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DEVELOPING LOCATION FACTORS BY FACTORING – AS APPLIED IN ARCHITECTURE & ENGINEERING, AND ENGINEERING, PROCUREMENT & CONSTRUCTION

TCM Framework: 7.3 – Cost Estimating and Budgeting, 10.4 – Project Historical Database Management

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INTRODUCTION

Location factors are a vital product of any cost engineering service organization supporting industries with global assets and projects. One thing is for certain—location factors will be challenged. So, not only is it important to have an easily-understood and logical method of developing location factors, the process must be supported with hard data from a well-defined survey and a project execution knowledge that only comes through experience. This Recommended practice documents such a process.

International markets and politics are constantly changing, and those involved with developing location factors must constantly collect, analyze, and understand the effects created by these changes. Location-factor development should not be a mathematical exercise that is done on an as-needed basis, but should be a continually improving process. The factoring method of developing location factors is a tool for living that process.

This recommended practice provides a generic method of developing location factors in support of the Total Cost Management (TCM) cost estimating and budgeting and database management processes for construction related projects. The method applies to construction projects of all types including buildings, infrastructure, utilities, process plants, and so on. This generic method provides a basis for users to tailor their own detailed process around their own needs and computing capabilities. Location factors are used during preliminary project evaluations (i.e., Class 5 or 4 estimates). They are not intended to be used when preparing appropriation-quality estimates (i.e., Class 3 or better estimates).

A location factor is an instantaneous (i.e., current—has no escalation or currency exchange projection), overall total project factor for translating the total cost of the project cost elements of a defined construction project scope of work from one geographic location to another. This factor recognizes differences in productivity and costs for labor, engineered equipment, commodities, freight, duties, taxes, procurement, engineering, design, and project administration. The cost of land, scope/design differences for local conditions and codes, and differences in operating philosophies are not included in a location factor.

Location factors provide a way to evaluate relative cost differences between two geographic locations. They often are applied to conceptual estimates for identifying "go/no-go" projects at an early stage. The ability to produce meaningful data during the conceptual stage is critical to the efficient management of the funds and resources of owners. This is what drives location-factor developers toward methods that are accurate, flexible, easily managed, and allow a quick turnaround.

Listed below are some common methods of developing location factors that do not use the factoring approach covered by this recommended practice. While the methods are valid approaches, reasons why these methods may not be preferred are noted.

Cost-versus-cost (comparing actual costs from two similar projects):
It is rare to find two projects that truly have the same scope. Even if they are the same, there is no assurance that all costs have been captured, or that the estimated average exchange rate conversions for offshore purchases were accurately identified. There is also the inherent possibility of error when trying to normalize historical project costs.

Cost-versus-estimate (comparing the actual cost of a project at one location to an estimate for the same scope of work at another location):
Again, there is no assurance that all costs have been captured or that the estimated average exchange rate conversions for non-domestic purchases were accurately identified on the cost side. Also, comparing

actual and estimated costs is complicated by the issue of contingency and risks that may or may not be properly addressed in the estimate.

Estimate-versus-estimate (comparing the same project scope of work estimated at two or more locations):
Project scopes and risks can be interpreted differently by different estimators. Also, the basis of estimates typically differ and are difficult to reconcile. This can lead to significant cost differences.

Aside from these drawbacks, given the need to capture and normalize costs on a one-off basis, these methods require more time, funds, and resources than most companies are willing to allocate or spend. This is not to say that none of the above methods should be used. Under the right circumstances, they all could be. It is just that they do not lend themselves to an ongoing continuous and expeditious process.

EVOLUTION OF THE FACTORING METHOD

Years ago, when many owner companies in the process industries needed appropriation-quality estimates for non-domestic locations, they would develop a major equipment and engineered items list with detailed specifications. Then they would go out and get hard quotes from the vendors who would be supplying this equipment for the project. For chemical and petrochemical projects, this could amount to 25 to 50 percent of the total project cost.

