COST ESTIMATING

RODNEY D. STEWART

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Preface

In many years of working in the fields of project management, procurement, and cost estimating, I have found that a common thread of methodology and practice exists in virtually all cost estimating situations. There are certain principles, practices, and procedures that hold true whether it is an industrial process, a manufactured product, a multimillion dollar construction project, or a business service that is being estimated. This book describes these principles, practices, and procedures; provides a simple cost-effective, step-by-step methodology for cost estimating; and points out pitfalls, problems, mistakes, and inaccuracies that can occur in cost estimates that can determine the difference between success and failure. The book is organized so that you can view the overall picture or delve more deeply into each step of the cost estimating process. It is not a highly technical, sophisticated treatise on the mathematical and statistical aspects of cost estimating. Rather, this book is a simple, straightforward exposition of the basic concepts and steps required to develop industrial engineering type, man-hour and material-based, and parametric cost estimates. It is designed for the shelf of any professional who is a cost estimator, price estimator, cost analyst, price analyst, or systems cost analyst; and it will be useful whether he is working in a university, a small firm, a large corporation, or a government agency. It is a necessary constituent of the library of any business or organization that is interested in making a profit consistently and achieving maximum results for dollars spent.

As you read and apply the principles, practices, and procedures presented in this book, you will find that you will more fully appreciate the connection between the content of a work activity and the resources required to accomplish that activity. You will realize the sizeable benefits of good estimating. Further, after having applied an organized approach to estimating the cost of your work activity or work output, you will have a better appreciation for the value of the work to you as a producer and to the consumer.

Good luck—good reading—and good estimating.

RODNEY STEWART

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Why Cost Estimating?

For which one of you, when he wants to build a tower, does not first sit down and calculate the cost, to see if he has enough to complete it? Otherwise, when he has laid a foundation, and is not able to finish, all who observe it ridicule him, saying, "this man began to build and was not able to finish."

Luke 15:28–30

ESTIMATING IN A WORLD OF LIMITED RESOURCES

Frank Borman, the first man on the moon, was interviewed on the TODAY Show several years ago. Colonel Borman's commentary went something like this:

> When our Apollo Spacecraft came out from behind the moon for the first time, I saw a wonderous sight—the beautiful green earth—about the size of a basketball, against the bleak horizon of the moon's landscape. It was then that I realized how much our earth is like a self-contained spacecraft.
>
> There it was, a tiny ball with a very thin atmosphere—an atmosphere that must sustain all of known human life. I realized then that the earth, like our Apollo Spacecraft, has a finite amount of air, water, food, and natural resources. I also realized that, unlike my spacecraft (which would be jettisoned and discarded after we had used up all of the supplies and left our wastes there) the earth must continue to sustain life for years and years to come if the human race is to survive. Further, with the population increasing at an ever expanding rate, natural resources will continue to be used more rapidly and could be depleted sooner than we think.

This viewpoint emphasized the fact that the earth's material resources are really very limited, and that the use of these resources must be carefully planned and controlled in order to assure our continued survival on this planet. We are like a man stranded on a desert island with a limited amount of food, or an airplane pilot lost over the ocean with a limited amount of fuel. Each must estimate and plan his consumption of his most valuable resource based on the time or distance to be covered and the quantity of the resource available. The solutions to either of these problems of scarce or limited resources require the best possible estimate of future occurrences.

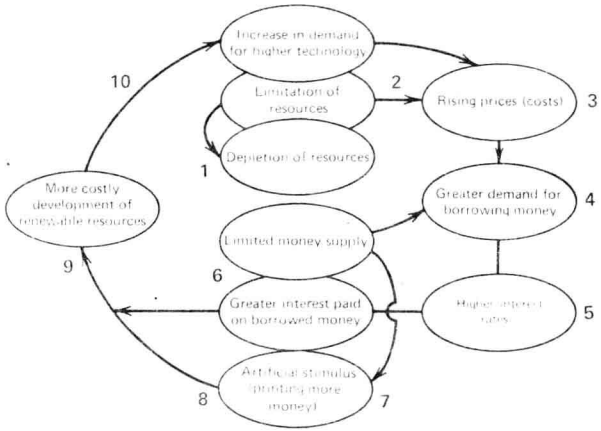

Figure 1-1. Inflationary cycle.

The law of supply and demand says that the more limited the supply at a given demand rate, the greater the cost or price of a raw material, commodity, or service. This is one of the reasons that the cost of nonrenewable resources such as fossil fuels and precious metals is increasing rapidly. In an environment of continuing inflation, it is necessary to have techniques and tools readily available that can rapidly and accurately estimate the costs of processes, products, projects, and services. The rising costs of materials and labor are compounded by the facts that money is becoming more costly to borrow, and the materials required and skills needed to produce higher technology products are becoming more sophisticated and more costly.

