1: Design, Projects, and Economics

This chapter first explains the role of economics in design, and then it presents how design is performed as part of a project. This leads to a discussion of basic concepts of project economics, a brief overview of the text, and then a chapter summary.

1.1 Design Strategies

Organizations must use their resources efficiently to be successful, so someone designing a system must consider its economics. This can be illustrated by a simple example involving two recent graduates assigned to solve similar problems. Their design strategies are quite different.

The first designer quickly identified a way to solve the problem, analyzed it very carefully, and then produced a design with outstanding technical characteristics, design A. The economics were not analyzed until it was time to do the final report. The cost of the proposed design, including the salary of the designer, was $150,000. The benefits were savings of $28,000 per year for five years. This is shown in the cash flow diagram in the top portion of Figure 1.1. The down arrow at time 0 is the expenditure, and the up arrows at times 1 through 5 are the revenues.

The second designer briefly investigated several alternatives for solving the problem, including estimating costs and benefits. Two methods appeared to be better than the others, so their technical and economic aspects were examined further. Finally, the best alternative was chosen, design B, and then its design and economics were further refined. The resulting design was adequate from a technical viewpoint. It cost a total of $70,000 and resulted in savings of $23,000 per year for five years, as shown in the middle of Figure 1.1.

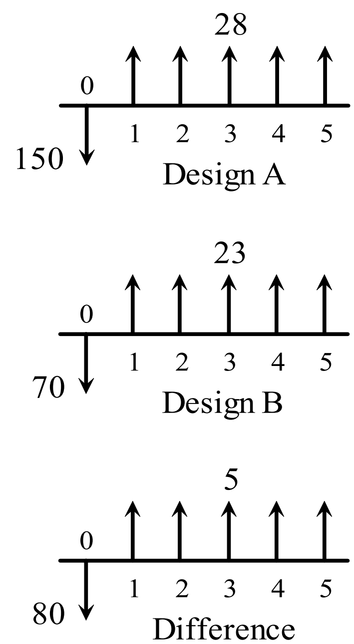

Figure 1.1 Design Economics

Both designs solve the problem. Design A is more technically advanced, but design B is adequate. Examine the differences in the cash flows of the designs, shown at the bottom of Figure 1.1. The technical advances of design A provide extra savings of $5,000 per year for five years, but these savings cost $80,000 more initially. The extra benefits clearly are not worth the extra costs. The objective of a company is to make money, so the graduate producing design B is the more valuable employee.

A design strategy that integrates both function and economics has a clear advantage over one that only considers function. The design activity is imbedded within a larger framework of project management and development, as described in the next section.

1.2 Projects

Projects should begin with a clear statement of objectives and the criteria for evaluating potential designs. Then alternatives are identified and analyzed in stages, beginning with initial analyses in which only rough designs and estimates of cash flows are used to eliminate obviously inferior alternatives. The designs and estimates are improved enough to make decisions about which alternatives need more study and which can be discarded. This continues until either one alternative is chosen or they are all rejected. If an alternative is chosen, then the project is implemented and follow-up procedures are carried out. Figure 1.2 summarizes these steps, and the following sections describe them further.

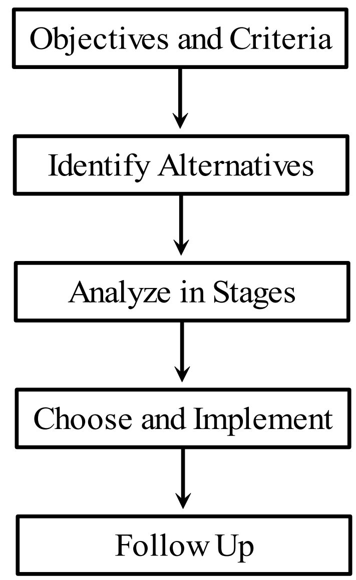

Figure 1.2 Steps in a Technical Project

Objectives and Criteria

The starting point is to obtain a clear statement of objectives. Care must be exercised so that objectives are not defined too narrowly. For example, consider a process in which bark is removed from pine trees in a sawmill. A narrowly defined project might investigate only efficient mechanisms for loading the bark onto trucks and hauling it to a land fill. A more broadly defined project would simply state that the accumulated bark requires disposal. This allows alternatives such as using the bark for fuel.

