Case Study 1
Heliotronics - Estimating an Experience Curve

GENEVA SCHOOL OF ECONOMICS AND MANAGEMENT

UNIVERSITÉ DE GENÈVE

Background: The Experience Curve I

Basic premise: Repetitive tasks should result in productivity for subsequent, similar tasks This improvement is usually quantified at a rate $Y = AX^b$, where

Y represents the inflation-adjusted production cost per unit of a product

X represents the total cumulative production of a product

b is the experience parameter not to be confused with the learning rate.

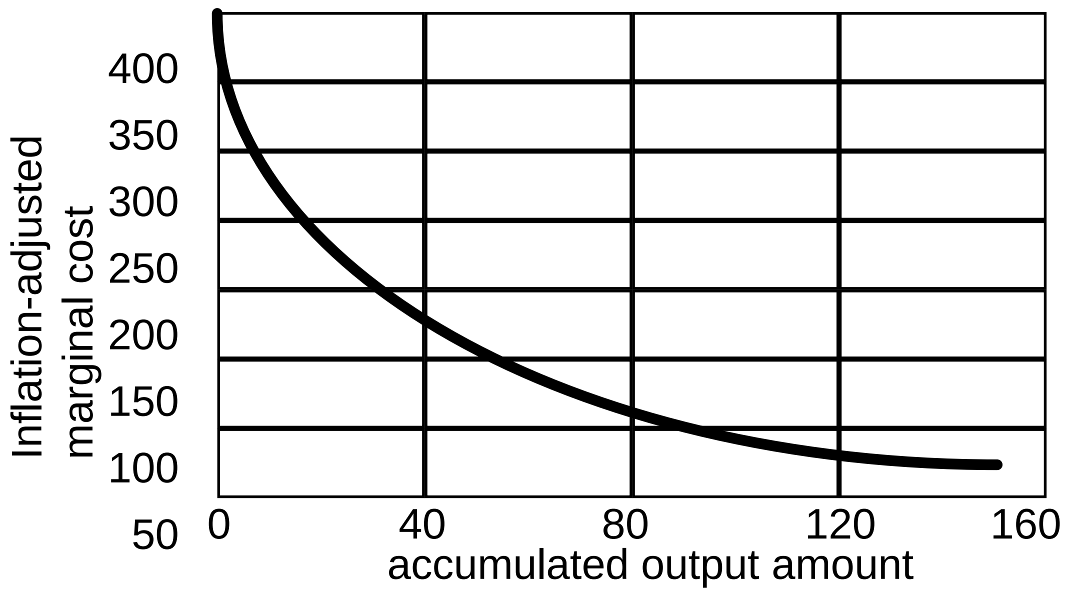
A represents the production cost of the first unit

In simplest terms, the cost of manufacturing or installing a unit should decrease as the number of units involved increases. As the number of units produced doubles, the cost per unit decreases by a fixed percentage

The concept of learning curves is not new, originated in the mid-1930’s with T.P. Wright in the Journal of Aeronautical Sciences. This empirical „Law“ has been (re)discovered by The Boston Consulting Group in the 60ies and has been empirically validated in various industries

Background: The Experience Curve II

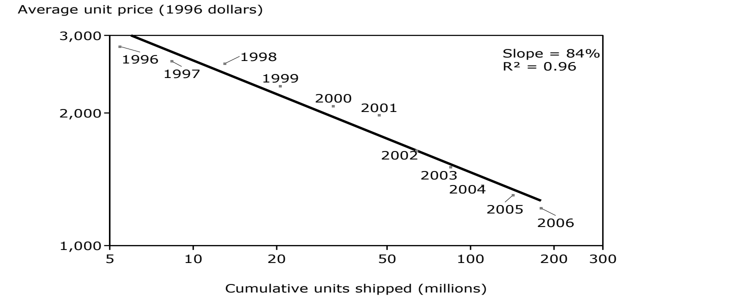
- The experience curve reflects declining cost as a function of accumulated experience operationalized through accumulated output.
- Efficiency results not only from repetition but also from product and distrubution innovations as well as product design simplifications.
- The experience curve shows the interrelation that exists between:
  - the potential of a cost decrease and
  - accumulated output in a certain period of time



Each duplication of the accumulated output of a product in a certain period of time decreases the inflation-adjusted marginal cost with a constant percentage (typically between 10-30%), the learning rate.