The inflationary cycle that brings about a need for continuing application of good cost estimating techniques is shown on Figure 1-1. As shown, (1) depletion and use of our natural resources at a rate exceeding renewal results in a limitation of resources. (2) The increase in demand for higher technology, more sophisticated processes, products, projects, and services, coupled with the limitation of resources available to produce these outputs causes prices to increase. (3) Increasing costs, coupled with a limited money supply, cause a greater demand for borrowed money. (3) This greater demand, and the limited money supply, result in higher interest rates. (5) Because of the need for money to lend, financial institutions give greater interest rates, and help pay for this by the higher interests they charge their customers. (6) The greater interest that must be paid on borrowed money tends to restrict the flow of dollars and continues to limit the money supply. (7) In the meantime, the federal government continues to bolster the money supply by approving budgets that require a greater output of dollars than is taken in through taxes and other income. To do this, more money is printed than can be backed by income or gold reserves. This practice reduces the buying power of the dollar and results in higher costs of renewable resources and

higher costs of the high-technology products needed to satisfy increasing demand (8-10). Thus the inflationary cycle is completed and starts again. Because of the dynamic nature of this cycle, estimating the costs of a work output must be done frequently and periodically to keep estimates accurate and credible.

INCREASED PRODUCTIVITY AS A SOLUTION

One way to use and to stretch the availability of limited resources judiciously is to increase productivity. Increased productivity does not necessarily mean increased production. Increased productivity means obtaining a greater output of goods or services for a given amount of natural, manufactured, financial, or human resources. Increased productivity can be achieved by improving the efficiency, economy, and effectiveness of any form of work output. The ability to plan, schedule, estimate, and carry out an activity, therefore, has significant impact on the effective use of resources. The development of realistic estimates of the projected cost of an activity will result in adequate resource allocation and, as a result, more likely project completion. If more projects are completed within their original cost estimates, greater productivity will result. Fewer projects or work activities will be cancelled for lack of funds when they are partially completed. Better cost estimates for all work activities may result in fewer being started because it will become apparent that all desired projects cannot be started within the limit of resources available. But those that are started will have greater likelihood of being completed if realistic estimates are made.

PRODUCTIVITY AND THE PROFIT MOTIVE

Making a profit and providing the best possible work output, whether it be a process, a product, a project, or a service, are two motivators in increasing productivity. These two forces or motivations are not always given equal emphasis in a given work activity, but one or both are present in all successful ventures; they are both significant factors in the continuing improvement in the quality of life—and affect our overall productivity as a nation.

To assure maximum productivity, it is necessary to have an accurate estimate of the costs required to accomplish a job before it is started and to efficiently and effectively manage the job within the cost constraints established. Too often we have failed in one or both of these respects, and underestimates or cost overruns have resulted. The accuracy and credibility of a cost estimate or series of cost estimates, in fact, can be the source of success or failure of a business, commercial activity, or government project. If a commercial or industrial activity consistently produces high cost estimates and bases its prices on these estimates, it is subject to business failure because the work output is not cost-competitive in the marketplace. A company that consistently bids high will

lose business to ones that bid low. On the other hand, bids or estimates that are consistently too low will result in a loss of profit; and a company cannot reap a negative profit very long and still stay in business. Any business or corporation that wants to continue operating in a profitable mode must continually improve its estimating and pricing methods. (Some companies and businesses have become successful without employing good cost estimating and pricing techniques, but very few of these companies *stay* successful without them). Many companies employ "loss leaders" (products that are priced below their cost) to capture a market or to draw customers to other products of the same company; but, to stay in business, these companies must have a mix of profit and loss that results in an overall profit in the long run.

Excess profits are often criticized by consumers or small businessmen who believe that they are being victimized by larger corporations or monopolies. The potential ability to make not only a profit but also to make a large profit is what makes business risks both feasible and attractive for an industry or investor. Without these risks, the advancements in technology and improvements in the standard of living we have experienced would not have been possible.

The subject of productivity is far more complex when it comes to the activities of state, local, and federal government departments and agencies. Since the profit motive does not exist in government, it is even more important to be able to predict and control costs. Cost estimating by independent organizations within government departments and agencies is on the increase because the taxpayer is becoming more concerned about the need for efficiency, economy, and effectiveness in government. Since tax-based income levels are relatively fixed, government tends to look for the most work output per dollar rather than the lowest cost per work output. Both approaches require a form of cost estimating. The latter requires an "estimating-to-cost" or "design-to-cost" technique that provides a work output based on the resources available. This technique is more difficult than the simple process of defining a work output and estimating its cost because it requires an iterative process of defining—estimating—redefining—reestimating, and so on until a work output is defined that can be accomplished within the funds allotted. Either of these techniques will help in estimating accurately enough to assure a continued business base and a continued profit.

