CHAPTER 9

Project Cash Flows and Risk

A MANAGERIAL PERSPECTIVE

When RJR Nabisco canceled its smokeless cigarette project, called Premier, The Wall Street Journal called it “one of the most stunning new product disasters in recent history.” RJR had spent more than $300 million on the product and had test marketed it for five months. The company had even built a new plant and was all set to produce smokeless cigarettes in huge quantities.

The new cigarette had two fatal flaws—it had to be lit with a special lighter and even then it was hard to light, and many, if not most, smokers didn’t like the taste. In addition, it seems smokers didn’t like the fact that there was no smoke to blow out or ashes to flick because Premier heated the tobacco rather than burning it. When the cigarette was introduced in 1988, these problems were well known early on, yet RJR still pumped money into the project.

What led RJR’s top managers to downplay the flaws and to spend more than $300 million on a bad product? According to industry observers, many people inside the company were aware of the seriousness of the situation, but they were hesitant to voice their concerns because they did not want to offend the top managers. The top managers, meantime, were so infatuated with their “new toy” that they assumed consumers would embrace the smokeless cigarette in spite of its obvious flaws.

Interestingly, most of the top managers smoked, but none smoked the new smokeless cigarette!

At the time the Premier line was introduced, RJR was not a well-run company, even though it was entrenched in highly profitable markets and was generating billions of dollars of cash each year. The smokeless cigarette project didn’t kill the company, but it did contribute to the downfall of the management team that backed the project.

Unfortunately, it seems RJR was intent on salvaging its investment in the first smokeless cigarette it introduced, so in 1996 it introduced a second smokeless cigarette called Eclipse. It invested an additional $150 million in the Eclipse brand, only to discover that it too was a flop. In fact, it lasted about the same length of time as the Premier line—just a few months.

Had RJR’s top managers followed the procedures set forth in this chapter, perhaps they would not have sunk as much money into the smokeless cigarette projects. Instead, they would have discovered their original project should have been rejected because it was not expected to generate the cash flows necessary to make it a viable investment.

The basic principles of capital budgeting were covered in Chapter 8. In this chapter we examine some additional issues, including cash flow estimation and incorporating risk into the capital budgeting decision. In addition, we present some of the challenges multinational firms face when applying the capital budgeting decision-making methods we describe in both Chapter 8 and this chapter.

Cash Flow Estimation

CASH FLOW
The actual cash, as opposed to accounting net income, that a firm receives or pays during some specified period.

The most important, but also the most difficult, step in the analysis of a capital project is estimating its cash flows—the investment outlays and the net cash flows expected after the project is purchased. Many variables are involved in cash flow estimation, and many individuals and departments participate in the process. For example, the forecasts of unit sales and sales prices normally are made by the marketing group based on its knowledge of advertising effects, the state of the economy, competitors' reactions, and trends in consumers' tastes. Similarly, the capital outlays associated with a new product generally are determined by the engineering and product development staffs, while operating costs are estimated by cost accountants, production experts, personnel specialists, purchasing agents, and so forth.

Because it is difficult to make accurate forecasts of the costs and revenues associated with a large, complex project, forecast errors can be quite large. For example, in the 1970s, when several major oil companies decided to build the Alaska Pipeline, the original cost estimates were in the neighborhood of $700 million, but the final cost was closer to $8 billion. Similar (or even worse) miscalculations are common in forecasts of product design costs. Further, as difficult as plant and equipment costs are to estimate, sales revenues and operating costs over the life of the project generally are even more uncertain. For example, several years ago Federal Express developed an electronic delivery service system (ZapMail). It used the correct capital budgeting technique, the net present value (NPV) method, but it incorrectly estimated the project's cash flows. Projected revenues were too high and projected costs were too low; thus, virtually no one was willing to pay the price required to cover the project's costs. As a result, cash flows failed to meet the forecasted levels, and Federal Express ended up losing about $200 million on the venture. This example demonstrates a basic truth—if cash flow estimates are not reasonably accurate, any analytical technique, no matter how sophisticated, can lead to poor decisions and hence to operating losses and lower stock prices. Because of its financial strength, Federal Express was able to absorb losses on the project with no problem, but the ZapMail venture could have forced a weaker firm into bankruptcy.

The financial staff's role in the forecasting process includes (1) coordinating the efforts of the other departments, such as engineering and marketing, (2) ensuring that everyone involved with the forecast uses a consistent set of economic assumptions, and (3) making sure that no biases are inherent in the forecasts. This last point is extremely important, because division managers often become emotionally involved with pet projects or develop empire-building complexes, both of which can lead to cash flow forecasting biases that make bad projects look good—on paper. The RJR smokeless cigarette project discussed in the Managerial Perspective is an example of this problem.

It is almost impossible to overstate the difficulties one can encounter with cash flow forecasts. Also, it is difficult to overstate the importance of these forecasts. In this chapter, we will give you a sense of some of the inputs that are involved in forecasting the cash flows associated with a capital project and in minimizing forecasting errors.
Self-Test Questions

What is the most important step in the analysis of a capital project?
What is the financial staff's role in the capital projects forecasting process?

Relevant Cash Flows

RELEVANT CASH FLOWS
The specific cash flows that should be considered in a capital budgeting decision.

One important element in cash flow estimation is the determination of relevant cash flows, which are defined as the specific set of cash flows that should be considered in the capital budgeting decision. This process can be rather difficult, but two cardinal rules can help financial analysts avoid mistakes: (1) Capital budgeting decisions must be based on cash flows after taxes, not accounting income, and (2) only incremental cash flows are relevant to the accept/reject decision. These two rules are discussed in detail in the following sections.

Cash Flow versus Accounting Income

In capital budgeting analysis, after-tax cash flows, not accounting profits, are used—it is cash that pays the bills and can be invested in capital projects, not profits. Cash flows and accounting profits can be very different. To illustrate, consider Table 9-1, which shows how accounting profits and cash flows are related to one another. We assume that Unilate Textiles is planning to start a new division at the end of 2000; that sales and all costs, except depreciation, represent actual cash flows and are projected to be constant over time; and that the division will use accelerated depreciation, which will cause its reported depreciation charges to decline over time.1

The top section of the table shows the situation in the first year of operations, 2001. Accounting profits are $7 million, but the division's net cash flow—money that is available to Unilate—is $22 million. The $7 million profit is the return on the funds originally invested, while the $15 million of depreciation is a return of part of the funds originally invested, so the $22 million cash flow consists of both a return on and a return of part of the invested capital.

The bottom part of the table shows the situation projected for 2086. Here reported profits have doubled because of the decline in depreciation, but net cash flow is down sharply because taxes have doubled. The amount of money received by the firm is represented by the cash flow figure, not the net income figure. And although accounting profits are important for some purposes, it is cash flows that are relevant for the purposes of setting a value on a project using discounted cash flow (DCF) techniques—cash flows can be reinvested to create value, profits cannot. Therefore, in capital budgeting, we are interested in net cash flows, which, in most cases, we can define as

1Depreciation procedures are discussed in detail in accounting courses, but we do provide a summary and review in Appendix 9A at the end of this chapter. The tables provided in Appendix 9A are used to calculate depreciation charges used in the chapter examples. In some instances, we simplify the depreciation assumptions in order to reduce the arithmetic. Because Congress changes depreciation procedures fairly frequently, it is always necessary to consult the latest tax regulations before developing actual capital budgeting cash flows.
Table 9-1

<table>
<thead>
<tr>
<th></th>
<th>Accounting Profits</th>
<th>Cash Flows</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I. 2001 Situation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sales</td>
<td>$50,000</td>
<td>$50,000</td>
</tr>
<tr>
<td>Costs except depreciation</td>
<td>(25,000)</td>
<td>(25,000)</td>
</tr>
<tr>
<td>Depreciation</td>
<td>(15,000)</td>
<td>—</td>
</tr>
<tr>
<td>Net operating income or cash flow</td>
<td>$10,000</td>
<td>$25,000</td>
</tr>
<tr>
<td>Taxes based on operating income (30%)</td>
<td>(3,000)</td>
<td>(3,000)</td>
</tr>
<tr>
<td>Net income or net cash flow</td>
<td>$7,000</td>
<td>$22,000</td>
</tr>
<tr>
<td><strong>Net cash flow = Net income plus depreciation = $7,000 + $15,000 = $22,000</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**II. 2006 Situation**

|                      |                    |            |
| Sales                | $50,000            | $50,000    |
| Costs except depreciation | (25,000)       | (25,000)   |
| Depreciation         | (5,000)            | —          |
| Net operating income or cash flow | $20,000      | $25,000    |
| Taxes based on operating income (30%) | (6,000)   | (6,000)    |
| Net income or net cash flow | $14,000       | $19,000    |
| **Net cash flow = Net income plus depreciation = $14,000 + $5,000 = $19,000** |

Net cash flow = Net income + Depreciation

= Return on capital + Return of capital

not in accounting profits per se.²

**Incremental Cash Flows**

In evaluating a capital project, we are concerned only with those cash flows that result directly from the decision to accept the project. These cash flows, called *incremental cash flows*, represent the changes in the firm's total cash flows that occur as a direct result of the project.

²Actually, net cash flow should be adjusted to reflect all noncash charges, not just depreciation. However, for most projects, depreciation is by far the largest noncash charge. Also, note that Table 9-1 ignores interest charges, which would be present if the firm used debt. Most firms do use debt and hence finance part of their capital budgets with debt. Therefore, the question has been raised as to whether interest charges should be reflected in capital budgeting cash flow analysis. The consensus is that interest charges should not be dealt with explicitly in capital budgeting—rather, the effects of debt financing are reflected in the cost of capital, which is used to discount the cash flows. If interest were subtracted and cash flows were then discounted, we would be double counting the cost of debt.
result of accepting the project. To determine if a specific cash flow is considered incremental, we need to find out whether it is affected by the purchase of the project. Cash flows that will change because the project is purchased are incremental cash flows that need to be included in the capital budgeting evaluation; cash flows that are not affected by the purchase of the project are not relevant to the capital budgeting decision. Unfortunately, identifying the relevant cash flows for a project is not always as simple as it seems. Some special problems in determining incremental cash flows are discussed next.

**Sunk Costs**  Sunk costs are not incremental costs, and they should not be included in the analysis. A sunk cost is an outlay that has already been committed or that has already occurred and hence is not affected by the accept/reject decision under consideration. To illustrate, in 1999 Unilate Textiles considered building a distribution center in New England in an effort to increase sales in that area of the country. To help with its evaluation, Unilate hired a consulting firm to perform a site analysis and provide a feasibility study for the project; the cost was $100,000, and the amount was expensed for tax purposes. This expenditure is not a relevant cost that should be included in the capital budgeting evaluation of the prospective distribution center because Unilate cannot recover this money, regardless of whether the new distribution center is built.

**Opportunity Costs**  The second potential problem relates to opportunity costs, which are defined as the cash flows that could be generated from assets the firm already owns provided they are not used for the project in question. To illustrate, Unilate already owns a piece of land that is suitable for a distribution center. When evaluating the prospective center in New England, should the cost of the land be disregarded because no additional cash outlay would be required? The answer is no, because there is an opportunity cost inherent in the use of the property. In this case, the land could be sold to yield $150,000 after taxes. Use of the site for the distribution center would require forgoing this inflow, so the $150,000 must be charged as an opportunity cost against the project. Note that the proper land cost in this example is the $150,000 market-determined value, irrespective of whether Unilate originally paid $50,000 or $500,000 for the property. (What Unilate paid would, of course, have an effect on taxes and hence on the after-tax opportunity cost.)