Examples of Experience Curves

Price experience curve: Dell PCs (US; 1996-2006)



Notes: Units include entire Dell product portfolio
Source: CSFB and UBS analyst reports

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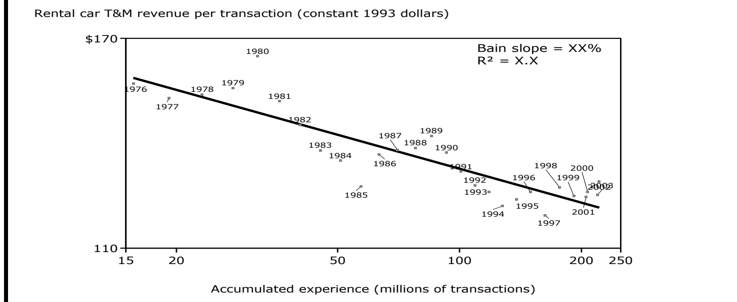
Price experience curve: rental cars (US; 1976-2003)



Note: Pricing doesn't include pass-thrus; 2003 Avis LOR decreased 3%, average price per day increased relative to 2002; 1996 - 97 pro forma adjusted for First Gray Line acquisition; Slope shows percentage change in unit price as accumulated experience doubles
Source: Avis Domestic Car Rental Operations Key Data (CY1975-1999); Avis Domestic Car Rental Operations Key Data (2000-2003)

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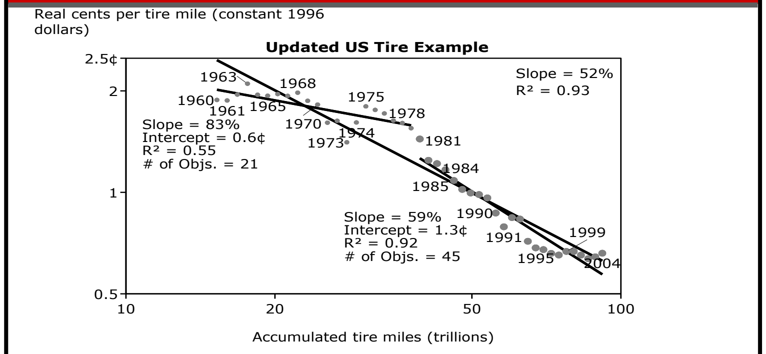
Cost experience curve: radial tires (US; 1960-2004)



Sources: National Transportation Statistics 2005 (Bureau of Transportation Statistics); MTD Annual Factbooks; previous e-curve (1960-1980 prices converted on percentage change basis)

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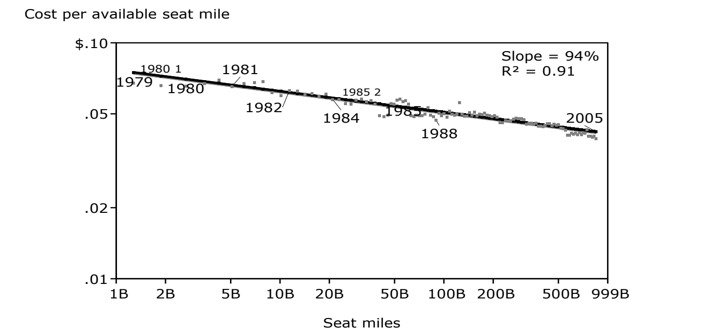
Cost experience curve: Southwest Airlines (US; 1979-2005)



