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Cost and scale-up factors, international inflation indexes and location factors

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Abstract

This paper updates and expands upon a previous study (Int. J. Prod. Econom. 54 (1998) 41) on cost and location factors used in the US and internationally. The current study includes 43 US cost and location factors and 30 international cost and location factors for 12 countries. In addition, cost scale-up factors for a wide variety of equipment, plants and processes from air pollution abatement to waste-to-energy facilities are presented. This study reviews the use of these indexes and scale-up factors, and presents caveats for their use.

Keywords: Cost estimation; US and international inflation and location indexes; Cost-capacity factors; Scale-up factors; *R* factors

1. Introduction

Project planners and estimators frequently find themselves making quick order-of-magnitude estimates of the cost of projects such as the construction of a new plant or to estimate the budget for a new Internet startup. If the cost of similar projects is available, a cost estimator can make adjustments for variables such as time, location and size. These calculations require the use of appropriate cost scale-up and location factors. Cost indexes measure the cost of a given project relative to a basis. An inflation index typically references a base year, which is assigned an index value of 100. Index values for other years are proportional to the base year in the same ratio as their cost.

The first cost indexes were developed by Carli in 1750 to determine the effects of the discovery of America on the purchasing power of money in Europe. One type of cost index is the inflation index, which attempts to adjust costs of similar projects during different time periods. The engineering news record (ENR) index started in 1909 is the oldest inflation index currently used by engineers (Grogan, 1994). Scale-up factors are used today for estimating the cost of chemical plants, air pollution control or waste to energy facilities, for example.

One of the problems in using cost indexes and scale-up factors is finding the most appropriate data to use. The major purpose of this paper is

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to present a large number of indexes categorized to help the cost estimator locate the correct one to use. This paper will review the use of inflation and location indexes and capacity scale-up factors, the different types available, and some caveats for using them.

2. Cost indexes and scale-up factors

Inflation indexes track the change in costs for similar projects for different time periods. Location indexes are used to adjust project costs for different locations. Cost capacity factors adjust the cost of similar projects of different sizes or capacities. Through the use of cost indexes, a cost estimator could use construction cost data for an oil refinery built in Chicago in 1995 with capacity X to estimate the cost of a similar oil refinery to be built in Houston in 2001 with capacity Y.

Inflation and location indexes use a base year or location, respectively, to generate index values. The ratio of the two values used is the ratio of their costs. A cost estimator uses the index values for Project 1 (with known cost) and for Project 2 (with unknown cost) to calculate the cost of Project 2. The following equation summarizes the use of these two indexes:

$$\text{Cost}_2 = \text{Cost}_1 \left(\frac{\text{Inflation Index}_2}{\text{Inflation Index}_1} \right) \times \left(\frac{\text{Location Index}_2}{\text{Location Index}_1} \right). \quad (1)$$

Cost capacity or scale-up factors are used for estimating the costs of projects of different sizes. In contrast to inflation and location indexes, the ratio of the capacities of two similar projects is *not* usually the same as the ratio of their costs. Let us assume Project 2 is similar to Project 1, but has twice the capacity. Usually these will be *economies of scale*, such as for chemical plants. In this case, the cost of Project 2 will be *less* than twice the cost of Project 1. Scale-up factors handle this type of adjustment, as shown in the following equation:

$$\text{Cost}_2 = \text{Cost}_1 \left(\frac{\text{Size}_2}{\text{Size}_1} \right)^R. \quad (2)$$

There are three cases encountered. The most common case is when $R < 1$ and we have *economies of scale* (Remer and Chai, 1990a, b, 1993a, b; Remer and Idrovo, 1990, 1993; Remer et al., 1994; Remer and Wong, 1996). In a few cases, such as for single screw, stainless steel extruders where the R factor is 2.60 (Remer and Chai, 1990b, 1993a) and international airports where the R factors are 2.90 (Remer and Wong, 1996), there are *diseconomies of scale* and $R > 1$. For modular type facilities, such as membranes used in water treatment, $R = 1$. Combining Eqs. (1) and (2) above yields

$$\text{Cost}_2 = \text{Cost}_1 \left(\frac{\text{Inflation Index}_2}{\text{Inflation Index}_1} \right) \times \left(\frac{\text{Location Index}_2}{\text{Location Index}_1} \right) \left(\frac{\text{Size}_2}{\text{Size}_1} \right)^R. \quad (3)$$

For more details on determining R from a set of data, refer to Remer and Idrovo (1990, 1993), Remer et al. (1994) and Remer and Wong (1996).

3. Different types of cost and scale-up factors

Cost indexes can be categorized by compiler intent, measured cost, industry or location. Compilers use cost indexes for: contractor price, valuations and general or special purposes. Contractor price indexes measure the change in selling prices of various types of buildings, such as the Turner general building index. Valuation indexes represent replacement costs, such as the Marshall and Swift industrial equipment index. General-purpose cost indexes cover a broad spectrum of a particular industry of a type of cost, such as the ENR index for construction. Special-purpose indexes cover a particular industry, such as the

Nelson–Farrar Refinery cost index or the Handy Whitman Public Utilities index.

Another difference between cost indexes is the type of cost that is measured. Indexes can measure labor, construction, operation, equipment, commodities, and other types of project costs. These costs can be further subdivided. For example, a compiler of a construction cost index could consider engineering, material, labor, and land costs as sub-costs of construction. Cost indexes can also be categorized by industry, such as chemical engineering, manufacturing, or biotechnology.