Engineering/design/procurement and field administration budgets would make up another 20 to 30 percent of the total project cost. That left only the labor and commodities to estimate, which would account for the remaining 30 to 40 percent of the cost. To do this, they would survey the site for labor and commodity pricing (primarily steel, piping, and wiring) and compare these to domestic costs. Labor and commodity factors would then be developed and applied.

It was from this factoring activity that the factoring method evolved. Since computer estimating programs were being written to help with the factoring of labor and commodities, it became obvious that this factoring process could be extended to an entire construction project as well as projects of any type.

THE FACTORING METHOD

The term *factoring method* is descriptive of a process as shown in Figure 1.

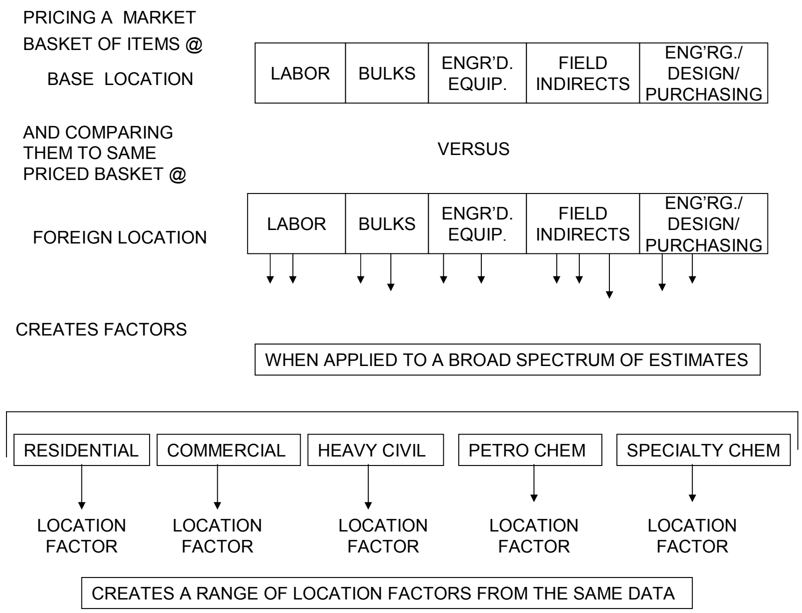

Figure 1. Factoring Method Process

A factoring method offers a disciplined, logical, manageable, and cost-effective approach for developing location factors. Although these factors are usually developed to reflect the relative cost differences between various countries, they also can be developed to reflect regional differences within the base country itself. This method does require a certain level of computer-aided estimating capability. That amount is dictated by the budgets and needs of the users. A simplified overview of a factoring method includes the following:

- selecting a detailed estimate of a model facility for the base location;
- creating a parallel estimate by applying non-domestic labor, material, and equipment factors (all developed at a constant exchange rate) to the base estimate, then calculating allowances for taxes, fees, import duties, freight, etc., with expected percentages for the foreign location, then calculating engineering, design, procurement, and project administration costs with expected percentages or factors for the foreign location; and
- ratioing the base estimate to the parallel factored/percentaged estimate to produce a location factor.

Benefits

The benefits of the factoring method include the following:

- It generates relative cost differences (percent), not absolute currency values, which means that estimates for factoring can be used over and over again, and various estimates can be used and maintained for providing location factors that represent various types of construction (civil, residential, petrochemical, specialty chemicals, etc.); and
- The pricing of labor, material, equipment, and other project-specific data is compared and tracked at a trade and commoditiy level and can be surveyed on a periodic basis. Because the factors are not project scope specific, this helps ensure consistency and continuity and can be an ongoing process – not only used on an "as-needed basis". Turnaround is quick and it can be managed by one person.

