CHAPTER 3

Project Selection and Portfolio Management

Chapter Outline

Chapter Objectives

After completing this chapter you should be able to:

1. Explain six criteria for a useful project-selection/screening model.
2. Understand how to employ checklists and simple scoring models to select projects.
3. Use more sophisticated scoring models, such as the Analytical Hierarchy Process.
4. Learn how to use financial concepts, such as the efficient frontier and risk/return models.
5. Employ financial analyses and options analysis to evaluate the potential for new project investments.
6. Recognize the challenges that arise in maintaining an optimal project portfolio for an organization.
7. Understand the three keys to successful project portfolio management.

PROJECT PROFILE

Project Selection Procedures: A Cross-Industry Sampler

The art and science of selecting projects is one that organizations take extremely seriously. Firms in a variety of industries have developed highly sophisticated methods for project screening and selection to ensure that the projects they choose to fund offer the best promise of success. As part of this screening process, organizations often evolve their own particular methods, based on technical concerns, available data, and corporate culture and preferences. This list gives you a sense of the lengths to which some organizations go with project selection:

- Hoechst AG, a pharmaceutical firm, uses a scoring portfolio model with 19 questions in five major categories when rating project opportunities. The five categories include: probability of technical success, probability of commercial success, reward to the company, business strategy fit, and strategic leverage (ability of the project to employ and elevate company resources and skills). Within each of these factors are a number of specific questions, which are scored on a 1 to 10 scale by management.
- The Royal Bank of Canada has developed a scoring model to rate its project opportunities. The criteria for the portfolio scoring include project importance (strategic importance, magnitude of impact, and economic benefits) and ease of doing (cost of development, project complexity, and resource availability). Expected annual expenditure and total project spending are then added to this rank-ordered list to prioritize the project options. Decision rules are used (e.g., projects of low importance that are difficult to execute get a "no go" rating).
- The Weyerhaeuser corporate R&D program has put processes in place to align and prioritize R&D projects. The program has three types of activities: technology assessment (changes in external environment and impact to the company); research (building knowledge bases and competencies in core technical areas); and development (development of specific commercial opportunities). Four key inputs are considered when establishing priorities: significant changes in the external environment; long-term future needs of lead customers; business strategies, priorities, and technology needs; and corporate strategic direction.
- Mobil Chemical uses six categories of projects to determine the right balance of projects that will enter its portfolio: (1) cost reductions and process improvements; (2) product improvements, product modifications, and customer satisfaction; (3) new products; (4) new platform projects and fundamental/breakthrough research projects; (5) plant support; and (6) technical support for customers. Senior management reviews all project proposals and determines the division of capital funding across these six project types. One of the key decision variables involves a comparison of "what is" with "what should be."
- At 3M's Traffic Control Materials Division, during project screening and selection, management uses a project viability chart to score project alternatives. As part of the profile and scoring exercise, personnel must address how the project accomplishes strategic project objectives and critical business issues affecting a specific group within the target market. Projected project return on investment is always counterbalanced with riskiness of the project option.
- Exxon Chemical's management begins evaluating all new project proposals in light of the business unit's strategy and strategic priorities. Target spending is decided according to the overall project mix portfolio. As the year progresses, all projects are reprioritized using a scoring model. As significant differences between projected and actual spending are uncovered, the top management group makes adjustments for next year's portfolio.[1]

INTRODUCTION

All organizations must select the projects they decide to pursue from among numerous opportunities. What criteria determine which projects should be supported? Obviously, this is no simple decision. The consequences of poor decisions can be enormously expensive. Recent research suggests that in the realm of information technology (IT), companies squander over $50 billion a year on projects that are created but never used by their intended clients. How do we make the most reasonable choices in selecting projects? What kind of information should we collect? Should decisions be based strictly on financial analysis, or should other criteria be considered? In this chapter, we will try to answer such questions as we take a closer look at the process of project selection.

We will examine a number of different approaches for evaluating and selecting potential projects. The various methods for project selection run along a continuum from highly qualitative, or judgment-based, approaches to those that rely on quantitative analysis. Of course, each approach has benefits and drawbacks, which must be considered in turn.

We will also discuss a number of issues related to the management of a **project portfolio**—the set of projects that an organization is undertaking at any given time. For example, Rubbermaid, Inc. routinely undertakes hundreds of new product development projects simultaneously, always searching for opportunities with strong commercial prospects. When a firm is pursuing multiple projects, the challenges of strategic decision making, resource management, scheduling, and operational control are magnified.

3.1 PROJECT SELECTION

Firms are literally bombarded with opportunities, but of course, no organization enjoys infinite resources to be able to pursue every opportunity that presents itself. Choices must be made, and to best ensure that they select the most viable projects, many managers develop priority systems—guidelines for balancing the opportunities and costs entailed by each alternative. The goal is to balance the competing demands of time and advantage.[2] The pressures of time and money affect most major decisions, and decisions are usually more successful when they are made in a timely and efficient manner. For example, if your firm's sales department recognizes a commercial opportunity it can exploit, you need to generate alternative projects quickly to capitalize on the prospect. Time wasted is generally opportunity lost. On the other hand, you need to be careful: You want to be sure that, at least as far as possible, you are making the best choice among your options. Thus organizational decision makers develop guidelines—*selection models* that permit them to save time and money while maximizing the likelihood of success.

A number of decision models are available to managers responsible for evaluating and selecting potential projects. As you will see, they run the gamut from qualitative and simple to quantitative and complex. All firms, however, try to develop a screening model (or set of models) that will allow them to make the best choices among alternatives within the usual constraints of time and money.

Suppose you were interested in developing a model that allowed you to effectively screen project alternatives. How might you ensure that the model was capable of picking potential "winners" from the large set of possible project choices? After much consideration, you decide to narrow the focus for your screening model and create one that will allow you to select only projects that have high potential payoffs. All other issues are ignored in favor of the sole criterion of commercial profitability. The question is: Would such a screening model be useful? Souder[3] identifies five important issues that managers should consider when evaluating screening models:

1. ***Realism:*** An effective model must reflect organizational objectives, including a firm's strategic goals and mission. Criteria must also be reasonable in light of such constraints on resources as money and personnel. Finally, the model must take into account both commercial risks and technical risks, including performance, cost, and time. That is: Will the project work as intended? Can we keep to the original budget or is there a high potential for escalating costs? Is there a strong risk of significant schedule slippage?
2. ***Capability:*** A model should be flexible enough to respond to changes in the conditions under which projects are carried out. For example, the model should allow the company to compare different types of projects (long-term versus short-term projects, projects of different technologies or capabilities, projects with different commercial objectives). It should be robust enough to accommodate new criteria and constraints, suggesting that the screening model must allow the company to use it as widely as possible in order to cover the greatest possible range of project types.

3. ***Flexibility:*** The model should be easily modified if trial applications require changes. It must, for example, allow for adjustments due to changes in exchange rates, tax laws, building codes, and so forth.
4. ***Ease of Use:*** A model must be simple enough to be used by people in all areas of the organization, both those in specific project roles and those in related functional positions. Further, the screening model that is applied, the choices made for project selection, and the reasons for those choices should be clear and easily understood by organizational members. The model should also be timely: It should generate the screening information rapidly, and people should be able to assimilate that information without any special training or skills.
5. ***Cost:*** The screening model should be cost effective. A selection approach that is expensive to use in terms of either time or money is likely to have the worst possible effect: causing organizational members to avoid using it because of the excessive cost of employing the screening model. The cost of obtaining selection information and generating optimal results should be low enough to encourage use of the models rather than diminish their applicability.

Let's add a sixth criterion for a successful selection model:

6. ***Comparability:*** It must be broad enough to be applied to multiple projects. If a model is too narrowly focused, it may be useless in comparing potential projects or foster biases toward some over others. A useful model must support general comparisons of project alternatives.

Project selection models come in two general classes: numeric and nonnumeric.[4] **Numeric models** seek to use numbers as inputs for the decision process involved in selecting projects. These values can be derived either objectively or subjectively; that is, we may employ objective, external values ("The bridge's construction will require 800 cubic yards of cement") or subjective, internal values ("You will need to hire two code checkers to finish the software development within eight weeks"). Neither of these two input alternatives is necessarily wrong: An expert's opinion on an issue may be subjective but very accurate. On the other hand, an incorrectly calibrated surveyor's level can give objective but wrong data. The key is to remember that most selection processes for project screening involve a combination of subjective and objective data assessment and decision making. **Nonnumeric models,** on the other hand, do not employ numbers at decision inputs, relying instead on other data.

Companies spend great amounts of time and effort trying to make the best project selection decisions possible. These decisions are typically made with regard for the overall objectives that the company's senior management staff have developed and promoted based on their strategic plan. These objectives can be quite complex and reflect a number of external factors that can affect a firm's operations. For example, suppose the new head of Sylvania's Lighting Division mandated that the strategic objectives of the organization were to be sales growth at all costs. Any new project opportunity would be evaluated against this key strategic imperative. Thus, a project offering the potential for opening new markets might be viewed more favorably than a competing project that promised a higher potential rate of return.

The list of factors that can be considered when evaluating project alternatives is enormous (see Table 3.1). In general terms, we may look at risk and commercial factors, internal operating issues, and other factors.

Table 3.1 is only a partial list of the various elements that a company must address when considering new project alternatives. Although the list can be long, in reality the strategic direction emphasized by top management often highlights certain criteria over others. In fact, if we apply Pareto's 80/20 principle, which states that a few issues (20%) are vital and many (80%) are trivial, it may be fairly argued that for many projects, less than 20% of all possible decision criteria account for over 80% of the decision of whether or not to pursue the project.

This being said, we should also reflect on two final points regarding the use of any decision-making approach to project selection. First, the most complete model in the world is still only a partial reflection of organizational reality. The potential list of inputs into any project selection decision is literally limitless; so much so, in fact, that we must recognize this truth before exploring project selection lest we erroneously assume that it is possible, given enough time and effort, to identify all relevant issues that play a role. Second, embedded in every decision model are both objective and subjective factors. We may form opinions based on objective data; we may also derive complex decision models from subjective inputs. It is worthwhile acknowledging that there exists a place for both subjective and objective inputs and decisions in any useful screening model.

TABLE 3.1 Issues in Project Screening and Selection

1. Risk—Factors that reflect elements of unpredictability to the firm, including:
   a. Technical risk—risks due to the development of new or untested technologies
   b. Financial risk—risks from the financial exposure caused by investing in the project
   c. Safety risk—risks to the well-being of users or developers of the project
   d. Quality risk—risks to the firm's goodwill or reputation due to the quality of the completed project
   e. Legal exposure—potential for lawsuits or legal obligation
2. Commercial—Factors that reflect the market potential of the project, including:
   a. Expected return on investment
   b. Payback period
   c. Potential market share
   d. Long-term market dominance
   e. Initial cash outlay
   f. Ability to generate future business/new markets
3. Internal operating issues—Factors that refer to the impact of the project on internal operations of the firm, including:
   a. Need to develop/train employees
   b. Change in workforce size or composition
   c. Change in physical environment
   d. Change in manufacturing or service operations resulting from the project
4. Additional factors
   a. Patent protection
   b. Impact on company's image
   c. Strategic fit

3.2 APPROACHES TO PROJECT SCREENING AND SELECTION

A **project-screening model** that generates useful information for project choices in a timely and useful fashion at an acceptable cost can serve as a valuable tool in helping an organization make optimal choices among numerous alternatives.[5] With these criteria in mind, let's consider some of the more common project-selection techniques.

Method One: Checklist Model

The simplest method of project screening and selection is developing a **checklist,** or a list of criteria that pertain to our choice of projects, and then applying them to different possible projects. Let's say, for example, that in our company, the key selection criteria are cost and speed to market. Because of our strategic competitive model and the industry we are in, we favor low-cost projects that can be brought to the marketplace within one year. We would screen each possible project against these two criteria and select the project that best satisfies them. But depending on the type and size of our possible projects, we may have to consider literally dozens of relevant criteria. In deciding among several new product development opportunities, a firm must weigh a variety of issues, including the following:

- ***Cost of development:*** What is a reasonable cost estimate?
- ***Potential return on investment:*** What kind of return can we expect? What is the likely payback period?
- ***Riskiness of the new venture:*** Does the project entail the need to create new-generation technology? How risky is the venture in terms of achieving our anticipated specifications?
- ***Stability of the development process:*** Are both the parent organization and the project team stable? Can we expect this project to face funding cuts or the loss of key personnel, including senior management sponsors?
- ***Governmental or stakeholder interference:*** Is the project subject to levels of governmental oversight that could potentially interfere with its development? Might other stakeholders oppose the project and attempt to block completion? For example, environmental groups commonly referred to as "intervenor"

stakeholders have a long history of opposing natural resource development projects and work in opposition to project objectives.[6]

- ***Product durability and future market potential:*** Is this project a one-shot opportunity, or could it be the forerunner of future opportunities? A software development firm may, for example, develop an application for a client in hopes that successful performance on this project will lead to future business. On the other hand, they may perceive that the project is simply a one-time opportunity with little potential for future work with the customer.

This is just a partial list of criteria that may be relevant when we are selecting among project alternatives. A checklist approach to the evaluation of project opportunities is a fairly simple device for recording opinions and encouraging discussion. Thus, checklists may best be used in a consensus-group setting, as a method for initiating conversation, stimulating discussion and the exchange of opinions, and highlighting the group's priorities.