Cost indexes differ by the location to which they apply. Because cost indexes are usually based on data from a specific region, cost estimators should ensure that the indexes apply to the project location.

4. Notes on using the listings in this study

Lists of cost indexes and scale-up factors are presented in Appendices A–C. Appendix A contains cost and location factors for projects located within the United States. Appendix B contains indexes compiled with international data. International indexes for 12 specific countries are listed by country name, while those compiled with data from many countries are listed under the location "worldwide". Appendix C summarizes references for scale-up factors for specific industries or facilities.

Appendices A and B contain the following information about each index:

- Index name;
- Cost measure;
- Location (Appendix B);
- Industry;
- Compiler information: includes address, phone and FAX number, email and web address);
- Index availability: includes how often index is updated, where it can be obtained, and cost of subscription/copy;
- Description: contains extra information to allow the reader to differentiate between two indexes and choose the one that is most appropriate to his/her project.

Appendix C contains the following information:

- Industry or field;
- Information on references including authors and publishers.

5. Example

Suppose that in the year 2000, a cost estimator needed to calculate the construction cost for a new waste-to-energy facility in location 1, with a capacity of 2000 TPD (waste disposal capacity measured in tons per day). The estimator knows that a similar facility with 1000 TPD was built in another part of the country, say location 2, in 1995, with a total cost of $70 million. After a literature search, the cost estimator finds the applicable cost capacity factor of 0.90 for waste-to-energy facilities (Ellsworth and Richard, 1998). Using the Chemical Engineering M & S Index, she gets the inflation cost factors of 1089.0 for the year 2000 and 1027.5 for the year 1995. From a location reference source such as Richardson's, she finds a ratio of 1.1 for location 2 versus location 1. Using Eq. (3):

$$\text{Cost}_2 = \text{Cost}_1 \left(\frac{\text{Inflation Index}_2}{\text{Inflation Index}_1}\right) \times \left(\frac{\text{Location Index}_2}{\text{Location Index}_1}\right)\left(\frac{\text{Size}_2}{\text{Size}_1}\right)^R$$

she obtains

$$\text{Cost}_2 = (\$70\text{ million})\left(\frac{1089.0}{1027.5}\right)\left(\frac{1.1}{1.0}\right)\left(\frac{2000}{1000}\right)^{0.9},$$

$$\text{Cost}_2 = \$138\text{ million}.$$

Therefore, the estimated rough cost of the new waste-to-energy facility is $138 million.

6. Caveats

- Inflation indexes are statistically weighted composite averages, and thus, should only be

used for ballpark or order-of-magnitude calculations.

- Inflation indexes are usually limited in scope to a particular industry or industrial segment. As noted by Miller (1995), the ENR construction index may be misapplied in the process industries (Park, 1973). The ENR index was intended for use with civil engineering projects involving large quantities of unskilled labor, which may not be the case for process plants or process plant equipment.
- Inflation indexes measuring similar types of cost may be constructed of different weighted averages of sub-costs. For example, the Bureau of Labor Statistics compiles two Employment Cost Indexes for various types of workers, one for benefits and the other for wages and salaries (Monthly labor Rev., 1995). Examining the cost measured by a particular inflation index and how the index is calculated increases the probability of an accurate cost estimate calculation.
- Some indexes do not account for technological changes in design and construction. As technology progresses, the cost weightings for a particular index can change, which may or may not be reflected by the inflation index. For example, production technology developments may shift manufacturing costs from labor to plant equipment. An inflation index that tracks manufacturing cost may not adjust to these changes. Estimators should always check the applicability of cost indexes used in their calculations.
- Inflation indexes compare costs for products that evolve over time. Comparing the costs of a chemical plant constructed today versus 20 years ago should reflect not only the increased cost of materials, but also the additional cost of government-mandated environmental equipment. Cost estimators should be aware that some inflation indexes do not adjust for these additional costs.
- Inflation index calculations become increasingly inaccurate as the time interval between data points is increased, i.e., a 5-year calculation is usually more accurate than a 20-year escalation.
- Some inflation indexes are based on published list prices (rather than market prices) and time-averaged labor conditions. These indexes can be insensitive to short-term economic cycle swings.
- Scale-up factors should only be used in the capacity range for which the factors were developed. The factors can sometimes be used outside these ranges, but the accuracy is not as reliable. In some very limited cases, the scale-up factors may change because of different technology or field erection versus factory assembly, for example.

7. Summary

Inflation, location and scale-up factors are powerful tools in performing order-of-magnitude cost estimates. This paper reviews their use and presents about 70 cost and location factor listings and 9 scale-up factor references to assist estimators in locating these data. We included an example calculation using cost, location and scale-up factors. Caveats for using these factors are also presented.

Appendix A

Cost and location factors for the United States are given in Table 1.

Appendix B

International cost and location factors are given in Table 2.

Appendix C

Sources for capacity factors are given in Table 3.

