



Learning Curves

M Taylor 2012




Agenda

- Learning Curve (LC) Concept
- LC in the real world
- The Curve
- Application



What is Learning Curve?

- Observed in aircraft manufacturing ~1940s
- Unit production time decreased with QTY
- When an task is performed repetitively, we "learn" and improve our speed and efficiency the more we repeat the task.
- At first, learning was attributed to increased motor skills in the workers as they repeated their tasks
 - Later it was realized that management also could contribute to learning with better tools and processes



The Learning Effect

- Production time decreased as production volume increased – by an exponential amount!

Two slightly different models in use


- Time to produce a unit decreases by a fixed percentage each time the QTY produced is doubled (Unit Model)

or

- Cumulative Average time to produce the units decreases by a fixed percent

1= 100 hrs
2= 90 hrs
4= 81 hrs

Same effect but different curves

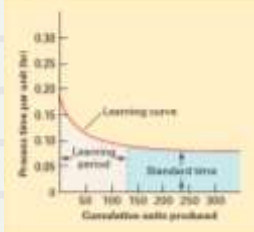



The Chart

Using a Log chart – the “curve” is a straight line. Handy for extrapolation or regression analysis

Note how an industry might use LC to find a “standard time”


- Relationship between time to produce a unit vs the number of units produced





Common Examples


- Bid Preparation: In a large job, how much time(labor) will it take to make all of the pieces?
- Financial Planning: Direct Labor costs will be higher early in a job than later
- Labor Requirements: To produce the required number of units per day will require fewer people the longer we make the item
- Home Building – If all houses in a development are built the same way – at the same time - the builder gets big benefits in reduced construction time.
- Management or production process improvements



The Slope

Source for industry figures, Galorath


- In industry, Slope typically seen from 70% to 100%
- It's counterintuitive, but 100% means no learning at all
- The highest rate of learning achieved in most industrial situations is about 70%
- LC could apply to different elements of a process at different slopes. Isolate the specific processes and analyze individually. Useful to prepare for eventual changes in the SOW.



Useful Formulas

U Model: If the slope is $S\%$, any doubling of the production quantity from some unit $\#n$ to another unit $\#2n$ results in a reduction in labor hours from H_n to $S\%$ of H_n .


CA Model: If the slope is $S\%$, the average hours for units 1 through $2n$ are $S\%$ of the average hours for units 1 through n .



Calculators - Examples


References at the end

- Calculate based on unit time or running average – slightly different curves with similar results.
- Use calculator tools to extrapolate or estimate
- Use actual data whenever possible to find the best curve and slope




Practical Application

- Fit learning curves to historical data when available
 - This is usually the best source, but not always indicative of the future
- Guidelines for use when historical data are not available:
 - Operations that are fully automated tend to have slopes of 100%, or a value very close to that (no learning can happen).
 - Operations that are entirely manual tend to have slopes in the vicinity of 70% (maximum learning can happen). (cont.)



Practical Application


- Guidelines (cont.)
 - If an operation is 75% manual and 25% automated, slopes in the vicinity of 80% are common.
 - If it is 50% manual and 50% automated, expect about 85%.
 - If it is 25% manual and 75% automated, expect about 90%.
 - The average slope for the aircraft industry is about 85%. But there are departments in a typical aircraft factory that may depart substantially from that value.
 - Shipbuilding slopes tend to run between 80 and 85%.



Practical Application

- The following typical values assume repetitive operations. They are not valid if operations are sporadic, as in a job shop environment.

Manufacturing Activity	Typical Slope %
Electronics	90-95
Machining	90-95
Electrical	75-85
Welding	88-92




Cal Poly Mgmt Course

Foundations of Operations Management

Topics


- Topic 1: Overview of Operations Management
- Topic 2: Forecasting
- Topic 3: Inventory Management
- Topic 4: Production Planning and Control
- Topic 5: Quality Management
- Topic 6: Project Management
- Topic 7: Supply Chain Management
- Topic 8: Lean Manufacturing
- Topic 9: Simulation
- Topic 10: Final Project

One source of information




Discussion

- Commonly used in Manufacturing, financial management and cost estimating
- How could LC affect price?
- Which contracts would most likely benefit?
- Can a company or organization exhibit the effects of LC?