EXAMPLE 3.1 Checklist

Let's assume that SAP Corporation, a leader in the business applications software industry, is interested in developing a new application package for inventory management and shipping control. It is trying to decide which project to select from a set of four potential alternatives. Based on past commercial experiences, the company feels that the most important selection criteria for its choice are: cost, profit potential, time to market, and development risks. Table 3.2 shows a simple checklist model with only four project choices and the four decision criteria. In addition to developing the decision criteria, we create evaluative descriptors that reflect how well the project alternatives correspond to our key selection criteria. We evaluate each criterion (which is rated *high, medium,* or *low*) in order to see which project accumulates the most positive checks—and may thus be regarded as the optimal choice.

SOLUTION

Based on this analysis, Project Gamma is the best alternative in terms of maximizing our key criteria—cost, profit potential, time to market, and development risks.

TABLE 3.2 Simplified Checklist Model for Project Selection

		Performance on Criteria		
Project	**Criteria**	**High**	**Medium**	**Low**
Project Alpha	Cost	X		
	Profit potential			X
	Time to market		X	
	Development risks			X
Project Beta	Cost		X	
	Profit potential		X	
	Time to market	X		
	Development risks		X	
Project Gamma	Cost	X		
	Profit potential	X		
	Time to market			X
	Development risks	X		
Project Delta	Cost			X
	Profit potential			X
	Time to market	X		
	Development risks		X	

Of course, the flaws in such a model include the subjective nature of such ratings as *high, medium,* or *low.* Such terms are inexact and subject to misinterpretation or misunderstanding. Checklist screening models also fail to resolve trade-off issues. What if our criteria are *differentially weighted*—that is, what if some criteria are more important than others? How will relative, or weighted, importance affect our final decision? Let's say, for instance, that we regard time to market as our paramount criterion. Is Project Gamma, which rates as low on this criterion, still "better" than Project Beta or Delta, both of which rate high on time to market though lower on other, less important criteria? Are we willing to make a trade-off, accepting low time to market in order to get the highest benefits in cost, profit potential, and development risks?

Because the simple checklist model does not deal satisfactorily with such questions, let's turn next to a more complex screening model in which we distinguish more important from less important criteria by assigning each criterion a simple *weight.*

Method Two: Simplified Scoring Models

In the **simplified scoring model,** each criterion is ranked according to its relative importance. Our choice of projects will thus reflect our desire to maximize the impact of certain criteria on our decision. In order to score our simplified checklist, we assign a specific weight to each of our four criteria:

Criterion	**Importance Weight**
Time to Market	3
Profit Potential	2
Development Risks	2
Cost	1

Now let's reconsider the decision that we made using the basic checklist approach illustrated in Table 3.2.

EXAMPLE 3.2 Scoring Models

Using the criterion weighting values we developed above, SAP Corporation is attempting to determine the optimal project to fund. As you can see in Table 3.3, although adding a scoring component to our simple checklist complicates our decision, it also gives us a more precise screening model—one that more closely reflects our desire to emphasize certain criteria over others.

TABLE 3.3 Simple Scoring Model

Project	Criteria	(A) Importance Weight	(B) Score	(A) × (B) Weighted Score
Project Alpha				
	Cost	1	3	3
	Profit potential	2	1	2
	Development risk	2	1	2
	Time to market	3	2	6
	Total Score			13
Project Beta				
	Cost	1	2	2
	Profit potential	2	2	4
	Development risk	2	2	4
	Time to market	3	3	9
	Total Score			19

TABLE 3.3 Continued

Project	Criteria	(A) Importance Weight	(B) Score	(A) × (B) Weighted Score
Project Gamma				
	Cost	1	3	3
	Profit potential	2	3	6
	Development risk	2	3	6
	Time to market	3	1	3
	Total Score			18
Project Delta				
	Cost	1	1	1
	Profit potential	2	1	2
	Development risk	2	2	4
	Time to market	3	3	9
	Total Score			16

SOLUTION

In Table 3.3, the numbers in the column labeled *Importance Weight* specify the numerical values that we have assigned to each criterion: *Time to Market* always receives a value of *3, profit potential* a value of *2, development risk* a value of *2,* and *cost* a value of *1.* We then assign relative values to each of our four dimensions.

The numbers in the column labeled *Score* replace the *X's* of Table 3.2 with their assigned score values:

(*High* = 3
Medium = 2
Low = 1)

In Project Alpha, for example, the *High* rating given *Cost* becomes a *3* in Table 3.3 because *High* is here valued at *3.* Likewise, the *Medium* rating given *Time to Market* in Table 3.2 becomes a *2.* But notice what happens when we calculate the numbers in the column labeled *Weighted Score.* When we multiply the numerical value of *Cost* (*1*) by its rating of *High* (*3*), we get a *Weighted Score* of *3.* But when we multiply the numerical value of *Time to Market* (*3*) by its rating of *Medium* (*2*), we get a *Weighted Score* of *6.* We add up the total *Weighted Scores* for each project, and according to Table 3.3, Project Beta (with a total of *19*) is the best alternative, compared to the other options: Project Alpha (with a total of *13*), Project Gamma (with a total of *18*), and Project Delta (with a total of *16*).

Thus the simple scoring model consists of the following steps:

- ***Assign importance weights to each criterion:*** Develop logic for differentiating among various levels of importance and devise a system for assigning appropriate weights to each criterion. Relying on collective group judgment may help to validate the reasons for determining importance levels. The team may also designate some criteria as "must" items. Safety concerns, for example, may be stipulated as nonnegotiable. In other words, all projects must achieve an acceptable safety level or they will not be considered further.
- ***Assign score values to each criterion in terms of its rating (High = 3, Medium = 2, Low = 1):*** The logic of assigning score values is often an issue of scoring sensitivity—of making differences in scores distinct. Some teams, for example, prefer to widen the range of possible values—say, by using a 1-to-7 scale instead of a 1-to-3 scale in order to ensure a clearer distinction among scores and, therefore, among project choices. Such decisions will vary according to the number of criteria being applied and, perhaps, by team members' experience with the accuracy of outcomes produced by a given approach to screening and selection.
- ***Multiply importance weights by scores to arrive at a weighted score for each criterion:*** The weighted score reflects both the value that the team gives each criterion and the ratings that the team gives each criterion as an output of the project.
- ***Add the weighted scores to arrive at an overall project score:*** The final score for each project becomes the sum of all its weighted criteria.

The pharmaceuticals company Hoechst Marion Roussel uses a scoring model for selecting projects that identifies not only five main criteria—reward, business strategy fit, strategic leverage, probability of commercial success, and probability of technical success—but also a number of more specific subcriteria. Each of these 19 subcriteria is scored on a scale of 1 to 10. The score for each criterion is then calculated by averaging the scores for each criterion. The final project score is determined by adding the average score of each of the five subcategories. Hoechst has had great success with this scoring model, both in setting project priorities and in making go/no-go decisions.[7]

The simple scoring model has some useful advantages as a project selection device. First, it is easy to use it to tie critical strategic goals for the company to various project alternatives. In the case of the pharmaceutical company Hoechst, the company has assigned several categories to strategic goals for its project options, including *Business strategy fit* and *Strategic leverage.* These strategic goals become a critical hurdle for all new project alternatives. Second, the simple scoring model is easy to comprehend and use. With a checklist of key criteria, evaluation options (high, medium, and low), and attendant scores, top managers can quickly grasp how to employ this technique.

Limitations of Scoring Models

The simple scoring model illustrated here is an abbreviated and unsophisticated version of the weighted-scoring approach. In general, scoring models try to impose some structure on the decision-making process while, at the same time, combining multiple criteria.

Most scoring models, however, share some important limitations. A scale from 1 to 3 may be intuitively appealing and easy to apply and understand, but it is not very accurate. From the perspective of mathematical scaling, it is simply wrong to treat evaluations on such a scale as real numbers that can be multiplied and summed. If *3* means *High* and *2* means *Medium,* we know that *3* is better than *2,* but we do not know by how much. Furthermore, we cannot assume that the difference between *3* and *2* is the same as the difference between *2* and *1.* Thus in Table 3.3, if the score for Project Alpha is *13* and *19* is the score for Project Beta, may we assume that Beta is 46 percent better than Alpha? Unfortunately, no. Critics of scoring models argue that their ease of use may blind novice users to the sometimes-false assumptions that underlie them.

From a managerial perspective, another drawback of scoring models is the fact that they depend on the relevance of the selected criteria and the accuracy of the weight given them. In other words, they do not ensure that there is a reasonable link between the selected and weighted criteria and the business objectives that prompted the project in the first place.

Here's an example. As a means of selecting projects, the Information Systems steering committee of a large bank adopted three criteria: *contribution to quality, financial performance,* and *service.* The bank's strategy was focused on customer retention, but the criteria selected by the committee did not reflect this fact. As a result, a project aimed at improving service to potential *new* markets might score high on *service* even though it would not serve *existing* customers (the people whose business the bank wants to retain). Note, too, that the criteria of *quality* and *service* could overlap, leading managers to double-count and overestimate the value of some factors.[8] Thus, the bank employed a project selection approach that neither achieved its desired ends nor matched overall strategic goals.

Method Three: The Analytical Hierarchy Process

The **Analytical Hierarchy Process (AHP)** was developed by Dr. Thomas Saaty[9] to address many of the technical and managerial problems frequently associated with decision making through scoring models. An increasingly popular method for effective project selection, the AHP is a four-step process.

STRUCTURING THE HIERARCHY OF CRITERIA The first step consists of constructing a hierarchy of criteria and subcriteria. Let's assume, for example, that a firm's IT steering committee has selected three criteria for evaluating project alternatives: (1) *Financial benefits,* (2) *Contribution to strategy,* and (3) *Contribution to IT infrastructure.* The *Financial benefits* criterion, which focuses on the tangible benefits of the project, is further subdivided into long-term and short-term benefits. *Contribution to strategy,* an intangible factor, is subdivided into three subcriteria: (a) *Increasing market share for product X;* (b) *Retaining existing customers for product Y;* and (c) *Improving cost management.*

Table 3.4 is a representational breakdown of all these criteria. Note that subdividing relevant criteria into a meaningful hierarchy gives managers a rational method for sorting among and ordering priorities. Higher-order challenges, such as *Contribution to strategy,* can be broken down into discrete sets of supporting

TABLE 3.4 Hierarchy of Selection Criteria Choices

First Level	Second Level
1. Financial Benefits	1A: Short-term
	1B: Long-term
2. Contribution to Strategy	2A: Increasing market share for product X
	2B: Retaining existing customers for product Y
	2C: Improving cost management
3. Contribution to IT Infrastructure	

requirements, including *market share, customer retention,* and *cost management,* thus building a hierarchy of alternatives that simplifies matters. Because the hierarchy can reflect the structure of organizational strategy and critical success factors, it also provides a way to select and justify projects according to their consistency with business objectives.[10] This illustrates how we can use meaningful strategic issues and critical factors to establish logic for both the types of selection criteria and their relative weighting.

Recently, a large U.S. company used the AHP to rank more than a hundred project proposals worth millions of dollars. Because the first step in using the AHP is to establish clear criteria for selection, 10 managers from assorted disciplines, including finance, marketing, management information systems, and operations, spent a full day establishing the hierarchy of criteria. Their challenge was to determine the key success criteria that should be used to guide project selection, particularly as these diverse criteria related to each other (relative weighting). They found that, in addition to clearly defining and developing the criteria for evaluating projects, the process also produced a more coherent and unified vision of organizational strategy.

ALLOCATING WEIGHTS TO CRITERIA The second step in applying AHP consists of allocating weights to previously developed criteria and, where necessary, splitting overall criterion weight among subcriteria. Mian and Dai[11] and others have recommended the so-called **pairwise comparison approach** to weighting, in which every criterion is compared with every other criterion. This procedure, argue the researchers, permits more accurate weighting because it allows managers to focus on a series of relatively simple exchanges—namely, two criteria at a time.

The simplified hierarchy in Figure 3.1 shows the breakdown of criterion weights across the same three major criteria that we used in Table 3.4. As Figure 3.3 shows, *Financial benefits* received a weighting value of 52%, which was split between *Short-term benefits* (30%) and *Long-term benefits* (70%). This configuration means that *long-term financial benefits* receives an overall weighting of $(0.52) \times (0.7) = 36.4\%$.

The hierarchical allocation of criteria and splitting of weights resolves the problem of double counting in scoring models. In these models, criteria such as *Service, Quality,* and *Customer satisfaction* may be either separate or overlapping factors, depending on the objectives of the organization. As a result, too little or too much may be assigned to a given criterion. With AHP, however, these factors are grouped as subcriteria and share the weight of a common higher-level criterion.