Table 1
Cost and location factors for the United States

Index name	Cost measure	Industry	Compiler information	Index availability	Description
Academic Library Price Index	Operation	Education	Research Association of Washington, 2605 Klingle Rd. NW, Washington, DC 20008, (202) 966-3326	Compiler (annually)	Measures the inflation affecting the operation of academic libraries. Used as a component in the Higher Education Price Index. Index data to 1976.
ACCRA Cost of Living Index (COLI)	Cost of Living	General	ACCRA, P.O. Box 407, Arlington, VA 22210, Phone: (703) 522-4980, FAX: (703) 522-4985, sam@accra.org, www.accra.org, For Index info: www.coli.com	Compiler (annually) membership: $95 for professional members, $350 for business members	Presents data in two forms: Composite Index and Average Prices. Composite Index is composed of six components, including housing and health care. Average prices reports median, mean, standard deviations and range for 59 costs. Taxes not considered.
Associated equipment distributor's compilation of averaged rental rates for construction equipment	Equipment	Construction Rental Rates	Associated Equipment Distributors, 615 West 22nd St., Oak Brook, IL 60523, Phone: (630) 574-0605, FAX: (630) 574-0132, info@aednet.org, www.aednet.org	Compiler (annually) CED Magazine. Subscription: $25.00 yearly	US nationally averaged rental rates for construction equipment items as reported by distributor members of association. No geographic breakdown. Data for each year released the following May.
Association of American Railroads Railroad Cost Index	Construction	Railroad	Association of American Railroads, Economics and Finance Dept., 50 F. St., Washington, DC 20001, Phone: (202) 639-2334, FAX: (202) 639-2986, www.aar.org	Compiler (quarterly or annually). Contact Clyde Crimmel at (202) 639-2309, or send email to ccrimmel@aar.org	Includes two rail cost indexes: Rail Cost Recovery Index (RCR) and the Rail Cost Adjustment Factor (RCAF). Components include labor, fuel, materials, supplies, and other operating expenses.
Austin BCI	Building	Industrial	The Austin Company, 6095 Parkland Blvd., Cleveland, OH 44124-4186, Phone: (440) 544-2600, FAX: (440) 544-2684, Austin.info@theaustin.com, www.theaustin.com	Engineering News-Record (quarterly cost roundup). Compiler (quarterly). Wall Street Journal (daily). Bulletin of the National Assoc. of Purchasing Agents (quarterly)	Derived by periodically repricing a typical one-story steel frame industrial building of 116760 ft^2 and an office building of 8325 ft^2. Includes labor and basic material costs including site work, electrical, mechanical, HVAC, concrete foundations and floors, sprinklers, and plumbing. Since 1913.
B2B Web Price Index	Web Services	General	NetB2B.com, New York, NY, (212) 210-0402, www.netb2b.com	BtoB magazine (bi-monthly). $59 subscription	Long-running national benchmark of how much marketers can expect to pay for Web services. Participating developers are sent the descriptions of services, and return the prices they would charge their clients to develop the projects. The results are then aggregated into the median, high, and low prices.

Table 1 *(continued)*

Index name	Cost measure	Industry	Compiler information	Index availability	Description
Bid Price Index	Construction	Highway-Federal	US Department of Transportation, Federal Highway Administration, 400 7th Street, SW, Washington, DC 20590, (202) 523-0163, www.fhwa.dot.gov	Price Trends for Federal-Aid Highway Construction (quarterly); Survey of Current Business (monthly); Engineering News-Record (quarterly cost roundup); Highway and heavy construction (quarterly); Highway statistics (annually)	Tracks cost of current prices for base period quantities. Derived from average unit bid prices for excavation, surfacing, and structures. Restructured when necessary. Quarterly since 1972. Annually, since 1962.
Boeckh Building Cost Index	Building	General	E.H. Boeckh Co., 2885 South Calhoun Road, P.O. Box 510291, New Berlin, WI 53151-0291, Phone: (800) 285-1288, FAX: (262) 780-0306, www.boeckh.com	Boeckh Building Cost Index Numbers. $130 per copy. Engineering News-Record (quarterly cost roundup). One-year subscription $74.00	Index data for 11 building types in 202 US and 53 Canadian cities, calculated from weighted cost changes of 115 components, 19 building labor trades, 89 building materials, and 8 tax and insurance elements.
Boeckh Building Cost Modifier	Building	General	E.H. Boeckh Co., 2885 South Calhoun Road, P.O. Box 510291, New Berlin, WI 53151-0291, Phone: (800) 285-1288, FAX: (262) 780-0306, www.boeckh.com	Boeckh Building Cost Modifier Numbers. $130 per copy. Engineering News-Record (quarterly cost roundup). One-year subscription $74.00	Modifier is calculated for 11 building types in 190 US cities, from weighted cost changes of 115 elements in each location, 19 labor trades, 89 building materials, and 7 tax and insurance elements.
Bureau of Labor Statistics Employment and Earnings for States and Areas	Employment and earnings	General	Bureau of Labor Statistics, US Department of Labor, Office of Public Affairs, Postal Square Building, 2 Massachusetts Ave., NE, Room 4110, Washington, DC 20212, (202) 691-5900 stats.bls.gov	Employment and earnings (monthly). Also, at website stats.bls.gov/ecthome.htm	Provides annual average data on industry, employment, hours, and earnings for all 50 states, DC, Puerto Rico, Virgin Islands, and 265 major labor areas.
Bureau of Labor Statistics Employment and Earnings for the United States	Employment and earnings	General	Bureau of Labor Statistics, US Department of Labor, Office of Public Affairs, Postal Square Building, 2 Massachusetts Ave., NE, Room 4110, Washington, DC 20212, (202) 691-5900, stats.bls.gov	Employment and earnings (monthly). Also, at website stats.bls.gov/ecthome.htm	Includes monthly and annual figures for all employees, production workers, weekly earnings, weekly hours, hourly earnings, overtime hours, and women workers.
Bureau of Labor Statistics Producer Price Index—	Producer price	Construction machinery and equipment	Bureau of Labor Statistics, US Department of Labor, Office of Public Affairs, Postal Square Building,	Producer prices and Price Index (monthly)	Nine categories of construction equipment and machinery, including portable air compressors and parts.

