LEARNING CURVE THEORY, ITS ADAPTABILITY IN DETERMINATION OF LABOUR RELATED COST IN MANUFACTURING ENVIRONMENT

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ABSTRACT:

Knowledge / Application of learning Curve is useful both in planning and control. Standard cost for new operations should be reviewed and revised frequently to reflect the anticipated learning pattern. It helps to analyze / establish cost – volume – profit (CVP) relationship during the familiarization phase of product or process. It is very useful for cost estimates and immense value as a tool for forecasting. Cost predictions relating to direct labour virtually allow for the effect of learning process, which entails a mathematical/statistical techniques. It is geometrical progression which reveals that there is steadily decreasing cost for the accomplishment of a given repetitive operation, as the identical operation is increasingly repeated. Learning effect exists during the workers familiarization period on the job. After this experimental period is over, productivity tends to be stable and no further improvement is possible. Learning curve theory is essentially a measure of this experience gained in production of a commodity by the

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organization. People involved in the process become more efficient as each subsequent unit produced takes fewer man hours. A company must not blindly adopt another company's learning curve. The prudent approach for a company is to develop knowledge of its own learning preference.

Introduction:

Learning is the process by which an individual acquires skill, knowledge and ability. When a new product or process is started, the performance of a worker is not at its best and learning phenomenon takes place. As the experience is gained, the performance of a worker improves, time taken per unit of activity reduces and his productivity goes up. This improvement in productivity of a worker is due to learning effect. Cost predictions especially those relating to direct labour cost must allow for the effect of learning process. This technique is a mathematical technique. It can be very much used to accurately and graphically predict cost. It is a geometrical progression, which reveals that there is steadily decreasing cost for the accomplishment of a given repetitive operation, as the identical operation is increasingly repeated.

The amount of decrease is less and less with each successive unit produced. The slope of the decision curve can be expressed as a percentage. Experience curve, improvement curve and progress curve are other terms which can be synonymously used.

Learning curve is essentially a measure of the experience gained in production of an article by an individual or organization. As more units are produced, people involved in production become more efficient than before. Each subsequent unit takes fewer man-hours to produce. The amount of improvement will differ with each type of article produced. This improvement or experience gain is reflected in a decrease in man-hours or cost.

Historical Background:

The theory of learning curve was first introduced by T.P. Wright of Curtiss – Wright, Buffalo, U.S.A., who engaged in the production of airframes. As the quantity produced of a given item doubles, the cost of that item decreases at a fixed rate. This phenomenon is the basic premise on which the theory of learning curve was formulated. The key words, “doubles” and “rate” are important as the quantity produced doubles, the absolute amount of cost increase will be successively smaller, but the rate of decrease will remain fixed. This is the essence of learning curve theory and it occurs due to the following distinctive features in the manufacturing environment:

- Rejections and rework tend to diminish over time.
- Better tooling methods are developed and used.
- More productive equipments are designed and used.
- Design bugs are detected and corrected.

There happens a significant influence of all these features on labour as the quantity produced increases and the cost per unit drops. The reasons for this are that each unit entails:

- Less labour
- Less material
- More units produced from the same equipments;
- Cost of fewer delays and less lost time.

Adaptability:

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 onset can be used to predict labour cost in advance. The effect of experience on cost can be expressed in the learning curve ratio or improvement ratio:

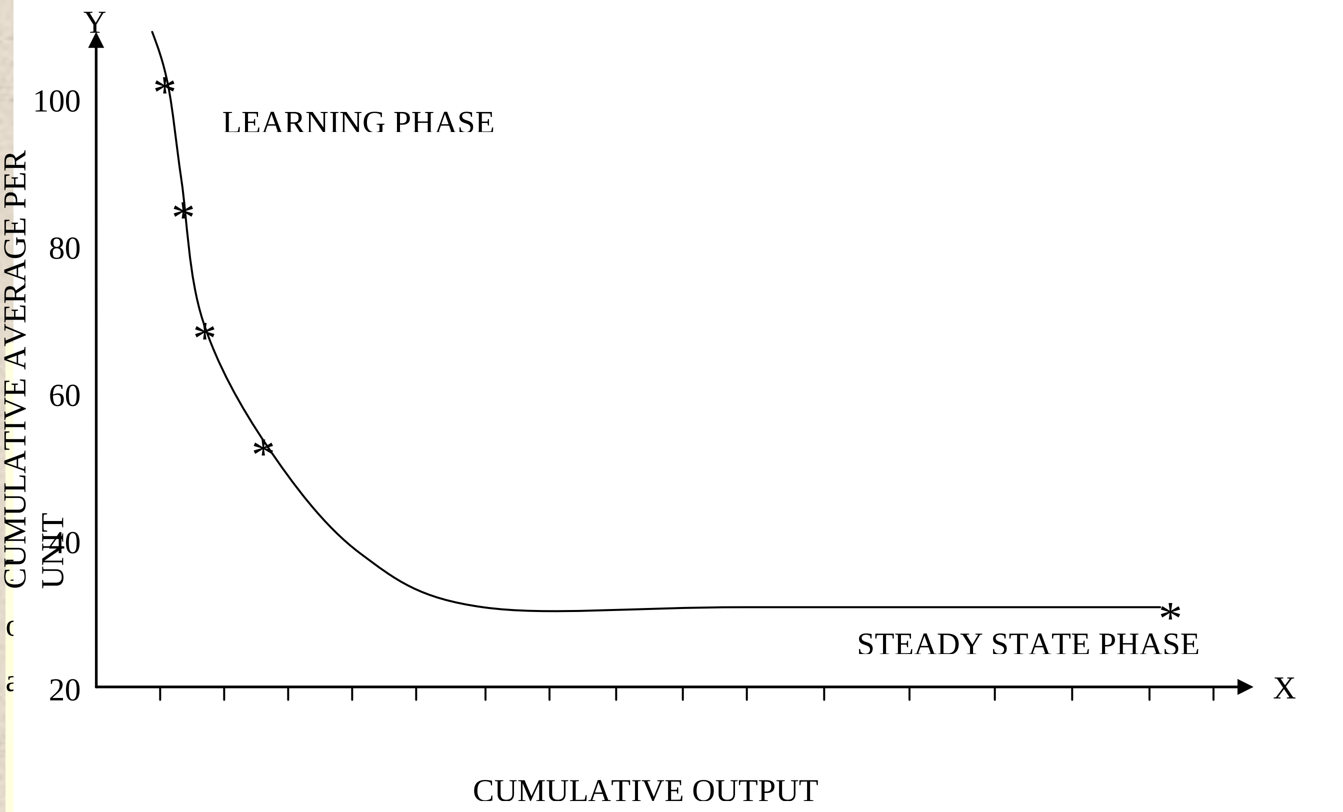
$$LCR = \frac{\text{Average labour cost of } 1^{st}\ 2\text{units}}{\text{Average labour cost of } 1^{st}\ N \text{ units}}$$

If the average labour cost of the first 500 units of a product is N25 and the average labour cost of first 1000 units is N20, the learning curve ratio will be 80% (i.e. $\frac{N20}{N25} \times 100$)

The learning ratio of 80% means that each time output doubles, the average cost declines to 80% of the previous amount. Since the average cost per unit of 1000 units is N20, the average cost of first 2000 units is likely to be 80% of this i.e. N16 per unit. The amount of production improvement in the manufacture of an article will determine the percentage of the learning curve. The effect of learning can be presented in a diagram known as learning curve. The units chosen in the progression must always have a ratio of two (i.e. unit 2 to unit 1, unit 50 to unit 25 etc).

An 80% learning curve can be drawn using the data.