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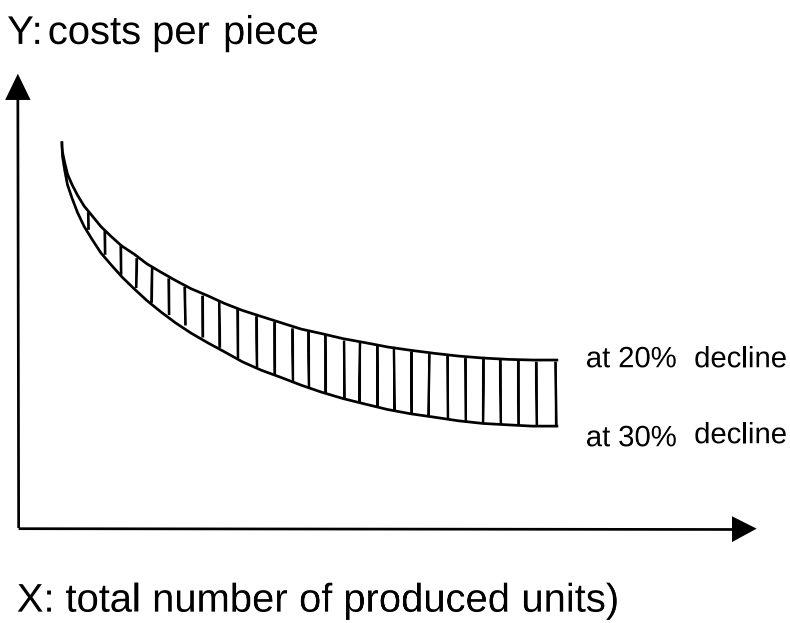
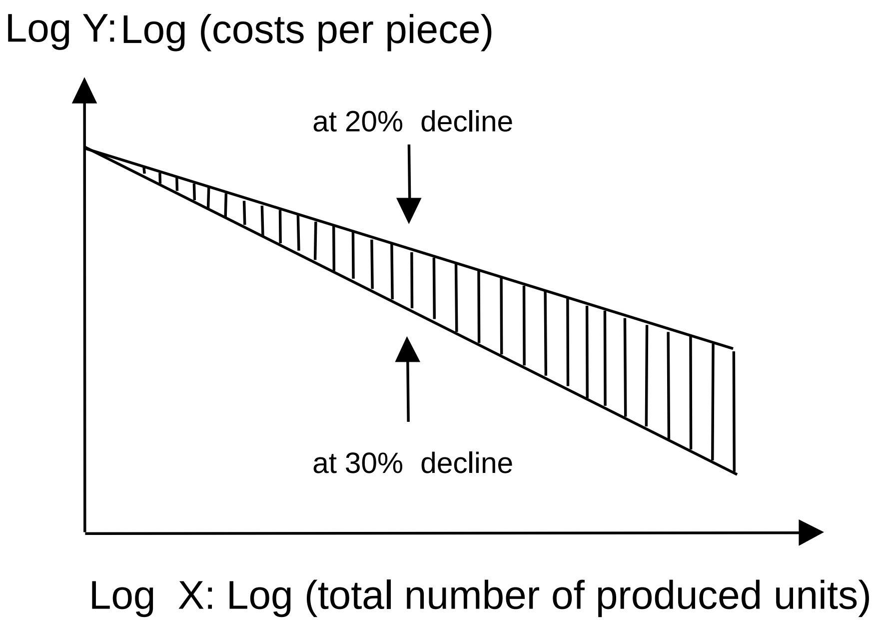
Graphical Visualization of Experience Curve for Linear / Double Logarithmic Scaling