construction machinery and equipment			2 Massachusetts Ave., NE, Room 4110, Washington, DC 20212, (202) 691-5900 stats.bls.gov		Based on direct price reporting of typical transaction and list prices generally from manufacturer to distributor. Monthly, since January 1947.
Bureau of Reclamation	Construction	General	Bureau of Reclamation, Denver Federal Center, P.O. Box 25007, 5th Ave. and Kipping, Denver, CO 80225, (303) 445-2784	Compiler (quarterly); Engineering News-Record (Bi-annually). Publications also available through US Government Bookstore at: bookstore.gpo.gov/index.html	Compiler's release covers 34 types of dam and water projects. ENR publishes the Bu-Rec's general property index that measures costs for office and maintenance buildings associated with its projects.
Chemical Engineering Plant Cost Index	Construction	Plant (chemical)	Chemical Engineering, McGraw-Hill, Inc., 1221 Avenue of the Americas, New York, NY 10020, Phone: (212) 512-2000, www.mcgraw-hill.com	Chemical Engineering (Bi-weekly); US Bureau of Labor Statistics survey of hourly earnings (monthly); BLS National Survey of Professional, Administrative, Technical, and Clerical Pay	Specifically for a chemical process plant, but used throughout the process industry. Cost components include equipment, machinery, labor, building materials, engineering, and supervision costs. Productivity corrections for wages/salaries and engineering services.
Consumer Price Index	Goods	Consumer	Bureau of Labor Statistics, US Department of Labor, Office of Public Affairs, Postal Square Building, 2 Massachusetts Ave., NE, Room 4110, Washington, DC 20212, (202) 691-5900, stats.bls.gov	BLS press release (initial). Consumer Prices and Price Index (monthly). BLS supplements (annually). More info at stats.bls.gov/cpihome.htm	Measures average changes in prices of about 400 goods and services bought by wage earners and clerical workers, both families and single persons. Weightings based on periodic surveys. Annually and monthly, since 1913.
Dept. of Commerce Composite CCI	Construction	General	Bureau of the Census, Construction Statistics Division, US Dept. of Commerce, Washington, DC 20233, www.census.gov	Construction reports (monthly); Construction review (bi-monthly); Engineering News-Record (quarterly cost roundup); or get historical data (1964 to 1999) at: www.census.gov/pub/const/C30/indexes.html	Combination of various cost indexes weighted monthly to the current-relative importance of major classes of construction. Publishes two construction-related indexes. First, a composite fixed-weight index is a ratio of the annual value of new construction put in place in current dollars to comparable values in 1992. This index reflects only a change in price. The second reflects changes in prices and also changes in the composition of value put in place. This reflects market conditions

Table 1 *(continued)*

Index name	Cost measure	Industry	Compiler information	Index availability	Description
					as well as price. Both published monthly.
Dept of Commerce Schedule of Annual Indexes for Carriers by Railroad	Construction	Railroad	Interstate Commerce Div., Bureau of the Accounts, Washington, DC 20423	Compiler (annually)	A series of indexes that trends reproduction cost changes in railroad property and equipment. Cost components include grading, tunnels, bridges, ties, rail, locomotives, and freight cars. Indexes applicable to national average only. Since 1915.
Dodge Building Cost Index	Construction	General	Marshall and Swift, 1617 Beverly Blvd, Los Angeles. CA 90026, Phone: (800) 526-2756, (800) 262-4729, www.marshallswift.com	Dodge Unit Cost Guide. $79.95	Components include labor (22 trades), material, and equipment costs includes crew sizes, productivity rates, individual prices for hard-to-find items, and location factors for 1000 regions in US and Canada included. Compiled quarterly.
Engineering News-Record Building Cost Index	Construction —structure cost dominates	General	Engineering News-Record McGraw-Hill, Inc., Two Penn Plaza, New York, NY 10121-2298, Phone: (212) 512-2000, FAX: (212) 904-2820, www.enr.com	Engineering News-Record (weekly). One-year subscription $74.00	Applicable to structure construction. Obtained by weekly repricing of a hypothetical block of construction in 20 US cities and 2 Canadian cities. Includes skilled labor, structural steel shapes, cement and lumber.
Engineering News-Record Building Cost Index	Construction —labor cost dominates	General	Engineering News-Record, McGraw-Hill, Inc., Two Penn Plaza, New York, NY 10121-2298, Phone: (212) 512-2000, FAX: (212) 904-2820, www.enr.com	Engineering News-Record (weekly). One-year subscription $74.00	Applicable where labor costs are a high proportion of total cost. Obtained by weekly repricing of a hypothetical block of construction in 20 US cities and 2 Canadian cities. Includes skilled labor, structural steel shapes, cement and lumber.
Engineering News-Record Common Wage Rate Indexes	Labor	Wage rate	Engineering News-Record, McGraw-Hill, Inc., Two Penn Plaza, New York, NY 10121-2298, Phone: (212) 512-2000, FAX: (212) 904-2820, www.enr.com	Engineering News-Record (weekly). One-year subscription $74.00	Data obtained by averaging current wage rates for common labor on buildings and other construction and by averaging rates for bricklayers, carpenters, and structural ironworkers in 20 US cities.
Engineering News-Record Skilled Wage Rates	Labor	Wage rate	Engineering News-Record, McGraw-Hill, Inc., Two Penn Plaza, New York, NY 10121-2298, Phone: (212) 512-2000, FAX: (212) 904-2820, www.enr.com	Engineering News-Record (weekly). One-year subscription $74.00	Covers skilled labor wage rates, based on base rates and fringe benefits, in dollars per hour for 20 cities in the US and Canada.
Factory Mutual BCI	Building	Industrial	Factory Mutual Engineering and Research, P.O. Box 7500, Johnston, RI	Compiler (semi-annually)	Includes 8 labor trades and 7 materials. Based on construction of

