Estimation Is Not An Event, It's A Process!

Clement James Goebel III, PMP, Partner, Menlo Innovations
jgoebel@menloinnovations.com

Introduction

In many organizations and even in some industries, accurately estimating projects is seen as a failed art form that seldom produces useful predictions. For the individuals and organizations that struggle with this situation there is often a desire to find better tools in order to produce improved results. However, additional tools can improve the situation only so much because ultimately the value of these tools is dependent on three key inputs: your understanding of the project scope, the risks associated with that scope, and the quality of the historical data you will use to inform your estimates. Therefore, improved estimation often requires organizational and/or process improvement. In many cases this includes collecting better quality historical data through better time tracking and cost accounting. Likewise improving project initiation and monitoring often involves increasing organizational competence in interpreting and acting upon estimates that change as a project progresses.

This paper reviews the fundamental strategies on which most estimation techniques are built. It catalogs the key inputs, limitations, and costs for each of the fundamental strategies. Then, it describes how the advantages and disadvantages of each strategy will often naturally align with different phases of a project and how revisiting earlier estimates as progressive elaboration unfolds during a project can improve an organization's ability to make productive decisions when managing its portfolio of projects.

Fundamental Estimation Strategy

Estimation is almost always accomplished by building a model that will predict future performance by using past experience or historical records. This might be as informal as a subject matter expert checking her gut reaction. On the other hand, an organization might keep detailed records on the costs and timelines for all aspects of every project and use this detailed historical record to feed a sophisticated process. In between these two extremes is a continuum of process options that will either increase the granularity of the historical data being collected, or require an increasing level of detail for the scope of the project being estimated. In general, three areas along this continuum can be described as Analogous, Parametric, and Bottom-up.

Exploring the Strategies with a Simple Example

In order to introduce the mechanisms used for estimating, we will start by describing a very simple fictional project. Assume that you will personally be hosting a celebration dinner for a successful project team. One key consideration for this endeavor will be securing the funding, and before asking someone to fund this or deciding to pay for it out of your own pocket it would make good sense to estimate the associated costs for the event.

Analogous – How Much Did A Prior One Cost?

The simplest and often quickest method of estimation is to recall an equivalent historical event or project and use the associated historical costs to predict the cost of the planned event or project. For many of our day to day activities, this type of estimation is done from memory. In a more formal process, our search for an analogous project or event should lead us to a catalog of historical data for prior projects. (See Exhibit 1)

When	Sponsor	Event	Menu	Attendees	Cost
May 04	Individual	Family birthday BBQ	Chicken, steak, drinks	63	$384
Jun 04	Company	Black tie dinner event	Steak, fish, drinks	16	$2,490
Jul 04	Company	Catered picnic	Brats, burgers, deserts	35	$400
Dec 04	Company	Catered holiday party	Meatballs, shrimp	314	$1,975
Feb 05	Company	Working dinner	Pizza, pop	14	$42
Mar 05	Company	Department meeting	Subs, salad, pop	35	$128
May 05	Individual	Dinner out	Sushi, tempura, drinks	4	$112
Jun 05	Company	Black tie dinner event	Steak, fish, drinks	8	$2,200
Jul 05	Company	Team lunch @ fancy deli	Fancy sandwiches	7	$88
Jul 05	Individual	Café lunch	Salads, sides, tea	3	$36

Exhibit 1

Even in this simple example several questions immediately come to mind when looking for a comparable or analogous event.

- How many of our project team members will be able to attend?
- How important was the completed project to our executive team?
- Will any of the project sponsors attend?
- Will any external customers attend?
- How formal should the event be?

These questions apply not only to our planned project, but to each of the projects in the historical record. For the purposes of our example, lets assume that the team has 20 members and that two of our company's executives will be attending along with a dozen external customers. Because external customers will attend we will also assume that we are looking for a casual event that will constrain costs but be nicer than pizza or subs; we will therefore exclude from consideration all formal events and anything where pizza or subs were served. As we review some of the remaining events, the next challenge is that none of the events had 34 attendees. So we will scale the historical cost records to match our expected group size.

