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Learning Curve Theory

Question 1

An electronics firm which has developed a new type of fire-alarm system has been asked to quote for a prospective contract. The customer requires separate price quotations for each of the following possible orders:

Order	*Number of fire-alarm systems*
First	*100*
Second	*60*
Third	*40*

The firm estimates the following cost per unit for the first order:

Direct materials	*₹. 500*
Direct labour	
Deptt. A (Highly automatic) 20 hours at ₹. 10 per hour	
Deptt. B (Skilled labour) 40 hours at ₹. 15 per hour	
Variable overheads	*20% of direct labour*
Fixed overheads absorbed:	
Deptt. A	*₹. 8 per hour*
Deptt. B	*₹. 5 per hour*

Determine a price per unit for each of the three orders, assuming the firm uses a mark up of 25% on total costs and allows for an 80% learning curve. Extract from 80% Learning curve table:

X	1.0	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
Y%	100.0	91.7	89.5	87.6	86.1	84.4	83.0	81.5	80.0

X represents the cumulative total volume produced to date expressed as a multiple of the initial order.

Y is the learning curve factor, for a given X value, expressed as a percentage of the cost of the initial order. *(8 Marks) (May, 2005); (11 Marks) (May, 2010)*

Answer

(i) Price per unit for first order of 100 units

	₹	₹
Direct material		500.00
Direct labour	Dept A 20 Hrs @ 10 = 200 Dept B 40 Hrs @ 15 = 600	800.00
Variable Overhead	20% of ₹ 800	160.00
Fixed Overhead	Dept A 20 Hrs @ 8 = 160 Dept B 40 Hrs @ 5 = 200	360.00
Total cost		1,820.00
Profit 25%		455.00
Selling price per unit		2,275.00

(ii) Price per unit for second order of 60 units

Learning will be applicable only in department B.

Cumulative output becomes 100 units + 60 units = 160 units i.e 1.6 times for which learning is 86.1 % from the tables.

Therefore Total Hrs for 160 units = 160 units $\times$ 40 $\times$ .861 = 5,510.4 Hrs

Therefore Hrs for 60 units = Hrs for 160 units less Hrs for 100 units

Or 5510.4 less 40 $\times$ 100 = 1510.4 Hrs

Therefore Hrs per unit = $\frac{1510.4}{60}$ = 25.17

Calculation of selling price per unit

		₹
Direct materials		500.00
Direct labour	Dept A 20 Hrs @ 10 = 200 Dept B 25.17 Hrs @ 15 = 377.55	577.55
Variable Overhead	20% of 577.55	115.51
Fixed Overhead	Dept A 20 Hrs @8= 160 Dept B 25.17 Hrs @5=125.85	285.85
Total cost		1,478.91
Profit 25%		369.73
Selling price per unit		1,848.64

(iii) Price per unit for third order of 40 units

Cumulative output becomes 100 + 60 + 40 = 200 units i.e. 2 times for which learning is 80% from the table

Total Hrs for 200 units = 200 $\times$ 40 $\times$ .80 = 6,400 Hrs

Hrs for 40 units = Hrs for 200 units less Hrs for 160 units

Or 6,400 less 5510.4 = 889.6 Hrs

Therefore Hrs per unit = $\frac{889.6}{40}$ = 22.24

Calculation of selling price per unit

		₹
Direct materials		500.00
Direct labour	Dept A 20 Hrs @ 10 = 200.00 Dept B 22.24 @ 15 = 333.60	533.60
Variable Overhead	20% of 533.60	106.72
Fixed Overhead	Dept A 20 Hrs @ 8 = 160 Dept B 22.24 Hrs @ 5 = 111.20	271.20
Total cost		1,411.52
Profit 25%		352.88
Selling price per unit		1,764.40

Question 2

Explain the concept 'Learning curve'. How can it be applied for Cost management?