			02919, information@fmglobal.com, www.factorymutual.com		5 model buildings ranging from a single story, steel-framed warehouse to a multi-story, reinforced concrete building. Used for heavy industry construction. Biannually, since 1940. Also indexes for residential construction, industrial processing machinery and equipment. Canadian indexes available.
Fru-Con BCI	Building	Industrial	Fru-Con Corporation, 15933 Clayton Rd., Ballwin (St. Louis), MO 63011, Phone: 1-800-9FRUCON, FAX: 636/391-4513, www.frucon.com	Compiler (monthly)	Based on an average industrial building in St. Louis region. Components include current labor and materials costs (fridges, concrete mortar, clay, lumber, plastics, metals, paint, and glass). Weightings adjusted if needed.
Handy-Whitman Public Utility CCI	Construction	Public Utility	Whitman, Requardt and Associates, 2315 Saint Paul St., Baltimore, MD 21218, Phone: (410) 235-3450, FAX: (410) 243-5716, Baltimore@wrallp.com, www.wrallp.com	Compiler (annually)	Treats construction costs separately for electric, gas, water, and telephone utility construction. Weightings and components revised when needed. For 6 US geographical regions in 48 contiguous states. Since 1912. There is also an index for a reinforced concrete building.
Higher Education Price Index	Operation	Education	Research Association of Washington, 2605 Klingle Rd. NW, Washington, DC 20008	Compiler (annually)	Measures the price level of goods and services colleges and universities purchase for their current education operations. Index data available to 1961.
JOC-ECRI Industrial Price Index	Raw materials	Industry	Economic Cycle Research Institute, 420 Lexington Avenue, Suite 1645, New York, NY 10170, Phone: (212) 557-7788, FAX: (212) 557-9874, www.businesscycle.com	Compiler. Journal of Commerce: www.joc.com	This index is designed to yield a cyclical leading indicator of the inflation cycle. Made of 18 components divided into 4 sub-indexes: Petroleum products, metals, textiles and miscellaneous. Created in 1986 and revised in 1994.
Lee Saylor BCI	Building	General	Saylor Publications, Inc., 9420 Topanga Canuon Blvd., Suite 203, Chatsworth, CA 91311, Phone: (800) 624-3352, FAX: (818) 718-8024, www.saylor.com	Compiler (monthly). Construction costs: $69.95 per copy	Components include 9 types of labor and 23 materials costs quoted in 20 cities. A Labor-Material Cost Index weighted at 54% labor and 46% materials. Subcontractor Index also available for 21 materials. Monthly. Lee Saylor went bankrupt in 1995. Index now compiled by Saylor Publications, Inc.

Table 1 *(continued)*

Index name	Cost measure	Industry	Compiler information	Index availability	Description
Marshall and Swift Industrial Equipment Cost Index	Equipment	General	Marshall and Swift, 1617 Beverly Blvd, Los Angeles. CA 90026, Phone: (800) 526-2756, www.marshallswift.com	Marshall Valuation Service (monthly). $289.95. Valuation Book (quarterly). $149.95	Represents a composite of the equipment costs of an entire plant based on a national average. Covers 48 industries with the general average for all. Since 1913. Also available for 18 Canadian cities.
Marshall and Swift Commercial Building Estimator Software	Building	General	Marshall and Swift, 1617 Beverly Blvd, Los Angeles. CA 90026, Phone: (800) 526-2756, www.marshallswift.com	Commercial Estimator 7. $649.95	Allows user to quickly estimate costs on nearly 250 commercial, industrial, retail, agricultural or institutional buildings including all classes, sizes, shapes and quality levels.
Marshall and Swift Building Cost Index	Building	Industrial, Appraisal	Marshall and Swift, 1617 Beverly Blvd, Los Angeles. CA 90026, Phone: (800) 526-2756, www.marshallswift.com	Marshall Valuation Service (monthly). $289.95. Valuation Book (quarterly). $149.95	Index is an average of 100 US cities combined into various regional, district, and national indexes. Tracks costs of 5 types of buildings in various parts of US: fire-proof steel, reinforced concrete, masonry, wood, and pre-engineering steel frames. Components include materials, equipment and labor. Since 1901.
Means Building Construction Cost	Construction	General	R.S. Means Company, Inc., P.O. Box 800, 63 Smiths Lane, Kingston, MA 02364-0800, Phone: (800) 334-3509, FAX: (800) 632-6732, www.rsmeans.com	CostWorks software. Allows user to access industry-standard Means construction costs. $99.95	Tracks construction costs for 16 components in 305 US cities and Canadian cities and 50 components for New York, Houston, LA, Chicago, and Boston. National averages for 30 largest US cities included.
Means Assemblies Cost	Complete Building Assemblies	General	R.S. Means Company, Inc., P.O. Box 800, 63 Smiths Lane, Kingston, MA 02364-0800, Phone: (800) 334-3509, FAX: (800) 632-6732, www.rsmeans.com	CostWorks software. Allows user to access industry-standard Means construction costs. $149.95	Tracks assemblies costs for 16 components in 305 US cities and Canadian cities. National averages for 30 largest US cities included.
Means Concrete and Masonry Cost	Construction	General	R.S. Means Company, Inc., P.O. Box 800, 63 Smiths Lane, Kingston, MA 02364-0800, Phone: (800) 334-3509, FAX: (800) 632-6732, www.rsmeans.com	CostWorks software. Allows user to access industry-standard Means construction costs. $99.95	Cost facts for virtually all concrete/masonry estimating needs, from complicated formwork to various sizes and face finishes of brick and block. Unit cost section contains more than 8500 selected entries.
Means Electrical Cost	Construction	General	R.S. Means Company, Inc., P.O. Box 800, 63 Smiths Lane, Kingston, MA 02364-0800, Phone: (800) 334-3509, FAX: (800) 632-6732, www.rsmeans.com	CostWorks software. Allows user to access industry-standard Means construction costs. $99.95	More than 15,000 unit and systems costs with design tables.