ASSIGNING NUMERICAL VALUES TO EVALUATION DIMENSIONS For our third step, once the hierarchy is established, we can use the pairwise comparison process to assign numerical values to the dimensions of our

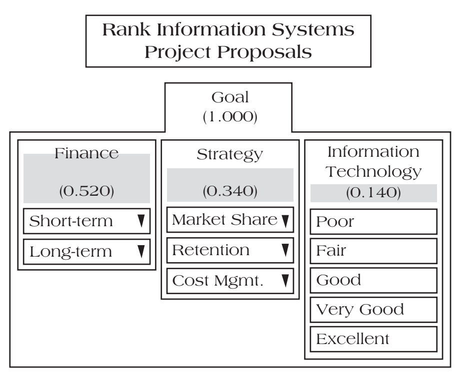

FIGURE 3.1 Sample AHP with Rankings for Salient Selection Criteria

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	Nominal	Priority	Bar Graph
Poor	0.00000	0.000	
Fair	0.10000	0.050	
Good	0.30000	0.150	
Very Good	0.60000	0.300	
Excellent	1.00000	0.500	
Total	2.00000	1.000	

FIGURE 3.2 Assigning Numerical Values to Labels

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evaluation scale. Figure 3.2 is an evaluation scale with five dimensions: *Poor, Fair, Good, Very Good,* and *Excellent.* Figure 3.2 also shows that for purposes of illustration, we have assigned the values of *0.0, 0.10, 0.30, 0.60,* and *1.00,* respectively, to these dimensions. Naturally, we can change these values as necessary. For example, if a company wants to indicate a greater discrepancy between *Poor* and *Fair,* managers may increase the range between these two dimensions.

By adjusting values to suit specific purposes, managers also avoid the fallacy of assuming that the differences between numbers on a scale of, say, 1 to 5 are equal—that is, assuming that the difference between 4 and 5 is the same as the difference between 3 and 4. With the AHP approach, the "best" outcome receives a perfect score of 1.00 and all other values represent some proportion relative to that score.

When necessary, project managers are encouraged to apply different scales for each criterion. Note, for example, that Figure 3.2 used scale points ranging from *Poor* to *Excellent.* Suppose, however, that we were interviewing a candidate for our project team and one of the criterion items was "Education Level." Clearly, using a scale ranging from *Poor* to *Excellent* makes no sense, so we would adjust the scales to make them meaningful; for example, using levels such as "High School," "Some College," "College Graduate," and so forth. Allocating weights across dimensions gives us a firmer understanding of both our goals and the methods by which we are comparing opportunities to achieve them.

EVALUATING PROJECT PROPOSALS In our final step, we multiply the numeric evaluation of the project by the weights assigned to the evaluation criteria and then add up the results for all criteria. Figure 3.3 shows

Finance	Short-term			
Poor 1 (.000)	Fair 2 (.100)	Good 3 (.300)	Very Good 4 (.600)	Excellent 5 (1.000)

	Alternatives	Total	Finance		Strategy			Technology
			Short-Term .1560	Long-Term .3640	Market Share .1020	Retention .1564	Cost Management .0816	.1400
1	Perfect Project	1.000	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
2	Aligned	0.762	Good	Excellent	Good	Excellent	Good	Excellent
3	Not Aligned	0.538	Excellent	Good	Excellent	Good	Excellent	Good
4	All Very Good	0.600	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
5	Mixed	0.284	Poor	Fair	Good	Very Good	Excellent	Good
6								
7								
8								
9								
10								

FIGURE 3.3 The Project Rating Spreadsheet

Source: J. K. Pinto and I. Millet. 1999. *Successful Information System Implementation: The Human Side,* Second Edition, figure on page 78. Newtown Square, PA: Project Management Institute. Copyright and all rights reserved. Material from this publication has been reproduced with the permission of PMI.

how five potential projects might be evaluated by means of an AHP program offered by Expert Choice, a maker of decision software.[12] Here's how to read the key features of the spreadsheet:

- The second row specifies the value assigned to each of five possible ratings (from *Poor = 1 = .000* to *Excellent = 5 = 1.000*).
- The fourth row specifies the five decision criteria and their relative weights (*Finance/Short-Term* = .1560, *Strategy/Cost Management* = .0816, and so forth). (Note that three criteria have been broken down into six subcriteria.)
- The second column lists the five projects (*Perfect Project, Aligned,* etc.).
- The column labeled "Total" gives a value for each alternative. This number is found by multiplying each evaluation by the appropriate criterion weight and summing the results across all criteria evaluations.

To illustrate how the calculations are derived, let us take the *Aligned* project as an example. Remember that each rating (excellent, very good, good, etc.) carries with it a numerical score. These scores, when multiplied by the evaluation criteria, yield:

$$(.1560)(.3) + (.3640)(1.0) + (.1020)(.3) + (.1564)(1.0) + (.0816)(.3) + (.1400)(1.0) = .762$$

The *Perfect Project,* for example, was rated *Excellent* on all six dimensions and thus received a score of 1.000. Note, too, the evaluations of the *Aligned* and *Not Aligned* project choices. Although both projects received an equal number of *Excellent* and *Good* rankings, the *Aligned* project was clearly preferable because it was rated higher on criteria viewed as more important and thus more heavily weighted.

Unlike the results of typical scoring models, the AHP scores are significant. The *Aligned* project, for example, which scored 0.762, is almost three times better than the *Mixed* project, with its score of 0.284. This feature—the ability to quantify superior project alternatives—allows project managers to use AHP scores as input to other calculations. We might, for example, sort projects by the ratios of AHP scores to total their development costs. Let's say that based on this ratio, we find that the *Not Aligned* project is much cheaper to initiate than the *Aligned* project. This finding may suggest that *from a cost/benefit perspective,* the *Not Aligned* project offers a better alternative than the *Aligned* project.

The AHP methodology can also dramatically improve the process of developing project proposals. In firms that have incorporated AHP analysis, new project proposals must contain, as part of their core information, a sophisticated AHP breakdown listing the proposed project, alternatives, and projected outcomes. The Analytical Hierarchy Process offers a real advantage over traditional scoring models, primarily because it reduces many of the technical and managerial problems that plague such approaches.

The AHP does have some limitations, however. First, current research suggests that the model does not adequately account for "negative utility"; that is, the fact that certain choice options do not contribute positively to the decision goals but actually lead to negative results. For example, suppose that your company identified a strong project option that carried a prohibitively expensive price tag. As a result, selecting this project is really not an option because it would be just too high an investment. However, using the AHP, you would first need to weigh all positive elements, develop your screening score, and then compare this score against negative aspects, such as cost. The result can lead to bias in the project scoring calculations.[13] A second limitation is that the AHP requires that all criteria be fully exposed and accounted for at the beginning of the selection process. Powerful members of the organization with political agendas or pet projects they wish to pursue may resist such an open selection process.

Method Four: Profile Models

Profile models allow managers to plot **risk/return** options for various alternatives and then select the project that maximizes return while staying within a certain range of minimum acceptable risk. "Risk," of course, is a subjective assessment: That is to say, it may be difficult to reach overall agreement on the level of risk associated with a given project. Nevertheless, the profile model offers another way of evaluating, screening, and comparing projects.[14]

Let us return to our example of project screening at SAP Corporation. Suppose that instead of the four project alternatives for the new software project we discussed earlier, they had identified six candidates for development. For simplicity's sake, they chose to focus on the two criteria of risk and reward.

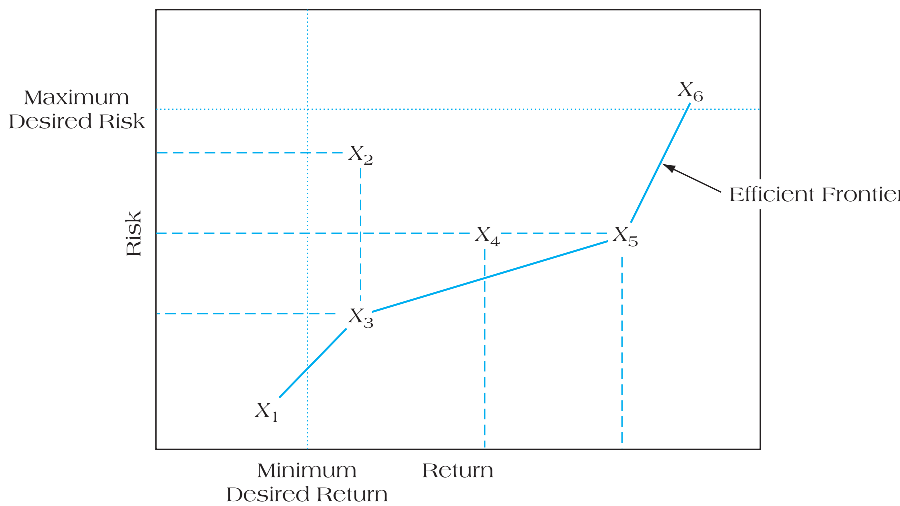

FIGURE 3.4 Profile Model

Source: Evans and Souder (1998), "Methods for Selecting and Evaluating Projects," in Pinto (Ed.), *The Project Management Institute Project Management Handbook.* San Francisco, CA: Jossey-Bass Publishers. Reprinted with permission of John Wiley & Sons, Inc.

In Figure 3.4, the six project alternatives are plotted on a graph showing perceived *Risk* on the *y*-axis and potential *Return* on the *x*-axis. Because of the cost of capital to the firm, we will specify some minimum desired rate of return. All projects will be assigned some risk factor value and be plotted relative to the maximum risk that the firm is willing to assume. Figure 3.4, therefore, graphically represents each of our six alternatives on a profile model. (Risk values have been created here simply for illustrative purposes.) Consider Project X_4 for example. In our example, SAP can employ a variety of measures to assess the likely return offered by this project, including discounted cash flow analysis and internal rate of return expectations. Likewise, it is increasingly common for firms to quantify their risk assessment of various projects, enabling us to plot them along the *y*-axis. The key lies in employing identical evaluation criteria and quantification approaches across all projects to be profiled on the graph. Clearly, when project risks are unique or we have no way of comparing the relative risks from project to project, it is impossible to accurately plot project alternatives.

We see that Project X_2 and Project X_3 have similar expected rates of return. Project X_3, however, represents a better selection choice. Why? Because SAP can achieve the same rate of return with Project X_3 as it can with Project X_2 but with less risk. Likewise, Project X_5 is a superior choice to X_4: Although they have similar risk levels, X_5 offers greater return as an investment. Finally, while Project X_6 offers the most potential return, it does so at the highest level of risk.

The profile model makes use of a concept most widely associated with financial management and investment analysis—the *efficient frontier.* In project management, the **efficient frontier** is the set of project portfolio options that offers either a maximum return for every given level of risk or the minimum risk for every level of return.[15] When we look at the profile model in Figure 3.4, we note that certain options (X_1, X_3, X_5, X_6) lie along an imaginary line balancing optimal risk and return combinations. Others (X_2 and X_4), however, are less desirable alternatives and would therefore be considered inferior choices. The efficient frontier serves as a decision-making guide by establishing the threshold level of risk/return options that all future project choices must be evaluated against.

One advantage of the profile model is that it offers another alternative to compare project alternatives, this time in terms of the risk/return trade-off. It is sometimes difficult to evaluate and compare projects on the basis of scoring models or other qualitative approaches. The profile model, however, gives managers a chance to map out potential returns while considering the risk that accompanies each choice. Thus profile models give us another method for eliminating alternatives, either because they threaten too much risk or promise too little return. On the other hand, profile models also have disadvantages:

1. They limit decision criteria to just two—risk and return. Although an array of issues, including safety, quality, and reliability, can come under the heading of "risk," the approach still necessarily limits the decision maker to a small set of criteria.

2. In order to be evaluated in terms of an efficient frontier, some value must be attached to risk. Expected return is a measure that is naturally given to numerical estimate. But because risk may not be readily quantified, it may be misleading to designate "risk" artificially as a value for comparison among project choices.

EXAMPLE 3.3 Profile Model

Let's consider a simple example. Suppose that our company has identified two new project alternatives and we wish to use risk/return analysis to determine which of the two projects would fit best with our current project portfolio. We assess return in terms of the profit margin we expect to achieve on the projects. Risk is evaluated at our company in terms of four elements: (1) technical risk—the technical challenge of the project, (2) capital risk—the amount invested in the project, (3) safety risk—the risk of project failure, and (4) goodwill risk—the risk of losing customers or diminishment of our company's image. The magnitude of each of these types of risk is determined by applying a "low, medium, high" risk scale where 1 = low, 2 = medium, and 3 = high.

After conducting a review of likely profitability for both the projects and evaluating their riskiness, we conclude the following:

	Risk	Return Potential
Project Saturn	10	23%
Project Mercury	6	16%

Figure 3.5 shows our firm's efficient frontier for the current portfolio of projects. How would we evaluate the attractiveness of either Project Saturn or Project Mercury?

SOLUTION

When we consider the two choices, Projects Saturn and Mercury, in terms of their projected risk and return, we can chart them on our profile model relative to other projects that we are undertaking. Figure 3.5 illustrates the placement of the two new project options. Note that Project Saturn, although within our maximum risk limit, does not perform as well as the other projects in our current portfolio (it has a higher risk rating for its projected return than other comparable projects). On the other hand, Project Mercury offers us a 16% rate of return for a lower level of risk than the current efficient frontier, suggesting that this project is an attractive option and a better alternative than Project Saturn.