(4 Marks) (May, 2006)

Answer

The first time when a new operation is performed, both the workers and the operating procedures are untried. As the operation is repeated and the workers become more familiar with work, labour efficiency increases and the labour cost per unit declines. This process continues for some time and a regular rate of decline in cost per unit can be established. This rate can be used to predict future labour costs. The learning process starts from the point when the first unit comes out of the production line. In other words 'Learning curve' is a function that measures how labour hours per unit decline as units of production increase because workers are learning and becoming better at their jobs.

Cost Management Application:

1. Learning curve is useful in analysing cost volume profit relationship. The company can set low price of its product to generate high demand. As the production increases, cost per unit drops.
2. It helps in budgeting and profit planning.
3. It enables the company in price fixation. In particular, the company can fix a lower price for repeat orders.
4. It helps the design engineers to take suitable decisions based on expected rates of improvement.
5. It helps in price negotiations.
6. It is useful in setting standards and in performance evaluation.

Question 3

Discuss the application of the learning curve. *(4 Marks) (May, 2007)*

Answer

Application of Learning curve: Learning curve helps to analyse cost-volume profit relationships during familiarisation phase of product or process to arrive at cost estimates.

It helps in budgeting and profit planning.

It helps in pricing and consequent decision making – e.g. acceptance of an order, negotiations in establishing contract prices etc. with the advantage of the knowledge of decreasing unit cost.

It helps in setting standards in the learning phase.

Question 4

What are the distinctive features of learning curve theory in manufacturing environment? Explain the learning curve ratio. *(9 Marks) (Nov., 2007)*

Answer

As the production quantity of a given item is doubled, the cost of the item decreases at a fixed rate. This phenomenon is the basic premise on which the theory of learning curve has been formulated. As the quantity produced doubles, the absolute amount of cost increase will be successively smaller but the rate of decrease will remain fixed. It occurs due to the following distinctive features of manufacturing environment:

(i) Better tooling methods are developed and used.

(ii) More productive equipments are designed and used to make the product.

(iii) Design bugs are detected and corrected.

(iv) Engineering changes decrease over time.

(v) Earlier teething problems are overcome.

(vi) Rejections and rework tend to diminish over time.

In the initial stage of a new product or a new process, the learning effect pattern is so regular that the rate of decline established at the outset can be used to predict labour cost well in advance. The effect of experience on cost is summarized in the learning curve ratio or improvement ratio.

$$\text{Learning curve ratio} = \frac{\text{Average labour cost of first 2N units}}{\text{Average labour cost of first N units}}$$

For example, if the average labour cost for the first 500 units is ₹ 25 and the average labour cost for the first 1,000 units is ₹ 20, the learning curve ratio is (₹ 20/25) or 80%. Since the average cost per unit of 1,000 units is ₹ 20, the average cost per unit of first 2,000 units is likely to be 80% of ₹ 20 or ₹ 16.

Question 5

M Ltd. Manufactures a special product purely carried out by manual labour. It has a capacity of 20,000 units. It estimates the following cost structure:

Direct material	*30 ₹/ unit*
Direct labour (1 hour / unit)	*20 ₹/ unit*
Variable overhead	*10 ₹/ unit*

Fixed overheads at maximum capacity is ₹1,50,000.

It is estimated that at the current level of efficiency, each unit requires one hour for the first 5,000 units. Subsequently it is possible to achieve 80% learning rate. The market can absort the first 5,000 units at ₹.100 per unit. What should be the minimum selling price acceptable for an order of 15,000 units for a prospective client? *(7 Marks) (May, 2008)*

Answer

	5,000 units	20,000 units
Material	1,50,000	6,00,000
Direct Labour	1,00,000	2,56,000
		Refer to W Note i
Variable Overhead	50,000	2,00,000
Total Variable Cost	3,00,000	10,56,000
Fixed Cost	1,50,000	1,50,000
Total Cost	4,50,000	12,06,000
Total cost / unit	90	60.3
Sales 100 × 5,000	5,00,000	5,00,000

