

Learning Curves Tutorial
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Introduction to Learning Curves

T.P. Wright first documented the idea of learning curves and its effect on efficiency in the American aircraft industry in 1936. Wright found that there was a pattern in the way that people learned; he found that per unit production time reduced at an unvarying rate. Researchers took Wrights' idea and expounded upon it during World War II, where the emphasis was primarily on cost efficiency.

Since World War II, the term learning curve has been expanded to other business and non-business applications such management, distribution, team learning, health care, investing, and even exercise. These more general applications of learning curves are more accurately described by the term experience curve or practice curve. For the purposes of this paper a learning curve describes the nonlinear relationship between labor hours per unit and units of output, we assume a single driver units of output for our purposes though more complex formulas exist.

How would a company use learning curves?

The most important question in regards to learning curves is how would a company use learning curves in their business? One practical application of learning curves is in forecasting budgets if companies can accurately estimate the rate of learning they can also estimate product cost. Understanding cost is also paramount to pricing decisions, should the company follow a prestige pricing or price skimming strategy. Determining human resource needs is another application in which learning curves can be used, as companies become more efficient they may eliminate jobs or choose to move them to other functional areas. However as G.J. Steven points out, "It is important to appreciate that the learning curve is not a cost-reduction technique since the rate of future

time reduction can be predicted by the learning curve model. Cost reduction only occurs if management action is taken, for example, to increase the rate of time reduction by providing additional training, provision of better tools etc” (Steven 65).

Basic Learning Curve Calculations

There are different models for learning curves that have been proposed and used by businesses. None are generally accepted as being superior. For explanatory purposes we will use the Incremental Unit-Time Learning Model. The following mathematical background is borrowed in part from Horngren, Foster, and Datar's Cost Accounting textbook. This model is based on the equation $y = aX^b$ where y = the time to produce the last unit of output, a = the time to produce the first unit of output, X = cumulative number of units produced, and b = the rate of learning. The rate of learning is calculated by taking the natural log of the percentage of learning and dividing by the natural log of 2 ($\ln(\% \text{ of learning}) / \ln 2$). Ultimately what this equation is describing is that the incremental unit time decreases at a constant rate each time the quantity of units produced doubles. The lower your percentage of learning is the faster individual units are produced and thus the faster average time per unit. As a practical matter there is no hard and fast rule for determining the percentage of learning, in Figure 1 a 90% learning curve is assumed.

Figure: 1

| Cumulative units | Individual unit time (y): Labor hours | Cumulative total time: Labor hours | Cumulative average time per unit: Labor hours |
|-------------------------|--|---|--|
| 1 | 10 | 10 | 10.00 |
| 2 | 9 | 19 | 9.50 |
| 3 | 8.46 | 27.46 | 9.15 |
| 4 | 8.1 | 35.56 | 8.89 |
| 5 | 7.83 | 43.39 | 8.68 |
| 6 | 7.62 | 51.01 | 8.50 |
| 7 | 7.43 | 58.44 | 8.35 |
| 8 | 7.29 | 65.73 | 8.22 |
| 9 | 7.16 | 72.89 | 8.10 |
| 10 | 7.05 | 79.94 | 7.99 |
| 11 | 6.95 | 86.89 | 7.90 |
| 12 | 6.85 | 93.74 | 7.81 |
| 13 | 6.77 | 100.51 | 7.73 |
| 14 | 6.7 | 107.21 | 7.66 |
| 15 | 6.63 | 113.84 | 7.59 |
| 16 | 6.56 | 120.4 | 7.53 |

Once the percentage of learning is established the numbers can be easily generated using an excel spreadsheet. The individual unit times are based on the equation $y = aX^b$ where a and b will be constant throughout the range of units. Notice how quickly the effects of the learning curve takes place by the time just 16 units are produced the average time per unit has dropped by almost 25%. If the right percentage of learning has been applied a manager could now take this data and produce production schedules, delivery plans, personnel staffing schedules, as well as budget forecasts. The benefits of learning curves were underscored by professor Charles Bailey at the University of Central Florida when he stated, “The potential applications of learning curves far outstrip their current usage” (Anthes 44).

The learning curve is effected by several outside forces not the least of which is human attributes. As Roark and Briscoe explain, “Just as the areas of standard costing

and budgeting have had to incorporate behavioral concepts to increase their effectiveness, so must learning curve applications include behavioral considerations” (Briscoe 32). In other words even the most accurate performance estimates does not insure that our estimates will be accurate. Because we are dealing with human beings planned performance and actual performance can vary for a myriad of reasons.

A discussion of learning curves would not be complete without mentioning that all learning is not created equal. For example, a computer custom manufacturing facility, if an engineer designs a way put an external jumper wire into a board it leads to greater effects on the learning curve than would a single production worker learning to solder on the external jumper wire faster. In fact the engineers breakthrough would negate the learning of the production worker by eliminating the need for the soldering altogether. Learning is influenced in different magnitudes at various points in the production process. Briscoe and Roark define these points as sources of learning, which they break into three basic categories preproduction, intratask, and exoteric learning. These sources could easily be termed before, during, and after production. Briscoe and Roark reinforce the manufacturing facility example when they state, “Learning that is achieved from one type will tend to reduce the learning that can be obtained from another” (36).

Real World Application

As previously mentioned learning curves can be used for a number of applications, perhaps the most basic of these is budgeting. According to G.J. Steven one company that is utilizing the benefits of learning curves is Above & Beyond Ltd., a manufacturer of high-technology guidance systems. For companies who budget for high-technology projects, knowing the labor costs associated with that project is critical. Labor

time and cost tend to be very high because such projects are highly technical and are being performed by very highly paid specialists. Using learning curves helps Above & Beyond determine more realistic task times, which improves pricing decisions and the overall competitiveness of the firm.

Additional Resources

Professor Charles Bailey offers freeware for performing learning curve calculations at www.bus.ucf.edu/bailey. NASA also has software available that allows anyone to perform learning curve calculations online at www.jsc.nasa.gov/bu2/learn.html. More powerful software is available for purchase by businesses from companies like Production Technology of Tampa, Florida (Anthes43).

Conclusion

In conclusion the idea behind learning curves is that people get better at producing products as they get more experienced. Learning curves first introduced in the 1930's by T.P. Wright and were used initially in the aircraft production industry. While several methods exist no one learning curve model is generally accepted as the best. Learning curves are very easy to calculate using computer spreadsheets, and the information provided can be used in making decisions on everything from procurement to packaging. While learning curves are useful it is not a cost-reduction technique, human attributes must be considered and not all learning is equal to the organization. Learning curves can be used to answer a myriad of questions for organizations, and their use will only continue to grow as efficiency continues to become more of a requirement and less of a goal.

Works Cited

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