Event	Menu	Size	Cost	Scale Factor	Projected Cost
Family birthday BBQ	Chicken, steak, drinks	63	$384	* (34 / 63)	$207
Catered holiday party	Meatballs, shrimp	314	$1,975	* (34 / 314)	$213
Dinner out	Sushi, tempura, drinks	4	$112	* (34 / 4)	$952
Team lunch @ Fancy Deli	Fancy sandwiches	7	$88	* (34 / 7)	$427
Café lunch	Salads, sides, tea	3	$36	* (34 / 3)	$408
				average	$441

Exhibit 2

With our targeted set of historical data scaled to match our desired party size, we might be led to predict that our event should cost between $207 and $952. Unfortunately, a mathematical scaling of the cost data could very well lower the predictive value of the historical data. For example, perhaps the caterer used for the holiday party has a minimum order size. If we use the lowest prediction of $207 from the Family Birthday Party, there is probably a built in assumption that the project manager will have to spend at least one full day preparing and cooking which is not included in the historical cost data. Likewise, our highest prediction, $952, comes from a small party dining out together as a personal expense. If we remove these two historical data points the considered set, the range of the remaining observations narrows to between $213 and $427.

Analogous estimating is used informally by most people almost by reflex, based upon their personal recollections. A formal or rigorous application of analogous estimating requires an additional investment of time and energy. This additional investment occurs both in tracking and maintaining historical cost data, as well as the time invested interpreting and rationalizing the analogous project or projects selected as the model for the prediction.

Parametric - Can We Predict Based on a Few Key Criteria?

As demonstrated in the simple analogous example, comparing any two projects can be challenging because inevitably there are differences to consider. With additional effort, it should be possible to study our historical data and distill from it some general predictive equations. This process converts our qualitative evaluation against the historical data to a quantitative calculation. Many businesses that produce the same type of product over and over in different sized batches often produce these kinds of parametric equations and even use them to drive their pricing models. For example, assume that we have decided to have our party catered by the Fancy Deli previously used to host a team lunch. The deli provides a simple set of choices/inputs that will allow us to feed our group of 34 for between $314 and $578, before ordering beverages. (See Exhibit 2)

Catering Trays		under 15 people	15 people and over
Without Dessert	Sandwich Basket	$13.50	$13.00
	Classic Deli Tray	$13.00	$10.50
	Deluxe Deli Tray	$15.00	$11.75
	Rosie's No Red Meat Tray	$12.00	$9.25
With Dessert	Sandwich Basket	$15.50	$14.75
	Classic Deli Tray	$15.00	$12.50
	Deluxe Deli Tray	$17.00	$13.50

Exhibit 3 (Zingerman's)

By choosing a few key inputs, or parameters, we can zero in on the primary cost drivers that affect the project's overall cost. However, it should be noted that by the time the Deli has provided this model (really a fixed bid) to us, they will likely have produced identical output dozens of times and will effectively have a repeatable process instead of a project. The deli is not using this data to predict a new and novel, or unique, product.

Producing a similar parametric equation or process to help us predict the cost of future projects requires evaluating historical data to identify the key measurable cost drivers. Potential cost drivers might not emerge from a summary tabulation of key project metrics and might require deeper research. For example, some potential cost drivers for ordering food might include:

- Is this an infrequent regularly scheduled event, or an adhoc event?
- Will any of our clients/customers be present at the event, or only our employees?
- Is food being ordered to support a revenue producing activity?
- Do some departments have pre-approved expense accounts?