Basis

A fully-developed factoring method requires a detailed survey of labor, material, equipment, and other project-specific data completed for the base location on a periodic interval (say once a year). The same survey then can be priced out in a new location and compared to the base data. The survey must be organized, constructed, and worded in such a way that the suppliers understand exactly what is being requested. What seems clear and precise in one culture may not be in another. With first-time suppliers, a face-to-face explanation and walk-through of the survey and a review of the factoring method that the survey supports needs to take place.

Once a survey is priced out and compared against comparable base location data, the individual factors, as well as the resulting location factor, need to be shared with the suppliers. Obtaining several sources of data from a location helps to improve the accuracy of the output. The type of information that needs to be surveyed depends on the structure and level of detail required for the specific factoring method used. The most common sources for pricing a survey are active full-service design contractors in the various locations.

AN EXAMPLE OF A FACTORING METHOD

	APPROX.
1. ALL-IN LABOR	23%
2. COMMODITIES	17%
3. ENGINEERED EQUIPMENT[1]	34%
4. FIELD INDIRECTS	7%
5. ENGINEERING/DESIGN/PROCUREMENT	18%
6. TAXES & FREIGHTS	1%
	100%

Table 1. Typical Cost Distribution for a U.S. Chemical Plant

Before starting, keep in perspective the effect of each major cost element on the location factor. Historical US splits for chemical-type projects are shown in Table 1, which illustrates that all of the major cost components of a project are important. Too often, emphasis is placed only on the labor portion. Percentages for items beyond the detailed line items of an estimate (items 4 and 5) can influence the overall location factor by about 25 percent in the US. Percentages applied for these items (items 4 and 5) are closely tracked by engineering companies and are obtained quite readily by industry and by country. For this reason, the following example develops factors for labor, commodities, and equipment only. Using historical percentages for the field management and engineering/design/procurement eliminates the need for any detailed analysis.

LABOR

Figure 2 is an example of how to develop labor factors. Note that the Figure highlights the date that the example covers. It is important that the information used in an analysis be current (even if the example is a bit dated).

SITE:	TAMPICO, MEXICO
CURRENCY:	PESOS
EXCHANGE RATE:	9.2 PESOS/$1.00
DATE:	MARCH 2002
RATES EFFECTIVE:	CURRENT
RATES EXPIRE:	JANUARY 2003
PRODUCTIVITY FACTOR	1.75
BASIC WORKWEEK	5 DAYS/45 HOURS
MECHANIC TO HELPER RATIO:	50%/50%
Labor hourly rates include (120% x base rate): worked day factor, work duty, contractors directs, indirects, overhead & profit, and transportation	

Figure 2. Labor Estimating Data

[1] In this example, "engineered equipment" includes process, electrical, and control equipment including all engineered items.

CRAFT	50% MECH.	50% HELPER	AVG. RATE	WEIGHTS Building &Civil (B&C)	Mechanical &Electrical (M&E)	WTD. B&C RATES	WTD. M&E RATES	WTD. AVG.
LAB.	37.5	32.9	35.2	7%	3%	2.5	1.1	
CARP.	37.5	32.9	35.2	6%	2%	2.1	0.7	
MILLWRHT.	47.9	41.4	44.7		5%	0.0	2.3	
IRONWKS.	42.2	34.2	38.2	2%	5%	0.8	1.9	
P.E.O.	47.9	41.4	44.7	2%	2%	0.9	0.9	
PAINT.	37.5	32.9	35.2	1%	2%	0.4	0.7	
PIPEFTR.	48.5	42.2	45.4		32%	0.0	14.5	
PLUMBER	46.3	40.9	43.6	3%		1.3	0.0	
ELEC.	45.7	40.3	43.0	3%	13%	1.3	5.6	
INSUL.	42.2	34.2	38.2		8%	0.0	3.1	
SHEETMTL.	42.2	34.2	38.2	1%	3%	0.4	1.1	
		TOTALS				38.3	42.4	41.4 PESOS
		PRODUCTIVITY FACTOR X				1.75	1.75	
		EQUIVALENT WORKHOUR				66.9	74.2	
		EXCHANGE RATE X				$0.109	$0.109	
		EQUIVALENT RATE TAMPICO				$7.28	$8.07	$7.87
		COMPARATIVE RATES USGC				$28.14	$31.80	$30.89
		LABOR FACTORS				0.26	0.25	0.25