15,000 × *x(assumed selling price)*		15,000 *x*
(Total Sales less Total Cost) = Profit	50,000	15,000 x – 7,06,000

Or minimum selling price = 50.4(refer to Working Note ii)

Working Note: I

Units	*Hours*
5,000	5,000
10,000	10,000 × 1 × .8 = 8,000 hours
20,000	20,000 × 1 × .8 × .8 = 12,800 hours

Working Note: II

15,000 *x* – 7,06,000 > 50,000

15,000 *x* > 7,56,000

or *x* > 50.4

Alternative Solution:

Total cost / unit of capacity 20,000 = 60.3

Weighted average selling price > 80.4

i.e. $\frac{5,000 \times 100 + 15,000\,x}{20,000}$ > 60.3

= 5,00,000 + 15,000 *x* > 60.3 × 20,000

= 15,000 *x* > 12,06,000 – 5,00,000

Or

15,000 *x* > 7,06,000

x > 47.06

Minimum price to cover production Cost = 47.06

Minimum price to cover same amount of profit = 50.40 (refer to Working Note 1)

Working Note 1

(– 47.06 + 50.04) × 15,000 units = ₹ 50,000

Question 6

A company which has developed a new machine has observed that the time taken to manufacture the first machine is 600 hours. Calculate the time which the company will take to manufacture the second machine if the actual learning curve rate is (i) 80% and (ii) 90%.

Explain which of the two learning rates will show faster learning. *(3 Marks) (Nov., 2008)*

Answer

(i) Actual learning curve rate is 80%.

Time taken to produce the first machine	= 600 hours
Average time taken to produce two machines	= 600 × 80% hours
	= 480 hours.
Cumulative time taken to produce two machines	= 480 × 2 hours
	= 960 hours.
Time taken to produce the second machine	= (960 – 600)hours
	= 360 hours.

(ii) *Actual learning curve rate is 90%.*

Time taken to produce the first machine	= 600 hours
Average time taken to produce two machines	= 600 × 90% hours
	= 540 hours.
Cumulative time taken to produce two machines	= 540 × 2 hours
	= 1080 hours.
Time taken to produce the second machine	= (1080 – 600) hours
	= 480 hours.

The time taken to produce the second machine is lower at 80% learning rate and hence 80% learning rate shows faster learning rate.

Question 7

The Gifts Company makes mementos for offering chief guests and other dignitaries at functions. A customer wants 4 identical pieces of hand-crafted gifts for 4 dignitaries invited to its function.

For this product, the Gifts Company estimates the following costs for the 1st unit of the product

	₹/unit
Direct variable costs (excluding labour)	*2,000*
Direct labour (20 hours @ ₹ 50 hour)	*1,000*

90 % learning curve ratio is applicable and one labourer works for one customer's order.

(i) What is the price per piece to be quoted for this customer if the targeted contribution is ₹ 1,500 per unit?

(ii) If 4 different labourers made the 4 products simultaneously to ensure faster delivery to the customer, can the price at (i) above be quoted? Why? (6 Marks)(Nov., 2009)

Answer

(i) *₹/u*

	1st unit	*Avg/u after 4th at*
Variable Cost	2000	2000
Labour	1000	810
Target Contribution		1500
Price to be quoted		4310 (₹ /u)

(ii) No, the company cannot quote this price for varying products because the learning curve Ratio does not apply to non-repeated jobs. Each product will carry a different price according to its direct labour hours.

Question 8

Explain distinctive features of learning curve theory in manufacturing environment.

(4 Marks)(Nov., 2010)

Answer

The production quantity of a given item doubled the cost of that item decrease at a fixed rate. This phenomenon is the basic premise on which the theory of learning curve has been formulated.

The distinctive features of a learning curve are:

1. Better tooling methods are developed and used
2. More productive equipments are designed and used to make the product.
3. Design bugs are detected and corrected.
4. Better design engineering reduces material and labour costs.
5. Early teething problems are overcome. As production progresses management is prompted to achieve better planning and better management.
6. Rejections and rework tend to diminish over time.
7. As quantity produced increases the Cost per unit decreases, since each unit entails:

(i) Lesser labour (ii) Greater productivity of material and labour (iii) Fewer delays and lesser time losses.

