient of variation for the profits [C/V]

$$C/V = \frac{\sigma}{E(P)}$$

.....equation 22

$$\sigma = \sqrt{\sum_{t=1}^{n}\left[P_t - E(P)\right]^2 P_t}$$

.....**.....equation 23**

Where:

- Standard deviation of profits.

P_t – profits

E(P) – expected profits

P_t – probabilities of occurrence T = condition

	Joint probability	**Profits**	**weighted profits**	**Deviations**	**Deviations squared**	**Deviations squared * probability**
	E	**G**	**H**	**G-50,325**	**I= G^2**	**J =E*I**
1	0.09					

		52,500	4,725.0	2,175.0	4,730,625.0	425,756.25
2	0.165	30,000	4,950.0	(20,325.0)	413,105,625.0	68,162,428.13
3	0.045	(37,500)	(1,687.5)	(87,825.0)	7,713,230,625.0	347,095,378.13
4				-	-	-
5	0.18	85,000	15,300.0	34,675.0	1,202,355,625.0	216,424,012.50
6	0.33	60,000	19,800.0	9,675.0	93,605,625.0	30,889,856.25
7	0.09	(15,000)	(1,350.0)	(65,325.0)	4,267,355,625.0	384,062,006.25
8						
9	0.03	117,500	3,525.0	67,175.0	4,512,480,625.0	135,374,418.75
10	0.055	90,000	4,950.0	39,675.0	1,574,105,625.0	86,575,809.38
11	0.015	7,500	112.5	(42,825.0)	1,833,980,625.0	27,509,709.38
12		E[P]	50,325.0		variance	1,296,519,375.00
					Std dev	36,007.21

$$C/V = \frac{\sigma}{E(P)} = \frac{36{,}007.21}{50{,}325} = 0.72$$

Margin of Safety

The **margin of safety** is the excess of expected sales over breakeven sales. The margin of safety is, therefore, the amount sales can decrease before the company incurs an operating loss. It is the ***cushion*** between profit and loss.

Managers use the margin of safety to evaluate the risk of both their current operations and their plans for the future. Let's apply the margin of safety to our fictitious company.

From the example we used to discuss sensitivity analysis, recall that Smart Touch Learning's original breakeven point was **54 tablets**. Suppose the company expects to sell 100 tablets. The margin of safety can be expressed in units, in dollars, or as a ratio (Horngren 2014)

The margin of safety is:

Expected sales - Breakeven sales = Margin **of safety in units**

100 tablets - 54 tablets = 46 tablets

Margin of safety in units * Sales price per unit = Margin of safety in dollars

46 tablets × Shs.500 per tablet = Shs.23,000

Margin of safety in units / Expected sales in units = Margin of safety ratio

46 tablets / 100 tablets = 46% Or

Margin of safety ratio

$$= \frac{Expected\ sales - Breakeven\ sale}{Expected\ sales} = \frac{100 - 54}{100} * 100\% = 46\%$$

Sales can drop by 46 tablets, or Shs.23,000, before Smart Touch Learning incurs a loss. This margin of safety is 46% of total expected sales. In other words, the company can lose almost half of its business before incurring an operating loss. That is a comfortable margin of safety. Both margin of safety and target profit use CVP analysis, but from different perspectives. Margin of safety focuses on the sales part of the equation—that is, how many sales dollars the company is generating

above breakeven sales dollars. Conversely, target profit focuses on how much operating income is left over from sales revenue after covering all variable and fixed costs (Horngren 2014).

Environment of fundamental uncertainty

- Uncertainty events are those events whose nature cannot be predicted with statistical confidence. Variables are neither known nor can probabilities be assigned to the likely occurrence of the variables. Decision Making Process depends on the risk attitude of the decision maker. Decision makers can either be: Risk averse, Risk neutral or Risk seeker (taker)
- **Risk averse:** This is a decision maker who acts on the assumption that the worst outcome will occur and thus chooses an alternative with the least risk possible.
- **Risk neutral:** This is a decision maker who is not concerned with risk at all and therefore makes decision based on other factors other than risk.
- **Risk seeker (taker):** This is a decision maker who is interested on the best possible outcome no matter how small the chances are that the outcome will occur. The person takes as much risk as possible with the prime intention of achieving maximum returns
- For example try to maximize the minimum return [use **maximin** criteria] where one anticipates minimum returns. If the risk attitude is to achieve maximum return then maximize the maximum return [**maximax c**riteria].
  - The following techniques are used to make decisions;

a. Maximax decision rule
b. Maximin decision rule
c. Laplace criterion of rationality
d. Minimax regret decision rule (Drury 2004; Strathmore 1992).