Figure 2. Labor Estimating Data (Continued)

Wage rates from Tampico, Mexico were acquired. When comparing wage rates, be sure to compare them at the same level and from the specific area of the country that you are interested in. If the US Gulf Coast labor cost in the base estimate (which will be factored) represents lump-sum contractor "all-in" billing rates, then be sure that the rates for Tampico reflect an "all-in" billing rate. If the Gulf Coast labor cost in the base estimate represents a base wage plus employee benefits, then compare the same for Tampico.

Other pertinent labor data that is required to complete the analysis includes the following:

- mechanic/helper ratio;
- weighting by craft (Figure 2 reflects a typical weighting for a chemical plant and then consolidates the items into a building and civil (B&C) rate and a mechanical and electrical (M&E) rate);
- the labor productivity factor; and
- an exchange rate and date for the basis of our location factor.

The labor productivity factor, as used in location factoring as covered by this RP, is arrived at by comparing the direct workhours required to accomplish a given task divided by an established base. For example, if it takes one worker 1.25 hours to perform a task normally performed by another worker in 1.0 hour, the productivity factor is 1.25/1.0 = 1.25. This factor is influenced primarily by methods of construction, working skills, the use of labor-saving tools and equipment, the climate, communication barriers, and social habits. This is a very subjective factor, and it is often necessary to rely on experience and relationships to other known locations to estimate productivity factors for new locations.

Considering all of the above data for Tampico, we can develop estimated average billing rates for a chemical plant. By adding in the labor productivity factor and an exchange rate, equivalent dollar rates to compare against our identically-developed, open-shop Gulf Coast rates can be arrived at producing estimated labor factors. The estimated weighted average billing rate in the local currency (41.4 pesos in figure 2) is something that should be confirmed with local engineering/construction companies. It is usually easy to check on, and adds to the credibility of the labor factors.

When the developed labor factors are applied against the detailed labor portion of the base estimate (described below), the result is a non-domestic labor cost in US dollars. Figure 2 arrives at two factors (B&C and M&E). Some factoring methods develop a labor factor for each craft. As mentioned above, users need to decide what is right for their application.

Variables

The spreadsheet that the Figure 2 analysis was prepared from allows a user to easily substitute desired rates, ratios, weightings, productivity factors, and exchange rates. This allows the labor analysis to be tailored for a specific process, provided that the historical data is available.

EQUIPMENT AND MATERIAL

Equipment and material factors together affect the development of location factors more than any other element (see figures 3, 4, and 5). Because of this, that portion of the survey must be well-thought-out and researched. The specifications for the material and equipment must be prepared in a way that is easy to translate and understand, gives examples of comparable equipment, and is not so specific that the vendor quotes a price for something that is uncommon and costly in the surveyed country instead of quoting an allowable substitute.

The survey of equipment and material pricing providing the 25 individual factors shown in Figure 3 is supported by detailed pricing of 11 major categories (figures 4 and 5 are examples of two of the 11 categories). They have anywhere from 3 to 12 items per category and are weighted for a typical chemical plant. As mentioned above, the survey should be priced by contractors who currently have the most project work going on in that specific location. These surveys can require a significant amount of workhours, and you should have the funding for this effort planned out ahead of time.

A tailored material and equipment survey is not required for each estimate that you are going to factor. Instead, the survey should be quite generic and allow knowledgeable adjustments when choosing and applying the developed factors. The example given in figure 4 illustrates how to develop a stainless-steel equipment factor. Items D, E, and F, given in the figure 4 example, are for small, medium, and large stainless-steel vessels, respectively. They are weighted to arrive at an average factor for stainless equipment for a typical chemical project.