**Externalities: Effects on Other Parts of the Firm**  The third potential problem involves the effects of a project on other parts of the firm; economists call these effects externalities. For example, Unilate does have some existing customers in New England who would use the new distribution center because its location would be more convenient than the North Carolina distribution center they have been using. The sales, and hence profits, generated by these customers would not be new to Unilate; rather, they would represent a transfer from one distribution center to another. Thus, the net revenues produced by these customers should not be treated as incremental income in the capital budgeting decision. Although they often are difficult to quantify, externalities such as these should be considered.

**Shipping and Installation Costs**  When a firm acquires fixed assets, it often must incur substantial costs for shipping and installing the equipment. These charges are added to the invoice price of the equipment when the total cost of the project is being
Identifying Incremental Cash Flows

is considered a use of the project's cash flows that are not budgeted decisions always as simplifies flows are determined. Also, for depreciation purposes, the depreciable basis of an asset, which is the total amount that can be depreciated, includes the purchase price and additional expenditures required to make the asset operational, including shipping and installation. Therefore, the full cost of the equipment, including shipping and installation costs, is used as the depreciable basis when depreciation charges are calculated. So if Unilite Textiles bought a computer with an invoice price of $100,000 and paid another $10,000 for shipping and installation, then the full cost of the computer, and its depreciable basis, would be $110,000.

Keep in mind that depreciation is a noncash expense, so there is not a cash outflow associated with the recognition of depreciation expense each year. But because depreciation is an expense, it affects the taxable income of a firm, thus the amount of taxes paid by the firm, which is a cash flow.

**Inflation**

Inflation is a fact of life, and it should be recognized in capital budgeting decisions. If expected inflation is not built into the determination of expected cash flows, then the calculated net present value and internal rate of return will be incorrect—both will be artificially low. It is easy to avoid inflation bias—simply build inflationary expectations into the cash flows used in the capital budgeting analysis. Expected inflation should be reflected in the revenue and cost figures, thus the annual net cash flow forecasts. The required rate of return does not have to be adjusted by the firm for inflation expectations because investors include such expectations when establishing the rate at which they are willing to permit the firm to use their funds. Investors decide at what rates a firm can raise funds in the capital markets, and they include an adjustment for inflation when determining the rate that is appropriate.

**Self-Test Questions**

Briefly explain the difference between accounting income and net cash flow. Which should be used in capital budgeting? Why?

Explain what these terms mean, and assess their relevance in capital budgeting: incremental cash flow, sunk cost, opportunity cost, externalities, shipping plus installation costs, and depreciable basis.

Explain why incremental analysis is important in capital budgeting. How should inflation expectations be included in analysis of capital projects?

**Identifying Incremental Cash Flows**

Generally, when we identify the incremental cash flows associated with a capital project, we separate them according to when they occur during the life of the project. In most cases, we can classify a project's incremental cash flows as (1) cash flows that occur only at the start of the project's life—time period 0, (2) cash flows that continue throughout the project's life—time periods 1 through n, and (3) cash flows that occur only at the end, or the termination, of the project—time period n. We discuss these three incremental cash flow classifications and identify some of the relevant cash flows next. But keep in mind, when identifying the incremental cash flows for capital budgeting, the primary question is which cash flows will be affected by purchasing the project—if a cash flow does not change, it is not relevant for the capital budgeting analysis.
Initial Investment Outlay

The initial investment outlay refers to the incremental cash flows that occur only at the start of a project's life, CF₀. The initial investment includes such cash flows as the purchase price of the new project and shipping and installation costs. If the capital budgeting decision is a replacement decision, the initial investment must also take into account the cash flows associated with the disposal of the old, or replaced, asset, which include any cash received or paid to scrap the old asset and any tax effects associated with the disposal.

In many cases, the addition or replacement of a capital asset has an impact on the net working capital of the firm. For example, normally, additional inventories are required to support a new operation, and expanded sales also lead to additional accounts receivable. For example, if Unilate builds the new distribution center in New England, the inventories held at that location will be in addition to the inventories currently held at its other distribution centers. If it is estimated the New England distribution center will require $5 million of inventory to operate normally, then Unilate must purchase an additional $5 million of inventory if the distribution center is built. This cash flow is considered part of the initial investment because the $5 million inventory increase will occur only when, and because, the distribution center opens. This inventory increase and any increase in accounts receivable resulting from the additional sales expected to be generated by the New England distribution must be financed. But, as we shall see later in the book, Unilate can expect its accounts payable and accruals to increase spontaneously as a result of the expanded operations, and this will reduce the net cash needed to finance inventories and receivables. The difference between the required increase in current assets and the spontaneous increase in current liabilities is the change in net working capital. If this change is positive, as it generally is for expansion projects like the new distribution center being considered by Unilate, then additional financing, over and above the cost of the fixed assets, is needed to fund the increase in current assets.

We should note that there are instances in which the change in net working capital associated with a capital project actually results in a decrease in the firm's current funding requirements, which frees up cash flows for investment. Usually this occurs if the project being considered is much more efficient than the existing asset(s). In any event, the change in net working capital that results from the acceptance of a project is an incremental cash flow that must be considered in the capital budgeting analysis. And because the changes in net working capital requirements occur at the start of the project's life, this cash flow impact is an incremental cash flow that is included as a part of the initial investment outlay.

Incremental Operating Cash Flows

Most capital projects also affect the day-to-day cash flows generated by the firm. For example, Unilate has discovered that it can reduce its total operating costs by $10 million by purchasing a new weaving machine to replace a machine it has been using for ten years. The cost reduction would result because the technological advancements of the new machine would allow Unilate to use less electricity and fewer raw materials (wool, cotton, and so on) in its manufacturing process. These cost savings, as well as any changes in depreciation expense, will affect the taxes paid by Unilate each year the new machine is in service. Thus, Unilate's normal operating cash flows will change if the project is accepted. We define incremental operating cash flows as the changes in
day-to-day cash flows that result from the purchase of a capital project. The impact of incremental operating cash flows continues until the firm disposes of the asset.

In most cases, the incremental operating cash flows for each year can be computed directly by using the following equation:

\[
\text{Incremental operating cash flow}_t = \Delta \text{Cash revenues}_t - \Delta \text{Cash expenses}_t - \Delta \text{Taxes}_t \\
= \Delta \text{NI}_t + \Delta \text{Depr}_t \\
= \Delta \text{EBT}_t \times (1 - T) + \Delta \text{Depr}_t \\
= (\Delta \text{S}_t - \Delta \text{OC}_t - \Delta \text{Depr}_t) \times (1 - T) + \Delta \text{Depr}_t \\
= (\Delta \text{S}_t - \Delta \text{OC}_t) \times (1 - T) + T(\Delta \text{Depr}_t)
\]

The symbols in Equation 9–1 are defined as follows:

\( \Delta = \) The Greek symbol delta, which represents the change in something.

\( \Delta \text{NI}_t = \text{NI}_{t, \text{accept}} - \text{NI}_{t, \text{reject}} = \) The change in net income in period \( t \) that results from accepting the capital project; the subscript accept is used to indicate the firm’s operations that would exist if the project is accepted, and the subscript reject indicates the level of operations that would exist if the project was rejected (the existing situation without the project).

\( \Delta \text{Depr}_t = \text{Depr}_{t, \text{accept}} - \text{Depr}_{t, \text{reject}} = \) The change in depreciation expense in period \( t \) that results from accepting the project.

\( \Delta \text{EBT}_t = \text{EBT}_{t, \text{accept}} - \text{EBT}_{t, \text{reject}} = \) The change in earnings before taxes in period \( t \) that results from accepting the project.

\( \Delta \text{S}_t = \text{S}_{t, \text{accept}} - \text{S}_{t, \text{reject}} = \) The change in sales revenues in period \( t \) that results from accepting the project.

\( \Delta \text{OC}_t = \text{OC}_{t, \text{accept}} - \text{OC}_{t, \text{reject}} = \) The change in operating costs, excluding depreciation, in period \( t \) that results from accepting the project.

\( T = \) Marginal tax rate.

We have emphasized that depreciation is a noncash expense. So why is the change in depreciation expense included in the computation of incremental operating cash flow shown in Equation 9–1? The change in depreciation expense needs to be computed because, when depreciation changes, taxable income changes and so does the amount of income taxes paid; and the amount of taxes paid is a cash flow.

**Terminal Cash Flow**

The terminal cash flow occurs at the end of the life of the project, and it is associated with the final disposal of the project and returning the firm’s operations to where they were before the project was accepted. Consequently, the terminal cash flow includes...
the salvage value, which could be either positive (selling the asset) or negative (paying for removal), and the tax impact of the disposition of the project. In addition, we generally assume the firm returns to the operating level that existed prior to the acceptance of the project; thus, any working capital accounts changes that occurred at the beginning of the project's life will be reversed at the end of its life. For example, as an expansion project's life approaches termination, inventories will be sold off and not replaced, and receivables will also be converted to cash. As these changes occur, the firm will receive an end-of-project cash flow equal to the net working capital requirement that occurred when the project was begun. Unlate expects the life of the New England distribution center to be ten years, so the inventories at that location will be reduced to zero in the tenth year. Because inventories will not have to be replenished during the last sales period, cash flows in Year 10 will increase by $5 million.

**Self-Test Questions**

Identify the three classifications for the incremental cash flows associated with a project, and give examples of the cash flows that would be in each category.

Why are the changes in net working capital recognized as incremental cash flows both at the beginning and the end of a project's life?

**Capital Budgeting Project Evaluation**

Up to this point, we have discussed several important aspects of cash flow analysis. Now we illustrate cash flow estimation for expansion projects and for replacement projects.

**Expansion Projects**

Remember from Chapter 8 that an expansion project is one that calls for the firm to invest in new assets to increase sales. We illustrate an expansion project analysis with a project that is being considered by Household Energy Products (HEP), a Dallas-based technology company. HEP's research and development department has created a computerized home appliance control device that will increase a home's energy efficiency by simultaneously controlling all household appliances, large and small, the air-conditioning/heating system, the water heater, the security system, and the filtration and heating systems for pools and spas. At this point, HEP wants to decide whether it should proceed with full-scale production of the appliance control device.