(a) Linear Scaling



(b) Double Logarithmic Scaling



➲Adapted from Homburg & Krohmer, 2000, p. 74

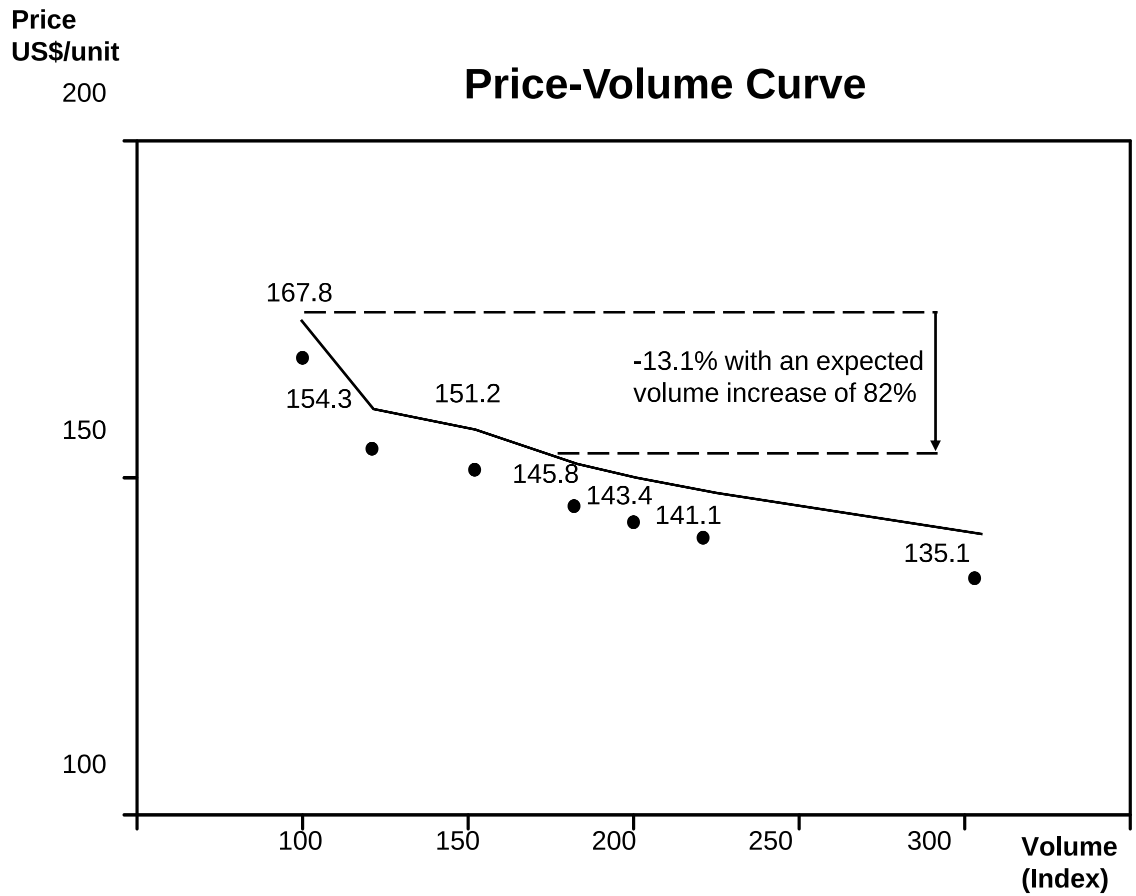
Learning Rates for different Products

Examples:

Product groups	**Learning rate**
Electric stove	11.7 %
Automobile	12 %
Air conditioning	12.3 %
Wash-dryer	12.5 %
Gas stove	17.2 %
Television set	20.0 %
Electric razor	23.0 %
Integrated circuit	27.8 %
Semiconductor	40-50 %

Applications of the Experience Curve I

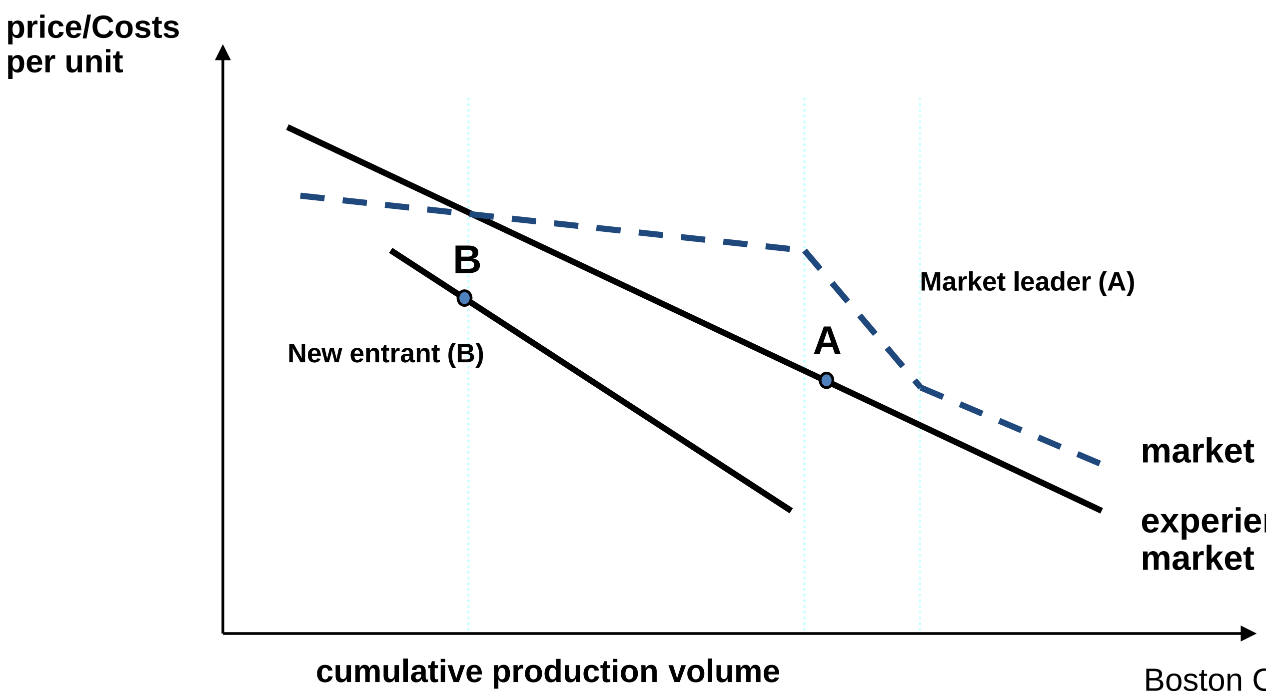
Example Supplier Consolidation: Effect of Increased Volume on Price -Metal Components-