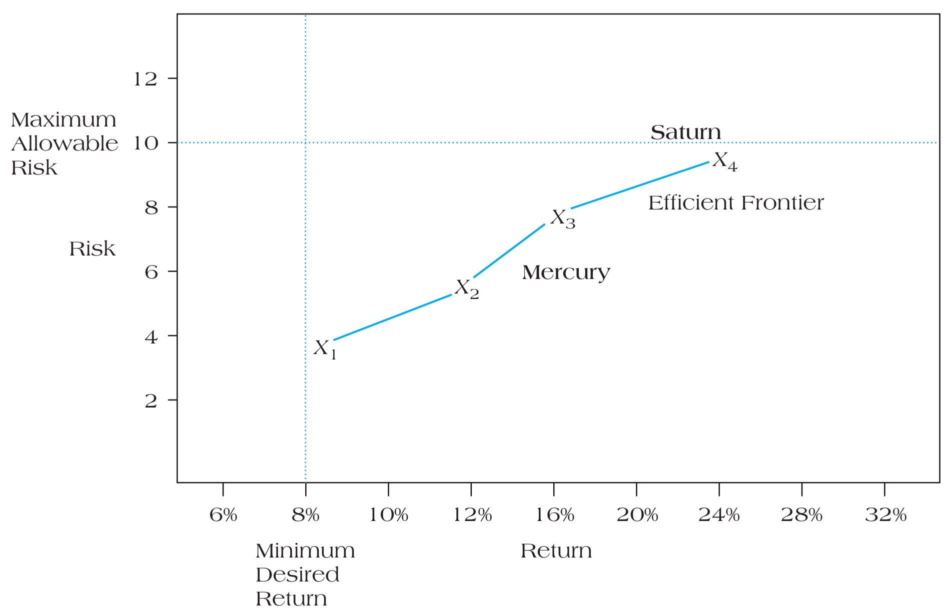

FIGURE 3.5 Efficient Frontier for Our Firm

3.3 FINANCIAL MODELS

Another important series of models relies on financial analysis to make project selection decisions. In this section, we will examine three common financial models: *discounted cash flow analysis, net present value,* and *internal rate of return.* These are not the only financial methods for assessing project alternatives, but they are among the more popular.

Financial models are all predicated on the **time value of money** principle. The time value of money suggests that money earned today is worth more than money we expect to earn in the future. In other words, $100 that I receive four years from now is worth significantly less to me than if I were to receive that money today. In the simplest example, we can see that putting $100 in a bank account at 3% interest will grow the money at a compounded rate each year. Hence, at the end of year 1, the initial investment will be worth $103. After two years, it will have grown to $106.09, and so forth. The principle also works in reverse: To calculate the *present value* of $100 that I expect to have in the bank in four years' time I must first discount the amount by the same interest rate. Hence, assuming an interest rate of 3%, I need only invest $88.85 today to yield $100 in four years.

There are two reasons why we would expect future money to be worth less: (1) the impact of inflation, and (2) the inability to invest the money. Inflation, as we know, causes prices to rise and hence erodes consumers' spending power. In 1900, for example, the average house may have cost a few thousand dollars to build. Today these costs have soared. As a result, if I am to receive $100 in four years, its value will have decreased due to the negative effects of inflation. Further, not having that $100 today means that I cannot invest it and earn a return on my money for the next four years. Money that we cannot invest is money that earns no interest. In real terms, therefore, the real, **present value of money** must be discounted by some factor the farther out into the future I expect to receive it. When deciding among nearly identical project alternatives, if Project A will earn our firm $50,000 in two years and Project B will earn our company $50,000 in four years, Project A is the best choice because we will receive the money sooner.

Payback Period

The intent of project **payback period** is to estimate the amount of time that will be necessary to recoup the investment in a project; that is, how long it will take for the project to pay back its initial budget and begin to generate positive cash flow for the company. In determining payback period for a project, we must employ a discounted cash flow analysis, based on the principal of the time value of money. The goal of the **discounted cash flow (DCF) method** is to estimate cash outlays and expected cash inflows resulting from investment in a project. All potential costs of development (most of which are contained in the project budget) are assessed and projected prior to the decision to initiate the project. They are then compared with all expected sources of revenue from the project. For example, if the project is a new chemical plant, projected revenue streams will be based on expected capacity, production levels, sales volume, and so forth.

We then apply to this calculation a *discount rate* based on the firm's cost of capital. The value of that rate is weighted across each source of capital to which the firm has access (typically, debt and equity markets). In this way we weight the cost of capital, which can be calculated as follows:

$$K_{\text{firm}} = (w_d)(k_d)(1 - t) + (w_e)(k_e)$$

The weighted cost of capital is the percentage of capital derived from either debt (w_d) or equity (w_e) times the percentage costs of debt and equity (k_d and k_e, respectively). (The value t refers to the company's marginal tax rate: Because interest payments are tax deductible, we calculate the cost of debt after taxes.)

There is a standard formula for payback calculations:

$$\text{Payback period} = \text{investment/annual cash savings}$$

The reciprocal of this formula can be used to calculate the average rate of return for the project.

Once cost of capital has been calculated, we can set up a table projecting costs and revenue streams that are discounted at the calculated rate. The key is to determine how long it will take the firm to reach the *breakeven point* on a new project. Breakeven point represents the amount of time necessary to recover the initial investment of capital in the project. Shorter paybacks are more desirable than longer paybacks, primarily because the farther we have to project payback into the future, the greater the potential for additional risk.

EXAMPLE 3.4 Payback Period

Our company wants to determine which of two project alternatives is the more attractive investment opportunity, using a payback period approach. We have calculated the initial investment cost of the two projects and the expected revenues they should generate for us (see Table 3.5). Which project should we invest in?

SOLUTION

For our example, the payback for the two projects can be calculated as in Table 3.6. These results suggest that Project A is a superior choice over Project B, based on a shorter projected payback period (2.857 years versus 4.028 years) and a higher rate of return (35% versus 24.8%).

TABLE 3.5 Initial Outlay and Projected Revenues for Two Project Options

	Project A		Project B	
	Revenues	Outlays	Revenues	Outlays
Year 0		$500,000		$500,000
Year 1	$ 50,000		$ 75,000	
Year 2	150,000		100,000	
Year 3	350,000		150,000	
Year 4	600,000		150,000	
Year 5	500,000		900,000	

TABLE 3.6 Comparison of Payback for Projects A and B

Project A	Year	Cash Flow	Cum. Cash Flow
	0	($500,000)	($500,000)
	1	50,000	(450,000)
	2	150,000	(300,000)
	3	350,000	50,000
	4	600,000	650,000
	5	500,000	1,150,000
Payback = 2.857 years			
Rate of Return = 35%			
Project B	**Year**	**Cash Flow**	**Cum. Cash Flow**
	0	($500,000)	($500,000)
	1	75,000	(425,000)
	2	100,000	(325,000)
	3	150,000	(175,000)
	4	150,000	(25,000)
	5	900,000	875,000
Payback = 4.028 years			
Rate of Return = 24.8%			

Net Present Value

The most popular financial decision-making approach in project selection, the **net present value (NPV) method,** projects the change in the firm's value if a project is undertaken. Thus a *positive* NPV indicates that the firm will make money—and its value will rise—as a result of the project. Net present value also employs discounted cash flow analysis, discounting future streams of income to estimate the present value of money.

The simplified formula for NPV is as follows:

$$NPV_{(\text{project})} = I_0 + \sum F_t/(1 + r + p_t)^t$$

Where:
F_t = the net cash flow for period t
r = the required rate of return
I = initial cash investment (cash outlay at time *0*)
p_t = inflation rate during period t

The optimal procedure for developing an NPV calculation consists of several steps, including the construction of a table listing the outflows, inflows, discount rate, and discounted cash flows across the relevant time periods. We construct such a table in Example 3.5 (see Table 3.7).

EXAMPLE 3.5 Net Present Value

Assume that you are considering whether or not to invest in a project that will cost $100,000 in initial investment. Your company requires a rate of return of 10%, and you expect inflation to remain relatively constant at 4%. You anticipate a useful life of four years for the project and have projected future cash flows as follows:

Year 1: $20,000

Year 2: $50,000

Year 3: $50,000

Year 4: $25,000

SOLUTION

We know the formula for determining NPV:

$$NPV = I_0 + \sum F_t/(1 + r + p)^t$$

We can now construct a simple table to keep a running score on discounted cash flows (both inflows and outflows) to see if the project is worth its initial investment. We already know that we will need the following categories: *Year, Inflows, Outflows,* and *NPV.* We will also need two more categories:

Net flows: just the difference between inflows and outflows
Discount factor: simply the reciprocal of the discount rate $(1/(1 + k + p)^t)$

In Table 3.7, if we fill in the *Discount Factor* column assuming that $k = 10\%$ and $p = 4\%$, we can begin work on the *NPV.* Note that *Year 0* means the present time, *Year 1* the first year of operation.

TABLE 3.7 Running Score on Discounted Cash Flows

Year	Inflows	Outflows	Net Flow	Discount Factor	NPV
0		100,000	(100,000)	1.000	
1	20,000		20,000	0.8772	
2	50,000		50,000	0.7695	
3	50,000		50,000	0.6749	
4	25,000		25,000	0.5921	

TABLE 3.8 Discounted Cash Flows and NPV (I)

Year	Inflows	Outflows	Net Flow	Discount Factor	NPV
0		100,000	(100,000)	1.000	(100,000)
1	20,000		20,000	0.8772	17,544
2	50,000		50,000	0.7695	38,475
3	50,000		50,000	0.6749	33,745
4	25,000		25,000	0.5921	14,803
Total					$4,567

How did we arrive at the *Discount Factor* for Year 3? Using the formula we set above, calculate the appropriate data:

$$\textit{Discount factor} = (1/(1 + .10 + .04)^3) = .6749$$

Now supply the data for the *Inflows, Outflows,* and *Net Flows* columns.

Finally, we complete the table by multiplying the *Net Flow* amount by the *Discount Factor.* The results give us the data for the *NPV* column of our table. The sum of the discounted cash flows (their net present value) shown in Table 3.8 gives us the *NPV* of the project.

The total is a positive number, indicating that the investment is worthwhile and should be pursued.

Net present value is one of the most common project selection methods in use today. Its principal advantage is that it allows firms to link project alternatives to financial performance, better ensuring that the projects a company does choose to invest its resources in are likely to generate profit. Among its disadvantages is the difficulty in using NPV to make accurate long-term predictions. For example, suppose that we were considering investing in a project with an expectation that it would continue to generate returns over the next 10 years. In choosing whether or not to invest in the project today, we must make some assumptions about the future interest rates and our **required rate of return** (**RRR**) for the next 10 years. In uncertain financial or economic times, it can be risky to make long-term investment decisions when discount rates may fluctuate.

Discounted Payback

Now that we have considered the time value of money, as shown in the NPV method, we can apply this logic to the simple payback model to create a screening and selection model with a bit more power. Remember that with NPV we use discounted cash flow as our means to decide whether or not to invest in a project opportunity. Now, let's apply that same principle to the **discounted payback method.** Under the discounted payback method, the time period we are interested in is the length of time until the sum of the discounted cash flows is equal to the initial investment.

Let's try a simple example to illustrate the difference between straight payback and discounted payback methods. Suppose we require a 12.5% return on new investments and we have a project opportunity that will cost an initial investment of $30,000 with a promised return per year of $10,000. Under the simple payback model, it should only take three years to pay off the initial investment. However, as Table 3.9 demonstrates, when we discount our cash flows at 12.5 percent and start adding them, it actually takes four years to pay back the initial project investment.

The advantage of the discounted payback method is that it allows us to make a more "intelligent" determination of the length of time needed to satisfy the initial project investment. That is, while simple payback is useful for accounting purposes, discounted payback is actually more representative of financial realities that all organizations must consider when pursuing projects. The effects of inflation and future investment opportunities do matter with individual investment decisions and so, should also matter when evaluating project opportunities.

Internal Rate of Return

Internal rate of return (**IRR**) is an alternative method for evaluating the expected outlays and income associated with a new project investment opportunity. IRR asks the simple question: What rate of return will this

TABLE 3.9 Discounted Payback Method

Year	Project Cash Flow* Discounted	Undiscounted
1	$8,900	$10,000
2	7,900	10,000
3	7,000	10,000
4	6,200	10,000
5	5,500	10,000
Payback Period	4 Years	3 Years

*Cash flows rounded to the nearest $100.

project earn? Under this model, the project must meet some required "hurdle" rate applied to all projects under consideration. Without detailing the mathematics of the process, we will say only that IRR is the discount rate that equates the present values of a project's revenue and expense streams. If a project has a life of time *t*, the IRR is defined as:

$$IO = \sum_{n=1}^{t} \frac{ACF^{t}}{(1 + IRR)^{t}}$$

Where:

ACF^t = the annual after-tax cash flow for time period *t*
IO = the initial cash outlay
n = the project's expected life
IRR = the project's internal rate of return

IRR is found through a straightforward process, although it requires tables representing present value of an annuity in order to determine the project's rate of return. Alternatively, many pocket calculators can determine IRR quickly. Without such tables or access to a calculator, it is necessary to employ an iterative process to identify the approximate IRR for the project.

EXAMPLE 3.6 Internal Rate of Return

Let's take a simple example. Suppose that a project required an initial cash investment of $5,000 and was expected to generate inflows of $2,500, $2,000, and $2,000 for the next three years. Further, assume that our company's required rate of return for new projects is 10%. The question is: Is this project worth funding?

SOLUTION

Answering this question requires four steps:

1. Pick an arbitrary discount rate and use it to determine the net present value of the stream of cash inflows.
2. Compare the present value of the inflows with the initial investment; if they are equal, you have found IRR.
3. If the present value is larger (or less than) than the initial investment, select a higher (or lower) discount rate for the computation.
4. Determine the present value of the inflows and compare it with the initial investment. Continue to repeat steps 2–4 until you have determined the IRR.

Using our example, we know:

Cash investment = $5,000
Year 1 inflow = $2,500
Year 2 inflow = $2,000
Year 3 inflow = $2,000
Required rate of return = 10%

Step One: Try 12%.