Incremental Qty	Cumulative Qty	Working	Average time per unit	Cumulative time taken
1	1	-	100	100
1	2	$\frac{100 \times 80}{100}$	80	160
2	4	$\frac{80 \times 80}{100}$	64	256
4	8	$\frac{64 \times 80}{100}$	51	408
8	16	$\frac{31 \times 80}{100}$	41	656



80% LEARNING CURVE

Application

Determination of labour related cost is one area where learning curve theory can be applied successfully. Considering the data procured from an organization for this purpose;

Data: 1

TEXLON & co. ltd observed that a 90% learning curve ratio applies to all labour related costs each time a new model enters production. It is anticipated that 230 units will be produced during the month of October 2010. Direct labour cost for the first lot of 10 units amount to 1000 hours at N8 per hour. Variable overhead cost is assigned to products at the rate of N2 per direct labour hour.

Determine:

(i) Total labour and labour related costs to produce 320 units

(ii) Average cost of the first 40 units, the first 80 units and the first 100 units produced.

(iii) Incremental cost of units 41-80 and units 101-200

COST PROJECTED BASED ON 90% LEARNING CURVE

Incremental Qty	Cumulative Qty	AV time taken per unit	Cumulative time taken	Incremental hours
10	10	100	1000	-
10	20	90	1800	800
20	40	81	3240	1440
40	80	72.9	5832	2392
80	160	65.61	10,497.6	4665.6
160	320	59.049	18895.68	8398.08

From the Table

(i) Total labour related cost for 320 units:

18,895.68 x N10 = N188956.80

(ii) Average cost of 1st 40units produced:

81 x N10 = N810 per unit

(iii) Average cost of 1st 80 units produced:

72.9 x N10 = N729 per unit

(iv) Incremental cost of units 41-80:

2592 x N10 = N25920

Applying Basic Learning Curve Equation

Mathematically

$Yx = KX^s$……………………………………………… (1)

Where:

X, is the cumulative number of units or lots produced.

Y, is the cumulative average unit cost of those units X or lots.

K, is the average cost of the first unit or lot.

S, is the improvement exponent or the learning coefficient or the index of learning which is:

$$S = \frac{\text{logarithm of learning ratio}}{\text{Logarithm of 2}}$$

Learning Curve Equation $Yx = KX^s$ becomes a linear equation when it is written in its logarithmic form:

$\text{Log } Yx = \log K + S \log X$…………………(2)

Each of the above two equations defines cumulative average cost. Either of them can be converted to a formula for the total labour cost of all units produced up to a given point. Total cost under equation 1 can be determined using:

Total cost, $XYx = X\,(XKs) = KXs^H$…………………………..(3)

USING BASIC EQUATION

(i) To derive the average cost of the first 100 units produce and

(ii) The incremental cost of units 101-200.

$Yx = KX^s$

The 1st production lot contained 10 units.

K = 1000hrs (time taken for the 1st lot) and

X = 10 (the number of lots needed to produce 100 units)

Taking the logarithm of the above relation,

$\text{Log } Y_{10} = \log 1000 + (-0.1518 \log 10)$

$= 3.0 - 0.1518$

$= 2.8482$

$Y_{10} = 705$

Y_{10} means that average processing time for the first 10 lots of output is 705 hours per lot. Each lot contains 10 units of output. Therefore, the average cost of the first 100 units is N705 per unit. The incremental cost of units 101-200 corresponds to the incremental cost of lots 11-20. This is equal to the total cost of first 20 lots minus the total cost of the first 10 lots.

$Y_{10} = 705$

$Y_{20} = (1000)(20-0.1518)$

$= 634.5$

Time for first 20 lots = 20(634.5) = 12690 hrs

Less time for 10 lots = 10(705) = 7050hrs

5640hours

This means the incremental cost of lots 11-20 units

= (5640hrs x N10)

= N56400

Data 2:

Test of Validity Using Standard Modulation

TEXLON Co. Ltd experiencing difficulty in its budgeting process because it finds it necessary to quantify the learning effect as new products are introduced. Substantial product changes occur and result in the need for retraining.