HEP's marketing department plans to target sales of the appliance computer toward the owners of larger homes; the computer is cost-effective only in homes with 4,000 or more square feet of living space. The marketing vice president believes that annual sales would be 15,000 units if the units are priced at $2,000 each, so annual sales are estimated at $30 million. The engineering department has determined the firm would need no additional manufacturing or storage space; it would just need the equipment to manufacture the devices. The necessary equipment would be purchased and installed late in 2000, and it would cost $9.5 million, not including the $500,000 that would have to be paid for shipping and installation. The equipment would fall into the Modified Accelerated Cost Recovery System (MACRS) five-year class for the purposes of depreciation (see Appendix 9A for depreciation rates and an explanation of MACRS).
The project would require an initial increase in net working capital equal to $4 million, primarily because the raw materials required to produce the devices will significantly increase the amount of inventory HEP currently holds. The investment necessary to increase net working capital will be made on December 31, 2000, when the decision to manufacture the appliance control occurs. The project's estimated economic life is four years. At the end of that time, the equipment would have a market value of $2 million and a book value of $1.7 million. The production department has estimated that variable manufacturing costs would total 60 percent of sales and fixed overhead costs, excluding depreciation, would be $5 million a year. Depreciation expenses would vary from year to year in accordance with the MACRS rates. HEP's marginal tax rate is 40 percent; its cost of funds, or required rate of return, is 15 percent; and, for capital budgeting purposes, the company's policy is to assume that operating cash flows occur at the end of each year. Because manufacture of the new product would begin on January 1, 2001, the first operating cash flows would occur on December 31, 2001.

**Analysis of the Cash Flows**  The first step in the analysis is to summarize the initial investment outlays required for the project; this is done in the 2000 column of Table 9-2. For HEP's appliance control device project, the cash outlays consist of the purchase price of the needed equipment, the cost of shipping and installation, and the required investment in net working capital (NWC). Notice that these cash flows do not carry over in the years 2001 through 2004—they occur only at the start of the project. Thus, the initial investment outlay is $4 million.

Having estimated the investment requirements, we must now estimate the cash flows that will occur once production begins; these are set forth in the 2001 through 2004 columns of Table 9-2. The operating cash flow estimates are based on information provided by HEP's various departments. The depreciation amounts were obtained by multiplying the depreciable basis by the MACRS recovery allowance rates as set forth in the footnote to Table 9-2. As you can see, from the values given in footnote a in the table, the incremental operating cash flow differs each year only because the depreciation expense, and thus the impact depreciation has on taxes, differs each year.

The final cash flow component we need to compute is the terminal cash flow. For this computation, remember that the $4 million investment in net working capital will be recovered in 2004. Also, we need an estimate of the net cash flows from the disposal of the equipment in 2004. Table 9-3 shows the calculation of the net salvage value for the equipment. It is expected that the equipment will be sold for more than its book value, which means the company will have to pay taxes on the capital gain because, in essence, the equipment was depreciated too quickly, allowing HEP to reduce its tax liability by too much in the years 2001–2004. The book value is calculated as the depreciable basis (purchase price plus shipping and installation) minus the accumulated depreciation. The net cash flow from salvage is merely the sum of the salvage value and the tax impact resulting from the sale of the equipment, $1.88 million in this case. Thus, the terminal cash flow totals $5.88 million.

Notice that the total net cash flow for the year 2004 is the sum of the incremental cash flow for the year and the terminal cash flow. In the final year of a project's economic life, the firm incurs two types of cash flows—the incremental operating cash flow attributed to the project's normal operation and the terminal cash flow associated with the disposal of the project. For the appliance control device project HEP is considering, the incremental operating cash flow in 2004 is $4.68 million and the terminal cash flow is $5.88 million, so the total expected net cash flow in 2004 is $10.56 million.
### Table 9-2: HEP Expansion Project Net Cash Flows, 2000-2004 (thousands of dollars)

<table>
<thead>
<tr>
<th>I. Initial Investment Outlay</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
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<tr>
<td>Cost of new asset</td>
<td>$(9,500)</td>
<td></td>
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<tr>
<td>Shipping and installation</td>
<td>(500)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase in net working capital</td>
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<td>Initial investment</td>
<td>$(14,000)</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>II. Incremental Operating Cash Flow*</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales revenue</td>
<td>$30,000</td>
<td>$30,000</td>
<td>$30,000</td>
<td>$30,000</td>
<td></td>
</tr>
<tr>
<td>Variable costs (60% of sales)</td>
<td>(18,000)</td>
<td>(18,000)</td>
<td>(18,000)</td>
<td>(18,000)</td>
<td></td>
</tr>
<tr>
<td>Fixed costs</td>
<td>(5,000)</td>
<td>(5,000)</td>
<td>(5,000)</td>
<td>(5,000)</td>
<td></td>
</tr>
<tr>
<td>Depreciation on new equipment</td>
<td>(2,000)</td>
<td>(3,200)</td>
<td>(1,900)</td>
<td>(1,200)</td>
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<tr>
<td>Earnings before taxes (EBT)</td>
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<td>$ 3,800</td>
<td>$ 5,100</td>
<td>$ 5,800</td>
<td></td>
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<tr>
<td>Taxes (40%)</td>
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<td>(1,520)</td>
<td>(2,040)</td>
<td>(2,320)</td>
<td></td>
</tr>
<tr>
<td>Net income</td>
<td>$ 3,000</td>
<td>$ 2,280</td>
<td>$ 3,060</td>
<td>$ 3,480</td>
<td></td>
</tr>
<tr>
<td>Add back depreciation</td>
<td>2,000</td>
<td>3,200</td>
<td>1,900</td>
<td>1,200</td>
<td></td>
</tr>
<tr>
<td>Incremental operating cash flows</td>
<td>$ 5,000</td>
<td>$ 5,480</td>
<td>$ 4,960</td>
<td>$ 4,680</td>
<td></td>
</tr>
</tbody>
</table>

| III. Terminal Cash Flow             | 2000     | 2001     | 2002     | 2003     | 2004     |
| Return of net working capital       |          |          |          |          | 4,000    |
| Net salvage value (see Table 9-3)   |          |          |          |          | 1,880    |
| Terminal cash flow                  |          |          |          |          | $5,880   |

| IV. Annual Net Cash Flow            | 2000     | 2001     | 2002     | 2003     | 2004     |
| Total net cash flow each year       | $(14,000)| $ 5,000  | $ 5,480  | $ 4,960  | $10,560  |
| Net present value (15%)             |          |          |          |          | $3,790   |

*Using Equation 9-1, the incremental operating cash flows can be computed as follows:

<table>
<thead>
<tr>
<th>YEAR</th>
<th>INCREMENTAL OPERATING CASH FLOW COMPUTATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>$5,000 = ($30,000 - $18,000 - $5,000 - 5,000) * (1 - 0.40) + $2,000 (0.40)</td>
</tr>
<tr>
<td>2002</td>
<td>5,480 = (30,000 - 18,000 - 5,000 - 5,000) * (1 - 0.40) + 3,200 (0.40)</td>
</tr>
<tr>
<td>2003</td>
<td>4,960 = (30,000 - 18,000 - 5,000 - 5,000) * (1 - 0.40) + 1,900 (0.40)</td>
</tr>
<tr>
<td>2004</td>
<td>4,680 = (30,000 - 18,000 - 5,000 - 5,000) * (1 - 0.40) + 1,200 (0.40)</td>
</tr>
</tbody>
</table>

*Depreciation for the new equipment was calculated using MACRS (see Appendix 9A):

<table>
<thead>
<tr>
<th>YEAR</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent depreciated</td>
<td>20%</td>
<td>32%</td>
<td>19%</td>
<td>12%</td>
</tr>
</tbody>
</table>

These percentages were multiplied by the depreciable basis of $10,000 to get the depreciation expense each year.

**Making the Decision** A summary of the data and the computation of the project’s NPV are provided with the cash flow time line that follows. The amounts are in thousands of dollars, just like in Table 9-2.
Table 9-3: HEP Expansion Project Net Salvage Value, 2004 (thousands of dollars)

I. Book Value of HEP's Project in 2004
Cost of new asset in 2000
Shipping and installation
Depreciable basis of asset
Depreciation from 2001-2004
= (0.20 + 0.32 + 0.19 + 0.12) × $10,000
Book value in 2004

II. Tax Impact of the Sale of HEP's Project in 2004
Selling price of asset in
Book value of asset in
Gain (loss) on sale of asset
Taxes (40%)

III. Net Salvage Value, CF, in 2004
Cash flow from sale of project
Tax impact of sale
Net salvage value cash flow

Cash Flow Time Line for HEP's Appliance Control Device Project (dollars are in thousands)

The project appears to be acceptable using the NPV and internal rate of return (IRR) methods, and it also would be acceptable if HEP required a maximum payback period of three years. Note, however, that the analysis thus far has been based on the assumption that the project has the same degree of risk as the company's average project. If the project was judged to be riskier than an average project, it would be necessary to increase the required rate of return used to compute the NPV. Later in this chapter, we will extend the evaluation of this project to include a risk analysis.
Replacement Analysis

All companies make replacement decisions. The analysis relating to replacements is the same as for expansion projects—identify the relevant cash flows, and then find the net present value of the project. But, to some extent, identifying the incremental cash flows associated with a replacement project is more complicated than for an expansion project because the cash flows both from the new asset and from the old asset must be considered. Replacement analysis is illustrated with another HEP example.

HEP has a lathe for trimming molded plastics that was purchased ten years ago at a cost of $7,500. The machine had an expected life of 15 years at the time it was purchased, and management originally estimated, and still believes, that the salvage value will be zero at the end of the 15-year life. The machine has been depreciated on a straight-line basis; therefore, its annual depreciation charge is $500, and its present book value is $2,500 = $7,500 - 10($500).

HEP is considering the purchase of a new special-purpose machine to replace the lathe. The new machine, which can be purchased for $12,000 (including freight and installation), will reduce labor and raw materials usage sufficiently to cut annual operating costs from $7,500 to $4,000. This reduction in costs will cause before-tax profits to rise by $7,500 - $4,000 = $3,500 per year.

It is estimated that the new machine will have a useful life of five years, after which it can be sold for $2,000. The old machine's actual current market value is $1,000, which is below its $2,500 book value. If the new machine is acquired, the old lathe will be sold to another company rather than exchanged for the new machine. Net working capital requirements will increase by $1,000 if the lathe is replaced by the new machine; this increase will occur at the time of replacement. By an IRS ruling, the new machine falls into the three-year MACRS class, and because the risk associated with the new machine is considered average for HEP, the project's required rate of return is 15 percent. Should the replacement be made?

Table 9-4 shows the worksheet format HEP uses to analyze replacement projects. Determining the relevant cash flows for a replacement decision is more involved than for an expansion decision because we need to consider the fact that the cash flows associated with the replaced asset will not continue after the new asset is purchased—the cash flows associated with the new asset will take the place of the cash flows associated with the old asset. So because we want to evaluate how the acceptance of a capital budgeting project changes cash flows, we must compute the increase or decrease in cash flows that results from the replacement of the old asset with the new asset. Let's examine the cash flows computed in Table 9-4.

Analysis of Cash Flows First, the initial investment outlay of $11,400 includes the cash flows associated with the cost of the new asset and the change in net working capital, which also is included in the initial investment computation for the expansion decision shown in Table 9-2. But when a replacement asset is purchased, the asset being replaced must be removed from operations. If the asset can be sold to another firm or to a scrap dealer, its disposal will generate a positive cash flow; but if the firm must pay to have the old asset removed, the cash flow will be negative. And if the firm disposes of the old asset at a value different from its book value (its purchase price less accumulated depreciation), there will be a tax effect. In our example, the old asset has a book value equal to $2,500, but it can be sold for only $1,000. So HEP will incur a capital loss equal to $1,500 = $1,000 - $2,500 if it replaces the lathe with the new machine.
This loss will result in a tax savings equal to $1,500 \times 0.4 = $600$ to account for the fact that HEP did not adequately depreciate the old asset to reflect its market value. Consequently, the disposal of the old asset will generate a positive cash flow equal to $1,600—$1,000 selling price plus the $600 tax savings, which effectively reduces the amount of cash required to purchase the new machine and thus the initial investment outlay. Any cash flows associated with disposing of the old asset must be included in the computation of the initial investment because they affect the net amount of cash required to purchase the asset.