So we reorganize our historical data, grouping similar projects together, and then look for patterns in the data that could provide useful predictions. (See Exhibit 4)

	Event	Menu	Attendees	$/Person
Annual Formal Events	Black tie dinner event	Steak, fish, drinks	16	$155
	Black tie dinner event	Steak, fish, drinks	8	$275
Events Open To Clients	Catered holiday party	Meatballs, shrimp	314	$7
	Catered picnic	Brats, burgers, deserts	35	$12
	Café lunch	Salads, sides, tea	3	$12
	Dinner out	Sushi, tempura, drinks	4	$28
Internal Meetings Or Private Events	Working dinner	Pizza, pop	14	$3
	Department Meeting	Subs, salad, pop	35	$4
	Family birthday BBQ	Chicken, steak, drinks	63	$6
	Café lunch	Salads, sides, tea	3	$12
	Team lunch @ Fancy Deli	Fancy sandwiches	7	$13

Exhibit 4

Which we might reduce to the following predictions…

	Low Cost /Attendee	Avg Cost /Attendee	Highest Cost /Attendee	Prediction
Annual Formal Events	155	215	275	= $1,600 + $50 * attendees
Events Open To Clients	7	15	28	= $20 * attendees
Internal Meetings	3	7	13	= $10 * attendees

Exhibit 5

In this case, the predictions are intended to be conservative. In other words the prediction rule is intended to be higher than the actual cost more than half the time. Therefore, the predictive equation targets a prediction between the historical average observation and the historical high observation for each grouping of events or projects that share similar characteristics. Depending on the reason or purpose for your estimate, your prejudices should be different. For example, if you want to establish a very safe budgetary number you might create an equation that comes much closer to the highest observed values. On the other hand, if you are estimating in order to set a stretch goal for the team you might base your equations on average observed values or lower.

More commonly, the prediction equation is deduced from a best fit linear regression like we see in the category of Annual Formal Events. (See Exhibit 5) Or in the case of an equation with a larger set of identified and measurable drivers, a linear regression analysis might lead to an equation that requires many inputs. Ultimately the value of our parametric equations will be determined not by how complex or simple they are, but by the accuracy of their predictions. One simple test for any parametric equations that you are considering is to apply the prospective equations to your historical data and compare the predicted values to the historic actuals. (see Exhibit 6)

	Event	Attendees	Predicted Cost	Actual Cost	Delta	Delta%
Annual Formal Events	Black tie dinner event	16	$2,400	$2,490	+90	+4%
	Black tie dinner event	8	$2,000	$2,200	+200	+10%
Events Open To Clients	Catered holiday party	314	$6,280	$1,975	-4,305	-69%
	Catered picnic	35	$700	$400	-300	-43%
	Café lunch	3	$60	$36	-24	-40%
	Dinner out	4	$80	$112	+32	+40%
Internal Meetings	Working dinner	14	$140	$42	-98	-70%
	Department Meeting	35	$350	$128	-222	-63%
	Family birthday BBQ	63	$630	$384	-246	-39%
	Café lunch	3	$30	$36	+6	+20%
	Team lunch @ fancy deli	7	$70	$88	+18	+26%

Exhibit 6

All of the projects being described by any single parametric equation must exhibit very similar characteristics. Differences that might seem minor on the surface might actually be significant in the predictive quality of the equation and therefore need to be parameterized. One key challenge in this area will be that data collection might not have already occurred for non-obvious key cost drivers, and therefore create the need and cost for doing additional historical research. In cases where the projects for an organization are very unique, it will be difficult to capture enough data observations for each narrowly defined and easily compared project type to construct an effective linear regression prediction.

Bottom-up – Creating a shopping list of everything you need

One strategy that is available when organizations lack sufficiently detailed historical data, or the project under consideration does not have good analogies, is to perform a bottom-up estimate. The process for performing a bottom-up estimate is theoretically straightforward; create a detailed inventory for all of the project's component costs and obtain costing data or estimates for each individual element. Recalling our project team's celebration, it would be instructive to consider the Family Backyard BBQ as a model for our event. In this case, we decide on our menu, decide how many servings of each item we will prepare, look up the recipes, and prepare a shopping list for all the groceries that are required. Our estimate will then be based on a trip to the grocery store to collect up to date cost data for all of the items on our grocery list.