Illustration one:

ABC ltd is trying to set the selling price for one of its product. Three prices are under consideration-; Price per unit sh4, Sh.4.30 &
Sh.4.40

	Expected sales volume(in unit)		
States of nature	**Ksh 4**	**Ksh 4.30**	**Ksh 4.40**
Best possible	16,000 units	14,000units	12,500 units
Most likely	14,000 units	12,500 units	12,000 units
Worst possible	10,000 units	8,000 units	6,000 units

Assume that Fixed costs amounts Sh.20, 000 and unit variable cost at Sh.2.00.

Required: Advice the company on the price to set under:

a. Maximax decision rule
b. Maximin decision rule
c. Laplace criterion of rationality
d. Minimax regret decision rule.

Solution

A question of this nature, you are advised to first compute the payoffs. In this case the payoffs are the amount of profits for each alternative under the three states of nature (see table 2.1 below). The decision maker has control over the selling prices (alternatives) but not the outcomes (states of nature)

Profit =total revenues less total costs

Profit =(S-V) Q-F

Where; S = unit selling price

V= unit VC

Q = number of units

F = TFC

I will point out that the first step is to prepare the pay off matrix table.

See table 1.1 below:

Table 1.1 Payoff matrix

	Alternatives or actions

States nature of	**Ksh 4.00**	**Sh.4.30**	**Sh.4.40**
Best possible	Sh. 12,000	Sh.12,200	Sh. 10,000
Most likely	8,000	8,750	8,800
Worst possible	0	(1,6000)	(5,600)
Maximum	12,000	12,200	10,000

Hint I.e. Pay off Sh4 per unit under best possible is = [4-2]16000-20000= Sh, 12,000

I] Maximax decision rule

- This criterion looks at the best possible result and therefore chooses the maximum payoff of each alternative and then the decision is to select the maximum of the maximums.
- This criterion appeals to risk taker or those who are ready to undertake huge losses if they were to occur.

Steps to follow:

a. Compute the pay offs for each alternative [see table 1.1 above].

b. For each alternative, select the highest pay off

c. Select an alternative with the highest pay off [highest of the maximums] in step (b) and thus the decision. See the working on table 1.2 below

Table 1.2: Maximax rule

	Alternatives or actions		
States of nature	**Ksh 4.00**	**Sh.4.30**	**Sh.4.40**
Best possible	Sh.12,000	Sh.12,200	Sh.10,000
Most likely	8,000	8,750	8,800
Worst possible	0	(1,600)	(5,600)
Step [b] Maximum	12,000	12,200	10,000
Step [C]		12,200	

- Therefore, the decision is to set a price of sh 4.30 per unit because it maximizes the maximum payoffs.
- The limitation of this approach is that the method is very optimistic.

II] Maximin decision rule

- The decision maker looks at the worst possible outcome for each alternative, and then chooses an alternative that offers the **least and attractive worst outcome**. This is an alternative that maximizes the minimum pay-off.
- This Criteria appeals to risk averse decision maker since it is a criterion of extreme caution or pessimistic.
- Can also be applied by companies which can not be able to take huge losses if they were to occur.

Steps to follow:

(a) Compute the pay offs for each alternative [refer to table 1.1 from the above]

(b) For each alternative (price), select the lowest payoff.

(c) Select an alternative with the highest pay-off of the minimums identified in step (b) and thus the decision.

Table 1.3: Maximin rule

	Alternatives or actions		
States of nature	**Ksh 4.00**	**Sh.4.30**	**Sh.4.40**
Best possible	Sh.12,000	Sh.12,200	Sh.10,000
Most likely	8,000	8,750	8,800
Worst possible	0	(1,600)	(5,600)
Step [b] Minimum	**0**	(1,600)	(5,600)
Step [c]	**0**		

- The decision therefore is to set a price of **sh4** per unit since it maximizes the minimum payoffs.
- The criterion is very cautious and over conservatism.

III] Laplace criterion of rationality

- It holds that if decision makers do not know the probability of various state of nature and have no reason to think otherwise, then the state of nature should be considered to be equally likely(having equal chances).
- On the bases of this the expected monetary value should be computed for each alternative and the alternative with the highest expected monetary value (EMV) should be decision.