Nelson–Farrar Refinery Construction Cost Index	Construction	Refinery	Oil and Gas Journal, 1421 S. Sheridan Rd., Tulsa, OK 74112, Phone: (918) 835-3161, Fax: (918) 832-9290, ogj.pennnet.com/cd_anchor_home/	Oil and Gas Journal. Subscription: $49.50 print, $79.50 online	Components include process equipment, electrical machinery, instrumentation, heat exchangers, materials, and labor costs. Since 1926.
Nelson–Farrar Refinery Operating Cost Index	Operating	Refinery	Oil and Gas Journal, 1421 S. Sheridan Rd., Tulsa, OK 74112, Phone: (918) 835-3161, Fax: (918) 832-9290, ogj.pennnet.com/cd_anchor_home/	Oil and Gas Journal. Subscription: $49.50 print, $79.50 online	Measures inflation effects on refinery operating costs. Components include fuel, labor, chemicals, maintenance, and investment costs.
Producer Price Index	Goods	Producer	Bureau of Labor Statistics, US Department of Labor, Office of Public Affairs, Postal Square Building, 2 Massachusetts Ave., NE, Room 4110, Washington, DC 20212, (202) 691-5900, stats.bls.gov	BLS press release(initial). Producer Prices and Price Index (monthly). BLS supplements (annually). More info at stats.bls.gov/ppihome.htm	Covers all commodities produced or imported and sold in US primary markets. Listed separately and by groups, such as crude materials and finished goods. Based on sales of large lots in the primary market, reported by survey. Data since 1890.
Research and Development Price Index	Goods	Education	Research Association of Washington, 2605 Klingle Rd. NW, Washington, DC 20008	Compiler (annually)	Measures the inflation affecting university research funding and expenditures. Index data available to 1961.
Richardson Cost Trend Reporter	Labor	Construction	Richardson Engineering Services, Inc., P.O. Box 9103, Mesa. AZ 85214-9103, Phone: (480) 497-2062, FAX: (480) 497-5529, www.resi.net	Compiler (semi-annually)	Tracks average labor rates for various types of construction crews. Averaged for the entire US. Enables detailed labor cost estimation for construction projects.
Richardson International Construction Factors	Location Factors	Construction	Richardson Engineering Services, Inc., P.O. Box 9103, Mesa. AZ 85214-9103, Phone: (480) 497-2062, FAX: (480) 497-5529, www.resi.net	Compiler (semi-annually)	Provides location factors based on typical process plants for 14 major process industry locations around the world.
School Price Index	Operation	Education	Research Association of Washington, 2605 Klingle Rd. NW, Washington, DC 20008	Compiler (annually)	Measures the price level of goods and services purchased by primary and secondary education institutions.
Smith, Hinchman and Grylls BCI	Building	General	Smith, Hinchman and Grylls, Inc., 455 W. Fort St., Detroit, MI 48226, (313) 227-0100, www.smithgroup.com	Engineering News-Record (quarterly cost roundup); Compiler (quarterly)	Based on compiler's cost experience on buildings constructed in eastern cities. Cost components include labor, material, labor productivity, plant and management efficiency, competition and price trends. Since 1902.

