Cost Estimation Techniques

Quantitative Cost Estimation Techniques

1. Unit Method
2. Factor Method
3. Index Method
4. Power-Sizing Method
5. Parametric Curve Fitting
6. The Learning Curve

1. Unit Method

Defined as the cost per unit: $/unit (the Unit Cost Factor)

Ex: $/hr $/mile $/sq.ft. $/kWh

Cost = (Unit Cost Factor) * (# Units)

$$C = fn$$

Ex. Annual Cost of Electricity = ($0.10/kwh) * (10,000 kwh/yr) = $1,000/yr

Ex. Cost of Construction = ($300/sf) * (2,300 sf) = $690,000

- Unit factors are often averages of a lot of data, and therefore can have a lot of variability.
- But they are very useful in providing quick estimates.

2. Factor Method

An extension of the Unit Method when there is more than one component to the cost equation:

$$C_{system} = (f_1 * n_1) + (f_2 * n_2) + (f_3 * n_3) + \ldots + (f_m * n_m)$$

$$C_{sys} = \sum_{i=1}^{m} (f_i * n_i)$$

where:

- C_{sys} = estimated cost of the system
- f_i = the unit factor for the i^{th} component
- n_i = the number of units associated with the i^{th} component
- m = the total number of components in the system

3. Index Method

Also known as the Ratio Method

An “index” related to how cost (or price) has changed over a period of time.

Ex. PPI = Producer Price Index (rate of inflation for producers)
CPI = Consumer Price Index (rate of inflation for consumers)

$$C_n = C_k \, (I_n / I_k)$$

where:

- C_n = estimated cost in year n
- C_k = actual cost in year k (the “reference” cost)
- I_n = index for year n
- I_k = index for year k

3. Index Method

Example: Andres needs to estimate the annual labor costs for a new production facility.

He obtains the following data:

- Labor Cost Index 10 years ago = 128
- Labor Cost Index today = 192
- Annual labor costs 10 years ago for a similar facility = $675,000

$$C_n = C_k \, (I_n / I_k)$$

The estimated annual labor costs today are:

$$C_{today} = \$675{,}000 \, (192 / 128)$$

$$C_{today} = \$1{,}012{,}500$$ *or about $1M*

3. Index Method

Solve: Michaela needs to estimate the cost of a new 5 MW natural gas turbine generator.

After a bit of research, she finds the following:

- The index for a gas turbine generator in 2005 = 156.4
- The index for a gas turbine generator in 2020 = 228.7
- A 5MW gas turbine costs $8 million in 2005.

What is the estimated cost of a 5MW gas turbine in 2020?

$$C_n = C_k \, (I_n / I_k)$$

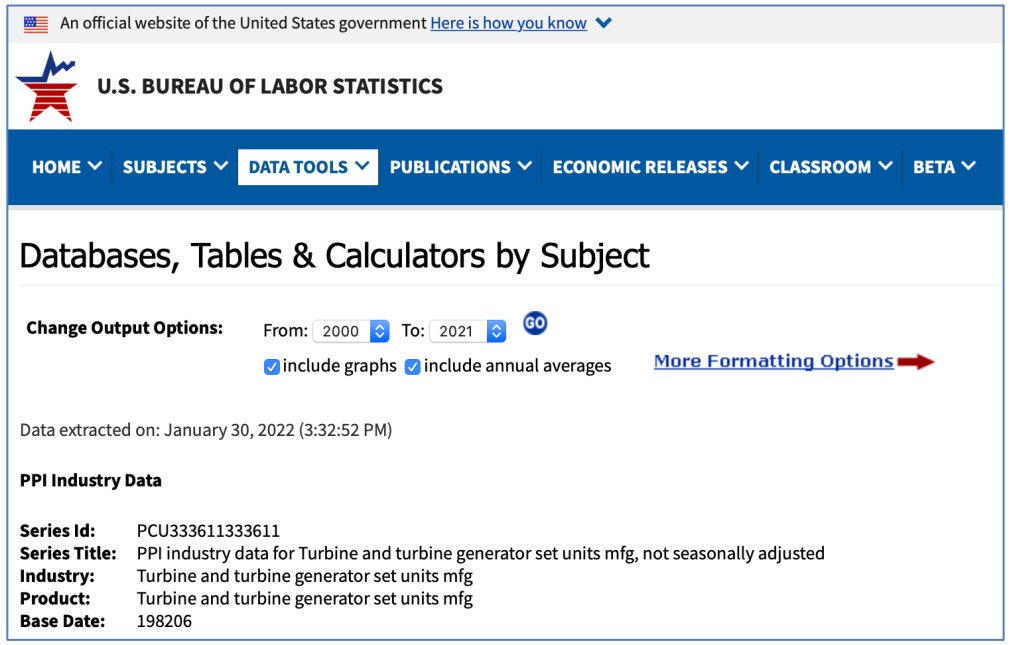
The estimated cost for the gas turbines is:

C_{today} = \$8,000,000 (228.7 / 156.4)

C_{today} = \$11,698,210 → *or since it is an estimate: \$11.7M*

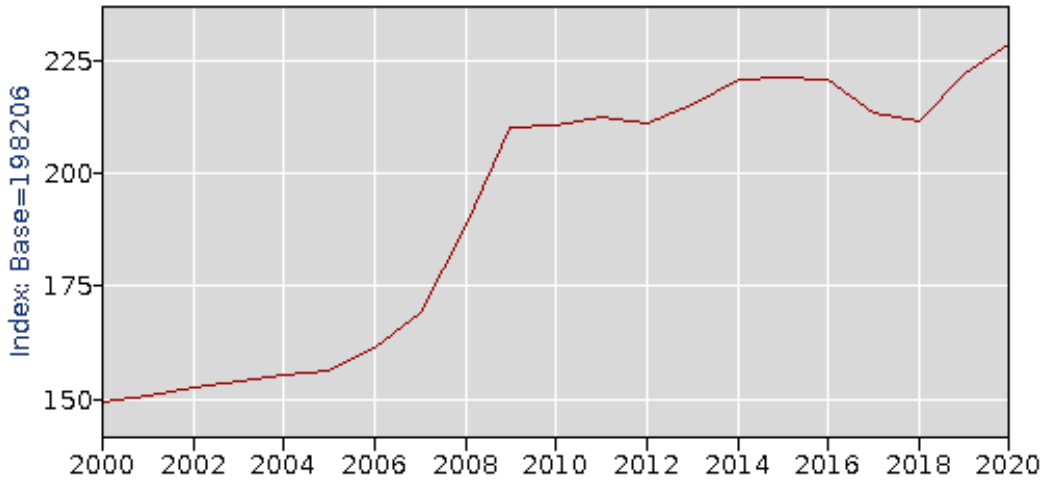
3. Index Method

So where did these indexes (indices) for gas turbine generators come from?



Check it out at: https://www.bls.gov

Year	Annual
2000	149.6
2001	150.8
2002	152.8
2003	154.0
2004	155.2
2005	156.4
2006	161.3
2007	169.0
2008	188.6
2009	209.9
2010	210.4
2011	212.5
2012	211.1
2013	215.0
2014	220.6
2015	221.1
2016	220.7
2017	213.5
2018	211.3
2019	222.2
2020	228.7



3. Index Method

Sometimes there are several cost components, each with its own index.

In this case, you can define a “weighted average index”

Ex. What is the weighted average index for a plant constructed in 2020, given the following:

Description	% of Total Cost	Index
Labor	20%	160
Materials	30%	125
Equipment	50%	200

$I_{avg} = 0.20\ (I_{labor}) + 0.30\ (I_{materials}) + 0.50\ (I_{equip})$

$I_{avg} = 0.20*160 + 0.30*125 + 0.50*200$

$\mathbf{I_{avg} = 169.5}$

4. Power Sizing Method

Used to estimate cost of equipment and industrial plants based on size, output, or capacity.

$$C_A = C_B \left(\frac{S_A}{S_B} \right)^X$$

where:

- C_A = the estimated cost of equipment A
- C_B = the actual cost of equipment B (similar to A, just different scale)
- S_A = the size (or output or capacity) of equipment A
- S_B = the size (or output or capacity) of equipment B
- X = the power sizing exponent = ***the cost capacity factor***

4. Power Sizing Method

Example: A 1GW nuclear power plant costs about $8B to build and commission. What would a 100MW power plant cost if the power sizing exponent is 0.7?