Steps to follow:

(a) Compute the pay offs for each alternative [see table 1.1 above]

(b) Assign equal probabilities to each state of nature.

(c) For each alternative, calculate EMV. See equation 1 below.

(d) Select an alternative with the highest EMV computed in step (c) and thus the decision (Drury 2004; Strathmore 1992).

Table 1.4: Laplace decision rule

	Step [b]	**Alternatives**		
States of nature	**Probability**	**Ksh 4.00**	**Sh.4.30**	**Sh.4.40**
Best possible	1/3	Sh.12,000	Sh.12,200	Sh.10,000
Most likely	1/3	8,000	8,750	8,800
Worst possible	1/3	0	(1,600)	(5,600)
EMV- **step [c]**		**6,667**	6,450	4,400
Step [d]		**6,667**		

$$EMV = \sum_{t=1}^{n} [(MV_t)(P_t)] \quad \text{.....equation 1}$$

Where:

MV- this is the momentary value under condition t.

Pt –this is the probability of condition **t** occurring. n- This is the total number of conditions.

Workings for table 1.4 above

Selling price of Sh 4

EMV = 12000(1/3) + 800(1/3) + 0(1/3) = 6667

Selling price of Sh4.3

EMV = 12200(1/3) +8750(1/3) + -1600(1/3) =6450

Selling price of Sh 4.4

EMV = 10000(1/3) +8800(1/3) -5600(1/3) =4400

- Decision is to set a price of **ksh 4** since it has the highest EMV

IV] Minimax regret criterion

- This method seeks to minimize the maximum regret that would occur from picking a particular alternative.
- The regret is the opportunity lost from taking one decision given that a certain contingency occurs.
- **Steps to follow:**

(a) Compute the pay offs for each alternative [refer to **table 1.1**].

(b) Compute opportunity losses [Prepare an opportunity loss matrix] i.e. maximum pay-off for each outcome less the pay off under consideration in the same outcome. See table 2.5 below.

(c) For each alternative (price), select the largest opportunity loss.

(d) Select an alternative with the lowest/least opportunity loss in step (c) and thus the decision

Table 1.5 An opportunity loss matrix (step b)

		Alternatives -Prices per unit		
States of nature	**Highest pay off**	**Ksh 4.00**	**Sh.4.30**	**Sh.4.40**
Best possible	Sh 12,200	Sh.200	Sh.0	Sh.2,200
Most likely	8,800	800	50	0
Worst possible	0	0	1,600	5,600
Step **[c]** Maximum O.L		**800**	1,600	5,600
Step **d**		**800**		

For
- example: Opportunity loss [Ksh.4- BP] = Ksh 12,200-12,000 =200
  Decision is to set a price of **Sh. 4 per unit** because it minimizes the maximum
- opportunity losses (Drury 2004; Strathmore 1992)

The Environment of Risk

- Risk involves situations or events which may or may not occur but whose probabilities of occurrence can be calculated statistically and the frequency of their occurrence predicted from past records.
- Probability distribution is used to predict future outcomes i.e. use of expected monetary values, standard deviations, coefficient of variation and expected opportunity loss techniques.
- In the environment of risk decisions are made using either:

i) Expected monetary values [EMV] ii) Standard deviations $[\sigma]$

iii) Coefficient of variations or σ / EMV

iv) Expected opportunity loss (EOL)

NB. EMV and EOL techniques give the same result. The criteria which maximizes EMV also minimizes EOL

Illustration two:

ABC ltd is trying to set the selling price for one of its product. Three prices are under

consideration-; Price per unit sh4, Sh.4.30 & Sh.4.40

States of nature	Probabilities	Expected sales volume(in unit)		
		Ksh 4	**Ksh 4.30**	**Ksh 4.40**
Best possible	0.2	16,000 units	14,000units	12,500 units
Most likely	0.6	14,000 units	12,500 units	12,000 units
Worst possible	0.2	10,000 units	8,000 units	6,000 units

Fixed costs amounts to Sh.20, 000; unit variable cost Sh.2.00.

