PRICING MAGAZINE CONTRIBUTOR

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Material Discount Curves

THEORY VERSUS PRACTICE

By Daniel A. Chalfant CPCM

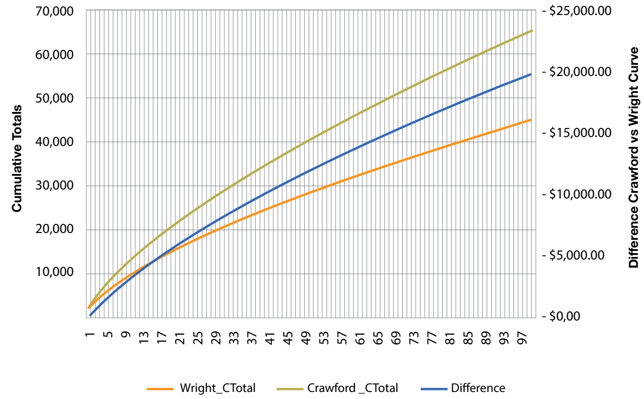
A material discount curve measures the price reduction that occurs when quantity is increased. It is also known as an experience curve, a price reduction curve, or a quantity/price curve. Some have often referred to this effect as the "Costco Principle"—an item tends to cost less per unit as you buy higher quantities.

Labor Learning Curve theory is foundational to the material discount curve. Much has been written about the labor learning curve, but much less has been written about the material discount curve. Buyers often use material discount curves to negotiate prices for different item quantities. Buyers also tend to select the appropriate curve based on Labor Learning Curve theory. We believe Labor Learning Curve theory overstates the anticipated reductions in material unit prices.

To provide context for our Material Discount Curve theory, let's review the publications that mark historical highlights in Learning Curve theory.

1936: T.P. Wright publishes "Factors Affecting the Cost of Airplanes" in Journal of the Aeronautical Sciences. His article leads to the classic cumulative average labor hour Learning Curve theory, which is that hours per unit will decrease as quantity increases.

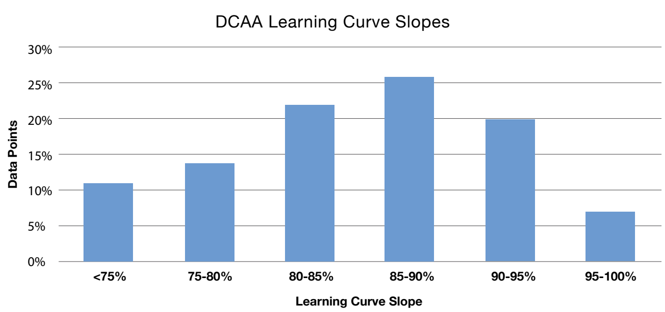
1949: A group at Stanford Research Institute (SRI) improves on the "Wright" theory. They name it the "Crawford" Learning Curve theory after James R. Crawford. It uses the unit value of labor hours instead of the cumulative value. This has since become the most popular Learning Curve theory.



1964: Fred Hartmeyer publishes Electronics Industry Cost Estimating Data . The book has one of the earliest references to Material Discount Curve theory. In his definition of the Material Discount Curve, Hartmeyer states "Material cost reductions can be projected…at different buy quantities."

1966: Bruce Henderson publishes the "Experience Curve" theory. Henderson's definition of the curve is that "a company's unit production cost will fall by a predictable amount for each doubling of experience, or accumulated production volume."

1969: The Defense Contract Audit Agency (DCAA) publishes empirical data on the learning curve and material discount curve . The DCAA report measures the actual learning curve on 443 defense contracts, and it calculates the average learning curve as an 84.9% slope. In 1983, the report is updated with the average learning curve calculated as an 84.6% slope. The 1983 report also includes 21 contracts measured only for material cost or total cost. The average for these 21 items is a 90.6% slope.



1975: The National Aeronautics and Space Administration (NASA) publishes Technical Memorandum TMX-64968 titled Guidelines for Application of Learning/Cost Improvement Curves . It includes improvement curve slope overall values by industry. The Aerospace industry average is reported as 85%. This memo also provides material discount curves by type of component for reference only. Although not specifically referenced, it is reasonable to presume that the averages are based on the 1969 DCAA study mentioned previously.