A different process, such as a pharmaceutical project, would have a different weighting and thus result in a different stainless-steel equipment factor. If a specific project had only stainless-steel vessels comparable to the small vessels in the survey, then you might only use the factor arrived at by comparing the small vessels. Factors need to be adjusted for currency and inflation from the time that the survey was completed. As with labor, the material and equipment factors are applied to the US-based estimate line items, and non-domestic costs in US dollars are produced.

		Jan. '02	This Project		
Currency Exchange Rates	U.S. Dollar =	9.20 Ps	9.20 Ps		
Category	Factor	Escal. Factor	Currency Adj.		Adj. Factor
Tanks & Columns C/S	0.90	1.0	1.0		0.90
Tanks & Columns S/S	1.00	1.0	1.0		1.00
Heat Exchangers C/S	1.00	1.0	1.0		1.00
Heat Exchangers S/S	1.10	1.0	1.0		1.10
Pumps – Steel	0.90	1.0	1.0		0.90
Pumps – S/S	1.00	1.0	1.0		1.00
Rotating Equip.	1.25	1.0	1.0		1.25
Electrical Equip. – Major	1.20	1.0	1.0		1.20
Instrumentation – Major	1.20	1.0	1.0		1.20
Piping C/S	0.90	1.0	1.0		0.90
Piping S/S	1.10	1.0	1.0		1.10
Insulation – Composite	1.10	1.0	1.0		1.10
Painted Steel	0.90	1.0	1.0		0.90
Galvanized Steel	1.05	1.0	1.0		1.05
Concrete Foundations	1.00	1.0	1.0		1.00
Ductwork – Composite	1.05	1.0	1.0		1.05
Electrical Commodities	1.20	1.0	1.0		1.20
Instrument Commodities	1.20	1.0	1.0		1.20
Open Structure				Weight	
Steel Galv.	1.05	1.0	1.0	84%	0.88
Concrete	0.85	1.0	1.0	13%	0.11
Lumber	1.10	1.0	1.0	3%	0.3
Closed Structure					1.02 say 1.0
Steel Painted	0.90	1.0	1.0	68%	0.61
Concrete	0.85	1.0	1.0	15%	0.13
Lumber	1.10	1.0	1.0	19%	0.17
Insulation	1.10	1.0	1.0	2%	0.02
					0.93 say 0.95

Additional Material Data:
Import Duties - 5% X CIF (1.5% NAFTA Rate)
Custom/Brokers Fees - 2% X Imports + Freights
Local Freight - 12% X Material & Equipment

Figure 3. Foreign Material Data

Category	Item Weight	United States Unit Price	Wtd. Price $	Local Currency	Mexico Unit $	Wtd. Price $
Tanks and Vessels						
(D) Tank, 304 S/S; 8' dia. X 10' straight side (2.4m X 3.1m); 4,300 gal. (16.3m3); flanged & dished top/bottom heads; 5/16" (8mm) shell; (6) 3" nozzels; 22" manhole; ASME code or equal;	43%	$22,300	$9,589	160,000Ps	$17,391	$7,478
(E) Tank, 304 S/S, 24' dia X 30' high (7.3m X 9.1m); 100,000 gal. (379 m3); domed roof/flat bottom; 5/16" (8 mm) shell; (6) 6" nozzles; (1) 24" manhole; API 650 or equal; 2" vacuum; incl'ds. Galv. ladder, platform & handrail; shop fabricated; field erected	35%	$350,000	$122,500	3,300,000Ps	$358,696	$125,543
(F) Distillation Col.; 304 S/S; 12' dia. X 47' straight side (3.7m X 14.3m); (20) 304 S/S sieve trays; 10 psi w/full vacuum (.7kg/cm2); 8' (2.4m) skirt; (2)	22%	$74,000	$16,280	641,700Ps	$69,750	$15,345
Sum of weighted S/S Tanks			$148,369			$148,366
Factor to U.S						1.0

Figure 4. Example of a Detailed Equipment Comparison

Variables

Some countries do not have the technology needed to manufacture certain specialized equipment. These items need to be identified in the parallel estimate so they do not get factored. Instead, use the estimated cost from the expected source (country), converted to the currency of the parallel estimate, and apply the appropriate percentages for freight, import duties, customs, and brokers' fees. Two other issues that must be addressed are:

- would certain items be imported because of quality or scheduling problems?
- what equipment would be so costly in another country that it is cheaper to import and pay any penalties?