Source: Bain Purchasing Practice

Consequences for Pricing Strategy

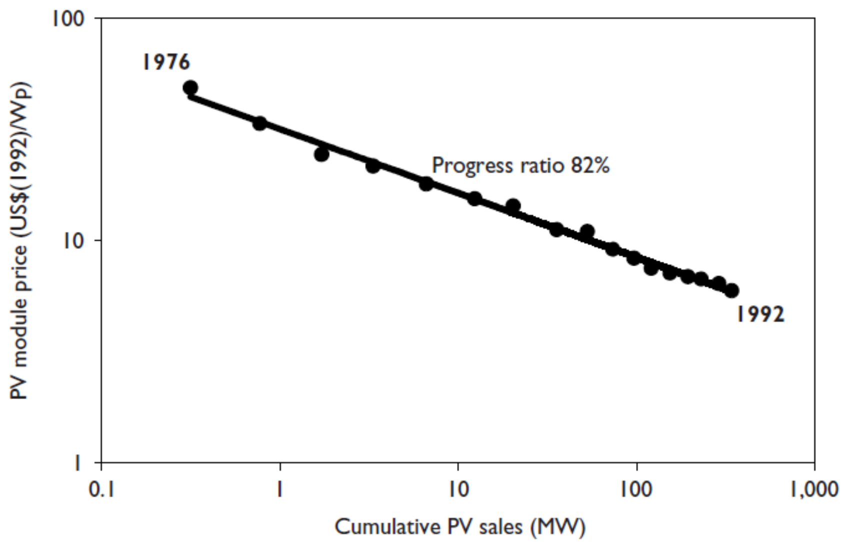
- Early entrance into a market allows a price premium
- High prices encourage competition



Boston Consulting Group 1968

Applications of the Experience Curve III

Figure 1.1. Experience Curve for PV Modules, 1976-1992



Experience curve for photovoltaic modules on the world market. The price for a module is given in constant 1992 US$ per peak watt, W_p. Peak watts are the power output from the module at optimum solar conditions as defined by certification agencies. Adopted from Williams and Terzian (1993).

The experience curve equation

The trend line in Figure 1.1 is a fit of a power function to the measured points. It is this line which is commonly referred to as the "experience curve". The curve is described by the following mathematical expression.