Grilled Ginger Cashew Chicken				
Ingredient	**Amount for 4**	**Scaled for 20**	**Min Order**	**Cost Est**
Boneless chicken breast halves	4	20		$34.93
White wine vinegar	6 tbs	30 tbs	12 oz	$1.69
Olive oil	¼ cup	1 ¼ cup	16.9 oz	$6.39
…	…	…	…	…
Soy sauce	½ cup	2 ½ cups	20 oz	$2.99
Cayenne pepper	1 tsp	5 tsps	1.8 oz	$4.19
Total estimate for chicken dish ingredients				$82.47

Exhibit 7 (More Thyme, LLC)

Bottom up estimating is instinctively practiced at some level by many people. While it is conceptually simple, there are several challenges in using this technique to create a predictive estimate. It is necessary to finalize many design decisions before you can inventory the associated detail affected by each decision: the compilation process is typically labor intensive, and it is very easy to become narrowly focused on one aspect of the project leaving entire areas un-estimated. For example, in planning a menu and producing cost estimates for the food our team might forget to determine if they need to rent tables and/or dining utensils. It is also easy to assume that each and every element of the plan will work out optimally, and thereby create an estimate that is the aggregate of optimal, optimistic, or idealized estimates.

A significant advantage for bottom-up decomposition of the project is that it reduces the need to find directly comparable historical data for projects that match the project being estimated. Instead the project can be decomposed into subsets of deliverables that subject matter experts might easily and confidently estimate assuming that the subsets have each been well described. The value of a bottom-up estimate is closely related to how well the deliverables are defined in a detailed work-breakdown-structure. Therefore, if your work-breakdown-structure closely resembles a generic project plan template, then your estimate likely resembles a generic estimate.

Three Basic Strategies

There are many estimation processes that at first glance might not match one of these three strategies. However,. most estimation methodologies build on or combine these basic elements:

- decompose the project into its key characteristics or into subsets of deliverables
- identify comparable historical data sets or parametric models
- use the best available model to produce an estimated range of likely results

The way in which each individual estimation process includes elements of these individual strategies, the level of detailed historical records, required up front investment, expected predictability, as well as the effort and cost of estimation will vary. Each of these techniques are also each more appropriate for different circumstances.

	Effort/Cost to Perform	Cost as Percentage	Overhead Investment Across All Projects	Typical Accuracy
Analogy	Hours	0.04% to 0.15%	Maintain cost records	-30% to +50%
Parametric	Hours or Days	0.04% to 0.45%	Maintain cost records Perform correlation analysis Verify continued relevance	-30% to +50%
Bottom up	Days or Weeks	0.45% to 2.0%	None, but historical cost records can improve accuracy for individual elements	-10% to +15%

Exhibit 8 (Milosevic 2003, 233)

Application within Commercial Construction

The commercial construction industry nicely illustrates how the basic estimation strategies can be used in concert with each other to provide different types of information at different points in the life cycle of a project. (Bledsoe 1999, 13) Early in a project's lifecycle, before the full budget has been approved or even allocated, there is often the need to rule out potential projects. In this case, an analogous estimate can be used by identifying similar projects and using their historical cost to predict the magnitude of likely investment required. This estimation method is the strategy being used when meeting an architect and describing your project in terms of some other building with which you are both familiar.

A commonly recognized refinement to this initial estimate is to refer to industry reference texts that catalog the average costs for various types of commercial buildings and look up their average cost per square foot. This parametric estimation technique is driven by the type of building, the intended geographic location, and the expected overall size. (See Exhibits 9 and 10)

	55,000 sq ft	100,000 sq ft	150,000 sq ft	Actual Cost Range
Apartment, 4-7 Story	$129 / sq ft	$121 / sq ft	-	$51 to $148 / sq ft
Hospital, 2-3 Story	$211 / sq ft	$204 / sq ft	$200 / sq ft	$124 to $315 / sq ft
Hospital, 4-8 Story	-	$215 / sq ft	$208 / sq ft	$127 to $311 / sq ft

