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The Use of Indexes for Trending in Engineering Valuation

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Abstract: Three types of indexes are indicated in this write up namely cost, mathematical and catalog indexes. Cost indexes are used for trending in engineering valuation. A cost index is defined as a dimensionless number used to trend the cost of an item from one time period to another. It is also a ratio of the real price in a given time period against that of a selected base period multiplied by 100. Trending which is one of the methods used in engineering valuation is the application of an index factor to the historical cost of an item in order to estimate the current cost of the item and vice versa. This application is demonstrated in this article. Additional examples on trending are indicated in the supplementary exercises at the end of the article. Indexes are meant to serve as guide and should not be used if more reliable methods are available. Appraisers must therefore exercise caution and good judgment in their use.

Keywords: Indexes, Trending, Engineering Valuation

Introduction

The types of indexes include cost indexes, mathematical indices and catalog index.

Cost indexes___A cost index is a dimensionless number used to adjust the cost of an item from one time period to another. The adjustment is necessary because of the changing value of money with time (Humphreys, 1991). A cost index is also the ratio of the actual price in a time period compared to that in a selected base period (a defined point in time or the average price in a certain year), multiplied by 100 (Wikipedia, 2019).

Mathematical indices

An index number is a number which is raised to a power. The power which is known as the index tells you the number of times you have to multiply the number by itself. For example, 2^5 means that you have to multiply 2 by itself five times. That is 2x2x2x2x2= 32.

There are six laws of indices. The first law of indices states that when multiplying two identical numbers with different powers, the answers will be the same number to the power of both exponents added together. That is $2^2x2^3 = 2^5 = 32$. The laws expressed mathematical are as follows (http://m/youtube.com.watch).

x^o	=	1
x^{-n}	=	$\frac{1}{x^n}$
x^n	x	$x^m = x^{n+m}$
$x^n \div$	x^m	$= x^{n-m}$
$(x^n)^m$	$= x^{nm}$	
$x^{n/m}$	=	$\sqrt[m]{x^n}$

Catalog index

This is a list of words or phrases and associated pointers to where useful materials relating to that heading can be found in a document or collection of documents. Examples are an index in the back matter of a book and an index that serves as a library catalog (Wikipedia, 2019).

Trending in Engineering Valuation

We are interested in cost indexes for engineering valuation. Cost indexes are used in trending. Trending is a method of pricing whereby an index factor is applied to the historical cost of an item in order to estimate the current cost of the item. When applying an index factor to trend the historical cost, the resulting trended cost represents the production cost new of the trended asset, not necessarily the replacement cost. Trending is therefore one of the methods adopted in engineering valuation.

Engineering valuation is the estimation of the monetary worth of a class of tangible assets that are held by a company for use in the production or supply of goods and services, for rental by others or for administrative purposes and expected to be used over a long period of time. Company assets include Plant and machinery, Vehicles, Land & buildings and Furniture/ Fixtures. (IACE, 2019)

Sources and uses of cost indexes

The sources and usefulness of cost indexes are presented as follows: Majority of indexes are developed using standard mix of costs of an asset within a typical classification and/or industry. Therefore, the use of an index in trending may or may not produce the actual value of a specific item. In other words, the specific asset value may not be

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accurate. However, the total value of all the assets may be reasonably correct. Indexes are designed to include many cost related factors. It therefore requires sound professional judgment as well knowledge of the source and limitations of the index in applying same. Representative sources for index data include the Bureau of labour statistics of the US Department of Labour, R.S. Means Company, Marshall Valuation Services and other national and regional sources like the Central Bank of Nigeria and the National Bureau of Statistics.