$$\text{Price at year } t = P_0 * X^{-E}$$

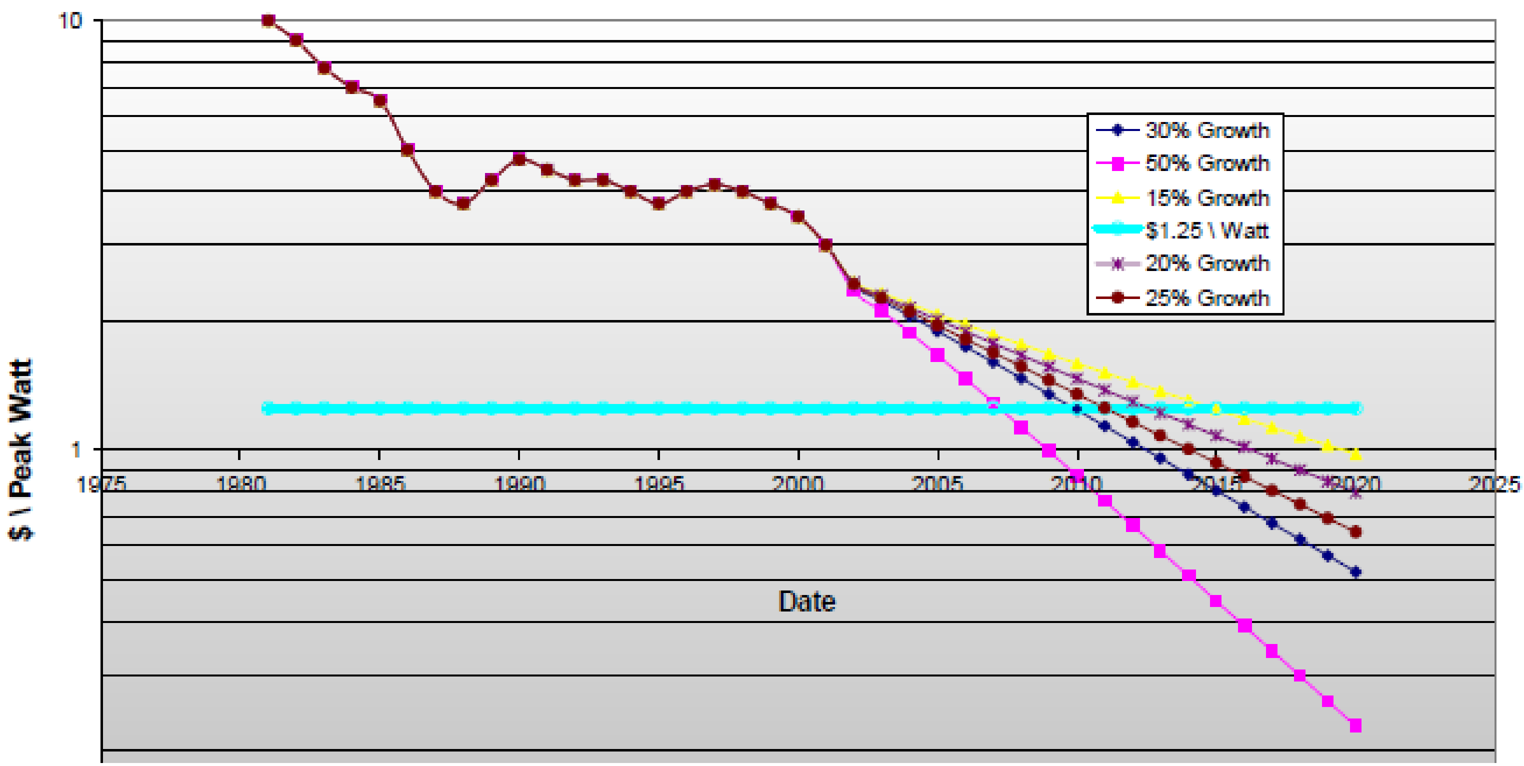
"P_0" is a constant equal to the price at one unit of cumulative production or sales. In Figure 1.1, P_0 is the price at 1 MW of cumulative sales and is equal to 32 US$(1992)/$W_p$. "X" is cumulative production or sales in year t. X in Figure 1.1 is the sum total in MW of all PV-Modules sold world-wide until the year t. For instance, in the year t = 1992 the price is 5.9 US$/$W_p$ and the sum of all sales until 1992 is 340 MW. "E" is the (positive) experience parameter, which characterises the inclination of the curve. Large values of E indicate a steep curve with a high learning rate. The relation between the progress ratio, PR, discussed in the text and the experience parameter is

$$PR = [P_0 * (2X)^{-E}] / [P_0 * X^{-E}] = 2^{-E}$$

The experience parameter for the curve in Figure 1.1 is E = 0.29, which gives a progress ratio of $2^{-0.29} = 0.82$ or 82%.

Forecasting future cost/prices of products

Influence of Market Growth Rate on Cost



The Heliotronics Case – A Customer from Switzerland

Heliotronics is a Massachusetts-based company that promotes innovative ideas and products to foster the adoption of utility grid-connected photovoltaic (PV). Also, the firm devises educational programmes dealing with sustainable energy production to local population and business prospects.

Heliotronics solar panels are currently functioning in 28 US states and in Canada. US clients include Harvard Business School, Piscataway Township School and the Barnard School.

The demand of solar panels is high and forecasts show high growth rates for the coming years. Several players attempt to enter in this high potential and profitable industry leading to a drop of market prices for solar panels. Americans and Europeans manufacturer are leading in producing high quality solar panels; Chinese firms are currently not able to match the high quality panels from the US and Europe but challenge the market with very low prices.