Year	Inflows	Discount Factor at 12%	NPV
1	2,500	.893	2,232.50
2	2,000	.797	1,594
3	2,000	.712	1,424
Present value of inflows			5,250.50
Cash investment			− 5,000
Difference			$ 250.50

Decision: Present value difference at 12% is 250.50, which is too high. Try a higher discount rate.

Step Two: Try 15%.

Year	Inflows	Discount Factor at 15%	NPV
1	2,500	.870	2,175
2	2,000	.756	1,512
3	2,000	.658	1,316
Present value of inflows			5,003
Cash investment			5,000
Difference			$3

Decision: Present value difference at 15% is $3, which suggests that 15% is a close approximation of IRR.

If the IRR is greater than or equal to the company's required rate of return, the project is worth funding. In the example above, we found that the IRR is 15% for the project, making it higher than the hurdle rate of 10% and a good candidate for investment. The advantage of using IRR analysis lies in its ability to compare alternative projects from the perspective of expected *return on investment* (ROI). Projects having higher IRR are generally superior to those having lower IRR.

IRR does, however, have some disadvantages. First, it is *not* the rate of return for a project. In fact, IRR equals the project's rate of return only when project-generated cash inflows can be reinvested in new projects at similar rates of return. If the firm can reinvest revenues only on lower-return projects, the "real" return on the project is something less than the calculated IRR. Several other problems with IRR make NPV a more robust determinant of project viability:[16]

- IRR and NPV calculations typically agree (that is, make the same investment recommendations) only when projects are independent of each other. If projects are not mutually exclusive, IRR and NPV may rank them differently. The reason is that NPV employs a weighted average cost of capital discount rate that reflects potential reinvestment while IRR does not. Because of this distinction, NPV is generally preferred as a more realistic measure of investment opportunity.
- If cash flows are not normal, IRR may arrive at multiple solutions. For example, if net outflows follow a period of net cash inflows, IRR may give conflicting results. If, following the completion of plant construction, it is necessary to invest in land reclamation or other incidental but significant expenses, an IRR calculation may result in multiple return rates, only one of which is correct.

Options Models

Let's say that a firm has an opportunity to build a power plant in a developing nation. The investment is particularly risky: The company may ultimately fail to make a positive return on its investment and may fail to find a buyer for the plant if it chooses to abandon the project. Both the NPV and IRR methods fail to account for this very real possibility—namely, that a firm may not recover the money that it invests in a project. Clearly, however, many firms must consider this option when making investment decisions.

An organization facing this possibility should determine two things:[17]

1. Whether it has the flexibility to postpone the project
2. Whether future information will help it make its decision

EXAMPLE 3.7 Options Model

A construction firm is considering whether or not to upgrade an existing chemical plant. The initial cost of the upgrade is \$5,000,000, and the company requires a 10% return on its investment. The plant can be upgraded in one year and start earning revenue the following year. The best forecast promises cash flows of \$1 million per year, but should adverse economic and political conditions prevail, the probability of realizing this amount drops to 40%, with a 60% probability that the investment will yield only \$200,000 per year.

SOLUTION

We can first calculate the NPV of the proposed investment as follows:

$$\text{Cash Flows} = .4(\$1 \text{ million}) + .6(\$200{,}000) = \$520{,}000$$

$$\begin{aligned}\text{NPV} &= -\$5{,}000{,}000 + \textstyle\sum \$520{,}000/(1.1)^t \\ &= -\$5{,}000{,}000 + (\$520{,}000/.1) \\ &= -\$5{,}000{,}000 + \$5{,}200{,}000 \\ &= \$200{,}000\end{aligned}$$

Because the \$520,000 is a perpetuity that begins in Year 1, we divide it by the discount rate of 10% to determine the value of the perpetuity. According to this calculation, the company should undertake the project. This recommendation, however, ignores the possibility that by waiting a year, the firm may gain a better sense of the political/economic climate in the host country. Thus the firm is neglecting important information that could be useful in making its decision. Suppose, for example, that by waiting a year, the company determines that its investment will have a 50% likelihood (up from the original projection of 40%) of paying off at the higher value of \$1 million per year. The NPV for the project would now be:

$$\begin{aligned}NPV &= 0.5 \times [-\$5{,}000{,}000 + \$1{,}000{,}000/0.1] \\ &= 0.5 \times [-\$5{,}000{,}000 + \$10{,}000{,}000] \\ &= 0.5 \times \$5{,}000{,}000 \\ &= \$2{,}500{,}000\end{aligned}$$

Choosing a Project Selection Approach

What can we conclude from our discussion of project-selection methods? First and foremost, we have learned to focus on the *method* that we use in making selection decisions. Have we been consistent and objective in considering our alternatives? The author has worked in a consulting and training capacity with a number of firms that have experienced recurrent problems in their project selections (they kept picking losers). Why? One reason that became increasingly clear was their failure to even attempt objectivity in their selection methods. Proposed projects were often "sacred cows" or the pet ideas of senior managers that were pushed to the head of the line or, worse, financially "tweaked" until they yielded satisfactory conclusions. Team members knew in advance that such projects would fail because the projects had been massaged to the point at which they seemingly optimized the selection criteria. The key lies in being objective about the selection process. If you continue to operate according to the "GIGO" principle—garbage in/garbage out—you'll soon be up to your knees in garbage.

A second conclusion suggests that a wide variety of selection methods may be appropriate for specific companies and project circumstances. Some projects require sophisticated financial evidence of their viability. Others may only need to demonstrate no more than an acceptable profile when compared to other options. In other words, any of the previously discussed selection methods may be appropriate under certain situations. Some experts, for example, favor weighted scoring models on the grounds that they offer a more accurate reflection of a firm's strategic goals without sacrificing long-term effectiveness for short-term financial gains.[18] They also argue that such important, nonfinancial criteria should not be excluded from the decision-modeling process. Perhaps the key lies in a selection algorithm broad enough to encompass both financial and nonfinancial considerations. Regardless of the approach that a company selects, we can be sure of one thing: Making good project choices is a crucial step in ensuring good project management downstream.

PROJECT PROFILE

Project Selection and Screening at GE: The Tollgate Process

General Electric has developed a highly sophisticated approach to project screening and selection that the company calls the Tollgate Process. As you can see from Figure 3.6, Tollgate involves a series of seven formal procedural checkpoints (labeled *100* to *700*) established along the project development timeline. As such, Tollgate is more than just a project-selection methodology; it involves controlling the selection and development of the project as it moves through its life cycle. Each stage in this control process is carefully monitored.

Each of the seven Tollgate stages can be broken down into a so-called *process map* that guides managers and teams in addressing specific necessary elements in the completion of a stage. These elements are the substeps that guide project screening in order to ensure that all projects conform to the same set of internal standards at GE.

Figure 3.7 lays out the Process Flow Map that is used to evaluate the progress each project makes at the various stages to final completion. Note that teams must complete all action substeps at each Tollgate stage. Once they have completed a given stage, a cross-functional management review team provides oversight at a review conference. Approval at this stage permits the team to proceed to the next stage. Rejection means that the team must back up and deal with any issues that the review team feels it has not addressed adequately. For example, suppose that the project fails a technical conformance test during field testing at the system verification stage. The technical failure would require the team to cycle back to the appropriate point to analyze the cause for the field test failure and begin remedial steps to correct it. After a project team has received approval from the review team, it needs the approval of senior management before moving on to the next Tollgate stage. Rejection at this point by senior management often effectively kills the project.

Some critics argue that formalized and sophisticated review processes such as Tollgate add excessive layers of bureaucratic oversight to the project-screening process. In fact, the sheer number of actions, steps, checklists, and managerial reviews stipulated by the Tollgate process can add significant delays to projects—a critical concern if a

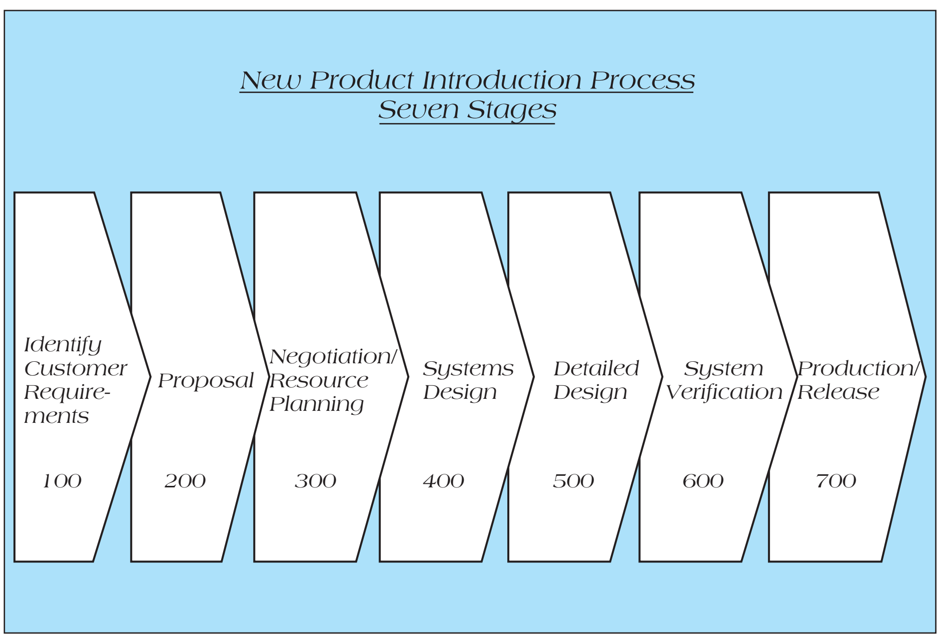

FIGURE 3.6 **GE's Tollgate Process**

Source: Used with permission of General Electric Company.

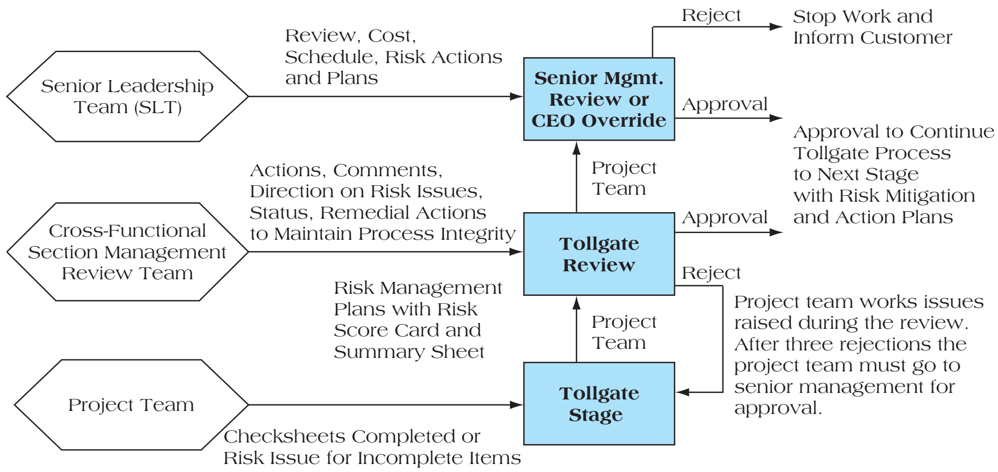

FIGURE 3.7 **The GE Tollgate Review Process Flow Map**

Source: Used with permission of General Electric Company.

project is needed to address an immediate problem. On the other hand, proponents of such techniques argue that the benefits—standardization across business units, comprehensive step-by-step risk analysis, clear links to top management—more than compensate for potential problems. GE itself points to significant improvements in early problem discovery and "real-time" risk management that Tollgate has promoted.

3.4 PROJECT PORTFOLIO MANAGEMENT

Project portfolio management is the systematic process of selecting, supporting, and managing a firm's collection of projects. Projects are managed concurrently under a single umbrella and may be either related or independent of one another. The key to portfolio management is realizing that a firm's projects share a common strategic purpose and the same scarce resources.[19] For example, Pratt & Whitney Jet Engines, a subsidiary of United Technologies Corporation, is similar to other major jet engine manufacturers in creating a wide portfolio of engine types, from those developed for helicopters to those for jet aircraft, from civilian use to military consumption. Although the products share common features, the technical challenges also ensure that the product line is highly diverse. The concept of project portfolio management holds that firms should not manage projects as independent entities, but rather should regard portfolios as unified assets. There may be multiple objectives, but they are also shared objectives.[20]

Artto[21] notes that in a project-oriented company, project portfolio management poses a constant challenge between balancing long-term strategic goals and short-term needs and constraints. Managers routinely pose such questions as the following:

- What projects should the company fund?
- Does the company have the resources to support them?
- Do these projects reinforce future strategic goals?
- Does this project make good business sense?
- Is this project complementary to other company projects?

Objectives and Initiatives

Each of the questions in the previous list has both short-term and long-term implications, and, taken together, they constitute the basis for both strategic project management and effective risk management. Portfolio management, therefore, entails decision making, prioritization, review, realignment, and reprioritization of a firm's projects. Let's consider each of these tasks in more detail.

DECISION MAKING The decision whether or not to proceed in specific strategic directions is often influenced by market conditions, capital availability, perceived opportunity, and acceptable risk. A variety of project alternatives may be considered reasonable alternatives during portfolio development.