Next, we need to compute the incremental operating cash flow each year. Section II of Table 9.4 shows these computations. The procedure is the same as before—determine how operating cash flows will change if the new machine is purchased to replace the lathe. Remember, the lathe is expected to decrease operating costs from $7,500 to $4,000, and thus increase operating profits by $3,500—less cash will have to be spent to operate the new machine. Had the replacement resulted in an increase in sales in addition to the reduction in costs (that is, if the new machine had been both larger and more efficient), then this amount would also be reported. Also, note that the $3,500 cost savings is constant over the years 2001–2005; had the annual savings been expected to change over time, this fact would have to be built into the analysis.

The change in depreciation expense must be computed to determine the impact such a change will have on the taxes paid by the firm. If the new machine is purchased, the $500 depreciation expense of the lathe (old asset) no longer will be relevant for tax purposes; instead, the depreciation expense for the new machine will be used. For example, in 2001, the depreciation expense for the new machine will be $3,960 because, according to the three-year MACRS classification, 33 percent of the cost of the new asset can be depreciated in the year it is purchased. Because HEP will dispose of the lathe if it buys the new machine, in 2001 it will replace the $500 depreciation expense associated with the lathe with the $3,960 depreciation expense associated with the new machine, and the depreciation expense will increase by $3,460 = $3,960 − $500. The computations for the remaining years are the same. Note that in 2005 the change in depreciation is negative. This results because the new machine will be fully depreciated at the end of 2004, so there is nothing left to write off in 2005; thus, if the lathe is replaced, its depreciation of $500 will be replaced by the new machine's depreciation of $0 in 2005, which is a change of $−500.

The terminal cash flow includes $1,000 for the return of net working capital, because a "normal" net working capital level will be restored at the end of the new machine's life—any additional accounts receivable created by the purchase of the new machine will be collected and any additional inventories required by the new machine will be drawn down and not replaced. The net salvage value of the new machine is $1,200—it is expected that the new machine can be sold in 2005 for $2,000, but $800 in taxes will have to be paid on the sale because the new machine will be fully

1If you think about it, the computation of the initial investment outlay for replacement decisions is similar to determining the amount you would need to purchase a new automobile to replace your old one—if the purchase price of the new car is $20,000 and the dealer is willing to give you $5,000 for your car as a trade-in, then the amount you need is only $15,000; but, if you need to pay someone to take your old car out of the garage because that is where you are going to keep the new car at night, then the total amount you need to purchase the new car actually is greater than $20,000.
<table>
<thead>
<tr>
<th>Table 9-4</th>
<th>HEP Replacement Project cash flows</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Initial Investment Outlay</td>
<td>Cost of new asset</td>
<td>$(12,000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Change in net working capital</td>
<td>(1,000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Net cash flow from sale of old asset</td>
<td>1,600</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Initial investment</td>
<td>$(11,400)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II. Incremental Operating Cash Flows</td>
<td>△ Operating costs</td>
<td>3,500</td>
<td>3,500</td>
<td>3,500</td>
<td>3,500</td>
<td>3,500</td>
<td>3,500</td>
</tr>
<tr>
<td></td>
<td>△ Depreciation</td>
<td>(3,460)</td>
<td>(4,900)</td>
<td>(1,300)</td>
<td>(340)</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td></td>
<td>△ Earnings before taxes (EBT)</td>
<td>40</td>
<td>(1,400)</td>
<td>2,200</td>
<td>3,160</td>
<td>4,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>△ Taxes (40%)</td>
<td>(16)</td>
<td>560</td>
<td>(880)</td>
<td>(1,264)</td>
<td>(1,600)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>△ Net income</td>
<td>24</td>
<td>(840)</td>
<td>1,320</td>
<td>1,896</td>
<td>2,400</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Add back △ depreciation</td>
<td>3,460</td>
<td>4,900</td>
<td>1,300</td>
<td>340</td>
<td>(500)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Incremental operating cash flows</td>
<td>3,484</td>
<td>4,060</td>
<td>2,620</td>
<td>2,236</td>
<td>1,900</td>
<td></td>
</tr>
<tr>
<td>III. Terminal Cash Flow</td>
<td>Return of net working capital</td>
<td>$1,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Net salvage value of new asset</td>
<td>1,200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Terminal cash flow</td>
<td>$2,200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV. Annual Net Cash Flows</td>
<td>Total net cash flow each year</td>
<td>$(11,400)</td>
<td>3,484</td>
<td>4,060</td>
<td>2,620</td>
<td>2,236</td>
<td>4,100</td>
</tr>
<tr>
<td></td>
<td>Net present value (15%)</td>
<td>$(261)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
V. Annual Net Cash Flows

Total net cash flow each year

<table>
<thead>
<tr>
<th></th>
<th>$(11,400)</th>
<th>$3,484</th>
<th>$4,060</th>
<th>$2,620</th>
<th>$2,236</th>
<th>$4,100</th>
</tr>
</thead>
</table>

Net present value (15%) $(-261)

*The net present cash flow from the sale of the old (replaced) asset is computed as follows:

Selling price (market value) $1,000
Subtract book value (2,500)
Gain (loss) on sale of asset (1,500)
Tax impact of sale of asset 600

Net cash flow from the sale of asset = $1,000 + $600 = $1,600

*The change in depreciation expense is computed by comparing the depreciation of the new asset with the depreciation that would have existed if the old asset was not replaced. The old asset has been depreciated on a straight-line basis, with 5 years of $500 depreciation remaining. The new asset will be depreciated using the rates for the 3-year MACRS class (see Appendix 9B). So the change in annual depreciation would be as follows:

<table>
<thead>
<tr>
<th>YEAR</th>
<th>NEW ASSET DEPRECIATION</th>
<th>OLD ASSET DEPRECIATION</th>
<th>CHANGE IN DEPRECIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>$12,000 × 0.33 = $3,960</td>
<td>-</td>
<td>$3,460</td>
</tr>
<tr>
<td>2002</td>
<td>$12,000 × 0.45 = $5,400</td>
<td>-</td>
<td>$4,900</td>
</tr>
<tr>
<td>2003</td>
<td>$12,000 × 0.15 = $1,800</td>
<td>-</td>
<td>$1,300</td>
</tr>
<tr>
<td>2004</td>
<td>$12,000 × 0.07 = $840</td>
<td>-</td>
<td>$340</td>
</tr>
<tr>
<td>2005</td>
<td>0</td>
<td>-</td>
<td>(500)</td>
</tr>
</tbody>
</table>

Accumulated depreciation = $12,000

*The book value of the new asset in 2003 will be zero because the entire $12,000 has been written off. So the net salvage value of the new asset in 2005 is computed as follows:

Selling price (market value) $2,000
Subtract book value (0)
Gain (loss) on sale of asset 2,000
Tax impact on sale of asset (800)

Net salvage value of the new asset = $2,000 − $800 = $1,200
depreciated by the time of the sale. Thus, the terminal cash flow is $2,200 = $1,080 + $1,200.

**Making the Decision** A summary of the data and the computation of the project’s NPV are provided with the following cash flow time line:

**Cash Flow Time Line for HEP’s Replacement Project:**
(Dollars are in thousands)

<table>
<thead>
<tr>
<th>Year</th>
<th>Net cash flows</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2000</td>
<td>(11,400)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3,030</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3,070</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,723</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,278</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,038</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NPV</td>
<td>$(261)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRR</td>
<td>14.0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Payback period | 3.6 years

According to the NPV and IRR methods, HEP should not replace the lathe with the new machine.

Before we leave our discussion of replacement decisions, we should note that a replacement decision involves comparing two mutually exclusive projects: retaining the old asset versus buying a new one. To simplify matters, in our replacement example we assumed that the new machine had a life equal to the remaining life of the old machine. If, however, we were choosing between two mutually exclusive alternatives with significantly different lives, an adjustment would be necessary to make the results of the capital budgeting analysis for the two projects comparable. To attain comparability, we can either (1) use a common life for the evaluation of the two projects or (2) compute the annual annuity that could be produced from the dollar amount of the NPV of each project. Both of these procedures are described in Appendix 9B. We mention the unequal life problem here to make you aware that the evaluation of mutually exclusive projects with significantly different lives requires a slightly different analysis to ensure a correct decision is made.

**Self-Test Question**

Explain and differentiate between the capital budgeting analyses required for expansion projects and for replacement projects.

---

*In this analysis, the salvage value of the old machine is zero. However, if the old machine was expected to have a positive salvage value at the end of five years, replacing the old machine now would eliminate this cash flow. Thus, the after-tax salvage value of the old machine would represent an opportunity cost to the firm, and it would be included as a Year 5 cash outflow in the terminal cash flow section of the worksheet.*
Incorporating Risk in Capital Budgeting Analysis

To this point, we have assumed the projects being evaluated have the same risk as the projects that the firm currently possesses. However, there are three separate and distinct types of project risk that need to be examined to determine if the required rate of return used to evaluate a project should be different than the average required rate of the firm. The three risks are (1) the project’s own stand-alone risk, or the risk it exhibits when evaluated alone rather than as part of a combination, or portfolio, of assets—the effect of the project on the other assets of the firm is disregarded; (2) corporate, or within-firm, risk, which is the effect a project has on the total, or overall, riskiness of the company, without considering which risk component, systematic or unsystematic, is affected—the effect the project has on the stockholders’ own personal diversification is disregarded; and (3) beta, or market, risk, which is project risk assessed from the standpoint of a stockholder who holds a well-diversified portfolio. As we shall see, a particular project might have high stand-alone risk, yet taking it on might not have much effect on either the firm’s risk or that of its owners because of portfolio, or diversification, effects.

Although more difficult, evaluating the risk associated with a capital budgeting project is similar to evaluating the risk of a financial asset such as a stock. Therefore, much of our discussion in this section relies on the concepts introduced in Chapter 5.

As we shall see shortly, a project’s stand-alone risk is measured by the variability of the project’s expected returns; its corporate risk is measured by the project’s impact on the firm’s earnings variability; and its beta risk is measured by the project’s effect on the firm’s beta coefficient. Taking on a project with a high degree of either stand-alone risk or corporate risk will not necessarily affect the firm’s beta to any great extent. However, if the project has highly uncertain returns, and if those returns are highly correlated with returns on the firm’s other assets and also with most other assets in the economy, the project will exhibit a high degree of all three types of risk. For example, suppose General Motors decides to undertake a major expansion to build solar-powered autos. GM is not sure how its technology will work on a mass production basis, so there are great risks in the venture—its stand-alone risk is high. Management also estimates that the project will have a higher probability of success if the economy is strong, because people will have more money to spend on the new autos. This means that the project will tend to do well if GM’s other divisions also do well and to do badly if other divisions do badly. This being the case, the project will also have high corporate risk. Finally, because GM’s profits are highly correlated with those of most other firms, the project’s beta coefficient will also be high. Thus, this project will be risky under all three definitions of risk.