Question 9

What are the limitations of the learning curve theory ? (4 Marks)(Nov., 2011)

Answer

Limitations of Learning Curve Theory

1. All activities of a firm are not subject to learning effect. (Activities that have not been performed in the present operational mode, those performed by new or unfamiliar employees are subjected to learning effect, while those performed by familiar or experienced workmen will not be subjected to learning effect)
2. It is correct that learning effect does take place and average time taken is likely to reduce. But in practice it is highly unlikely that there will be a regular consistent rate of decrease. Therefore any cost prediction based on conventional learning curves should be viewed with caution.
3. Considerable difficulty arises in obtaining valid data that will form basis for computation of learning effect.
4. Even slight change in circumstances quickly renders the learning curve obsolete. While the regularity of conventional learning curves can be questioned, it would be wrong to ignore learning effect altogether in predicting costs for decision purposes.

Question 10

What are the distinctive features of learning curve theory in manufacturing environment? Explain the learning curve ratio. *(4 Marks)(Nov, 2012)*

Answer

Learning curve ratio:

$$= \frac{\text{Average Labour cost of first 2N units}}{\text{Average Labour cost of first N units}}$$

As the production quantity of a given item is doubled, the cost of the item decreases at a fixed rate. It occurs because of the following distinctive features of manufacturing environment.

(i) Better tooling methods are developed and used

(ii) Design bugs are detected and corrected

(iii) More productive equipment is designed and used.

(iv) Engineering changes decrease over time.

(v) Earlier teething problems are overcome.

(vi) Rejections and rework tend to diminish overtime.

Question 11

Bring out the main applications of Learning Curve. *(4 Marks)(May, 2013)*

Answer

Knowledge of learning curve can be useful both in planning and control. Standard cost for new operations should be revised frequently to reflect the anticipated learning pattern. The main applications are summarised below:

- Helps to analyse CVP relationship during familiarisation phase: Learning curve is useful to analyse cost-volume-profit relationship during familiarisation phase of product or process and thus it is very useful for cost estimates. Learning curve can be used as a tool for forecasting.
- Helps in budgeting and profit planning: Budget manager should select those costs which reflect learning effect and then he should be able to incorporate this effect in process of developing budgets or in the exercises relating to project planning.
- Helps in pricing: The use of cost data adjusted for learning effect helps in development of advantageous pricing policy.
- Design makers: It helps design engineers in making decisions based upon expected (predictable from past experience) rates of improvement.
- Helps in negotiations: It is very useful to Government in negotiations about the contracts.
- Helps in setting standards: The learning curve is quite helpful in setting standards in learning phase.

Question 12

State whether the learning curve theory can be applied to .the following independent situations briefly justifying your decision:

(i) A labour intensive sculpted product is carved from the metal provided to the staff. The metal is sourced from different suppliers since it is scarce. The alloy composition of the input metal is quite different among the suppliers.

(ii) Pieces of hand-made furniture are assembled by the company in a far off location. The labourers do not know anything about the final product which utilizes their work. As a matter of further precaution, rotation of labour is done frequently.

(ill) Skilled workers have been employed for a long time. The company has adequate market for the craft pieces done by these experts.

(iv) A company funds that it always has an adverse usage of indirect material. It wants to apply learning curve theory to improve the way standards have been set. ***(4 Marks)(Nov., 2013)***

Answer

(i) 'Learning Curve Theory' will not be applicable as *alloy combination of the input metal is quite different* among the suppliers hence learning experience with one type of metal may not be beneficial for the workers to deal with other metal with separate alloy composition.

(ii) 'Learning Curve Theory' will not be applicable as in this situation *rotation of labour is done frequently*, labours will not be able to get the benefit of learning and apply their learning. Hence, learning curve theory can not be applied.