PRIORITIZATION Because firms have limited resources, they typically cannot fund every project opportunity. Thus they must prioritize. For this task, several criteria may be used:

- ***Cost:*** Projects with lower development costs are more favorable because they come with less upfront risk.
- ***Opportunity:*** The chance for a big payout is a strong inducement for funding.
- ***Top management pressure:*** Political pressure from top management (say, managers with pet projects) can influence decisions.
- ***Risk:*** Project payouts must justify some level of acceptable risk; those that are too risky are scratched.
- ***Strategic "fit":*** If a firm has a policy of pursuing a family of products, all opportunities are evaluated in terms of their *complementarity*—that is, either their strategic fit with existing product lines or their ability to augment the current product family.
- ***Desire for portfolio balance:*** A firm may want to offset risky initiatives by funding other projects. The Boston Consulting Group's product matrix framework, for example, balances company product lines in terms of relative market share and product growth, suggesting that firms maintain a strategic balance within their portfolios between products with different profiles. A firm might use its profitable but low-growth products to fund investment into projects with high growth prospects. Portfolio balance supports developing a strategy that allows companies to balance or offset risk; explore alternative market opportunities; and/or allow the funding of innovation in other product lines.

REVIEW All project alternatives are evaluated according to the company's prioritization scheme. Projects selected for the firm's portfolio are the ones that, based on those priorities, offer maximum return.

REALIGNMENT When portfolios are altered by the addition of new projects, managers must reexamine company priorities. In the wake of new project additions, a number of important questions should be considered. Does the new project conform to strategic goals as characterized by the project portfolio, or does it represent a new strategic direction for the firm? Does a new project significantly alter the firm's strategic goals? Does the portfolio now require additional rebalancing? The decision to change a portfolio by adding new projects restarts the analysis cycle in which we must again reexamine the portfolio for signs of imbalance or updating.

REPRIORITIZATION If strategic realignment means shifting the company's focus (i.e., creating new strategic directions), managers must then reprioritize corporate goals and objectives. In this sense, then, portfolio management means managing overall company strategy. A good example of this phenomenon was the disastrous L-1011 commercial jet project initiated by Lockheed over 20 years ago. The project's cost overruns coupled with poor demand so soured Lockheed's management on the commercial jet industry that they made the decision to refocus their priorities exclusively on defense-related aviation projects.

Developing a Proactive Portfolio

Portfolio management, therefore, is an important component in strategic project management. In addition to managing specific projects, organizations routinely strategically plan for profitability, and the road to profitability often runs through the area of strategic project management. One of the most effective methods for aligning profit objectives and strategic plans is the development of a proactive project portfolio, or an integrated family of projects, usually with a common strategic goal. Such a portfolio supports overall strategic integration, rather than an approach that would simply move from project opportunity to opportunity.

Consider the example of the large pharmaceutical firm Pfizer.[22] Pfizer and its competitors routinely manage large families of projects in an integrated manner. The overall integration of project management efforts helps the company's managers deal with certain realities of the pharmaceutical industry, such as extremely high development costs and long lead times for new products. At any particular point in time, for example, Pfizer has numerous projects under research and development, a smaller number of projects entering various stages of clinical trials, and finally, an even smaller line of projects already on the market. Each step in the cycle is fraught with risks and uncertainties. Will a drug work in clinical trials? Will it have minimal negative side effects? Can it be produced in a cost-effective manner? Is its release time-sensitive (is there, for instance, a limited market opportunity of which to take advantage)? Often the answers to such questions will reduce Pfizer's ongoing portfolio of development projects. In fact, as Table 3.10 shows, the **lead time** for bringing a new drug to market can easily stretch over 15 years. Moreover, the success rate of a drug actually being commercially developed is estimated to be less than 0.002%.

Under circumstances this risky, in which development time is lengthy, the financial repercussions of failure are huge, and success is never certain, pharmaceutical firms must practice highly sophisticated project

TABLE 3.10 Phases in New Drug Development

Phase	Duration	% of Success	Contents
Discovery	4–7 yrs	1%	Research a selected pool of molecules in computer models and test tubes.
Preclinical research			Test on animals and in test tubes to research the safety, possible indications, toxicology, and metabolism of the molecule.
Phase I	1 yr	70–75%	Small clinical studies on healthy volunteers to study the safety and ADME characteristics of the molecule.
Phase II	2 yrs	50%	Small studies on patients with the target disease to study the efficacy, dosage, and formulation of the drug.
Phase III	3 yrs	75–85%	Large clinical studies on patients to confirm the results of phase II. The most expensive phase in the project.
Marketing Application (MA)	1.5–3 yrs	75–80%	Compile marketing authorization application (MAA) to the authorities. After the authorization the drug may be sold and marketed.
Total	12–16 yrs	<0.002%	

Source: M. Lehtonen. 2001. "Resource Allocation and Project Portfolio Management in Pharmaceutical R&D," in Artto, Martinsuo, and Aalto (Eds.), (2001), *Project Portfolio Management: Strategic Management through Projects,* pp. 107–140, figure on page 112. Helsinki, Finland: Project Management Association.

portfolio management. Because failure rates are high and washouts constant, the need to take advantage of new product opportunities is critical. Only in this way can the company ensure a steady supply of new products in the pipeline.

The pitfalls and possibilities of the pharmaceuticals development process is illustrated in Figure 3.8. Drug companies compensate for the lengthy lead times necessary to get final approval of new products by simultaneously funding and managing literally scores of development efforts. Unfortunately, only a small proportion of an R&D portfolio will show sufficient promise to be advanced to the clinical-trial stage. Many projects are further weeded out during this phase, with very few projects reaching the stage of commercial rollout.

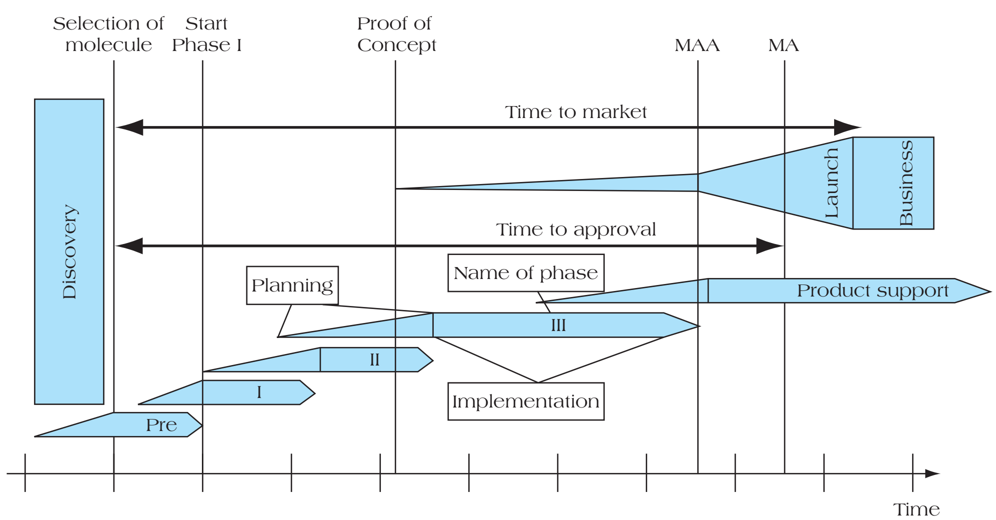

FIGURE 3.8 The Flow of New Drug Development over Time

Source: M. Lehtonen. 2001. "Resource Allocation and Project Portfolio Management in Pharmaceutical R&D," in Artto, Martinsuo, and Aalto (Eds.), (2001), *Project Portfolio Management: Strategic Management through Projects,* pp. 107–140, figure on page 120. Helsinki, Finland: Project Management Association.

Pfizer uses portfolio management to manage the flow of new drug development projects, much as Nokia and Erickson use it to keep track of product pipelines that include mobile phones, baseband modems, and firewall systems. Project portfolios are necessary because a certain percentage of projects will be canceled prior to full funding, others will be eliminated during development, and still others will fail commercially. This cycle leaves only a few projects to account for a firm's return on all of its investments. In short, any company that puts all its R&D eggs in one project basket runs huge risks if that project fails during development or proves disappointing in the marketplace. As a rule, therefore, companies guarantee themselves fallback options, greater financial stability, and the chance to respond to multiple opportunities by constantly creating and updating portfolios of projects.

Keys to Successful Project Portfolio Management

Although examples of successfully managed portfolios abound, few researchers have investigated the key reasons why some companies are better at it than others. Brown and Eisenhardt[23] recently studied six firms in the computer industry; all are involved in multiple project development activities. They determined that successfully managed project portfolios usually reflect the following three factors.

FLEXIBLE STRUCTURE AND FREEDOM OF COMMUNICATION Multiple-project environments cannot operate effectively when they are constrained by restrictive layers of bureaucracy, narrow communication channels, and rigid development processes. Successful portfolios emerge from environments that foster flexibility and open communication. When project teams are allowed to improvise and experiment on existing product lines, innovative new product ideas are more likely to emerge.

LOW-COST ENVIRONMENTAL SCANNING Many firms devote a lot of time and money in efforts to hit product "home runs." They put their faith (and financing) in one promising project and aim to take the marketplace by storm, often without sufficiently analyzing alternative opportunities or future commercial trends. As a rule, successful project portfolio strategies call for launching a number of low-cost probes into the future, the idea behind environmental scanning—developing and market-testing a number of experimental product prototypes, sometimes by entering strategic alliances with potential partners. Successful firms do not rely on home runs and narrowly concentrated efforts. They are constantly building and testing new projects prior to full-scale development. Rubbermaid, for example, routinely brings dozens of new product ideas to the market, samples the commercial response, and uses the resulting information to improve potential winners and discard products that don't measure up.

TIME-PACED TRANSITION Successful portfolio management requires a sense of timing, especially as firms make transitions from one product to the next. Successful firms use project portfolio planning routinely to develop long lead times and plan ahead in order to make the smoothest possible transition from one product to another, whether the product lines are diverse or constitute creating a follow-on upgrade. Gillette, for example, has made a lucrative business out of developing and selling new models of shaving razors. Gillette's product life cycle planning is highly sophisticated, allowing it to make accurate predictions of the likely life cycle of current products and the timing necessary for beginning new product development projects to maintain a seamless flow of consumer products.

Problems in Implementing Portfolio Management

What are some of the common problems in creating an effective portfolio management system? Although numerous factors can adversely affect the practice of portfolio management, recent research seems to suggest that the following are among the most typical problem areas.[24]

CONSERVATIVE TECHNICAL COMMUNITIES In many organizations, there is a core of technical professionals—project engineers, research scientists, and other personnel—who develop project prototypes. A common phenomenon is this group's unwillingness, whether out of pride, organizational inertia, or due to arguments supporting pure research, to give up project ideas that are too risky, too costly, or out of sync with strategic goals. Often, when top management tries to trim the portfolio of ongoing projects for strategic reasons, they find engineers and scientists reluctant to accept their reasoning. Data General Corporation, a manufacturer of computers and IT products, found itself increasingly under the dominance of its hardware engineering department, a group intent on pursuing their own new product goals and fostering their own vision for the organization. By the mid-1990s, with one product after another resulting in significant losses, the company could not continue to operate independently and was acquired by EMC Corporation.

OUT-OF-SYNC PROJECTS AND PORTFOLIOS Sometimes after a firm has begun realigning and reprioritizing its strategic outlook, it continues to develop projects or invest in a portfolio that no longer accurately reflects its new strategic focus. Strategy and portfolio management must accurately reflect a similar outlook. When strategy and portfolio management are out of alignment, one or both of two things will probably happen: either the portfolio will point the firm toward outmoded goals or the firm's strategy will revert to its old objectives.

UNPROMISING PROJECTS The worst-case scenario finds a company pursuing poor-quality or unnecessary projects. A recent battle in consumer video electronics pitted Sony's Blu-ray high definition Digital Video Disc (DVD) technology against Toshiba's offering, the High Definition Digital Versatile Disc (HD-DVD). Although the Sony product requires a relatively expensive machine to play the discs, it convinced the majority of the public that its format is the superior one. Major content manufacturers and retailers had been steadily withdrawing their support for the HD-DVD technology, leaving Toshiba to continue developing it alone. After pursing HD-DVD technology for several years at high cost, Toshiba announced in early 2008 that it was abandoning its foray. When portfolio management is geared to product lines, managers routinely rebalance the portfolio to ensure that there are a sufficient number of products of differing type to offset those with weaknesses. Revenues from "cash cows," for example, can fund innovative new products. Sometimes, of course, critical analysis of a portfolio requires hard decisions, project cancellations, and reallocated resources. But it is precisely this ongoing attention to the portfolio that prevents it from becoming weighted down with unpromising projects.

SCARCE RESOURCES A key resource for all projects is human beings. In fact, personnel costs comprise one of the highest sources of project expense. Additional types of resources include any raw materials, financial resources, or supplies that are critical to successfully completing the project. Before spending large amounts of time creating a project portfolio, organizations thus like to ensure that the required resources will be available when needed. A principle cause of portfolio underperformance is a lack of adequate resources, especially personnel, to support required development.

Portfolio management is the process of bringing an organization's project management practices into line with its overall corporate strategy. By creating complementarity in its project portfolio, a company can ensure that its project management teams are working together rather than at cross-purposes. Portfolio management is also a visible symbol of the strategic direction and commercial goals of a firm. Taken together, the projects that a firm chooses to promote and develop send a clear signal to the rest of the company about priorities, resource commitment, and future directions. Finally, portfolio management is an alternative method for managing overall project risk by seeking a continuous balance among various families of projects, between risks and return trade-offs, and between efficiently run projects and nonperformers. As more and more organizations rely on project management to achieve these ends, it is likely that more and more firms will take the next logical step: organizing projects by means of portfolio management.