An order for 30 units of a new product was received. So far 14 units has been completed; the first unit required 40 direct labour hours and a total of 240 direct labour hours has been recorded for the 14 units. The production manager expects an 80% learning effect for this type of work.

The direct costs attributed to the centre in which the unit is produced and its direct material costs are:

Direct material	N30.00 per unit
Direct labour	N60.00 per unit
Variable overhead	N0.50 per direct labour hour.

Fixed overhead N6,000 per four – week operating period. There are ten direct employees working a five day week, eight hours per day. Personal and other downtime allowances account for 25% of the total available time. The company usually quotes a four –week delivery period for orders:

(i) Determine whether the assumption of 80% learning effect is reasonable in this case.

(ii) The number of direct labour hours likely required for the expected second order of 20 units.

80% learning curve

Applying Standard Equation:

$Y_x \quad = \quad a_x^{\,b}$ or KX^s

Where:

Y = The cumulative average direct labour hour per unit (Productivity)

a = the average labour hour per unit for the first batch.

x = the cumulative number of batches proceed.

b = the index of learning

(i) For an 80% learning curve, the index of learning is:

$$b = \frac{\text{logarithm of leaning ratio}}{\text{logarithms of 2}}$$

$$= -0.3222$$

$$Y_x = ax^b$$

$$\text{i.e. } \log Y_x = \log a + b \log x$$

$$\log Y_{14} = \log 40 + (-0.322)(\log 14)$$

$$= 1.6021 + (-0.322)(1.1461)$$

$$= 1.16021 - 0.3675$$

$$= 1.2346$$

Y_{14} = 17.14 hours per unit.

Average productivity for 14 units:

= 17.14hrs per unit.

Time taken for 14 units is:

= 14 x 17.14.

= 239.96 hrs

This means the assumption of 80% learning effect is consistent and correct.

(ii) Expected direct labour hrs at 80% learning curve;

Productivity at 50 units output $= 40 \times 50^b$

or $\log Y_{50} = \log 40 + (-0.322)(\log 50)$

$= 1.6021 + (-0.322)(1.6990)$

$= 1.6021 – 0.5471$

$= 1.0550$

i.e. Productivity at 50 units = 11.35 hrs per unit.

Direct labour hrs required for 50 units is:

= 50 x 11.35 hrs per unit.

= 567.5 hrs

Productivity at 30 units is:

$\log Y_{30} = \log 40 + (-0.322)(\log 30)$

$= 1.6021 + (-0.322)(1.4779)$

$= 1.6021 – 0.4759$

$= 1.1262$

Productivity at 30 units = 13.38 hrs per unit.

Direct labour hrs required at 30 units:

= 30 x 13.38 hrs per unit

= 401.4 hrs

Therefore Time for Units 31 to 50:

= 567.5 – 401.4

= 166.1 hrs

(iii) Hrs taken for 30 units $= \simeq$ 402 hrs.

Cost of order: ₦

Materials	N30 x 30	900
Labour	N6 x 402	2412
V/O	N0.50 x 402	201
F/O	N5 x 402	2010
		5523

Cost per unit N5523 ÷ 30 = N184.1

Fixed overhead rate:

Total labour hrs for 4 weeks period:

= 10 workers x 5 days x 8hrs x 4 weeks =1600hrs

Less non-productive time 25% = 400 hrs

Effective hrs =1200 hrs

Therefore F/o rate = N6000 ÷ 1200hrs

= N5 per direct labour hr.

Observation

A company must strive to develop its own learning –preference pattern rather than adopting / imitating another company in the sense that learning curve advantage is internally tailor – made-phenomenon. Caution must be exercised to accurately determine the labour related production runs.

KEY WORDS:

1. Learning –Preference
2. ‘Doubles’ and ‘rate’
3. Productivity
4. Cost –prediction
5. Geometrical – progression

6. Man-hours

7. Slope –of-decion-curve

8. Familiarization – phase

9. Learning effect.

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