Criteria need to be determined to measure how well an alternative meets the objectives. Economics is the primary criterion for choosing the best alternative within this text, but other criteria might be important, such as safety, timeliness, reputation of the firm, strategic market position, and so forth. In general, any major considerations that cannot be reduced to economics should be reported.

Identify Alternatives

The second step is to define alternative solutions. This is dependent upon the statement of objectives, as illustrated above. For example, sometimes non-technical solutions might work quite well, such as selling the pine bark to garden supply stores or wholesale florists. It is often worthwhile to engage in a brainstorming session, a process in which several individuals toss a variety of ideas back and forth. All possibilities should be considered, since a seemingly useless idea might trigger a good suggestion.

Stages of Analysis

Once all alternatives have been defined, the next step is to perform an initial analysis to eliminate obviously poor ones. This stage involves only rough designs and estimates of costs and benefits. Errors of 25% or more are reasonable at this stage. It can be surprisingly difficult for a recent graduate to do this after four or more years of calculating answers to three decimal places, but it is absolutely necessary. Fortunately, as practical experience grows, so does the ability to rough out designs. If several alternatives still appear to be promising, then more design and problem investigation are necessary. An intermediate analysis might produce economic estimates accurate to within 15% to 20%. If still more analysis is required before choosing which alternative to implement, then a final analysis might result in estimates accurate to within 10%.

Accuracy estimates can be quite difficult to obtain, particularly for large projects. It has been known for a long time that cost overruns usually tend to be inversely proportional to the amount of design effort [Hachney, p. 87]. Projects in early stages of design generally are more expensive than estimated, since there is a tendency for preliminary designs to omit many details not recognized until the later stages of design. Some firms multiply initial cost estimates by factors to escalate estimates of costs as a function of how much design work has been done.

Choose, Implement, and Follow Up

Once the alternative that satisfies the objective is determined, then its implementation begins after enough design work has been completed. If a project is long, then implementation sometimes begins before all detailed design is complete. Some companies actively involve designer in the implementation of the project, and other companies assign them to another design task. In either event, it is important to follow up on the design and keep records so that the estimates and designs can be contrasted with what actually happens, thereby providing an opportunity to improve.

Actual Practice

Economic analysis in actual practice is usually quite different from the classroom experience. Examples and homework problems typically provide estimates of costs and benefits, and the student focuses on correctly performing economic computations. The situation is reversed in actual practice. The majority of the time is spent in the design and estimation effort, and the calculations necessary for economic comparisons of alternatives take comparatively little time. Another difference is that economic analyses are sometimes not stressed in design courses simply because there might not be time to do so. However, ignoring the economic consequences of design in industry is a grievous error. Graduates who excelled in college can find themselves bypassed by less technically skilled persons who know how to make money for their company.

1.3 Basics of Project Economics

The life span of a project can be very short, or it can last several years. An example of a short project is the production of 1,000 computer cases within a two week period. One alternative might be to use highly automated equipment that is expensive to set up but has low labor costs, whereas another alternative might use less automated equipment that has a low set-up cost but a higher labor cost. An example of a multiyear project is choosing an air conditioning system. A system with a high initial cost might produce savings over several years relative to a system with a low initial cost. It is much easier to analyze projects with costs and benefits occurring at essentially the same time than projects lasting several years, so most of the text is devoted to multiyear projects.