Exhibit 9 (RSMeans 2004, 80)

Location	Base Cost Multiplier
Alaska, Anchorage	1.25
Arizona, Phoenix	0.88
California, Los Angeles	1.07
Michigan, Ann Arbor	1.03
Ontario, Toronto	1.11

Exhibit 10 (RSMeans 2004, 451)

Because the variations from one commercial building to the next are significant, the results of this parametric equation will not result in a ready to bid construction project. Many factors can affect the cost of a construction project, and many of these cost drivers arise from a multitude of detailed decisions that need to be made for each project.

> Residential and office buildings tend to have a large degree of uniformity in their design and construction. While they have many shapes and different features such as exterior cladding and interior decorations and fittings, the problems of construction are more or less uniform. These types of structures can be called "simple" projects. By comparison, laboratories, manufacturing or chemical plants, and hospitals have significant variations from one project to another. These can be called "complex projects." The more complex a project is the more specialized it becomes. Therefore, ballpark estimates may become "shots in the dark" if it is a highly specialized or complex project. (Bledsoe 1999, 13)

Instead of using a simple parametric result to finalize construction contracts, it is instead used to justify the cost of moving forward with detailed planning and further estimating. The effort and investment required to produce this detail is what makes effective Bottom-up estimating so expensive (See Exhibit 11), and therefore using Analogous and Parametric estimates early in the process attractive because of their relatively low cost.

	Total Project Size in Thousands of Dollars			
Building Types	**100**	**500**	**5,000**	**50,000**
Factories, garages, warehouses	9.0%	7.0%	5.3%	4.5%
Churches, hospitals, homes, museums	15.0%	12.7%	9.5%	8.0%

Exhibit 11 – Architecture fees as a percent of total project cost (RSMeans 2004, 450)

As a project moves forward, the Assemblies method of estimating can be used to focus on the aspects of the project that are unique. Without doing a complete bottom-up estimate, this method breaks down the project into functional areas of interest and describes the functionality commonly sought, the standard solution being estimated and the parametric estimate associated with each subset of functionality. (See Exhibit 12) As the project proceeds, the estimate may be revised using a bottom up estimate given the detail provided in the blue print.

Area	Element	Selected Technique	Unit Cost	% Cost
Substructure				2.2%
1010	Standard foundations	Poured concrete	$1.43 / sq ft	
1030	Slab on grade	4" reinforced concrete	$1.32 / sq ft	
2020	Basement walls	4' foundation wall	$0.63 / sq ft	
Shell				19.9%
1010	Floor construction	Cast-in-place concrete	$12.51 / sq ft	
…	…	…	…	…
			$155.47 / sq ft	100%

Exhibit 12 (RSMeans 2004, 147)

So as a complex commercial construction project moves forward the cost estimates are updated and refined using methods that are appropriate at each phase for the amount of detailed scope available as well as the resources available to support estimation.

Conclusion

When organizations decide to improve the predictability of their estimates, they need to understand how their estimation process uses the underlying estimation techniques. They also need to evaluate the quality of historical data being used, assessing the granularity, the accuracy, and how well the historical projects model future projects.

For example, if your historical effort data for projects is based upon timesheets that are inaccurate, it will not matter how much you improve your parametric equations.

Improving your estimations also requires capturing and assessing the process flow of how estimates are assembled and how each estimate is used and by whom. Organizations that produce a single number as an estimate before beginning a project and then fail to update that estimate as the project unfolds, are likely to be unhappy with the value that estimating can add in managing their project portfolios.

Effective estimation is an ongoing process that continues throughout the life cycle of your projects. Estimates should be reviewed and updated on a regular basis, and they should expressed in a manner that communicates an explicit notion of their reliability, for example expressing estimates as a range of likely values. No magic tool will improve estimation; good estimation comes from rigorous process that is integrated into your other project management processes through out the life of the project. Like many other processes, it is best implemented using different techniques at different phases of your projects.

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