In June 2020, the sunny Canton Tessin in Switzerland has decided to equip most of its public building roofs with solar panels to cut down energy costs in the long run and to tackle sustainable development objectives. A call for tenders has been launched for 400 new solar panels to be delivered and installed in June 2022. Quality and price are important decision criteria to select a supplier. Interested companies should make a bid by December 2020.

The Heliotronics Case – What is a „good“ price?

Mr Clayton Handleman is the CEO of Heliotronics. He is very interested in this substantial contract from Switzerland and wonders about a competitive price for the bid. Mr Handleman discusses the bid with the company’s production director. Due to the substantial time lag between bid and offer it is not an easy task to determine a price for the bid. Especially since prices have decreased substantially over time in the past. The company’s production director estimates that by the time that Heliotronics will start producing the 400 solar panels for the canton Tessin in the second quarter of 2022 an additional 2400 solar panels will have been produced. Thus, the total production volume will be 4600 Units when the company starts to produce for the canton of Tessin. The estimate is too a large degree based on already existing orders. Indeed, it would be possible to produce the requested solar panels from April 2022 onwards and benefit from some productivity gains in the meantime.

We know from the experience curve that per unit production costs tend to decrease by a relatively constant percentage every time cumulative output doubles. Therefore, by the time Heliotronics will start manufacturing the 400 solar panels for the canton Tessin production cost per unit will likely have decreased because of the 2400 extra solar panels produced in the meantime. Due to the price-aggressive competition Heliotronics wants to make a competitive bid. In order to do that Mr. Handleman wants an estimate of the likely productivity gains that can be realized until April 2022 when the production of the solar panels for Switzerland would start. You are the business analyst in charge of providing an estimate about the average manufacturing cost for the solar panels for Switzerland. The accounting department provides you with data on the development of the average manufacturing cost per solar panel since heliotronics has started to produce solar panels a couple of years ago.

The Heliotronics Case – Data on Manufacturing Cost

Total number of solar panels produced at Heliotronics	Average manufacturing cost per solar panels at Heliotronic in $
100	1250,00
200	1108,70
300	1053,50
400	1033,40
500	989,80
600	999,00
700	914,90
800	931,00
900	922,30
1000	861,90
1100	820,90
1200	823,20
1300	876,70
1400	817,20
1500	837,20
1600	815,30
1700	804,60
1800	765,30
1900	820,60
2000	828,10
2100	765,20
2200	784,50

Table 1: Cumulative solar panel production at Heliotronics and average manufacturing cost per solar panel

To help Mr Handleman to determine a competitive price bid for the canton Tessin you need to estimate the manufacturing cost per solar panel for the 400 solar panels produced for Switzerland starting in April 2022. Please answer to the following questions:

1.Use an electronic spreadsheet to plot the data displayed in table 1 and draw a scatter plot (point diagram). Does the multiplicative learning model which assumes the following relationship: $Y = AX^b$ apply to this data set? In our case Y are the average manufacturing cost of the last batch of 100 solar panels at Heliotronic in $ after having produced a cumulative production of X solar panels. In the table X represents the column labeled total number of solar panels produced at Heliotronics. b is the experience parameter not to be confused with the learning rate. A is the price or cost of the first unit. Obviously $Y = AX^b$ is not a linear relationship of the type that regression analysis can model ($\mathbf{y = a + b_1 x_1}$). So the question now is to transform the data in order to get a linear relationship. Make an appropriate transformation of the data and redo the plot with the transformed data.

2.Once you have answered the above questions, conduct a linear regression with the transformed data: Use R to estimate the regression model. Please interpret the results of the regression analysis! How well does the model explain the data? What is the learning rate that applies in this case?

The Heliotronics Case – Questions

3. Please use the experience curve estimate from the regression model to calculate the expected average manufacturing cost per solar panel for the 400 solar panels that would be produced. for Switzerland. **Hint: estimate the average production cost per solar panel for 4700, 4800, 4900 and 5000 units and compute their mean.**

4. Please calculate a 95% confidence interval for the average manufacturing cost per solar panel for the panels produced for Switzerland by using the lower and upper bounds of the confidence interval estimate for the experience parameter. You should calculate two extra regression equations for both limits and then calculate the expected average manufacturing cost per solar panel for the 400 solar panels that would be produced for Switzerland as in exercise 3.