Multiyear Projects

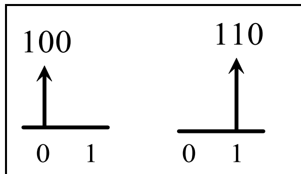

Figure 1.3 Choice

Multiyear projects require adjusting the way one assigns value to money. Instead of "how much" being the only question, "when" also becomes important. For example, consider an investor who can either receive $100 today from a project or wait for one year and then be paid $110, as shown in Figure 1.3. If the $100 is received today, then it will be reinvested. Suppose that the investor's objective is to maximize wealth after one year, so choosing between the $100 today or the $110 in a year depends upon the earnings of the $100 reinvested today.

If it can be reinvested with a rate of return of 10% per year, then it will accumulate to $110 after a year, the original $100 plus a $10 return. Notice that a reinvestment rate of return smaller than 10% provides a total of less than $110 after one year, and a rate in excess of 10% yields more than $110. Thus the investor would:

- be indifferent if the reinvestment rate is exactly equal to 10%,
- prefer the $110 one year hence if the reinvestment rate is less than 10%,
- choose the $100 today if the reinvestment rate is greater than 10%.

If the investor's options include alternatives involving more than one year of cash flows, then the more advanced analysis discussed in subsequent chapters would be required.

Banking, Industrial, and Governmental Investments

The text's development of models that recognize the "time-value" of money begins with banking transactions involving saving accounts and loans with fixed interest rates. This knowledge is usually quite helpful on a personal basis, as well as at a professional level. Several chapters are devoted to common banking problems having patterns of cash flows that also occur in the more complex industrial environment.

The industrial environment differs from the banking environment in the manner in which cash flows are reinvested. For example, funds invested in a savings account grow a well defined rate of interest, say 7% per year. However, when revenues are received from an industrial project, they are reinvested in a spectrum of new projects, some more profitable than others. Each of the new projects typically requires an initial investment and then produces revenues over a period of years, so it can be viewed as a savings account. Each new "saving account" can potentially pay a different rate of interest, so additional analysis is required to determine the appropriate value of the reinvestment rate to use for industrial projects. Determining this rate allows the analytical procedures used to analyze banking investments to be extended to industrial and then to governmental projects.

Overview

The remainder of this text focuses on how to analyze the economics of technical projects. The next chapter introduces the various types of analyses and suggests some general principles for conducting them. Subsequent chapters examine the various types of analyses in more detail.

1.4 Summary

This chapter first discusses design strategies and the need to consider economics at the same time as designing solutions to a problem. Next, considering this process within a project environment enhances understanding of the joint role of design and economic analysis. Projects have the following steps:

- State the objectives and decide upon the criteria for choosing the best alternative.
- Identify alternative solutions.
- Perform several stages of analyses in which both technical designs and economic estimates become progressively more accurate until a choice among the alternatives can be made.
- Choose the best project and implement it.
- Follow up afterwards to determine if design and estimation procedures can be improved.

In actual practice, economic computations take relatively little time compared to the effort required to estimate cash flows. This situation is reversed in the classroom where alternative designs and estimates usually are provided in the problem statement, and the focus is upon the economic computations. Graduates also should be aware that courses focusing on design frequently have little time to consider economics, whereas the reward system in industry is typically economically driven.

Project economics are much simpler for projects in which the cash flows occur at essentially the same time. Multiyear projects require recognizing the time-value of money, how sums closer to the present can grow when they are reinvested. The text will first examine this growth within the context of a single banking account, and then extend it to industrial and governmental environments.

Questions

Section 1: Design Strategies

1.1 What is the primary benefit of considering economics at the early stages of design?

Section 2: Projects

2.1 What are the steps of performing a technical project? How accurate are estimates at each stage of analysis?

2.2 What are basic differences between learning the economics of projects in the classroom and applying it in practice?

Section 3: Basics of Project Economics

3.1 What is the basic difference between the banking and the industrial and governmental environments insofar as multiyear projects?

Bibliography

1. Hachney, John W., *Control and Management of Capital Projects*, John Wiley & Sons, New York, 1965.