Required: Advice the company on the price to set under

1. **Expected monetary values [EMV]**
2. **Standard deviations** $[\sigma]$
3. **Coefficient of variations** EMV σ
4. **Expected opportunity Loss (EOL)**

Note that the illustration is similar to illustration one except probabilities of occurrences have been included. It's advisable to reflect on how to compute the payoffs. Hint refer to table 1.1

I] Expected Monetary Value [EMV]

Expected monetary values should be computed for each alternative and the alternative with the highest expected monetary value (EMV) should be the decision.

$$EMV = \sum_{t=1}^{n} [(MV_t)(P_t)] \quad \text{..... equation 1}$$

Where:

MV- this is the momentary value under condition t.

Pt –this is the probability of condition t occurring.

n- This is the total number of conditions.

Steps to follow:

(a) Compute the pay offs for each alternative [refer to table 1.1 above] **(b)** For each alternative, calculate EMV.

(c) Select an alternative with the highest EMV computed in step (b) above and thus the decision

Table 1.6 Expected Monetary Value [EMV] rule – step b)

		Alternatives [actions]		
States of nature	**Probabilities**	**Ksh 4.00**	**Sh.4.30**	**Sh.4.40**
Best possible	0.2	Sh.12,000	Sh.12,200	Sh.10,000
Most likely	0.6	8,000	8,750	8,800
Worst	0.2	0	(1,600)	(5,600)
possible				
Step [b] EMV		7,200	**7,370**	6160
Step [c]			**7,370**	

Hint I.e. EMV= 0.2(12,000) + 0.6(8,000) + 0.2(0) = 7,200

- The decision is to set a price of Ksh.4.30 since it maximizes the EMV (Drury 2004; Strathmore 1992).

II] Standard Deviation

Standard deviation is used to measure the amount of risk i.e. the higher the standard deviation, the higher the amount of risk.

$$\sigma = \sqrt{\sum_{t\ 1}^{n}\left[C_t - E(C)\right]^2\left[P_t\right]} \quad \text{..... Equation 2}$$

Where:

C_t = is the monetary value [pay off] under condition t E (C) = is EMV for each alternative.

P_t = probability under condition t.

Steps to follow:

(a) Compute the pay-offs for each alternative [refer to table 1.1 above]

(b) For each alternative, calculate the EMV [refer to table 1.6 above] **(c)** For each alternative, calculate the standard deviation. Refer to table 1.7 below.

(d) Select an alternative with the lowest standard deviation in step (c) above and thus the decision

Table 1.7 Standard deviation [Step [c]

		Alternatives [actions]		
States of nature	**Probabilities**	**Ksh 4.00**	**Sh.4.30**	**Sh.4.40**
Best possible	0.2	Sh.12,000	Sh.12,200	Sh.10,000
Most likely	0.6	8,000	8,750	8,800
Worst possible	0.2	0	(1,600)	(5,600)
Step [b] EMV		**7,200**	7,300	6,160
Step[C] Std deviations$[\sigma]$		**3,919**	4,680	5,898
Step [d]		**3,919**		

- The decision is to set a price of Ksh.4 since it minimizes the standard deviation [risk]

Workings for table 1.7 above:

σ_4 = [(12000 – 7200)^2 *0.2 + (8000 – 7200)^{2*} 0.6 + (0 - 7200])^{2*}0.2]] ^{½} =3919

$[\sigma_{4.3}]$= [(12200 – 7370) ^{2*}0.2 + (8750 – 7370) ^{2*}0.6 + (-1600 – 7370) ^{2*}0.2] ^{½} = 4680

$[\sigma_{4.4}]$= [(10000 – 6160) ^{2}* 0.2 + (8800 – 6160) ^{2}* 0.6 + (-5600 - 6160]) ^{2}*0.2]] ^{½} = 5898

III] Coefficient Of Variation (C/V)

- Coefficient of variation [C/V] measures the amount of risk relative to expected returns
  - Alternatives are normally compared at C/V.
  - The higher the C/V, the higher the amount of risk relative to expected returns.
- Usually, managers are (prefer) risk averse – so as to safeguard their job. However the owners are risk takers i.e. want to maximize their returns.