AT STAKE, THE ORGANIZATION'S REPUTATION

The cost estimating and pricing policy of a company or a government organization will have a definite effect on its business reputation. Accurately estimating a job and performing it within the estimated cost will go a long way toward building up a reputation that will enhance an organization's future business potential and will help to retain a good long-term business base.

If you want to stay in business for a long time, you must avoid "buying-in"

to jobs or tasks that you cannot complete within the allotted resources. There is a danger that larger companies may fall into this mode of operation when long-term, high-cost projects are undertaken because even a company that is going out of business pays its executives; and those in the marketing and management roles may be tempted to underbid unrealistically just to get the job in the hope that they will obtain "bail-out" changes or follow-on contracts at a later date.

Most successful companies do not resort to this tactic if they desire to stay in operation for a number of years. They fully realize that they will lose a certain percentage of their bids, and they take pride in offering a better service, better facilities, more qualified personnel, or an innovative design. A credible and realistically low bid can be achieved through good planning, organization, and design rather than through the use of an arbitrarily low or misleading cost estimate.

A company's reputation in performing work within the cost target established is becoming an increasingly important factor in selection to do important work in both the private and public sectors. The use of advanced technology in design, manufacturing, and admministration is a key factor in producing a competitive cost estimate. If a company is innovative and up-to-date in its management and technical approach, it will perform cost analyses of new techniques as they become available to it and will adopt those techniques that result in reasonably high life cycle cost savings (see Chapter 10 for a description of how to compute life cycle cost savings). The only way to know if advancements will pay off is to develop a detailed cost estimate that uses the best available inputs and assumptions and to perform an economic analysis to determine the costs versus benefits of an innovation.

A company can also protect its reputation in cost estimating and bidding by maintaining a good salary mix and skill mix. There is a danger of salary creep if the turnover of a company is so low that the percentage of senior employees grows each year the business is in operation. The solutions to this problem are (1) the maintenance of steady growth, (2) adding most of the new employees at the bottom of the salary structure, or (3) retiring or laying off employees once their skills and related salaries exceed the level that can support a competitive bid. Clearly, the former solution is much more satisfactory than the latter. A good detailed cost estimate, along with an analysis of cost estimates prepared over a 2- or 3- year period will provide management with the knowledge of potential grade and salary creep above that which could be attributed to inflation.

IN-DEPTH COST ESTIMATING IS NEEDED

There is considerable contention in the cost estimating community as to which method of cost estimating is the best: the "top-down" or parametric approach, or the "ground-up" or industrial engineering approach. The parametric approach uses historical data from previous work and projects the costs of new

work based on increased or decreased quantity, size, weight, power level, or other factors for the new work. The industrial engineering approach requires the estimating of man-hours and materials of each element and subelement of work, and the pricing and accumulation of all the costs of the elements and subelements into a total cost estimate. Actually, both methods of estimating are satisfactory for various phases of the estimating cycle; and the use of one or the other of these techniques depends upon the amount of historical data available, the use to which the estimate is to be applied, and the time available to perform the estimate. The parametric and the industrial engineering approaches become more closely related, and even become one and the same, as penetration is made into lower levels of the work.

The number of minutes or seconds it takes to accomplish a single assembly-line operation, an input to an industrial engineering type estimate, is really a parametrically derived value based on past experience. The two methods are the same; except that the parametric estimate has been traditionally used at a much higher level in a work operation. The use of a dollar-per-square-foot value to estimate the cost of a house (versus the minutes or seconds required to install an electrical socket) would be an example of the traditional use of a parametric estimate. Most large organizations use both types of estimates for their projects and combine the knowledge derived from these two estimates to develop their final cost estimate.

The top-level parametric estimate, used alone, has serious limitations from the standpoints of visibility of estimate components, identification of major cost drivers, isolation of inflation effects on each cost element, and adjustment of costs to reflect subtle changes in the work output.

Experience has shown that the most credible, supportable, useable, and accurate cost estimate is one where an in-depth analysis of the work and estimating of work elements is accomplished. This in-depth cost estimating procedure usually consists of one or more of the following types of activity:

1. Preparation of a complete list of all drawings, documents, publications, materials, and parts required to perform the job, and analysis of these items to establish a make or buy decision on each.
2. Detailed manufacturing or process planning, including a preliminary design of each major tool and piece of special equipment, and a complete analysis and description of the manufacturing or process flow.
3. Application of work standards and adjustment to account for expected performance against these standards.
4. Definition of each administrative, engineering, manufacturing, assembly, testing, shipping, and support task by discipline; and the use of standard industrial engineering methods, man-loading techniques, judgment of skilled personnel, and historical experience to arrive at a detailed estimate.