Self-Test Questions

What are the three types of project risk?
How is a project’s stand-alone risk measured?
How is corporate risk measured?
How is beta risk measured?
Stand-Alone Risk

What about a project's stand-alone risk—is it of any importance to anyone? In theory, stand-alone risk should be of little or no concern, because we know diversification can eliminate some of this type of risk. However, it is of great importance for the following reasons:

1. It is easier to estimate a project's stand-alone risk than its corporate risk, and it is far easier to measure stand-alone risk than beta risk.
2. In the vast majority of cases, all three types of risk are highly correlated—if the general economy does well, so will the firm, and if the firm does well, so will most of its projects. Thus, stand-alone risk generally is a good proxy for hard-to-measure corporate and beta risk.
3. Because of Points 1 and 2, if management wants a reasonably accurate assessment of a project's riskiness, it should spend considerable effort on determining the riskiness of the project's own cash flows—that is, its stand-alone risk.

The starting point for analyzing a project's stand-alone risk involves determining the uncertainty inherent in the project's cash flows. This analysis can be handled in a number of ways, ranging from informal judgments to complex economic and statistical analyses involving large-scale computer models. To illustrate what is involved, we shall refer to Household Energy Products' appliance control computer project that we discussed earlier. Many of the individual cash flows that were shown in Table 9–2 are subject to uncertainty. For example, sales for each year were projected at 15,000 units to be sold at a net price of $2,000 per unit, or $30 million in total. Actual unit sales almost certainly would be somewhat higher or lower than 15,000, however, and also the sales price might turn out to be different from the projected $2,000 per unit. In effect, the sales quantity and the sales price estimates are expected values taken from probability distributions, as are many of the other values that were shown in Table 9–2. The distributions could be relatively "tight," reflecting small standard deviations and low risk, or they could be "flat," denoting a great deal of uncertainty about the final value of the variable in question and hence a high degree of stand-alone risk.

The nature of the individual cash flow distributions, and their correlations with one another, determine the nature of the NPV distribution and, thus, the project's stand-alone risk. We next discuss three techniques for assessing a project's stand-alone risk: (1) sensitivity analysis, (2) scenario analysis, and (3) Monte Carlo simulation.

Sensitivity Analysis

The cash flows used to determine the acceptability of a project result from forecasts of uncertain events, such as economic conditions in the future and expected demand for a product. Intuitively, then, we know the cash flow amounts used to determine the net present value of a project might be significantly different from what actually happens in the future; but those numbers represent our best, and most confident, prediction concerning the expected cash flows associated with a project. We also know that if a key input variable, such as units sold, changes, the project's NPV also will change. Sensitivity analysis is a technique that shows exactly how much the NPV will change in response to a given change in an input variable, other things held constant.

In a sensitivity analysis, we begin with the base case situation that was developed using the expected values for each input; next each variable is changed by specific per-
one? In theory, diversification can for the follow-
ate risk, and it
related—if the
is well, so will
roxy for hard-
curate assess-

determining the risk.

determined handled in a 2 and statistical-
weject that we fable 9-2 are
5,000 units
unit sales al-
and also the
it. In effect, from prob-
ble 9-2. The
and low e final value
ns with one of the
a's stand-


centsage points above and below the expected value, holding other things constant; then a new NPV is calculated for each of these values; and, finally, the set of NPVs is plotted against the variable that was changed. Figure 9-1 shows the computer project's sensitivity graphs for three of the key input variables. The table below the graphs gives the NPVs that were used to construct the graphs. The slopes of the lines in the graphs show how sensitive NPV is to changes in each of the inputs: the steeper the slope, the more sensitive the NPV is to a change in the variable. In the figure we see that the project's NPV is very sensitive to changes in variable costs, less sensitive to changes in unit sales, and not very sensitive at all to changes in the required rate of return. So when estimating these variables' values, HEP should take extra care to ensure the accuracy of the forecast for variable costs per unit.

If we were comparing two projects, the one with the steeper sensitivity lines would be regarded as riskier because for that project a relatively small error in estimating a variable such as unit sales would produce a large error in the project's expected NPV. Thus, sensitivity analysis can provide useful insights into the riskiness of a project.

Before we move on, two additional points about sensitivity analysis warrant attention. First, spreadsheet computer models, such as Excel™ or Lotus 1-2-3™, are ideally suited for performing sensitivity analysis. We used a spreadsheet model to conduct the analyses represented in Figure 9-1; it generated the NPVs and then drew the graphs. Second, we could have plotted all the sensitivity lines on one graph; this would have facilitated direct comparisons of the sensitivities among different input variables.
Scenario Analysis

Although sensitivity analysis probably is the most widely used risk analysis technique, it does have limitations. Consider, for example, a proposed coal mine project whose NPV is highly sensitive to changes in output, in variable costs, and in sales price. However, if a utility company has contracted to buy a fixed amount of coal at an inflation-adjusted price per ton, the mining venture might be quite safe in spite of its steep sensitivity lines. In general, a project’s stand-alone risk depends on both (1) the sensitivity of its NPV to changes in key variables and (2) the range of likely values of these variables as reflected in their probability distributions. Because sensitivity analysis considers only the first factor, it is incomplete.

Scenario analysis is a risk analysis technique that considers both the sensitivity of NPV to changes in key variables and the likely range of variable values. In a scenario analysis, the financial analyst asks operating managers to pick a “bad” set of circumstances (low unit sales, low sales price, high variable cost per unit, high construction cost, and so on) and a “good” set. The NPVs under the bad and good conditions are then calculated and compared to the expected, or base case, NPV.

As an example, let us return to the appliance control computer project. Assume that HEP’s managers are fairly confident of their estimates of all the project’s cash flow variables except price and unit sales. Further, they regard a drop in sales below 10,000 units or a rise above 20,000 units as being extremely unlikely. Similarly, they expect the sales price as set in the marketplace to fall within the range of $1,500 to $2,500. Thus, 10,000 units at a price of $1,500 defines the lower bound, or the worst-case scenario, whereas 20,000 units at a price of $2,500 defines the upper bound, or the best-case scenario. Remember that the base case values are 15,000 units and a price of $2,000.

To carry out the scenario analysis, we use the worst-case variable values to obtain the worst-case NPV and the best-case variable values to obtain the best-case NPV. We then use the result of the scenario analysis to determine the expected NPV, standard deviation of NPV, and the coefficient of variation. To complete these computations, we need an estimate of the probabilities of occurrence of the three scenarios, the \( P_i \) values. Suppose management estimates that there is a 20 percent probability of the worst case scenario occurring, a 60 percent probability of the base case, and a 20 percent probability of the best case. Of course, it is very difficult to estimate scenario probabilities accurately. The scenario probabilities and NPVs constitute a probability distribution of returns just like those we dealt with in Chapter 5, except that the returns are measured in dollars instead of in percentages, or rates of return.

We performed the scenario analysis using a spreadsheet model, and Table 9-5 summarizes the results of this analysis. We see that the base case (or most likely case) forecasts a positive NPV result; the worst case produces a negative NPV; and the best case results in a very large positive NPV. But the expected NPV for the project is $4.5 million and the project’s coefficient of variation is 1.7. Now we can compare the project’s coefficient of variation with the coefficient of variation of HEP’s average project to get an idea of the relative riskiness of the appliance control computer project. HEP’s...
sis technique, project whose is price. Howe- an inflation of its steep be sensitivity of variables as re- s only the first

sensitivity of In a scenario set of circums- construction conditions are

Assume that of $2,000. Thus, a scenario he best-case ice of $2,000. uses to obtain a-case NPV. IPV, standard com- putations, orios, the Pi proba- bility of the and a 20 per- centage proba- bility that the re-

Table 9-5 sums- ly case) fore- the best case $4.5 mil- the project's project to get oject. HEP's

### Table 9-5

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Sales Volume (units)</th>
<th>Sales Price</th>
<th>NPV</th>
<th>Probability of Outcome (Pr_i)</th>
<th>NPV × Pr_i</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best case</td>
<td>20,000</td>
<td>$2,500</td>
<td>$17,494</td>
<td>0.20</td>
<td>$3,499</td>
</tr>
<tr>
<td>Most likely case</td>
<td>15,000</td>
<td>2,000</td>
<td>3,790</td>
<td>0.60</td>
<td>2,274</td>
</tr>
<tr>
<td>Worst case</td>
<td>10,000</td>
<td>1,500</td>
<td>6,487</td>
<td>0.20</td>
<td>(1,297)</td>
</tr>
</tbody>
</table>

Expected NPV = \sum_{i=1}^{n} Pr_i(NPV_i) = 0.20($17,494) + 0.60($3,790) + 0.20($6,487) = $4,475

\[ \sigma_{\text{NPV}} = \sqrt{\sum_{i=1}^{n} Pr_i(NPV_i - \text{Expected NPV})^2} \]

\[ = \sqrt{0.20(17,494 - 4,475)^2 + 0.60(3,790 - 4,475)^2 + 0.20(-6,487 - 4,475)^2} = 7,630 \]

\[ CV_{\text{NPV}} = \frac{\sigma_{\text{NPV}}}{\text{Expected NPV}} = \frac{7,630}{4,475} = 1.7 \]

existing projects, on average, have a coefficient of variation of about 1.0, so, on the ba- sis of this stand-alone risk measure, HEP's managers would conclude that the appliance computer project is riskier than the firm's "average" project.

**Monte Carlo Simulation**

Scenario analysis provides useful information about a project's stand-alone risk. However, it is limited in that it only considers a few discrete outcomes (NPVs) for the project, even though there really are many more possibilities. **Monte Carlo simulation**, so named because this type of analysis grew out of work on the mathematics of casino gambling, ties together sensitivities and input variable probability distributions.

Simulation is more complicated than scenario analysis because the probability distribution of each uncertain cash flow variable has to be specified. Once this has been done, a value from the probability distribution for each variable is randomly chosen to compute the project's cash flows, and then these values are used to determine the project's NPV. Simulation is usually completed using a computer because the process just described is repeated again and again, say, for 500 times, which results in 500 NPVs and a probability distribution for the project's NPV values. Thus, the output produced by simulation is a probability distribution that can be used to determine the most likely range of outcomes to be expected from a project. This provides the decision maker with a better idea of the various outcomes that are possible than is available from a point estimate of the NPV. In addition, simulation software packages can be used to estimate the probability of NPV > 0, of IRR > k, and so on. This additional information can be quite helpful in assessing the riskiness of a project.

Unfortunately, Monte Carlo simulation is not easy to apply because it is often difficult to specify the relationships, or correlations, among the uncertain cash flow.
Greater Risk? Greater Return, Please.

Indications are that financial managers are quite concerned about risk when making capital budgeting decisions. A recent survey of financial managers by Glenn Petry and James Sprow* suggests that about 75 percent of companies use different required rates of return to account for risk differences when making capital budgeting decisions—only 25 percent use a single rate for all capital projects. Most of the financial managers indicated that they attempt to compute the cost of the funds used by their firms, and that rate is appropriate for determining the acceptability of projects with average risk only. For riskier projects, some of the companies adjust the expected cash flows, but most raise the rates of return required from such investments. In addition, some firms use a reduced minimum payback period to evaluate projects with above-average risk. While this approach is not common, it appears manufacturers and retailing firms are more likely to use an adjusted payback period to account for project risk than are financial service organizations, service companies, or utilities.