These assumptions can greatly affect the material and equipment costs for an actual project, and thus a location factor when using this process. The location factor needs to consider expected or known strategies and the assumptions documented. This way, an adjustment could be made to the overall location factor if the assumptions for another project are different.

Adjustments

When the survey is priced out by only one source in a geographic location, it is not uncommon to have some of the individual equipment and material comparisons be drastically different. When this occurs, contact those who filled out the survey and discuss the specification for the item(s) in question. Reviewing the specification and getting a revised quote usually solves the problem. If it is not possible to go back to the suppliers of the surveyed data, then eliminate that item(s) from the roll-up of that category (see figure 5). This is not difficult to do if there are enough items in each category. If the entire category comparison does not seem realistic, then an approximate factor can be estimated, based on relationships with other categories. After working with a survey and region over a period of time, it is possible to approximate where a comparative factor will come out before actually doing the analysis.

APPLYING FACTORS

Once the labor, material, and equipment factors are developed, it is time to apply them to the detail line items of the base estimate. Table 2 illustrates how electrical wiring cost approximately 48 percent more in Tampico, Mexico, than in the US Gulf Coast area in January 2002, at 9.2 Pesos/$1.00.

Knowns =	9.2 Pesos/$1.00 January 2002			
	0.25 M&E Labor Factor			
	1.20 Electrical Commodities Factor			
	1.20 Major Electrical Equipment Factor			
	Labor	Commodities	Equipment	Total
Power Wiring (U.S.)	$32,670	$22,850	$45,660	$101,180
Factors	x 0.25	x 1.20	x 1.20	
Power Wiring (Mexico)	$8,168	$27,420	$54,792	$90,380

Table 2. Converting to U.S Dollars in Mexico

Similar factoring needs to occur against all of the detail line items of the base estimate. Each type of estimate (civil, commercial, chemical, etc.) uses a different mix of factors that produces a different location factor for the various types of construction. For this reason, a library of estimates should be maintained to factor, depending on the need at that particular time.

The base estimate could be 20 years old and it wouldn't matter because we are developing and looking at relative relationships, not absolute dollars. As mentioned earlier, a certain level of computer-aided estimating is required.

ROLL-UPS TO PROJECT LEVEL

After all of the details of the estimate have been factored, it is time to add in all the taxes, import duties, brokers' fees, etc. These are included as percentages (requested as such in the survey of data) of one of the elements of the estimate (i.e., duties/ocean freight/brokers' fees as a percentage of imports, local freight as a percentage of material/equipment, taxes as a percentage of material and equipment, etc.). It is necessary to know at what level each of these percentages must be applied. Applying them incorrectly could have a significant effect on the total estimate. Since a location factor is instantaneous, no escalation of these costs is required.

The next step is to capture the field-management costs. It is easier to request only those costs associated with management of the project work in the field and not all of the field indirects. This includes the salaries and expenses of the field-management team, their supplies, utilities, facilities, and the maintenance of those facilities. Total field indirects are difficult to capture, since interpretation can vary with each contractor. Field management is normally arrived at by applying a percentage of the total project costs (requested in the survey). Monies for social costs and contractors' overhead and profit must be included at this point if not built into the wage rates. This is usually entered as a percent of direct labor.