Steps to follow:

Compute the payoffs for each alternative [refer to table 1.1 above]

(a) For each alternative, calculate the EMV. [refer to table 1.6 above]

(b) For each alternative, calculate the standard deviations. [refer to table 1.7 above]

(c) For each alternative, compute coefficient of variation. [refer to table 1.8 below]

(d) Select an alternative with the lowest coefficient of variation step (d) above and thus the decision (Drury 2004; Strathmore 1992)

Table 1.8: coefficient of variation [step d]

		Alternatives [actions]		
States of nature	**Probabilities**	**Ksh 4.00**	**Sh.4.30**	**Sh.4.40**
Best possible	0.2	Sh.12,000	Sh.12,200	Sh.10,000
Most likely	0.6	8,000	8,750	8,800

Worst possible	0.2	0	(1,600)	(5,600)
EMV- step (b)		7,200	7,370	6,160
Standard deviations$[\sigma]$- step c		3,919	4,680	5,898
C/V = σ /EMV – step d		0.5	0.64	0.96
Step e		**0.5**		

- The decision is to set a price of Ksh.4 since it minimizes the coefficient of variation ie 0.5.

IV] Expected Opportunity Loss (EOL)

- This method seeks to minimize the expected maximum regret that would occur from picking a particular alternative.
- The regret is the opportunity lost from taking one decision given that a certain contingency occurs.

Steps to follow:

(a) Compute the payoffs for each alternative [refer to table 1.1 above].

(b) Compute opportunity losses [Prepare an opportunity loss matrix] i.e. maximum pay off for each outcome less the pay off under consideration in the same outcome. Refer to table 1**.5** above

(c) For each alternative, compute the EOL. Refer to table 2.9 below.

(d) Select an alternative with the lowest/least expected opportunity loss [EOL] in step (c) and thus the decision (Drury 2004; Strathmore 1992)

Refer to table 1.1 from our earlier workings. Reproduced below

Table 1.1 Payoff matrix – Step a

	Alternatives or actions

States of nature	**Ksh 4.00**	**Sh.4.30**	**Sh.4.40**
Best possible	Sh. 12,000	Sh.12,200	Sh. 10,000
Most likely	8,000	8,750	8,800
Worst possible	0	(1,6000)	(5,600)
Maximum	12,000	12,200	10,000

Hint I.e. Pay off Sh4 per unit under best possible is = [4-2]1600020000= Sh, 12,000

Table 1.9: Expected opportunity loss matrix [step c]

		Probabilities	**Alternatives -Prices per unit**		
States of nature	**Highest pay off**		**Ksh 4.00**	**Sh.4.30**	**Sh.4.40**
Best possible	Sh 12,200	0.2	Sh.200	Sh.0	Sh.2,200
Most likely	8,800	0.6	800	50	0
Worst possible	0	0.2	0	1,600	5,600
Step [c] EOL			520	350	1,560
Minimum EOL				**350**	

Hints:

- For example: Opportunity loss [price of Ksh.4 under the best possible (BP) = Ksh 12,200-12,000 =200, Opportunity loss [price of Ksh.4 under the most likely (ML) = Ksh 8,800-8,000 = 800
- EOL under the price of Ksh 4 is 0.2*200+ 0.6*800 + 0.2*0 = Ksh 520
- Decision is to set a price of Sh. 4.30 because it minimizes the expected opportunity losses.

1.4 Multi-Stage Decision Making

For a multistage decision making, we use decision trees. **A decision tree** can be defined as