(iii) 'Learning Curve Theory' will not be applicable as in this situation as *workers are skilled and employed for a long time*, they have already achieved maximum level of expertise by taking advantage of learning. Hence, at this point of time learning curve theory can not be applied.

(iv) 'Learning Curve Theory' will not be applicable as indirect materials are the materials which are not used directly in the production (not directly proportionate with volume of output) and usually used machines (e.g. lubricants, spares parts etc.) with less human interactions. Adverse usage of indirect materials can be controlled through proper monitoring and appropriate standard settings and not from applying learning curve theory.

Question 13

A labour intensive product is made and sold by XY Ltd. Its labour force has a learning rate of 80%, applicable only to direct labour and not to variable overheads.

The cost per unit of the first product is as follows:

	₹
Direct Materials	*20,000*
Direct Labour (@ ₹8 per unit)	*16,000*
Variable Overheads	*4,000*
Total Variable Cost	*40,000*

XY Ltd. has received an order from P Ltd. for 4 units of the product. Another customer, Q Ltd. is also interested in purchasing 4 units of the product. XY Ltd. has the capacity to fulfill both the orders. Q Ltd. presently purchases this product in the market for ₹34,400 and is willing to pay this price per unit of XY Ltd. product. But P Ltd. lets XY Ltd. choose one of the following options:

(i) A price of ₹33,000 per unit for the 4 units it proposes to take from XY Ltd.

OR

(ii) Supply P Ltd.'s idle labour force to XY Ltd. for only 4 units of production, with XY Ltd. having to pay only ₹ 2 per labour hour to P Ltd.' s workers. P Ltd.'s workers will be withdrawn after the first 4 units are produced. In this case, XY Ltd. need not use its labour for producing P Ltd.'s requirements. P Ltd. assures XY Ltd. that its labour force also has a learning rate of 80%. In this option, P Ltd. offers to buy the product from XY Ltd. at only 28,000 per unit.

P Ltd. and Q Ltd. shall not know of each other's offer.

If both orders came before any work started, what is the best option that XY Ltd. may choose? Present suitable calculations in favour of your arguments. *(9 Marks) (November, 2014)*

Answer

Workings

Units	Average LabourHrs. /unit
1	2,000 (₹16,000 ÷ ₹8) [for first unit of production]
2	1,600 (80% of 2,000 hours)
4	1,280 (80% of 1,600 hours)
8	1,024 (80% of 1,280 hours)

Variable Cost *per unit* excluding Labour Cost:

		(₹)
Material Cost	=	20,000
Variable Overheads	=	4,000
Variable Cost	=	24,000

If both the orders came together, learning rate 80% applies and 8 units can be made, with average time of 1,024 hours per unit.

Cost to XY		(₹)
Variable Cost excluding Labour	=	24,000
Labour Cost (1,024 hrs. × ₹8/hr)	=	8,192
	=	32,192

Option-I

In this case,

Particulars	Q	P	Total
Selling Price p. u. (₹)	34,400	33,000	
Variable Cost p. u. (₹)	32,192	32,192	
Contribution p. u. (₹)	2,208	808	
No. of Units	4	4	
Contribution (₹)	8,832	3,232	12,064

Option- II

If P Ltd supplies its labour. 80% learning curve will apply to 4 units each of XY Ltd. & P Ltd. Hence: hrs / unit = 1,280 (as calculated in the working note)

Particulars	Q	P	Total
Selling Price p. u. (₹)	34,400	28,000	
Variable Cost p. u. (₹) (Excluding Labour cost)	24,000	24,000	
Labour Cost p. u. (₹)			
1,280 hrs. × ₹ 8	10,240	--	
1,280 hrs. × ₹ 2	--	2,560	
Total Variable Cost p. u. (₹)	34,240	26,560	
Contribution p. u. (₹)	160	1,440	
Units	4	4	
Contribution (₹)	640	5,760	6,400

Decision

XY Ltd. should not take labour from P Ltd. It should choose Option-I.