Summary

1. **Explain six criteria for a useful project-selection screening model.** No organization can pursue every opportunity that presents itself. Choices must be made, and to best ensure that they select the most viable projects, many firms develop priority systems or guidelines—*selection models* that permit them to save time and money while maximizing the likelihood of success.

   There are a number of decision models available to managers responsible for evaluating and selecting potential projects. All firms, however, try to develop a screening model (or set of models) that will allow them to make the best choices within the usual constraints of time and money. Souder (1983) identifies five important issues that managers should consider when evaluating screening models: (1) *Realism:* An effective model must reflect organizational objectives and must be reasonable in light of such constraints on resources as money and personnel. Finally, the model must take into account both commercial risks and technical risks. (2) *Capability:* A model should be flexible enough to respond to changes in the conditions under which projects are carried out and robust enough to accommodate new criteria and constraints. (3) *Flexibility:* The model should be easily modified if trial applications require changes. (4) *Ease of Use:* A model must be simple enough to be used by people in all areas of the organization, and it should be timely: It should generate information rapidly, and people should be able to assimilate that information without any special training or skills. (5) *Cost:* The cost of gathering, storing, and arranging information in the form of useful reports or proposals should be relatively low in relation to the costs associated with implementing a project (in other words, low enough to encourage use of the models rather than diminish their applicability). To Souder's list we add one more criterion: (6) *Comparability:* The model must be broad enough that it can be applied to multiple projects, and it must support general comparisons of project alternatives.

2. **Understand how to employ checklists and simple scoring models to select projects, including the recognition of their strengths and weaknesses.** Checklists require decision makers to develop a list of the criteria that are deemed important when considering among project alternatives. For example, a firm may decide that all project alternatives must be acceptable on criteria such as return on investment, safety, cost of development, commercial opportunities, and stakeholder acceptability. Once the list is created, all project alternatives are evaluated against the list and assigned a rating of high, medium, or low depending upon how well they satisfy each criterion in the checklist. Projects that rate highest across the relevant criteria are selected. Checklists are useful because they are simple and require the firm to make trade-off decisions among criteria to determine which issues are most important in selecting new projects. Among their disadvantages are the subjective nature of the rating process and the fact that they assume equal weighting for all criteria when some, in fact, may be much more important than others in making the final decision.

   Simple scoring models are similar to checklists except that they employ criterion weights for each of the decision criteria. Hence, all project alternatives are first weighted by the importance score for the criterion and then final scores are evaluated against one another. The advantage of this method is that it recognizes the fact that decision criteria may be weighted differently, leading to better choices among project alternatives. Its disadvantages are due to the difficulty in assigning meaningful values to scoring anchors such as "High = 3, Medium = 2, Low =1." The results of simple scoring models using weighted rankings lies in the uncertainty of their interpretation. Further, these models depend upon the relevance of the selected criteria and the accuracy of the weight given to them if they are to be useful.

3. **Use more sophisticated scoring models, such as the Analytical Hierarchy Process.** The Analytical Hierarchy Process (AHP) is a four-step process that allows decision makers to understand the nature of project alternatives in making selection decisions. The AHP first structures the hierarchy of criteria to be used in the decision process, then allocates weights to these criteria. The next step is to assign numerical values to all evaluation dimensions, and finally, to use this scoring device in evaluating project alternatives. The AHP has been shown to create more accurate decision alternatives and lead to more informed choices, provided the organization's decision makers develop accurate decision criteria and evaluate and weight them honestly.

4. **Learn how to use financial concepts, such as the efficient frontier and risk/return models.** Many projects are selected as a result of their perceived risk/return trade-off potential. That is, all projects entail risk (uncertainty). Project organizations seek to balance higher risk with comparatively higher expectations of return if they are to consider funding the project. The efficient frontier concept is defined as the portfolio offering the lowest risk for its expected reward and is made up of projects reflecting various combinations of risk and return. The efficient frontier allows projects to be evaluated against each other by assessing the potential returns for each alternative compared to the risk the firm is expected to undertake in producing the project.

5. **Employ financial analyses and options analysis to evaluate the potential for new project investments.** Financial analysis using discounted cash flows and internal rates of return allow us to apply the concept of the time value of money to any decision we have to make regarding the attractiveness of various project alternatives. The time value of money suggests that future streams of return from a project investment should at least offset the initial investment in the project plus some required rate of return imposed by the company. Options analysis takes this process one step further and considers alternatives in which an investment is either made or foregone, depending upon reasonable alternative investments the company can make in the future. Each of these financial models argues that the principle determinant of an attractive project investment must be the money it promises to return. Clearly, therefore, a reasonably accurate estimate of future streams of revenue is required for financial models to create meaningful results.

6. **Recognize the challenges that arise in maintaining an optimal project portfolio for an organization.** There are a number of challenges associated with managing a portfolio of projects, including: (a) conservative technical communities that refuse to support new project initiatives, (b) out-of-sync projects and portfolios in which the projects no longer align with overall strategic portfolio plans, (c) unpromising projects that unbalance the portfolio, and (d) scarce resources, so that it is impossible to support new projects.

7. **Understand the three keys to successful project portfolio management.** The three keys to success project portfolio management include the creation or availability of a flexible structure and freedom of communication, in which excessive bureaucracy and administrative oversight have been reduced to allow the portfolio management team maximum flexibility in seeking out and investing in projects. Additionally, successful portfolio management strategies allow for low-cost environmental scanning, which launches a series of inexpensive "probes" into the future to develop and test-market project alternatives. Finally, successful portfolio management requires a time-paced transition strategy based on a sense of the timing necessary to successfully transition from one product to the next, whether the next product is a direct offshoot of the original, or an additional innovative product for the firm's portfolio.

Key Terms

Analytical Hierarchy Process (AHP) *(p. 78)*
Checklist *(p. 74)*
Discounted cash flow (DCF) method *(p. 84)*
Discounted payback method (p. 87)
Efficient frontier *(p. 82)*
Internal rate of return (IRR) *(p. 87)*
Lead time (p. *93*)
Net present value (NPV) method *(p. 86)*
Nonnumeric models *(p. 73)*
Numeric models *(p. 73)*
Pairwise comparison approach *(p. 79)*
Payback period *(p. 84)*
Present value of money *(p. 84)*
Profile models *(p. 81)*
Project portfolio *(p. 72)*
Project portfolio management *(p. 92)*
Project-screening model *(p. 74)*
Required rate of return (RRR) (p. 87)
Risk/return *(p. 81)*
Simplified scoring model *(p. 76)*
Time value of money *(p. 84)*

Solved Problems

3.1 Net Present Value

Your firm is trying to decide whether or not to invest in a new project opportunity based on the following information. The initial cash outlay will total $250,000 over two years. The firm expects to invest $200,000 immediately and the final $50,000 in one year's time. The company predicts that the project will generate a stream of earnings of $50,000, $100,000, $200,000, and $75,000 per year, respectively, starting in Year 2. The required rate of return is 12%, and the expected rate of inflation over the life of the project is forecast to remain steady at 3%. Should you invest in this project?

SOLUTION

In order to answer this question, we need to organize the following data in the form of a table (see Table 3.11):

Total outflow = $250,000
Total inflow = $400,000
Required rate of return (r) = 12%
Inflation rate (p) = 3%
Discount factor = $1/(1 + r + p)^t$

The result is Table 3.11.

Because the discounted revenue stream is positive ($11,725), the project would be a good investment and should be pursued.

3.2 Discounted Payback

Your firm has the opportunity to invest $75,000 in a new project opportunity but due to cash flow concerns, your boss wants to know when you can pay back the original investment. Using the discounted payback method, you determine that the project should generate inflows of $30,000, $30,000, $25,000, $20,000, and $20,000 respectively for an expected five years after completion of the project. Your firm's required rate of return is 10%. Calculate how long it should take to pay back the initial project investment.

TABLE 3.11 Discounted Cash Flows and NPV (II)

Year	Inflows	Outflows	Net Flow	Discount Factor	NPV
0	$0	$200,000	$(200,000)	1.000	$(200,000)
1	0	50,000	(50,000)	.8696	(43,480)
2	50,000	0	50,000	.7561	37,805
3	100,000	0	100,000	.6575	65,750
4	200,000	0	200,000	.5718	114,360
5	75,000	0	75,000	.4972	37,290
Total					**$(11,725)**

SOLUTION

To answer this question, it is helpful to organize the information into a table. Remember that:

Total outflow = \$75,000
Required rate of return = 10%
Discount factor = $1/(1 + .10)^t$

Year	Cash Flow	Discount Factor	Net Inflows
0	(\$75,000)	1.0	(\$75,000)
1	30,000	.91	27,300
2	30,000	.83	24,900
3	25,000	.75	18,750
4	20,000	.68	13,600
5	20,000	.62	12,400
Payback = 3.3 years			

3.3 Internal Rate of return

Suppose that a project required an initial cash investment of \$24,000 and was expected to generate inflows of \$10,000, \$10,000, and \$10,000 for the next three years. Further, assume that our company's required rate of return for new projects is 12%. Is this project worth funding? Is it still a good investment when the company's required rate of return is 15%?

Cash investment = \$24,000
Year 1 inflow = \$10,000
Year 2 inflow = \$10,000
Year 3 inflow = \$10,000
Required rate of return = 12%

SOLUTION

Step One: Try 10%.

Year	Inflows	Discount Factor at 10%	NPV
1	10,000	.909	9,090
2	10,000	.826	8,260
3	10,000	.751	7,510
Present value of inflows			24,860
Cash investment			– 24,000
Difference			\$860

Decision: Present value difference at 10% is \$860, which is too high. Try a higher discount rate.

Step Two: Try 12%.

Year	Inflows	Discount Factor at 12%	NPV
1	10,000	.893	8,930
2	10,000	.797	7,970
3	10,000	.712	7,120
Present value of inflows			24,020
Cash investment			– 24,000
Difference			\$20

Decision: Present value difference at 12% is \$20, which suggests that 12% is a close approximation of IRR. This project would be a good investment at 12% but it would not be acceptable if the firm's required rate of return were 15%.

Discussion Questions

1. If you were to prioritize the criteria for a successful screening model, which criteria do you rank at the top of your priority list? Why?
2. What are the benefits and drawbacks of project checklists for screening alternatives?
3. How does use of the Analytical HierarchyProcess (AHP) aid in project selection? In particular, what aspects of the screening process does the AHP seem to address and improve directly?
4. What are the benefits and drawbacks of the profile model for project screening? Be specific about the problems that may arise in identifying the efficient frontier.
5. How are financial models superior to other screening models? How are they inferior?
6. How does the options model address the problem of nonrecoverable investment in a project?
7. What advantages do you see in the GE Tollgate screening approach? What disadvantages do you see? How would you alter it?
8. Why is project portfolio management particularly challenging in the pharmaceutical industry?
9. What are the keys to successful project portfolio management?
10. What are some of the key difficulties in successfully implementing portfolio management practices?

Problems

1. **Checklist.** Suppose that you are trying to choose which of two IT projects to accept. Your company employs three primary selection criteria for evaluating all IT projects: (1) proven technology, (2) ease of transition, and (3) projected cost savings. One option, Project Demeter, is evaluated as:

Technology	high
Ease of transition	low
Projected cost savings	high

The second option, Project Cairo, is evaluated as:

Technology	medium
Ease of transition	high
Projected cost savings	high

Construct a table identifying the projects, their evaluative criteria, and ratings. Based on your analysis, which project would you argue in favor of adopting? Why?

2. **Checklist.** Consider the following information in choosing among the four project alternatives below (labeled *A, B, C,* and *D*). Each has been assessed according to four criteria:

- Payoff potential
- Lack of risk
- Safety
- Competitive advantage

Project A is rated:			
Payoff potential	high	Safety	high
Lack of risk	low	Competitive advantage	medium
Project B is rated:			
Payoff potential	low	Safety	medium
Lack of risk	medium	Competitive advantage	medium
Project C is rated:			
Payoff potential	medium	Safety	low
Lack of risk	medium	Competitive advantage	low
Project D is rated:			
Payoff potential	high	Safety	medium
Lack of risk	high	Competitive advantage	medium

Construct a project checklist model for screening these four alternatives. Based on your model, which project is the best choice for selection? Why? Which is the worst? Why?

3. **Scoring Model.** Suppose the information in Problem 2 was supplemented by importance weights for each of the four assessment criteria that follow, where 1 = low importance and 4 = high importance:

Assessment Criteria	Importance Weights
1. Payoff potential	4
2. Lack of risk	3
3. Safety	1
4. Competitive advantage	3

Assume, too, that evaluations of *high* receive a score of 3, *medium* 2, and *low* 1. Recreate your project scoring model and reassess the four project choices (*A, B, C,* and *D*). Now which project alternative is the best? Why?

4. **Scoring Model.** Now assume that for Problem 3, the same importance weights are altered as follows:

Assessment Criteria	Importance Weights
1. Payoff potential	1
2. Lack of risk	1
3. Safety	4
4. Competitive advantage	2

How does this new information alter your decision? Which project now looks most attractive? Why?