Other studies indicate similar results. For example, a couple of recent studies suggest that firms find risk to be an important consideration when making capital budgeting decisions; thus, the discount rate used to evaluate a project is based on the risk of the project.† Further, in another study, Erika Gilbert and Alan Reichert found that more than 40 percent of the firms surveyed consider the impact of a capital project on the other assets of the firm (i.e., they consider the impact on the firm’s portfolio of assets).*

It is interesting to note that firms generally do not attempt to use probability distributions to estimate cash flows for projects unless the outlay is extremely large. Perhaps the attitude is that it is not worth the effort to assign probabilities unless the project constitutes a major investment. When determining the terminal value of capital projects, most firms use either the expected market value or the book value of the asset at the anticipated liquidation date; in many cases, these values are expected to be the same.

In summary, it appears firms do make adjustments to the various techniques used for making capital budgeting decisions when the risks of the projects differ significantly from the average. And the most common approach for adjusting for project risk is to raise the discount rate (required rate of return) used to compute the project’s net present value.


Self-Test Questions

List three reasons why, in practice, a project’s stand-alone risk is important. Differentiate between sensitivity and scenario analyses. Why might scenario analysis be preferable to sensitivity analysis?
What is Monte Carlo simulation?
Identify some problems with (1) sensitivity analysis, (2) scenario analysis, and (3) Monte Carlo simulation.

Corporate (within-Firm) Risk

To measure corporate, or within-firm, risk, we need to determine how the capital budgeting project is related to the firm's existing assets. Remember from our discussion in Chapter 5 that two assets can be combined to reduce risk if their payoffs move in opposite directions—when the payoff from one asset falls, the payoff from the other asset rises. In reality, it is not easy to find assets with payoffs that move opposite each other. But, as we discovered in Chapter 5, as long as assets are not perfectly positively related (r = +1.0), some diversification, or risk reduction, can still be achieved. Many firms use this principle to reduce the risk associated with their operations—adding new projects that are not highly related to existing assets can help reduce corporate risk and reduce fluctuations associated with sales.

Corporate risk is important for three primary reasons:

1. Undersized stockholders, including the owners of small businesses, are more concerned about corporate risk than about beta risk.
2. Empirical studies of the determinants of required rates of return (k) generally find that both beta and corporate risk affect stock prices. This suggests that investors, even those who are well diversified, consider factors other than beta risk when they establish required returns.
3. The firm's stability is important to its managers, workers, customers, suppliers, and creditors, as well as to the community in which it operates. Firms that are in serious danger of bankruptcy, or even of suffering low profits and reduced output, have difficulty attracting and retaining good managers and workers. Also, both suppliers and customers are reluctant to depend on weak firms, and such firms have difficulty borrowing money at reasonable interest rates. These factors tend to reduce risky firms' profitability and hence the prices of their stocks; thus they also make corporate risk significant.

Therefore, corporate risk is important even if a firm's stockholders are well diversified.

Self-Test Question
List three reasons why corporate risk is important.

Beta (Market) Risk

The types of risk analysis discussed thus far in the chapter provide insights into a project's risk and thus help managers make better accept/reject decisions. However, these risk measures do not take account of portfolio risk, and they do not specify whether a project should be accepted or rejected. In this section, we show how the capital asset pricing model (CAPM) can be used to help overcome those shortcomings. Of course,
the CAPM has shortcomings of its own, but it nevertheless offers useful insights into risk analysis in capital budgeting.

**Beta (or Market) Risk and Required Rate of Return for a Project**

In Chapter 5 we developed the concept of beta, $\beta$, as a risk measure for individual stocks. From our discussion, we concluded systematic risk is the relevant risk of a stock because unsystematic, or firm-specific, risk can be reduced significantly or eliminated through diversification. This same concept can be applied to capital budgeting projects because the firm can be thought of as a composite of all the projects it has undertaken. Thus, the relevant risk of a project can be viewed as the impact it has on the firm's systematic risk. This line of reasoning leads to the conclusion that if the beta coefficient for a project, $\beta_{proj}$, can be determined, then the project required rate of return, $k_{proj}$, can be found using the following form of the CAPM equation:

$$k_{proj} = k_{RF} + (k_M - k_{RF})\beta_{proj}$$

As an example, consider the case of Erie Steel Company, an integrated steel producer operating in the Great Lakes region. For simplicity, let's assume that Erie is all equity financed, so the average required rate of return it needs to earn on capital budgeting projects is based solely on the average return demanded by stockholders (i.e., there is no debt that might require a different return). Erie's existing beta = $\beta_{Erie} = 1.1$; $k_{RF} = 8\%$; and $k_M = 12\%$. Thus, Erie's cost of equity is $12.4\% = k_e = 8\% + (12\% - 8\%)1.1$, which suggests that investors should be willing to give Erie money to invest in average risk projects if the company expects to earn 12.4 percent or more on this money. Here again, by average risk we mean projects having risk similar to the firm's existing assets.

Suppose, however, that taking on a particular project will cause a change in Erie's beta coefficient and hence change the company's required rate of return. For example, suppose Erie is considering the construction of a fleet of barges to haul iron ore, and barge operations have betas of 1.5, rather than 1.1. Because the firm itself might be regarded as a "portfolio of assets," just like the beta of any portfolio, Erie's beta is a weighted average of the betas of its individual assets. Thus, taking on the barge project will cause the overall corporate beta to rise to somewhere between the original beta of 1.1 and the barge project's beta of 1.5. The exact value of the new beta will depend on the relative size of the investment in barge operations versus Erie's other assets. If 80 percent of Erie's total funds end up in basic steel operations with a beta of 1.1 and 20 percent in the barge operations with a beta of 1.5, the new corporate beta will increase to $1.18 = 0.8(1.1) + 0.2(1.5)$. This increase in Erie's beta coefficient will cause its stock price to decline unless the increased beta is offset by a higher expected rate of return. Note that taking on the new project will cause the overall corporate required rate of return to rise from the original 12.4 percent to 12.7 percent because the new beta will be 1.18. This higher average rate can be earned only if the new project generates a return higher than the existing assets are providing. Because Erie's overall

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*To simplify things somewhat, we assume at this point that the firm uses only equity capital. If debt is used, the cost of capital would must be a weighted average of the costs of debt and equity. This point is discussed at length in Chapter 10.*
return is based on its portfolio of assets, the return required from the barge project must be sufficiently high so that, in combination with returns of the other assets, the average return is 12.7 percent; only 20 percent of the average return will be provided by the barge project. Thus, the barge project, with $\beta_{\text{Barge}} = 1.5$, should be evaluated at a 14 percent required rate of return because $k_{\text{Barge}} = 8\% + (4\%)(1.5) = 14\%$. On the other hand, a low-risk project such as a new steel distribution center with a beta of only 0.5 would have a required rate of return of ten percent.

Figure 9-2 gives a graphic summary of these concepts as applied to Erie Steel. Note the following points:

1. The SML is a security market line like the one we developed in Chapter 5. It shows how investors are willing to make trade-offs between risk as measured by beta and expected returns. The higher the beta risk, the higher the rate of return needed to compensate investors for bearing this risk. The SML specifies the nature of this relationship.

2. Erie Steel initially had a beta of 1.1, so its required rate of return on average-risk investments was 12.4 percent.

3. High-risk investments such as the barge line require higher rates of return, whereas low-risk investments such as the distribution center require lower rates of return. If Erie concentrates its new investments in either high-risk or low-risk projects as opposed to average-risk ones, its corporate beta will either rise or fall from the current value of 1.1. Consequently, Erie’s required rate of return on common stock would change from its current value of 12.4 percent.

4. If the expected rate of return on a given capital project lies above the SML, the expected rate of return on the project is more than enough to compensate for its risk, and the project should be accepted. Conversely, if the project’s rate of
return lies below the SML, it should be rejected. Thus, Project M in Figure 9-2 is acceptable, whereas Project N should be rejected. N has a higher expected return than M, but the differential is not enough to offset its much higher risk.

Measuring Beta Risk for a Project

In Chapter 5, we discussed the estimation of betas for stocks, and we indicated that it is difficult to estimate true future betas. The estimation of project betas is even more difficult and more fraught with uncertainty. One way a firm can try to measure the beta risk of a project is to find single-product companies in the same line of business as the project being evaluated and then use the betas of those companies to determine the required rate of return for the project being evaluated. This technique is termed the pure play method, and the single-product companies that are used for comparisons are called pure play firms. For example, if Eric could find three existing single-product firms that operate barges, it could use the average of the betas of those firms as a proxy for the barge project's beta.

The pure play approach can only be used for major assets such as whole divisions, and even then it is frequently difficult to implement because it is often impossible to find pure play proxy firms. However, when IBM was considering going into personal computers, it was able to obtain data on Apple Computer and several other essentially pure play personal computer companies. This is often the case when a firm considers a major investment outside its primary field.

Self-Test Questions

What is meant by the term “average-risk project”? How could you find the required rate of return for a project with average risk, low risk, and high risk?

Complete the following sentence: An increase in a company’s beta coefficient would cause its stock price to decline unless . . .

Explain why a firm should accept a given capital project if its expected rate of return lies above the SML. What if the expected rate of return lies on or below the SML?

What is the pure play method, and how is it used to estimate a project’s beta?

Project Risk Conclusions

We have discussed the three types of risk normally considered in capital budgeting analysis—stand-alone risk, within-firm (or corporate) risk, and beta (or market) risk—and we have discussed ways of assessing each. However, two important questions remain: (1) Should a firm be concerned with stand-alone and corporate risk in its capital budgeting decisions, and (2) what do we do when the stand-alone or within-firm risk assessments and the beta risk assessment lead to different conclusions?

These questions do not have easy answers. From a theoretical standpoint, well-diversified investors should be concerned only with beta risk, managers should be concerned only with stock price maximization, and these two factors should lead to the conclusion that beta risk should be given virtually all the weight in capital budgeting decisions. However, if investors are not well diversified, if the CAPM does not operate exactly as theory says it should, or if measurement problems keep managers from having confidence in the CAPM approach in capital budgeting, it might be appropriate to
give stand-alone and corporate risk more weight than financial theorists suggest. Note also that the CAPM ignores bankruptcy costs, even though such costs can be substantial, and that the probability of bankruptcy depends on a firm's corporate risk, not on its beta risk. Therefore, one can easily conclude that even well-diversified investors should want a firm's management to give at least some consideration to a project's corporate risk instead of concentrating entirely on beta risk.

Although it would be desirable to reconcile these problems and to measure project risk on some absolute scale, the best we can do in practice is to determine project risk in a somewhat nebulous, relative sense. For example, we can generally say with a fair degree of confidence that a particular project has more or less stand-alone risk than the firm's average project. Then, assuming that stand-alone and corporate risk are highly correlated (which is typical), the project's stand-alone risk will be a good measure of its corporate risk. Finally, assuming that beta risk and corporate risk are highly correlated (as is true for most companies), a project with more corporate risk than average will also have more beta risk, and vice versa for projects with low corporate risk.