Machinery and equipment indexes are not sufficient as those for some industries such as construction. However, information can be found in many trade magazines such as American Machinist, Chemist Engineering, Engineering New Records (ENR) (Quarterly reports), Iron Age, and Oil & Gas Journal. Some of these magazines actually publish an index while other produce information that must be posted from which an index may be developed. Additional index information for machinery and equipment is available from sources like Handy-Whitman (for public utilities), Statistics Canada (Ottawa), and the US Department of Labour (Producer Price Indexes).Finally, individual appraisers and appraisal firms can develop indexes to suit their own special needs as done by many insurance companies and engineering firms.

Application of an index

An index may be a useful tool in estimating the current cost of a machine from its historical cost. This is known as cost trending. Conversely, the same index may be used to estimate the historical cost when the current cost is known. This is sometimes referred to as reversed trending.

Example 1: To illustrate the use of an index to update the cost of a heat-treating furnace manufactured by a company in 1988 for $10,000. The problem is to determine the cost of the same oven (furnace) in 1995. Assume we have developed the subsequent indexes based on the manufacturer's actual price increase over years, considering that no technological improvements occurred.

Year	Index
1985	229
1986	234
1987	240
1988	251
1989	286
1990	307
1991	322
1992	341
1993	349
1994	367
1995	390

Solution: Find the change over time by using the differences in the
annual indexes or
Current index (1995) ÷ Historical index (1988) = Trend Factor
Trend factor x Historical cost = Current cost
(390÷251) x 10000 = 1.5538x10000 = $15538

Example 2: A project was built in 1986 at a cost of $750m.
The index for this project in 1986 was 238. What would be the project cost in 1989 if the index is 320 in 1989?

Solution: $\frac{320}{238}$ x 750m = $1008m

All indexes are calculated from a base year and vary depending on the index and when it began. To convert all indexes to a common base year, one may use the following relationship

Index value on new base = $\frac{\text{index value (Old base) to be converted}}{\text{index value (Old base for new base year}}$ x 100

Example 3: Convert the ENR Building cost index of March 1989 based on 1913 = 100 to a base year of 1967. The index for March 1989 is 2616 and 676 for 1967 based on 1913 = 100 (Engineering New Record, ENR).

Solution: The Index value for the new base year (1967 average value) on the old base year (1913=100) is 676
$\frac{2616}{676}$ x 100 = 387, ENR Building Cost Index for march 1989 (1967=100)

Limitations of indexes

Indexes are established for many different purposes. Their use may lead to erroneous result unless the appraiser is aware of the purpose for which the index was developed and the weightings or the mix used in developing the index.

For example, if functional obsolescence was considered when the index was prepared, an appraiser has to be aware of this fact, especially during the determination of the overall price changes without allowing for design modifications.

An index entitled machine shop may be presumed to reflect overall price changes in metal cutting machinery only if the percentage of the total weighting assigned to milling machines, drills,

grinders, numerical control turning machine is considered. If such an index is used to trend the cost of the entire machine shop with the appropriate mix of the shop in question, then the resulting trended total cost would probably be reasonable. However, if the same index was used to trend the cost of an individual machine, the result might well be incorrect by a large percentage.

Conclusion

Remember that an index represents average changes in cost. The broader the index, the more average costs are used.

Indexes are meant to serve as guide and should not be used if more reliable methods are available. Appraisers must therefore exercise caution and good judgment in their use.

In the periods of rapid inflation, it is not advisable to trend prices from a broad-based index for period longer than five years without comparing the trended results against other sources.

It is important when using indexes to be certain that the proper index is applied. Indexes are designed to measure relative cost changes for various items over time and generally will give erroneous results if applied to something else.

References

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Suplementary Exercise On Trending With Indexes

Exercise 1

Twelve years ago, a client purchased a new x-ray machine for $25,000 installed. Since then the manufacturer has serviced the machine in accordance with all maintenance recommendations, and the normal useful life of the machine is 12 years. Using the sample indexes below, what is the estimated cost to replace this machine today? What would the cost have been three years ago? What would the cost have been six years ago? (Carry all index factors out to four decimal places, rounded.)