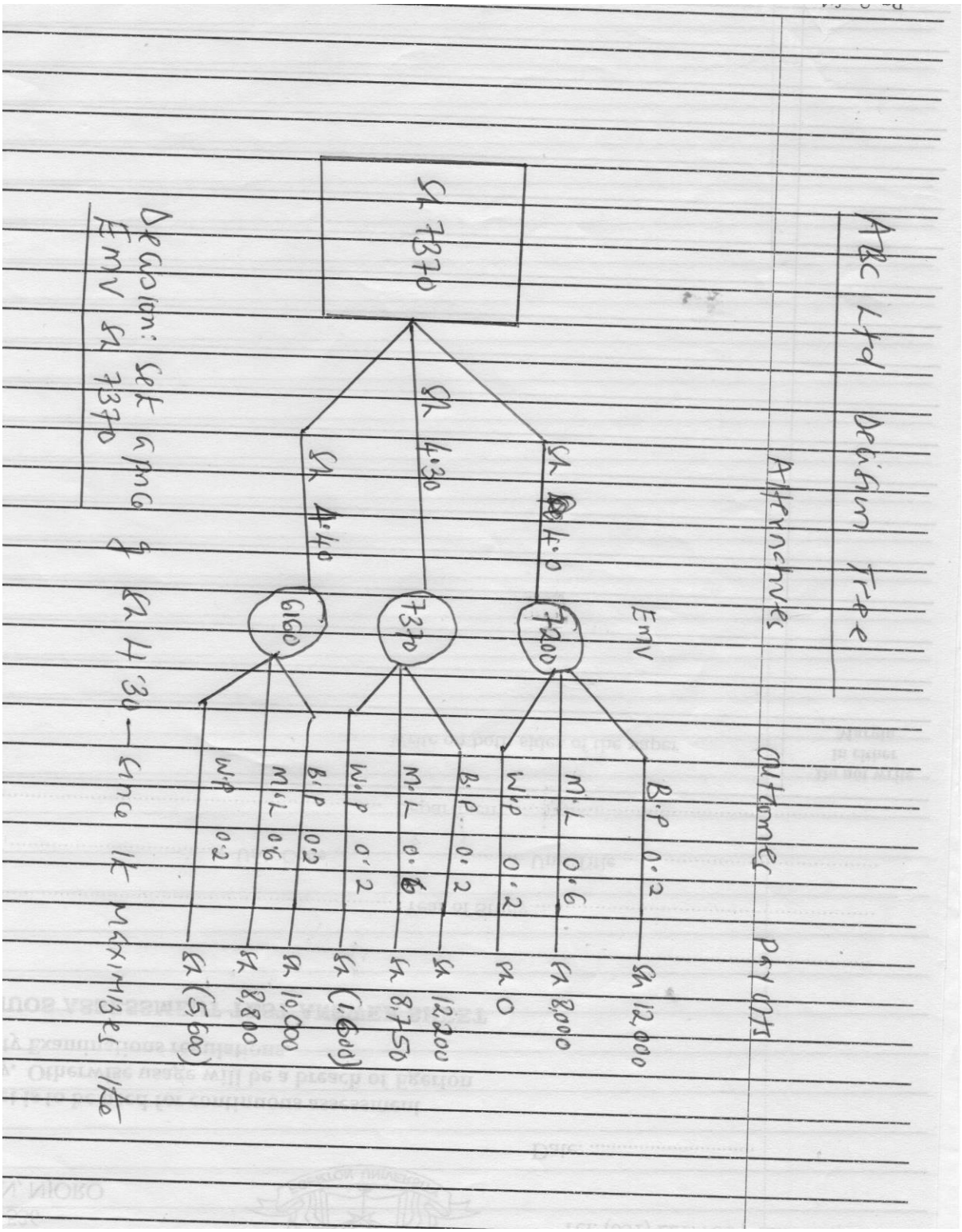
a graphic representation of the decision making process [DMP] indicating the decision alternatives, states of nature, associated probabilities and conditional payoffs for each combination of decision alternatives and their states of nature. It shows all the possible choices that can be made as braches on the tree (Drury 2004;
Strathmore 1992)

Illustration

Considering illustration two above of ABC pricing decision and using a decision tree advice the company on the best price to set (best alternative)

ABC ltd decision tree is presented below

TOPIC 3 PLANNING AND DECSION MAKING TECHNIQUES



valuation of Perfect and Imperfect Information

- The uncertainty about the future of taking a decision can sometimes be reduced by obtaining more information about what is likely to occur. Such information can be obtained from various sources like market research surveys, conducting a pilot test, building a pro-type of the model etc. Information can be categorized depending on how reliable it is likely to predict what is likely to happen in the future and thereby helping managers make better decisions.
- Therefore, **perfect information** is one that is guaranteed to predict the future with 100% accuracy while imperfect information is one which, although it might be quite good and better than having no information at all, it would be wrong in its prediction of the future.
- Both perfect and imperfect information is costly and therefore their value must be determined.

1.5.1 Value Of Perfect Information (VPI)

Value of $\left[\right.$ PI =EMV with PI – EMV without PI $\left.\right]$

Illustration

Consider ABC pricing decision given early (illustration two above), it is possible to obtain ideal information about the future market at a fee of sh500. Determine whether the **perfect information** [PI] would be acquired

Steps to follow in computing EMV with perfect information:

(a) Compute the payoffs for each alternative. Refer to table 1.1 above.