Self-Test Questions

In theory, is it correct for a firm to be concerned with stand-alone and corporate risk in its capital budgeting decisions? Should the firm be concerned with these risks in practice?

If a project's stand-alone, corporate, and beta risk are highly correlated, would this make the task of measuring risk easier or harder? Explain.

How Project Risk Is Considered in Capital Budgeting Decisions

Thus far, we have seen that purchasing a capital project can affect a firm's beta risk, its corporate risk, or both. We also have seen that it is extremely difficult to quantify either type of risk. In other words, although it might be possible to reach the general conclusion that one project is riskier than another, it is difficult to develop a really good measure of project risk. This lack of precision in measuring project risk makes it difficult to incorporate differential risk into capital budgeting decisions.

In reality, most firms incorporate project risk in capital budgeting decisions using the risk-adjusted discount rate approach. With this approach, the required rate of return, which is the rate at which the expected cash flows are discounted, is adjusted if the project's risk is substantially different from the average risk associated with the firm's existing assets. Therefore, average-risk projects would be discounted at the rate of return required of projects that are considered “average,” or normal for the firm; above-average risk projects would be discounted at a higher-than-average rate; and below-average risk projects would be discounted at a rate below the firm's average rate of return. Unfortunately, because risk cannot be measured precisely, there is no accurate way of specifying exactly how much higher or lower these discount rates should be; given the present state of the art, risk adjustments are necessarily judgmental and somewhat arbitrary.

Although the process is not exact, many companies use a two-step procedure to develop risk-adjusted discount rates for use in capital budgeting. First, the overall required rate of return is established for the firm's existing assets. This process is
completed on a division-by-division basis for very large firms, perhaps using the CAPM. Second, all projects generally are classified into three categories—high risk, average risk, and low risk. Then, the firm or division uses the average required rate of return as the discount rate for average-risk projects, reduces the average rate by one or two percentage points when evaluating low-risk projects, and raises the average rate by several percentage points for high-risk projects. For example, if a firm’s basic required rate of return is estimated to be 12 percent, an 18 percent discount rate might be used for a high-risk project and a nine percent rate for a low-risk project. Average-risk projects, which constitute about 80 percent of most capital budgets, would be evaluated at the 12 percent rate of return. Table 9–6 contains an example of the application of risk-adjusted discount rates for the evaluation of four projects. Each of the four projects has a five-year life, and each is expected to generate a constant cash flow stream during its life; therefore, each project’s future cash flow pattern represents an annuity. The analysis shows that only Project A and Project C are acceptable when risk is considered. Note, though, that if the average required rate of return is used to evaluate all the projects, Project C and Project D would be considered acceptable because their IRRs are greater than 12 percent. Using the average required rate of return would lead to an incorrect decision. Thus, if project risk is not considered in capital budgeting analysis, incorrect decisions are possible.

Although the risk-adjusted discount rate approach is far from precise, it does at least recognize that different projects have different risks, and projects with different risks should be evaluated using different required rates of return.

**Self-Test Questions**

How are risk-adjusted discount rates used to incorporate project risk into the capital budget decision process?

Briefly explain the two-step process many companies use to develop risk-adjusted discount rates for use in capital budgeting.
Capital Rationing

Capital budgeting decisions are typically made on the basis of the techniques presented in Chapter 8 and applied as described in this chapter—indeed, projects are accepted if their NPVs are positive, and choices among mutually exclusive projects are made by selecting the one with the highest NPV. In this analysis, it is assumed that if in a particular year the firm has an especially large number of good projects, management simply will go into the financial markets and raise whatever funds are required to finance all of the acceptable projects. However, some firms do set limits on the amount of funds they are willing to raise, and, if this is done, the capital budget must also be limited. This situation is known as capital rationing.

Elaborate and mathematically sophisticated models have been developed to help firms maximize their values when they are subject to capital rationing. However, a firm that subjects itself to capital rationing is deliberately forgoing profitable projects, and hence it is not truly maximizing its value. This point is well known, so few large, sophisticated firms ration capital today. Therefore, we shall not discuss it further, but you should know what the term capital rationing means.

Self-Test Questions

What is meant by the term capital rationing?
Why do few sophisticated firms ration capital today?

Multinational Capital Budgeting

Although the basic principles of capital budgeting analysis are the same for both domestic and foreign operations, some key differences need to be mentioned. First, cash flow estimation generally is much more complex for overseas investments. Most multinational firms set up a separate subsidiary in each foreign country in which they operate, and the relevant cash flows for these subsidiaries are the dividends and royalties repatriated, or returned, to the parent company. Second, these cash flows must be converted into the currency of the parent company, and thus are subject to future exchange rate changes. For example, General Motors’ German subsidiary might make a profit of 150 million marks in 2000, but the value of these profits to GM will depend on the dollar-to-mark exchange rate. Third, dividends and royalties normally are taxed by both foreign and home-country governments. Furthermore, a foreign government might restrict the amount of cash that can be repatriated to the parent company, perhaps to force multinational firms to reinvest earnings in the host country or to prevent large currency outflows, which might affect the exchange rate. Whatever the host country’s motivation, the result is that the parent corporation cannot use cash flows blocked in the foreign country to pay current dividends to its shareholders, nor does it have the flexibility to reinvest cash flows elsewhere in the world. Therefore, from the perspective of the parent organization, the cash flows relevant for the analysis of a foreign investment are the cash flows that the subsidiary legally can send back to the parent.

In addition to the complexities of the cash flow analysis, the rate of return required for a foreign project might be different than for an equivalent domestic project because foreign projects might be more or less risky. A higher risk could arise from two primary sources—(1) exchange rate risk and (2) political risk—while a lower risk might result from international diversification.
EXCHANGE RATE RISK

The uncertainty associated with the price at which the currency from one country can be converted into the currency of another country.

POLITICAL RISK

The risk of expropriation (seizure) of a foreign subsidiary’s assets by the host country or of unanticipated restrictions on cash flows to the parent company.

Exchange rate risk reflects the inherent uncertainty about the home currency value of cash flows sent back to the parent. In other words, foreign projects have an added risk element that relates to what the basic cash flows will be worth in the parent company’s home currency. The foreign currency cash flows to be turned over to the parent must be converted into U.S. dollars by translating them at expected future exchange rates—actual exchange rates might differ substantially from expectations.

Political risk refers to any action (or the chance of such action) by a host government that reduces the value of a company’s investment. It includes at one extreme the expropriation (seizure) without compensation of the subsidiary’s assets; but it also includes less drastic actions that reduce the value of the parent firm’s investment in the foreign subsidiary such as higher taxes, tighter repatriation or currency controls, and restrictions on prices charged. The risk of expropriation of U.S. assets abroad is small in traditionally friendly and stable countries such as Great Britain or Switzerland. However, in Latin America and Africa, for example, the risk might be substantial. Past expropriations include those of TTT and Anaconda Copper in Chile, Gulf Oil in Bolivia, Occidental Petroleum in Libya, and the assets of many companies in Iraq, Iran, and Cuba.

Generally, political risk premiums are not added to the required rate of return to adjust for this risk. If a company’s management has a serious concern that a given country might expropriate foreign assets, it simply will not make significant investments in that country. Expropriation is viewed as a catastrophic or ruinous event, and managers have been shown to be extraordinarily risk averse when faced with ruinous loss possibilities. However, companies can take steps to reduce the potential loss from expropriation in three major ways: (1) by financing the subsidiary with capital raised in the country in which the asset is located, (2) by structuring operations so that the subsidiary has value only as a part of the integrated corporate system, and (3) by obtaining insurance against economic losses from expropriation from a source such as the Overseas Private Investment Corporation (OPIC). In the latter case, insurance premiums would have to be added to the project cost.

Self-Test Questions

List some key differences in capital budgeting as applied to foreign versus domestic operations.

What are the relevant cash flows for an international investment?

Why might the required rate of return for a foreign project differ from that of an equivalent domestic project? Could it be lower?
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capital budgeting decisions. While this might seem
somewhat surprising, as Block concludes, it is impor-
tant for small firms to examine risk in their capital
budgeting analysis because investment in a "bad"
project is much more costly for a small firm than for a
large firm that benefits from diversification in its
portfolio of assets. Simply stated, in large firms, a
mistake on one project can be offset by successes with
others; but in small firms a capital budgeting mistake
can be disastrous, even fatal.

According to the study, more than 45 percent of
the small firms surveyed indicated that they use
higher required rates of return to evaluate projects
with higher-than-average risk; 30 percent adjust the
project's cash flows; and nearly 21 percent use some
type of subjective, nonquantitative risk analysis. Block
discovered that about 3 percent of the firms use some
type of probability analysis to incorporate risk in the
capital budgeting analyses.

Block's study includes a couple of additional results
that are related to the material covered in this chapter.
First, he found that nearly 74 percent of the capi-
tal budgeting projects of the firms surveyed are either
replacement decisions (57.6 percent) or decisions to
expand existing product lines (16.3 percent); only
8 percent are decisions to expand into new products
or businesses; and 18 percent of the decisions are
related to safety or environmental considerations. In
addition, risk analysis is considered important by
firms that plan to expand existing product lines or en-
ter into new lines of business—more than 90 percent
of the firms stated that risk analysis is part of the proj-
ect evaluation in these situations. Second, Block dis-
covered that, even though many of the respondents
did not understand what the term capital rationing
meant, nearly 93 percent do restrict the size of the
capital budget, even when additional acceptable pro-
jects are available. Perhaps the reason small firms do
not invest in all the acceptable projects (i.e., ration
capital) is because the banks that provide them funds
are more concerned with the time it takes to pay back
the loan rather than whether the projects are accept-
able using capital budgeting techniques such as NPV
and IRR.

In general, Block's study suggests that, compared
with large firms, small firms are not as well diversified
with respect to the assets they hold; thus, they must
be more concerned with stand-alone risk than with
either corporate (within-firm) risk or beta risk when
making capital budgeting decisions. Like larger firms,
however, small firms find it easier to adjust the rate of
return used to evaluate a project than to use one of
the other techniques discussed in this chapter.

"Stanley Block, "Capital Budgeting Techniques Used by
Small Business Firms in the 1990s," The Engineering Eco-

Summary

This chapter presented two issues in capital budgeting: cash flow estimation and evalua-
tion and risk analysis in capital budgeting. We also provided an indication of the
capital budgeting decision-making process in multinational firms. The key concepts
covered are listed here:

- The most important, but also the most difficult, step in analyzing a capital budg-
eting project is estimating the incremental after-tax cash flows the project will
produce.
- Net cash flows consist of net income plus depreciation. In determining incremen-
tal cash flows, opportunity costs (the cash flow forgone by using an asset)
must be included, but sunk costs (cash outlays that have been made and that
cannot be recouped) should not be included. Any externalities (effects of a proj-
ect on other parts of the firm) should also be reflected in the analysis. In addition,
inflation effects must be considered in project analysis. The best procedure is to
build inflation directly into the cash flow estimates.
Capital projects often require an additional investment in net working capital (NWC). An increase in NWC must be included in the Year 0 initial cash outlay and then shown as a cash inflow in the project's final year.

Replacement analysis is slightly different from that for expansion projects because the cash flows from the old asset must be considered in replacement decisions.