Table 2
International cost and location factors

Location	Index Name	Cost Measure	Industry	Compiler information	Description
Australia	Australian Builder	Raw materials	General	Australian Builder Publishing Co. Pty. Ltd., 332 Albert St., East Melbourne, Victoria 3002, Australia	Publication includes price information on raw materials. Covers current prices.
Australia	Building Cost Index	Building	General	The Australian Institute of Quantity Surveyors, P.O. Box 534, Crows Nest, NSW 2065, Australia, (02) 43-1277	Monitors construction labor and materials costs together. Adjusts for productivity changes. Monthly, since 1949.
Australia	Construction Cost Index	Building	General	Amax Australia Limited, 200 St. George's Terrace, Perth, WA 6000, Australia	Components include houses, office blocks, workshops, ore cars, and ore-handling structures. Quarterly since 1967.
Australia	Cordells Building Cost Book	Building	General	Cordells Building Publications, P.O. Box 96, East Melbourne, Victoria 3002, Australia	Covers present price information for non-residential building for each state in the Commonwealth of Australia.
Australia	Monthly Summary of Statistics	Price, Wages	General	Australian Bureau of Statistics, Wing 5, Cameron Offices, Chandler Street, Belconnen ACT 2617, Phone: (300) 135-070, FAX: (300) 135-211, www.abs.gov.au	Indexes include price indexes for manufactured products, materials used in manufacturing industry, materials used in house building in six state capitals, metallic materials. Also wage rates and average weekly earnings. Governmental statistics.
Brazil	A Construcao	Construction	General	A Construcao, Rua Anhais, 964, Sao Paulo, SP 01130, Brazil	Covers residential and non-residential construction costs and project costs. Published in Portuguese.
Brazil	Boletim de Custos	Building	General	Boletim de Custos, Rua Dana Mariana, 2, Botafogo, Rio de Janeiro, RJ, Brazil, boletim@montreal.com.br, www.montreal.com.br/boletim	Presents cost and price indexes for residential and non-residential construction. Published in Portuguese.
Brazil	Conjuctura	Machinery, equipment, construction material	General	Instituto Brasileiro de Economia, Fundacao Getulio Vargas, Praia de Botafogo, 188, Rio de Janeiro, RJ, Brazil, www.fgv.br/institucional/ibre.cfm	Covers industrial machinery, industrial equipment, and construction material. Published in Portuguese. Data may be obtained through: FGVDados Fgvdados.fgv.br/index.cfm
Brazil	NTC—Associacao Brasileira dos Transportadores de Cargas	Transportation rates	General	Associacao Brasileira dos Transportadores de Cargas, SAS Quadra 06, Ed. Camilo Cola, 10o Andar, Brasilia, DF 70070, Brazil, Phone: (061) 321-7172, FAX: (061) 323-3960, www.abtc.org.br	Covers transportation rates for industrial materials. Published in Portuguese.
Brazil	Revista de Precos	Construction	General	Revista de Precos, Av. N.X. de Copacabana, 749 GR 801, Rio de Janeiro, RJ, Brazil	Presents cost and price indexes for residential and nonresidential construction. Published in Portuguese.
Canada	Statistics Canada	Construction capital expenditures	General	Statistics Canada, Prices Division, Tunney's Pasture, Ottawa, Ontario K1A 0T6, Canada, www.statcan.ca	Covers construction costs and capital expenditures. Bibliography in French or English upon request.
England	A.C.E. Indexes of erected plant costs	Nonresidential construction, machinery, equipment	General	The Association of Cost Engineers, Ltd., Lea House, 5 Middlewich Road, Sandbach, Cheshire XW11 1XL, United Kingdom, Phone: (44) (0) 1270-764798, FAX: (44) (0) 1270-766180, www.acoste.org.uk	Components include mechanical and electrical materials and equipment, civil and building materials, labor, and construction equipment and transport. Annual since 1975.
England	Price Index Numbers for current cost accounting	Nonresidential construction machinery equipment	General	Department of Industry, Economics and Statistics Div., 4A Sanctuary Buildings, 16-20 Great Smith St., London SW1P 3D8, England	Government compiled index for replacement cost use. Indexes track nonresidential construction, machinery, and equipment. Annual, since 1938.

France	Index coefficients	Building, material	General	Roux S.A., 51 Rue Ampere, 75017, Paris 766-43-97, France	Covers building and machinery replacement costs. Each release covers 10 yr.
Germany	Fachserie 17: Preise	Machinery, construction	General	Verlag W. Kohihammer GmbH, Abt., Veroffentlichungen des Statisticschen Bunde, Samtes Phillipp-Reis-Strasse 3, Postfach 42 11 20 D-6500, Mainz 42 (Hechtssheim) (06031) 59344	Covers general machinery and building construction. Monthly, for 10 yr. Published in German.
Italy	Index	Labor, wages, construction	General	Index Centro Statistica Aziendale S.r.l., Via A. Baldesi 20, 50131, Firenze 055-576041, Italy	Covers wholesale prices, labor costs, wage rates, and railway car production costs. Construction costs tracked for residential and road construction. Published in Italian.
Italy	Indicatori Mensili	Price	General	Instituto Centrale di Statistica, Via Cesare Balbo, Roma 16-00100, Italy	Covers industrial, commercial, and consumer prices. Compiled by the Italian Government. Published in Italian.
Italy	Prezzi Informativi Delle Opere Edili in Milano	Construction consumer prices raw materials wage rates	General	Camera di Commercia Industria Artigianato e Agricoltura di Milano, Direttore Redazione, Amministrazione, Via Meravigli 9/B1S, 20123, Milano 02-88541, Italy	Indexes cover residential and nonresidential construction, consumer prices, raw materials, and wage rates. Published in Italian.
Japan	Construction Price Index by year, Price Indexes of general machinery and equipment	Construction	Insurance	The Non-Life Insurance Institute of Japan, 6-5, 3-Chome, Kanda, Surugadai, Chiyoda-Ku, Tokyo, Japan	Covers buildings of wood, steel, and reinforced concrete frame construction, general machinery and equipment, household personal properties, and location factors for nine cities. Used by industrial insurers in Japan. Published in English.
Japan	MRC Monthly Standard Building Cost Indexes and Unit Price Data Bulletin	Construction	General	Management Research Society for Construction Industry	Cost indexes for many components of construction and construction costs of certain building types. Location indexes for nice cities. Published in Japanese.
Mexico	Cifras de la Construccion	Construction	General	Camara Nacional de la Industria de la Construccion, C/O Sociedad Mexicana de Ingeniaria Economica y de Costos, A.C., Palacio de Mineria Tacuba, No. 5, D1g, Cuauhtemoc, DF 510-42-75, Mexico	General use index tracks construction industry. Published in Spanish. Monthly, since 1960.
Mexico	COSTOS	Construction	General	Centro de Precios Unitarios Prisma, S.A. de C.V., Paseo de la Reforma No. 36, C.P. 06048 D.F. Mexico, Phone: (52) 5-566-8166, www.prisma.com.mx	COSTOS is a monthly publication with 3500 detailed unit costs, 8000 material costs for each of the three largest cities, 70 material costs for another 51 cities, and cost indexes.
Mexico	Indice Nacional de Precios al Consumidor	Consumer Price	General	Banco Nacional de Mexico, C/O Sociedad Mexicana de Ingeniaria Economica y de Costos, A.C., Palacio de Mineria Tacuba, No. 5, D1g, Cuauhtemoc, DF 510-42-75, Mexico	Consumer Price Index. Monthly, since 1978. Published in Spanish.
Netherlands	Die Werkgroep Begrotings Problemen in de Chemische Industrie	Construction	Chemical	Nederlands Stichting Voor Kostentechniek Stichting, Nederlandse Apparaten, Voor de Procesindustrie, P.O. Box 443, 2260 AK Leidschendam, 070-200400, The Netherlands	Covers unit prices for chemical plant construction in the Netherlands. Annual averages included. Every 2 years, since June 1959. Published in Dutch.
New Zealand	Ministry of Works and Development Construction Cost Index	Construction	General	Ministry of Works and Development, P.O. Box 12, Wellington North 041, New Zealand	Construction Cost Index, components include labor, material, and plant costs. Quarterly, since 1946.