(b) For each state of nature, multiply the highest pay off with their probability of occurrences. Refer to the last column of table 1.10. **(c)** Take the summation of step (b) above and thus the EMV with perfect information.ie Ksh 7,720. See workings below

Table 1.10: EMV with perfect information

		Alternatives [actions]			**Total**

States of nature	Prob	Ksh 4.00	Sh.4.30	Sh.4.40	
Best possible	0.2		Sh.12,200		**Sh 2,440**
Most likely	0.6			8,800	5,280
Worst possible	0.2	0			0
EMV with PI					Ksh 7,720

Workings for table 1.10 above

Best possible 0.2 * 12,200 = 2,440

Most likely 0.6 * 8,800 = 5,280

Worst possible 0.2 * 0 = 0

EMV with PI = highest pay off for B.P *Probability + highest pay of for M.L*probability + highest pay of for W.P* probability

EMV with PI =12200(0.2) + 8800 (0.6) + (0)0.2

EMV with PI = Ksh 7720

Steps to follow in computing EMV without perfect information:

1. Compute the pay offs for each alternative. Recall from the previous workings on table 1.1.
2. For each alternative, calculate EMV. Recall this from the previous workings on table 1.6 above.
3. Select the highest EMV computed in step (2) above and thus EMV without perfect information. See the workings of table 1.11 below.

Table 1.11: EMV without perfect information

		Alternatives [actions]		
States of nature	**Probabilities**	**Ksh 4.00**	**Sh.4.30**	**Sh.4.40**
Best possible	0.2	Sh.12,000	Sh.12,200	Sh.10,000

Most likely	0.6	8,000	8,750	8,800
Worst possible	0.2	0	(1,600)	(5,600)
Step [2] EMV		7,200	7,370	6,160
Step [3] EMV without PI				KSH 7,370

Therefore, EMV without perfect information = 7370 (remember from our earlier discussion - this was the highest EMV under the expected monetary value criteria)

Value of PI = 7720-7370

VPI =Ksh 350

- Since cost of acquiring perfect information [i.e. Ksh 500] exceed the value of perfect information then, the company should not acquire ideal information.
- NB: [value of PI = EOL] (Drury 2004; Strathmore 1992)

PRACTICE QUESTION WITH ANSWER

kepa ltd an agro-vet that specializes in selling a particular pesticide to farmers in Narok county for Sh 2,000 per litre. The company buys the pesticide for Sh.1,600 per litre. The techniques used in making decisions keep changing every year and therefore litres unsold at the end of a year become outdated thus disposed off for Sh.1,000 per litre. From the management past experience, it's estimated that the annual demand for this pesticide is between 221 and 224 litres.

Use each of rules below in turn; decide how many litres the company should order under:

(a) Maximax pay off rule. **[5 marks]**

(b) Maximin payoff rule. **[4marks]**

(c) Minimax opportunity loss rule. [**4 marks]**

(d) Laplace decision rule. **[5 marks]**

(e) Expected opportunity loss rule assuming the outcomes are equally likely. **[4 marks]**

TOPIC 3 PLANNING AND DECSION MAKING TECHNIQUES

TOPIC 3 PLANNING AND DECSION MAKING TECHNIQUES

Learning activities

QUESTION ONE –ASSIGNMENT FOR MARKING

a) using an appropriate illustration, demonstrate a multiple product CVP analysis under the environment of uncertainty **[20 Marks]**

b) Discuss the limitation of the CVP model – hint criticize the assumptions **[10 Marks]**

c) How is a multi-product profit chart drawn **[5 marks]**

QUESTION TWO -Practice Question

TOPIC 3 PLANNING AND DECSION MAKING TECHNIQUES

Welabo Oil best Ltd process and sells three products namely: **Diesel, super and paraffin.** The manager who is trying to estimate the company's break-even points for the next month presents you with the following forecast concerning the unit selling prices , sales mix and variable costs per unit for the three products as follows;

Products	**Diesel**	**Super**	**Paraffin**
Variable costs per litre	Sh.1,200	Sh.700	Sh. 1,100
Sales litres	30,000	20,000	10,000
Unit selling price	Sh. 3,000	Sh 1,500	Sh. 2,100

The fixed production costs are budgeted at ksh. 2,500, 000 and the company's fixed selling and administration expenses are forecasted to be Sh.500, 000. The company has an effective tax rate of 12%.

Required:

(a) Determine Welabo Oil best Ltd budgeted net income.

[5 marks]

(b) Determine total break even points in: (i) Litres (ii) shillings
[8 marks]

(c) For each product calculate Break-even points in (i) units (ii) shillings. [8**marks]**

(d) Determine the total sales the manager must make in order to earn a net income of sh.5,000, 000 for the next month.
[4 marks]