5. **Screening Matrix.** Assume that the following information is relative to the process of screening various project opportunities. Our relevant criteria (including importance weightings) include the following:

Quality (5)
Cost (3)
Speed to Market (7)
Visibility (5)
Reliability (1)

Our company has four project alternatives, which satisfy the key features listed above as follows:

	Alpha	Beta	Gamma	Delta
Quality	1	3	3	5
Cost	7	7	5	3
Speed	5	5	3	1
Visibility	3	1	5	3
Reliability	5	5	7	7

Construct a project screening matrix to identify among these four projects the most likely candidate to be implemented.

6. **Profile Model.** Assume the project profile model shown in Figure 3.9.

Define the efficient frontier. The dotted lines represent the minimum return and the maximum risk that the company will accept. Which projects would be suitable for retaining and which should be dropped from the company's portfolio? Why?

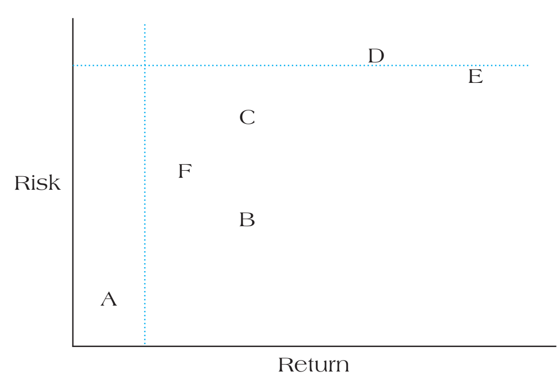

FIGURE 3.9 Project Profile Model (Problem 6)

7. Using the information from the profile model in Problem 6, construct an argument as to why project B is preferable to project C.
8. **Discounted Payback.** Your company is seriously considering investing in a new project opportunity but cash flow is tight these days. Top management is concerned about how long it will take for this new project to pay back the initial investment of $50,000. You have determined that the project should generate inflows of $30,000, $30,000, $40,000, $25,000, and $15,000 for the next five years. Your firm's required rate of return is 15%. How long will it take to pay back the initial investment?
9. **Net Present Value.** Assume that your firm wants to choose between two project options:

- Project A offers the following opportunity: $450,000 invested today will yield an expected income stream of $150,000 per year for five years, starting in Year 1.
- Project B requires an initial investment of $400,000, but its expected revenue stream is: Year 1 = 0, Year 2 = $50,000, Year 3 = $200,000, Year 4 = $300,000, and Year 5 = $200,000.

Assume that a required rate of return for your company is 12% and that inflation is expected to remain steady at 5% for the life of the project. Which is the better investment? Why?

10. **Net Present Value.** Your vice president for MIS informs you that she has researched the possibility of automating your organization's order-entry system. She has projected that the new system will reduce labor costs by $25,000 each year over the next five years. The purchase price (including installation and testing) of the new system is $105,250. The system is expected to have a useful life of five years, after which time it can be sold in the secondary computer systems market for $10,250. What is the net present value of this investment if the discount rate is 8.5% per year?
11. **Net Present Value.** A company has four project investment alternatives. The required rate of return on projects is 20%, and inflation is projected to remain at 3% into the foreseeable future. The pertinent information about each alternative is listed in the chart: Which project should be the firm's first priority? Why? If the company could invest in more than one project, indicate the order in which it should prioritize these project alternatives.
12. **Options Model.** A heavy manufacturing company wants to decide whether to initiate a new project. The success of the project depends heavily on the state of the economy, which has a 50/50 chance of being strong enough to support the venture. The project will require an initial investment of $1 million, and the company expects to earn $500,000 in annual revenues from the project—unless the economy goes into recession, in which case the project will return only $100,000 per year. The company requires a 12% return on its investments. Should it undertake the project?

Project Carol	Year	Investment	Revenue Streams
	0	$500,000	0
	1		50,000
	2		250,000
	3		350,000
Project George	**Year**	**Investment**	**Revenue Streams**
	0	$250,000	0
	1		75,000
	2		75,000
	3		75,000
	4		50,000
Project Thomas	**Year**	**Investment**	**Revenue Streams**
	0	$1,000,000	0
	1		200,000
	2		200,000
	3		200,000
	4		200,000
	5		200,000
	6		200,000
Project Anna	**Year**	**Investment**	**Revenue Streams**
	0	$75,000	0
	1		15,000
	2		25,000
	3		50,000
	4		50,000
	5		150,000

If the company decides to wait a year, the economy has a 75% chance of improving sufficiently to ensure $500,000 in annual returns. Does it make sense to wait for a year before making the investment? Use the options model approach to project evaluation to answer these two questions.

13. **Options Model.** Massivesoft Corporation is trying to decide whether or not to invest in a new software project. The initial investment will be $5 million. The project has a 40% chance of returning $1 million per year into the future and a 60% chance of generating only $100,000 in revenues. Assuming that Massivesoft requires a 15% return on capital investments, determine whether or not this is a viable project.

    If Massivesoft decides to wait one year before investing in the project, its odds of returning $1 million per year improve to 70%. Should Massivesoft wait one year to initiate the project?

14. **Portfolio Management.** Crown Corporation is interested in expanding its project portfolio. Currently, the firm specializes in water conservation and land reclamation projects. It anticipates, however, a huge increase in the demand for home fuel cells as an alternative to current methods of energy generation and usage. Although fuel-cell projects involve different technologies than those in which Crown currently specializes, the profit potential is very large. Develop a list of benefits and drawbacks associated with this potential expansion of Crown's project portfolio. In your opinion, do the risks outweigh the advantages from such a move? Justify your answer.

15. **Project Screening.** Assume you are the IT manager for a large urban health care system. You have lately found yourself bombarded with requests for new projects, including system upgrades, support services, automated record keeping, billing, and so forth. With an average of 50 software and hardware support projects going on at any time, you have decided that you must create a system for screening new project requests from the various departments within the health care system. Develop a project selection and screening system similar to GE's Tollgate process. What elements would you include in such a system? How many steps would you recommend? At what points in the process should "gates" be installed? How might a tollgate system for a software development company differ from one used by an architectural firm specializing in the development of commercial office buildings?

Case Study 3.1

Keflavik Paper Company

In recent years, Keflavik Paper Company has been having problems with its project management process. A number of commercial projects, for example, have come in late and well over budget. A comprehensive analysis of the process traced many of the problems back to faulty project-selection methods. Keflavik is a medium-sized corporation that manufactures a variety of paper products, including specialty papers and the coated papers used in the photography and printing industries. Despite cyclical downturns due to general economic conditions, the firm's annual sales have grown steadily though slowly. About five years ago, Keflavik embarked on a project-based approach to new product opportunities. The goal was to improve profitability and generate additional sales volume by developing new commercial products quickly, with better targeting to specific customer needs.

The results so far have not been encouraging. For one thing, the company's project development record has been spotty: While some projects have been delivered on time, others have been late. Budgets are routinely overrun, and product performance has been inconsistent, with the result that some projects yield good returns and others lose money. Top management hired a consultant to analyze the firm's processes and determine the most efficient way to fix its project management procedures. The consultant attributed the main problems not to the project management processes themselves, but to the manner in which projects are added to the company's portfolio. The primary mechanism for new project selection focused almost exclusively on discounted cash flow models, such as net present value analysis. Essentially, if it promised profitable revenue streams, a project was okayed by top management.

One result of this practice was the development of a "family" of projects that were often almost completely unrelated. No one, it seems, ever asked whether projects that were added to the portfolio fit with other ongoing projects. Keflavik attempted to expand into coated papers, photographic products, shipping and packaging materials, and other lines that strayed far from their original niche. New projects were rarely measured against the firm's strategic mission, and little effort was made to evaluate them according to its technical resources. Some new projects, for example, failed to fit because they required significant organizational learning and new technical expertise and training (all of which was also expensive and time consuming). The result was a portfolio of diverse, mismatched projects that was difficult to manage. Further, it decreased organizational learning as the diverse nature of the new product line and development processes made it impossible for Keflavik's project managers to move easily from one assignment to the next. Likewise, this hodgepodge of projects made it difficult to apply lessons learned from one project to the next. Because the skills acquired on one project were largely nontransferable, project teams routinely had to relearn processes whenever they moved on to a new project.

The consultant suggested that Keflavik rethink its project selection and screening processes. In order to lend some coherence to its portfolio, the firm needed to include alternative screening mechanisms. All new projects, for instance, had to be evaluated in terms of the company's strategic goals and were required to demonstrate complementarity with its current portfolio. He further recommended that in order to match project managers with the types of projects that the company was increasingly undertaking, it should analyze their current skill sets. Although Keflavik has begun implementing these and other recommendations, progress so far has been slow. In particular, top managers have found it hard to reject opportunities that offer positive cash flow. They have also had to relearn the importance of project prioritization. Nevertheless, a new prioritization scheme is in place, and it seems to be improving both the selection of new project opportunities and the company's ability to manage projects once they are funded.

Questions for Discussion

1. Keflavik Paper presents a good example of the dangers of excessive reliance on one screening technique (discounted cash flows). How might excessive or exclusive reliance on other screening methods discussed in this chapter lead to similar problems?
2. Assume that you are responsible for maintaining Keflavik's project portfolio. Name some key criteria that should be used in evaluating all new projects before they are added to the current portfolio.
3. What does this case demonstrate about the effect of poor project-screening methods on a firm's ability to manage its projects effectively?

Case Study 3.2

Project Selection at Nova Western, Inc.

Phyllis Henry, vice president of new product development, sat at her desk, trying to make sense of the latest new project proposals she had just received from her staff. Nova Western, Inc., a large developer of business software and application programs, had been experiencing a downturn in operating revenues over the past three quarters. The senior management team was feeling pressure from the board of directors to take steps to correct this downward drift in revenues and profitability. Their consensus opinion was that Nova Western needed some new product ideas, and fast.

The report Phyllis was reading contained the results of a project screening conducted by two independent groups within the new product development department. After several weeks of analysis, it appeared that two top contenders had emerged as the optimal new project opportunities. One project, code-named Janus, was championed by the head of software development. The other project idea, Gemini, had the support of the business applications organization. Phyllis's original charge to her staff was to prepare an evaluation of both projects in order to decide which one Nova Western should support. Because of budget restrictions, there was no way that both projects could be funded.

The first evaluation team used a scoring model, based on the key strategic categories at Nova Western, to evaluate the two projects. The categories they employed were: (1) strategic fit, (2) probability of technical success, (3) financial risk, (4) potential profit, and (5) strategic leverage (ability of the project to employ and enhance company resources and technical capabilities). Using these categories, the team evaluated the two projects as shown here. Scores were based on: 1 = low, 2 = medium, and 3 = high.

Project Janus

Category	Importance	Score	Weighted Score
1. Strategic Fit	3	2	6
2. Probability of technical success	2	2	4
3. Financial risk	2	1	2
4. Potential profit	3	3	9
5. Strategic leverage	1	1	1
			Score = 22

Project Gemini

Category	Importance	Score	Weighted Score
1. Strategic Fit	3	3	9
2. Probability of technical success	2	2	4
3. Financial risk	2	2	4
4. Potential profit	3	3	9
5. Strategic leverage	1	2	2
			Score = 28

The above results seem to suggest that Project Gemini is the choice for the next new project. However, Phyllis was also presented with an NPV analysis of the two projects by her second team of evaluators. Assuming a required rate of return of 15% and anticipated inflation

(*continued*)

rate of 3% over the lives of the two projects, their findings are shown as follows:

Project Janus

Initial investment = $250,000	
Life of the project = 5 years	
Anticipated stream of future cash flows:	
Year 1	= $50,000
Year 2	= 100,000
Year 3	= 100,000
Year 4	= 200,000
Year 5	= 75,000
Calculated NPV = $60,995	

Project Gemini

Initial investment = $400,000	
Life of the project = 3 years	
Anticipated stream of future cash flows:	
Year 1	= 75,000
Year 2	= 250,000
Year 3	= 300,000
Calculated NPV = $25,695	

The analyses of the two projects by different means had yielded different findings. The scoring model indicated that Project Gemini was the best alternative, and the financial screening favored the higher project NPV of Project Janus. Phyllis was due to present her recommendations to the full top management team this afternoon, seemingly armed with more questions than answers.

Questions for Discussion

1. Phyllis has called you into her office to help her make sense of the contradictions in project evaluation. How would you explain the reasons for this divergence of opinion from one technique to the next? What are the strengths and weaknesses of each screening method?
2. Choose the project that you feel, based on the above analysis, Nova Western should select. Defend your choice.
3. What does the above case suggest to you about the use of project selection methods in organizations? How would you resolve the contradictions found in this example?

Internet Exercises

1. Go to the Web sites for the following organizations:
   a. Merck & Company Pharmaceuticals at www.merck.com/about/
   b. Boeing Corporation at www.boeing.com/companyoffices/aboutus/index.html
   c. Rolls-Royce, Plc. at www.rolls-royce.com
   d. ExxonMobil, Inc. at www.exxonmobil.com/Corporate/about.aspx

   Based on your review of the companies' posted mission and strategic goals, what types of projects would you expect them to pursue? If you worked for one of these firms and sought to maintain strategic alignment with their project portfolio, what project options would you suggest?
2. Access the Web site www-01.ibm.com/software/awdtools/portfolio/. What is IBM's philosophy regarding project portfolio management as demonstrated by this software product? What do they mean by their goal of helping clients "align their IT and systems investments with business priorities"?
3. Internet Reading: Pellegrinelli, S. (1997), "Programme management: Organizing project-based change," *International Journal of Project Management,* 15, 141–49. This article can be found on the Prentice Hall Companion Website.

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