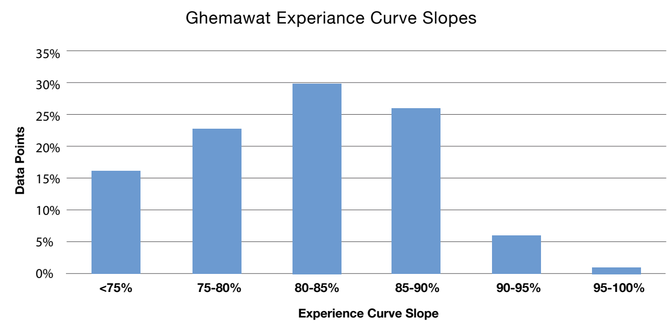
Slope by industry

Aerospace	85%	Complex machine tools	75-85%
Electronics manufacturing	90-95%	Machining or punch press	90-95%
Repetitive electrical operations	75-85%	Repetitive welding operations	90%
Raw materials	93-96%	Purchased parts	85-88%

Industrial buyers often use these industry slopes to negotiate deals with their suppliers.

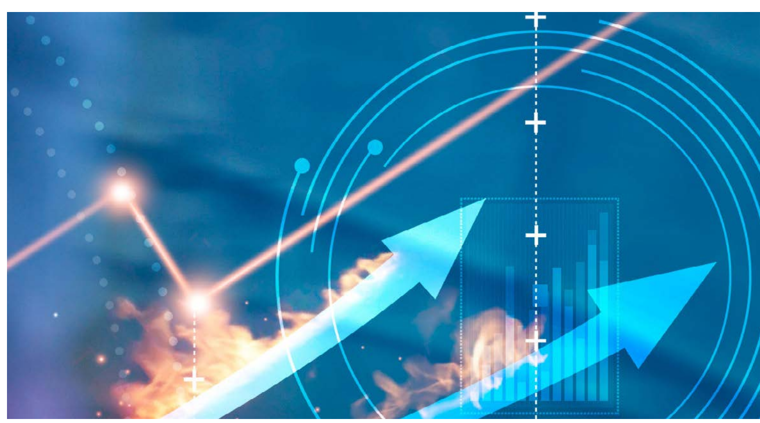
1985: Theodore Taylor publishes Handbook of Electronics Industry Cost Estimating Data . This is an update to Hartmeyer's text. Taylor includes a chapter on material discount curves, and he provides discount slopes for various material categories. Taylor's theoretical slopes range from 75% to 95%, depending on the type of material. His material discount curves follow the same pattern as the labor learning curves in NASA TMX-64968.

Also in 1985, Pankaj Ghemawat writes the Harvard Business Review article "Building Strategy on the Experience Curve". Having compiled data on 97 academic studies, Ghemawat calculates the average slope as 85%. He reports on the distribution of data by slope, similar to the DCAA report.



1995: Rodney D. Stewart, et. all, publishes Cost Estimator's Reference Manual . It includes labor improvement curve slope overall values by industry that are exactly the same as NASA TMX-64968. Stewart was Chief of the Cost Analysis Office at NASA, and one of the originators of NASA TMX-64968. Although not specifically referenced, it is reasonable to presume that Stewart knew of the 1969 or 1983 DCAA study.

2004: NASA publishes their Cost Estimating Handbook . It includes improvement curve slope overall values by industry, with reference to Stewart's Cost Estimator's Reference Manual. When the handbook is published again in 2008, it has the same data and reference. The NASA slopes are also identical to TMX-64968.



HISTORICAL SUMMARY

Much of the published information on labor learning curves and material discount curves is theoretical. Other than the DCAA report and Ghemawat's study, the published empirical data available is limited. Both the DCAA and Ghemawat calculated average curves of 85%.

HYPOTHESIS:

Our hypothesis is that the material discount curves will display higher average slopes than labor learning curves. We acknowledge the existence of the labor learning curve and the 85% average slope, but we do not believe that material discount curves display the same average slopes.
Although labor hours or labor dollars may decrease on an 85% slope, we do not believe material cost, other direct costs, indirect costs, and profit will decrease at the same rate. Therefore, the material discount curve should have a higher average slope than the labor learning curve. Additional research on empirical data is needed to prove or disprove this hypothesis.

EMPIRICAL DATA

The previous historical summary shows the lack of published empirical data. Due to this fact, we have included unpublished information from three large Aerospace companies. The names of the three companies will remain anonymous to protect potentially sensitive information. For this purpose, we will refer to them as Firm A, Firm B, and Firm C.