Sample Equipment Indexes

Age	50 Industry Average	Metalworking	Machine Shop	Office Equip	Electrical Equip	Medical Equip
15years ago,	580	700	735	500	630	715
14years ago,	640	770	810	555	700	785
13years ago	670	805	845	575	720	820
12years ago	680	825	865	590	720	840
11years ago	700	845	890	600	750	860
10years ago	710	860	900	615	755	880
9years ago	715	870	915	620	760	885
8years ago	730	880	925	630	770	900
7years ago	760	915	960	660	815	935
6years ago	800	960	1,000	690	860	980
5years ago	820	990	1,040	710	875	1,010
4years ago	835	1,010	1,050	720	880	1,030
3years ago	845	1,015	1,065	725	890	1,035
2years ago	860	1,030	1,080	735	900	1,050
1year ago	890	1,060	1,115	750	920	1,080
Current	930	1,120	1,180	800	975	1,140

Note: The above numbers are hypothetical for teaching purposes only.

Solution Exercise 1:

X-ray machine is a medical equipment.
Trend factor = 1140/840 = i.3571 (12 years life).
Current cost = 1.3571 x 25000 = $33928.57
Trend factor = 1035/840 = 1.2321 (3 years ago).
Current cost = 1.2321 x 25000 = $30803.57.
Trend factor = 980/840 = 1.1667 (6 years ago).
Current cost = 1.1667 x 25000 = $291667.67.

Exercise 2
Using the sample indexes above, develop trend factors (4 decimal places) and apply to the historical costs. (Use two decimal places for the trended cost.)

Item	Historical Cost New and Age	Trended Factor	Trended Cost
Uncoiler, McKay, 15-hp motor, 50,000-pound capacity	15 years ago $18,500		
a. Machine shop/50 Industry Average	1180/735	1.6054	29699.90
Entrance pinch roll, McKay, 20" diameter x 88" long, 15-hp gear motor	10 years ago $62,500		
b. Machine shop/50 Industry Average	1180/900	1.3111	81943.75
Leveler, Bliss, with 11"- 12" diameter rolls, 100-hp DC motor	12 years ago $48,500		
c. 50 Industry Average/Machine shop	930/680	1.3676	66328.60
Side trimmer and scrap chopper, Bliss, 72" maximum capacity, 60-hp DC motor	13 years ago $75,000		
d. Metalworking/50 Industry Average	1120/805	1.3913	104347.50
Scrap conveyor, Bliss, steel frame, 36" x 100" steel mesh belt, 15-hp motor	14 years ago $20,000		
e. Metalworking/ Machine shop	1120/770	1.4545	29090.00
Lab oven, solar model XK4-3000, SN 1796541	14 years ago $1,400		
f. Medical equipment	1140/785	1.4522	2033.08
Microscope, B&H model 200x5, SN 79384	12 years ago $350		
g. Medical equipment	1140/840	1.3571	474.99
Forklift, Datsun, model M4000, SN5543	10 years ago $7,275		
h. 50 Industry Average/Machine shop	930/710	1.3099	9529.52
Computer, IBM, model XT, SN 62351	8 years ago $2,800		
i. Office equipment	800/630	1.2698	3555.44
Calculator, Olivetti, Divisuma, model D-24, SN 16398	11 years ago, $330		
j. 0ffice equipment	800/600	1.3333	439.99
Progressive die, shop built	5 years ago $6,800		
k. Metalworking/ Machine shop	1120/990	1.1313	7692.84
Desk, wood, exec. Double pedestal 84" x 36"	7 years ago $3,765		
l. Office equipment	800/660	1.2121	4563.56
550 linear ft, stainless steel process piping	10 years ago $5,500		
m. 50 Industry Average/Machine shop	930/710	1.3099	7204.45
Electrical distribution panel, 1,200 amp. W/12 20-amp switches, 1-600 amp main switch. n. (Electrical equipment)	15 years ago $3,700 975/630	1.5476	5726,12

Note: The above costs are hypothetical for teaching purposes only.