Issues / Impacts

- LC can be interrupted by down-time
- LC can be impacted by changes in production process or personnel
- LC is affected by changes in the SOW
- Curve could change or just jog up
- Process could be automated
- Customizing a product could change "standard time" **BUT** the customization process could have it's own LC



Resources

- Excel handout ([link](#))
- DAU calculator excel ([link](#))
- DOE Guide Chapter 21 ([link](#))
- Business Analytics web page, includes description and a calculator ([link](#))




DOE guide

CHAPTER 21

LEARNING CURVE

1. INTRODUCTION

It is a fundamental lesson characteristic that a person engaged in a repetitive task will acquire his performance over time. If done not judiciously, this phenomenon is often experiencing a decrease in office per unit the repetitive operations can be developed. This phenomenon is not used for a specific application in cost analysis, cost estimating, or profitability studies related to the economics of labor costs and machine tools in an industry. It could be used as a starting portion of a project, such as the production of supports for the supercollider. This chapter discusses the development and application of the learning curve.



Business Analysis

- Business Analysis
- Business Analysis Tools
- Business Analysis Software
- Business Analysis Services
- Business Analysis Courses
- Business Analysis Books
- Business Analysis Journals
- Business Analysis Conferences
- Business Analysis Associations
- Business Analysis Organizations
- Business Analysis Societies
- Business Analysis Institutes
- Business Analysis Centers
- Business Analysis Foundations
- Business Analysis Academies
- Business Analysis Schools
- Business Analysis Universities
- Business Analysis Colleges
- Business Analysis High Schools
- Business Analysis Vocational Schools
- Business Analysis Trade Schools
- Business Analysis Apprenticeships
- Business Analysis Internships
- Business Analysis Fellowships
- Business Analysis Scholarships
- Business Analysis Grants
- Business Analysis Prizes
- Business Analysis Awards
- Business Analysis Honors
- Business Analysis Medals
- Business Analysis Trophies
- Business Analysis Diplomas
- Business Analysis Certificates
- Business Analysis Licenses
- Business Analysis Permits
- Business Analysis Registrations
- Business Analysis Accreditations
- Business Analysis Approvals
- Business Analysis Certifications
- Business Analysis Examinations
- Business Analysis Tests
- Business Analysis Assessments
- Business Analysis Evaluations
- Business Analysis Surveys
- Business Analysis Questionnaires
- Business Analysis Interviews
- Business Analysis Focus Groups
- Business Analysis Workshops
- Business Analysis Seminars
- Business Analysis Webinars
- Business Analysis Podcasts
- Business Analysis E-books
- Business Analysis Whitepapers
- Business Analysis Reports
- Business Analysis Studies
- Business Analysis Research
- Business Analysis Publications
- Business Analysis Journals
- Business Analysis Magazines
- Business Analysis Newspapers
- Business Analysis Websites
- Business Analysis Blogs
- Business Analysis Forums
- Business Analysis Social Media
- Business Analysis YouTube
- Business Analysis Twitter
- Business Analysis LinkedIn
- Business Analysis Facebook
- Business Analysis Instagram
- Business Analysis Pinterest
- Business Analysis SoundCloud
- Business Analysis DeviantArt
- Business Analysis Dribbble
- Business Analysis Behance
- Business Analysis ArtStation
- Business Analysis FreePress
- Business Analysis DeviantArt
- Business Analysis Dribbble
- Business Analysis Behance
- Business Analysis ArtStation
- Business Analysis FreePress

Learning Curve Spreadsheet

This spreadsheet calculates the learning curve effect on production costs. It is a useful tool for estimating the cost of a product over time. The spreadsheet is available for download from the following link: [Learning Curve Spreadsheet](#)

Mobile Survey Tool

This mobile survey tool allows you to create and distribute surveys on your mobile devices. It is a useful tool for gathering feedback from your customers. The tool is available for download from the following link: [Mobile Survey Tool](#)

7