The final areas to cover are the engineering, design, and procurement. They also are entered as a percent of the total project. Most of this work is contracted out to full-service design contractors. The percentages of the total project cost vary by type of project. These percentages are readily available from local contractors. Capital monies required by the owner to perform any of the up-front engineering must be considered. This could include the development of a basic engineering package and/or the procurement of proprietary equipment. This effort also is available and included as a percentage of the total project cost. Too often, owners' efforts in the field administration and engineering/design and procurement areas are overlooked or underestimated.

COMPARISON AT THE SUMMARY LEVEL

When the factoring and percentages described above are applied to the base estimate, a parallel estimate in US dollars for Mexico is created. The cost relationship between the base estimate and the parallel estimate produces the location factor. The factored estimate is reflective of the same project scope used for the base estimate. A location factor developed using a factoring method will not add, alter, or delete project scope. The location factor resulting from this comparison is instantaneous at the given exchange rate, at a specific point in time. No location factor should be referred to without these two qualifiers (exchange rate and point in time).

As mentioned earlier, the accuracy of the location factor can be improved by having several surveys filled out for each location. The more that is known about the execution strategy and the local/import content of a specific project, the more the process can be tailored to meet specific needs. Once the factor is developed, it may be desirable to round to the nearest .05 (i.e., 1.03 > 1.05). Although the factor is relatively accurate, it should not be viewed as precise (i.e. Class 5 or 4).

MAKING THE FACTORING METHOD WORK

The difficulty in making this method work lies within the survey. What may be clear and precise in the base location may be hard to interpret in another culture. It takes time and a lot of communication to develop a meaningful survey. It also takes knowledgeable adjustments and interpretations when developing and using the factors. Establishing relationships by sharing the output with suppliers over a period of time improves the quality of the information.

It usually takes two or three times of going through the exercise with the suppliers before a real understanding is reached. Explaining the method face-to-face is always a good start, but it is only when the resulting analysis of the survey data is used in the factoring process that a true appreciation of what is required hits home. As their confidence and understanding in the method builds over time— and provided that suppliers have a need for the result—the accuracy improves.

Not all companies will have the resources to carry out the fully-developed methodology described in this recommended practice, particularly if many locations and project types are to be covered. In reality, most factor developers will be faced with trade-offs such as how detailed to make the design model (i.e., quantified scope), how many item types to include, how many suppliers to survey and at what frequency. While trade-offs may sacrifice some accuracy, the basic method is still worth pursuing if the company expects to evaluate project options between locations regularly. Once the base method is in place, it can be improved over time.

APPLYING AND UPDATING LOCATION FACTORS

By definition, a location factor is instantaneous and is only good for a specified exchange rate at a certain point in time. A location factor developed from data supplied last year has to be adjusted for currency and inflation differences between the two countries before it can be used today. Tracking location factors monthly by tracking revised monthly exchange rates and one-twelfth of the forecasted annual inflation provides updated factors between re-analysis. This is accomplished by using the following formula:

$$NewFactor = OldFactor \times \frac{NewExchangeRate\$}{OldExchangeRate\$} \times \frac{LocalInflation}{BaseCountryInflation}$$

(Equation 1)

This formula also is used to update material and equipment factors (Figure 3). The location factors can be updated for about 2 years before requiring another complete analysis. Through periods of significant currency and inflation fluctuations, this timing needs to be shortened.

Location factors should rarely exceed 1.30 for countries that do not have extensive import restrictions. When it becomes 25 to 30 percent more expensive to build in another country using locally-procured material and equipment, the procurement strategy will more than likely change. Importing and paying the ocean freight and duties may then become feasible. The site could reduce project costs by purchasing material and equipment from non-domestic sources. This strategy keeps overall project costs down, and likewise, the location factor.

Project teams need to seriously consider vendor assistance requirements, the accessibility to spares, the timing of replacement deliveries, and maintenance of installed equipment before deciding to buy offshore. If the decision is made to procure locally, the location factor could go beyond the cost of importing. These decisions have to be made on a project-by-project basis.

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