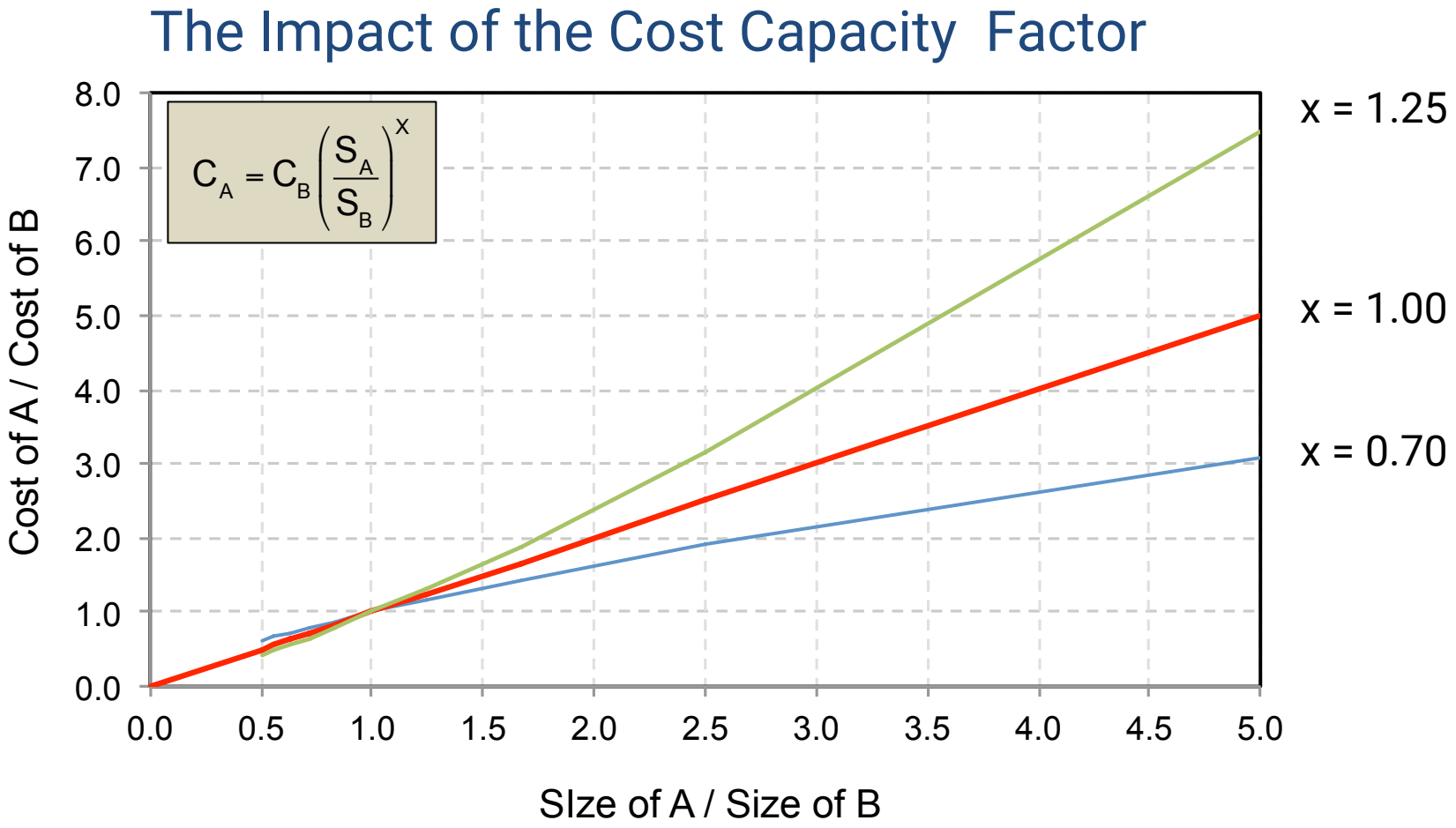
$$C_A = C_B \left(\frac{S_A}{S_B}\right)^x$$