Table 2 (*Continued*)

Location	Index Name	Cost Measure	Industry	Compiler information	Description
New Zealand	Monthly Abstract of Statistics	Various	General	Department of Statistics, Aorangi House, 85 Molesworth St., Wellington, New Zealand	Labor force indexes for manufacturing, chemical, canning/food, electronic, and mining industries. Exchange, interest, and national wage rates, Consumer Price Index, and manufacturers or producers selling price indexes included. Monthly, since 1977.
Tanzania	Producer Price Index	Producer Prices	Manufacturing	President's Office, Planning Commission, Bureau of Statistics, Dar-es-Salaam, Tanzania	Measures producer prices in manufacturing industry. Quarterly.
Worldwide	Monthly Bulletin of Statistics	Various	General	Statistical Office, UN, New York, NY 10017	Includes variety of production, trade, population, labor, financial, commodities, construction, wage, and miscellaneous cost and price indexes and statistics for approximately 190 countries. Published monthly, varied time periods for each index.
Worldwide	OECD Economic Outlook	Various	General	OECD Economics Department, 2 Rue Andre-Pascal, 75775 Paris Cedex 16, France	Covers Consumer Price Indexes, labor trends, wage rates, interest rates, imports and exports, private and public consumption, and investment for individual OECD countries.
Worldwide	Richardson International Construction Factors-Location Cost Manual	Construction	Processing	Richardson Engineering Services, Inc., P.O. Box 9103, Mesa. AZ 85214-9103, Phone: (480) 497-2062, FAX: (480) 497-5529, www.resi.net	Currently covers heavy processing plant construction in 14 different countries, countries covered expected to be expanded. Factors include labor, taxation, shipping, and environmental issues. Based on data from surveys.

Table 3
Sources for capacity factors

Industry/field	Paper	Reference	Description
Air-pollution control equipment	Air-pollution control: estimate the cost of scaleup	Remer et al. (1994)	16 types of air pollution control equipment including particulate control devices, gas-control devices, and auxiliary equipment.
Airport construction	Cost scale-up factors for airport construction	Remer and Wong (1996)	Cost capacity factors for US airport expansions and international airport construction.
Biopharmaceutical processes	Cost-estimating factors for biopharmaceutical process equipment	Remer and Idrovo (1990); Remer and Idrovo (1993)	58 types of bioprocess equipments.
Process equipment	Design cost factors for scaling-up engineering equipment	Remer and Chai (1990b, 1993a)	75 types of process equipment.
Process plants	Estimate costs of scaled-up process plants	Remer and Chai (1990a, 1993b)	200 types of process plants, primarily chemical plants
Chemical plants	Rapid estimation of plant costs	Gallegher (1967)	Methods to quickly calculate total installed plant costs, as well as costs of installed process sections, buildings and service systems.
Gas conditioners	Estimating the size and cost of gas conditioners	Vatuvuk (1981)	Cost estimation of cyclones, wet and dry coolers, spray chambers, quenchers and dilution ports.
Waste-to-energy facilities	Cost-to-capacity analysis for estimating waste-to-energy facility costs	Ellsworth and Richard (1998)	48 plants in the US used to calculate cost capacity factor.

Some notes on capacity factors:
- Also known as scale-up factors or *R* factors;
- Used to estimate the cost of similar plants, processes or equipment of different capacities or sizes;
- The above table indicates the references that summarize specific industries.

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