These three companies analyzed recent purchase order (PO) history organized by logical material groups. The material groups were not the same across the companies, so we assigned each group to one of five higher level material groups. The five groups are based on the material discount curves chapter of Taylor's *Handbook of Electronics Industry Cost Estimating Data.*

Taylor's material groups and theoretical slopes are:

Material Group	Standard Electronic Components	Fabricated Parts and Standard Catalog Items	Fabricated Parts - Built to Specification	Fabricated Parts - Special Complex Items	Fabricated Parts - State of the Art
Average Slope	95%	90%	85%	80%	75%

Using the empirical data, we calculated the average actual material discount curve per group for each of the three companies and the DCAA. Here are the results of our analysis:

Material Group	Standard Electronic Components	Fabricated Parts and Standard Catalog Items	Fabricated Parts - Built to Specification	Fabricated Parts - Special Complex Items	Fabricated Parts - State of the Art
DCAA	93%	92%	91%	84%	
Firm A	83%	91%	86%	86%	
Firm B	96%	93%	91%	83%	
FirmC	96%	95%	91%	85%	

In our study, we analyzed average slopes for 246 commodity groups. Adding the DCAA data brings the total to 267 data points. The data was collected from company PO history between 2017 and 2019. We placed more weight on Firms B and C data due to their higher number of observations. We did not find any commodities that fit our definition of Fabricated Parts - State of the Art.

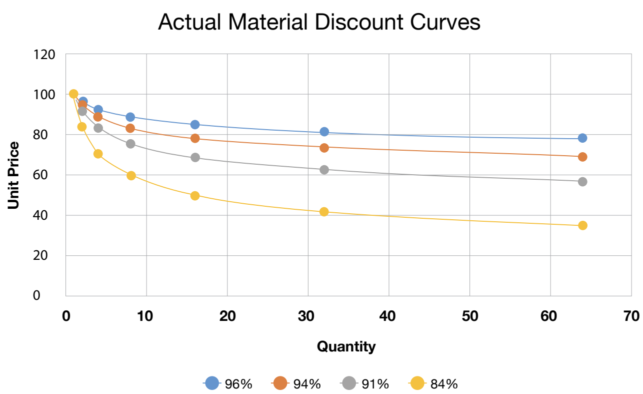
For each source in the study, the actual average slope for all material groups is as follows:

DCAA	FIRM A	FIRM B	FIRM C
90.6%	88.4%	90.8%	92.9%

The overall weighted average slope for all empirical data is 91.7%. This is a higher slope than the average Aerospace learning curve of 85%, as noted previously. The actual average curves by material group are much higher slopes than the labor learning curves.

Therefore, our hypothesis that material discount curves have higher slopes than learning curves is supported by recent empirical evidence.

We calculated the weighted average material discount curve for each of the five material groups. The following graph shows the average slope of the curve per group:



Based on the previously discussed empirical data, we recommend the following material discount curve average slopes by material group:

Material Group	Standard Electronic Components	Fabricated Parts and Standard Catalog Items	Fabricated Parts - Built to Specification	Fabricated Parts - Special Complex Items	Fabricated Parts - State of the Art
Average Slope	96%	94%	91%	84%	NA

These slopes should be applied to direct material cost, total cost, or prices being analyzed, and adjusted for differences in quantity. We recommend that the slopes be provided as guidance to buyers in analyzing and negotiation material prices.

1. *Factors Affecting the Cost of Airplanes, Journal of the Aeronautical Sciences, T. P. Wright, 1936.*

2. *Electronics Industry Cost Estimating Data, Fred Hartmeyer, Ronald Press Co. copyright 1964.*

3. *Boston Consulting Group, Experience Curve, Bruce Henderson, 1966.*

4. *DCAA Report on Improvement Curve Experience, 1969 and 1983.*

5. *National Aeronautics and Space Administration, TMX-64968, Dr. Leon M. Delionback, 1975.*

6. *Handbook of Electronics Industry Cost Estimating Data, Theodore Taylor, John Wiley & Sons, 1985.*

7. *Harvard Business Review #63, Building Strategy on the Experience Curve, P. Ghemawat, March 1985.*

8. *Cost Estimator's Reference Manual, Rodney Stewart, John Wiley & Sons, 1995.*

9. *National Aeronautics and Space Administration, Cost Estimating Handbook, 2004 & 2008.*