$$C_{100MW} = (\$8B) \left(\frac{100MW}{1000MW}\right)^{0.7}$$

$$C_{100MW} = (\$8B)(0.20)$$

$$C_{100MW} = \$1.6B$$

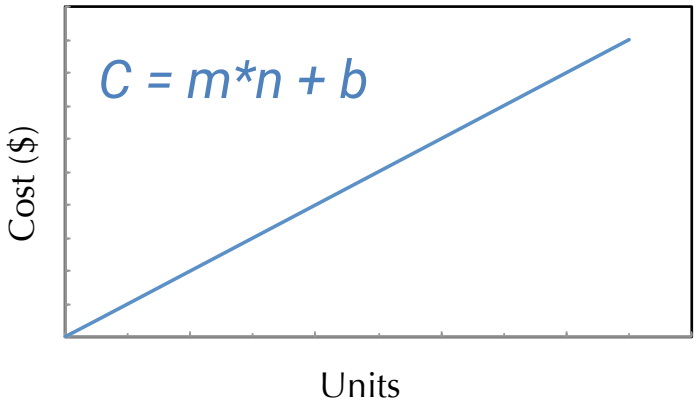
4. Power Sizing Method



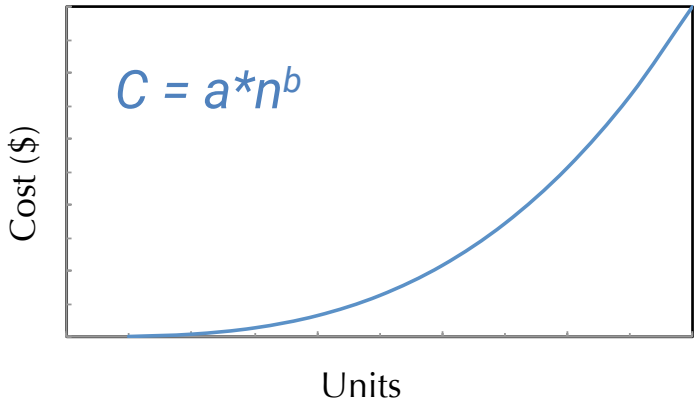
x < 1: Economies of Scale
x = 1: Linear dependence
x > 1: Diseconomies of Scale

5. Parametric Curve-Fitting Methods

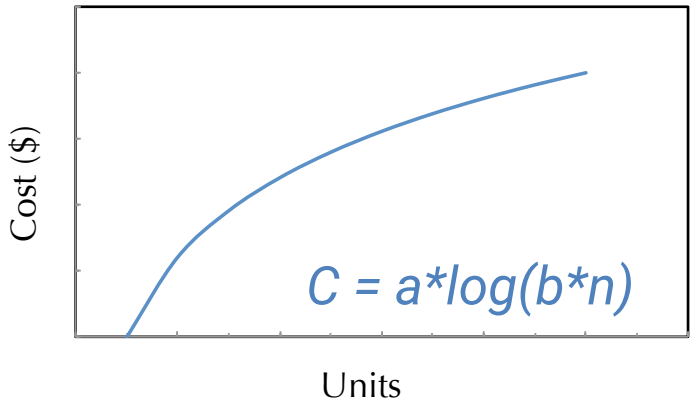
Linear Functions



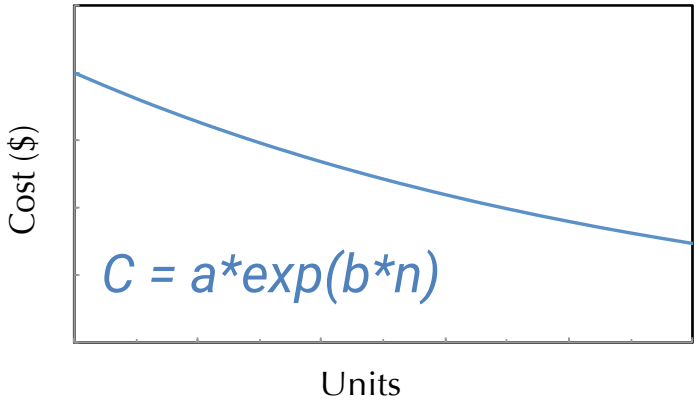
Power Law Functions



Logarithmic Functions



Exponential Functions



Main Takeaways…

- Cost estimation approaches include high-level “back of the envelope” estimates which are low cost but have high uncertainty, to very detailed analyses that take considerable effort but are very accurate.

- Several techniques were explored for estimating costs (with more to come).
  - ✓ Unit Method
  - ✓ Factor Method (an extension of the Unit Method)
  - ✓ Index Method
  - ✓ Power Sizing Method
  - ✓ Parametric Modeling (aka curve-fitting)

One of the hardest things to do in a financial analysis is estimating all the figures you need to perform the analysis!

Next Time…

Learning Curve Cost Models

Credits & References

Slide 1: One arrow hitting center target, horizontal banner by Olivier Le Moal, Adobe Stock (36961324.jpeg).

Slide 2: Pensive office worker wondering looking at side by Antonioguillem, Adobe Stock (201792382.jpeg).

Slide 5: Black electric bike isolated with clipping path by eshma, Adobe Stock (222853589.jpeg).

Slide 8: Screen shot from US Bureau of Labor and Statistics, *https://www.bls.gov (accessed April 14, 2022).*

Slide 11: Aerial view of nuclear power plant Temelin in Czech republic, European union by peteri, Adobe Stock (423820949a.jpeg).

Slide 15: Red downward arrow with coins stacks background by somchairakin, Adobe Stock (166656851.jpeg).