A project's stand-alone risk is the risk the project would have if it were the firm's only asset and if the firm's stockholders held only that one stock. Stand-alone risk is measured by the variability of the asset's expected returns, and it is often used as a proxy for both beta and corporate risk because (1) betas and corporate risk are difficult to measure and (2) the three types of risk are usually highly correlated.

Within-firm, or corporate, risk reflects the effects of a project on the firm's risk, and it is measured by the project's effect on the firm's earnings variability. Stockholder diversification is not taken into account.

Beta risk reflects the effects of a project on the risks borne by stockholders, assuming stockholders hold diversified portfolios. In theory, beta risk should be the most relevant type of risk.

Corporate risk is important because it influences the firm's ability to use low-cost debt, to maintain smooth operations over time, and to avoid crises that might consume management's energy and disrupt employees, customers, suppliers, and the community.

Sensitivity analysis is a technique that shows how much an output variable such as NPV will change in response to a given change in an input variable such as sales, other things held constant.

Scenario analysis is a risk analysis technique in which the best- and worst-case NPVs are compared with the project's expected NPV.

Monte Carlo simulation is a risk-analysis technique in which a computer is used to simulate probable future events and thus to estimate the profitability distribution and riskiness of a project.

The pure play method can be used to estimate betas for large projects or for divisions.

The risk-adjusted discount rate is the rate used to evaluate a particular project. The discount rate is increased for projects that are riskier than the firm's average project but is decreased for less risky projects.

Capital rationing occurs when management places a constraint on the size of the firm's capital budget during a particular period.

Investments in international capital projects expose the investing firm to exchange rate risk and political risk. The relevant cash flows in international capital budgeting are the dollar cash flows that can be turned over to the parent company.

Both the measurement of risk and its incorporation into capital budgeting involve judgment. It is possible to use a quantitative technique such as simulation as an aid to judgment, but in the final analysis the assessment of risk in capital budgeting is a subjective process.

Questions

9-1 Cash flows rather than accounting profits are listed in Table 9-2. What is the basis for this emphasis on cash flows as opposed to net income?
9-2  Look at Table 9-4 and answer these questions:
   a.  Why is the net salvage value shown in Section III reduced for taxes?
   b.  How is the change in depreciation computed?
   c.  What would happen if the new machine permitted a reduction in net working capital?
   d.  Why are the cost savings shown as a positive amount?

9-3  Explain why sunk costs should not be included in a capital budgeting analysis but opportunity costs and externalities should be included.

9-4  Explain how net working capital is recovered at the end of a project’s life and why it is included in a capital budgeting analysis.

9-5  In general, is an explicit recognition of incremental cash flows more important in new project analysis or replacement analysis? Why?

9-6  Why is it true, in general, that a failure to adjust expected cash flows for expected inflation biases the calculated NPV downward?

9-7  Define (a) simulation analysis, (b) scenario analysis, and (c) sensitivity analysis. If AT&T were considering two investments, one calling for the expenditure of $2 million to develop a satellite communications system and the other involving the expenditure of $30,000 for a new truck, on which one would the company be more likely to use simulation analysis?

9-8  Distinguish between beta (or market) risk, within-firm (or corporate) risk, and stand-alone risk for a project being considered for inclusion in the capital budget. Which type of risk do you believe should be given the greatest weight in capital budgeting decisions? Explain.

9-9  Suppose Reading Engine Company, which has a high beta as well as a great deal of corporate risk, merged with Simplicity Patterns Inc. Simplicity’s sales rise during recessions, when people are more likely to make their own clothes, and, consequently, its beta is negative but its corporate risk is relatively high. What would the merger do to the costs of capital in the consolidated company’s locomotive engine division and in its patterns division?

9-10  Suppose a firm estimates its required rate of return for the coming year to be ten percent. What are reasonable required rates of return for evaluating average-risk projects, high-risk projects, and low-risk projects?

Self-Test Problems
(Solutions appear in Appendix B)

key terms

ST-1  Define each of the following terms:
   a.  Cash flow; accounting income; relevant cash flow
   b.  Incremental cash flow; sunk cost; opportunity cost; externalities; inflation bias
   c.  Initial investment outlay; incremental operating cash flow; terminal cash flow
   d.  Change in net working capital; expansion project
   e.  Salvage value
   f.  Replacement analysis
   g.  Stand-alone risk; within-firm risk; beta (market) risk
   h.  Corporate risk
   i.  Sensitivity analysis
   j.  Scenario analysis
k. Monte Carlo simulation analysis
l. Project beta versus corporate beta
m. Pure play method of estimating project betas
n. Risk-adjusted discount rate; project required rate of return
o. Capital rationing
p. Exchange rate risk; political risk

new project analysis ST–2 You have been asked by the president of Ellis Construction Company, headquartered in Toledo, to evaluate the proposed acquisition of a new earthmover. The mover's basic price is $50,000, and it will cost another $10,000 to modify it for special use by Ellis Construction. Assume that the mover falls into the MACRS three-year class. (See Table 9A–2 for MACRS recovery allowance percentages.) It will be sold after three years for $20,000, and it will require an increase in net working capital (spare parts inventory) of $2,000. The earthmover purchase will have no effect on revenues, but it is expected to save Ellis $20,000 per year in before-tax operating costs, mainly labor. Ellis's marginal tax rate is 40 percent.

a. What is the company's net initial investment outlay if it acquires the earthmover? (That is, what are the Year 0 cash flows?)
b. What are the incremental operating cash flows in Years 1, 2, and 3?
c. What is the terminal cash flow in Year 3?
d. If the project's required rate of return is ten percent, should the earthmover be purchased?

replacement analysis ST–3 The Daumen Toy Corporation currently uses an injection molding machine that was purchased two years ago. This machine is being depreciated on a straight line basis toward a $500 salvage value, and it has six years of remaining life. Its current book value is $2,600, and it can be sold for $3,000 at this time. Thus, the annual depreciation expense is ($2,600 − $500)/6 = $350 per year.

Daumen is offered a replacement machine that has a cost of $8,000, an estimated useful life of six years, and an estimated salvage value of $800. This machine falls into the MACRS 5-year class. (See Table 9A–2 for MACRS recovery allowance percentages.) The replacement machine would permit an output expansion, so sales would rise by $1,000 per year; even so, the new machine's much greater efficiency would still cause operating expenses to decline by $1,300 per year. The new machine would require that inventories be increased by $2,000, but accounts payable would simultaneously increase by $500.

Daumen's marginal tax rate is 40 percent, and its required rate of return is 15 percent. Should it replace the old machine?

corporate risk analysis ST–4 The staff of Heyman Manufacturing has estimated the following net cash flows and probabilities for a new manufacturing process:

<table>
<thead>
<tr>
<th>Year</th>
<th>Net Cash Flows</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$P_R = 0.2</td>
</tr>
<tr>
<td>0</td>
<td>$(100,000)</td>
</tr>
<tr>
<td>1</td>
<td>20,000</td>
</tr>
<tr>
<td>2</td>
<td>20,000</td>
</tr>
<tr>
<td>3</td>
<td>20,000</td>
</tr>
<tr>
<td>4</td>
<td>20,000</td>
</tr>
<tr>
<td>5</td>
<td>20,000</td>
</tr>
<tr>
<td>5*</td>
<td>0</td>
</tr>
</tbody>
</table>
Line 0 gives the cost of the process, Lines 1 through 5 give operating cash flows, and Line 5* contains the estimated salvage values. Heymann's required rate of return for an average risk project is ten percent.

a. Assume that the project has average risk. Find the project's expected NPV. (Hint: Use expected values for the net cash flow in each year.)

b. Find the best-case and worst-case NPVs. What is the probability of occurrence of the worst case if the cash flows are perfectly dependent (perfectly positively correlated) over time? If they are independent over time?

c. Assume that all the cash flows are perfectly positively correlated; that is, there are only three possible cash flow streams over time: (1) the worst case, (2) the most likely, or base, case, and (3) the best case, with probabilities of 0.2, 0.6, and 0.2, respectively. These cases are represented by each of the columns in the table. Find the expected NPV, its standard deviation, and its coefficient of variation.

d. The coefficient of variation of Heymann's average project is in the range 0.8 to 1.0. If the coefficient of variation of a project being evaluated is greater than 1.0, two percentage points are added to the firm's required rate of return. Similarly, if the coefficient of variation is less than 0.8, one percentage point is deducted from the required rate of return. What is the project's required rate of return? Should Heymann accept or reject the project?

### Problems

#### 9–1
You have been asked by the president of your company to evaluate the proposed acquisition of a spectrometer for the firm's R&D department. The equipment's base price is $140,000, and it would cost another $30,000 to modify it for special use by your firm. The spectrometer, which falls into the MACRS three-year class, would be sold after three years for $60,000. (See Table 9A–2 for MACRS recovery allowance percentages.) Use of the equipment would require an increase in net working capital (spare parts inventory) of $8,000. The spectrometer would have no effect on revenues, but it is expected to save the firm $50,000 per year in before-tax operating costs, mainly labor. The firm's marginal tax rate is 40 percent.

a. What is the initial investment outlay associated with this project? (That is, what is the Year 0 net cash flow?)

b. What are the incremental operating cash flows in Years 1, 2, and 3?

c. What is the terminal cash flow in Year 3?

d. If the project's required rate of return is 12 percent, should the spectrometer be purchased?

#### 9–2
The Ewert Company is evaluating the proposed acquisition of a new milling machine. The machine's base price is $108,000, and it would cost another $12,500 to modify it for special use by the firm. The machine falls into the MACRS three-year class, and it would be sold after three years for $65,000. (See Table 9A–2 for MACRS recovery allowance percentages.) The machine would require an increase in net working capital (inventory) of $5,500. The milling machine would have no effect on revenues, but it is expected to save the firm $44,000 per year in before-tax operating costs, mainly labor. Ewert's marginal tax rate is 34 percent.

a. What is the initial investment outlay of the machine for capital budgeting purposes? (That is, what is the Year 0 net cash flow?)
b. What are the incremental operating cash flows in Years 1, 2, and 3?
c. What is the terminal cash flow in Year 3?
d. If the project's required rate of return is 12 percent, should the machine be purchased?

9-3 Atlantic Control Company purchased a machine two years ago at a cost of $70,000. At that time, the machine's expected economic life was six years and its salvage value at the end of its life was estimated to be $10,000. It is being depreciated using the straight line method so that its book value at the end of six years is $10,000. In four years, however, the old machine will have a market value of $0.

A new machine can be purchased for $80,000, including shipping and installation costs. The new machine has an economic life estimated to be four years. MACRS depreciation will be used, and the machine will be depreciated over its three-year class life rather than its five-year economic life. (See Table 9A-2 for MACRS recovery allowance percentages.) During its four-year life, the new machine will reduce cash operating expenses by $20,000 per year. Sales are not expected to change. But the new machine will require net working capital to be increased by $4,000. At the end of its useful life, the machine is estimated to have a market value of $2,500.

The old machine can be sold today for $20,000. The firm's marginal tax rate is 40 percent. The appropriate required rate of return is ten percent.
a. If the new machine is purchased, what is the amount of the initial investment outlay at Year 0?
b. What incremental operating cash flows will occur at the end of Years 1 through 4 as a result of replacing the old machine?
c. What is the terminal cash flow at the end of Year 4 if the new machine is purchased?
d. What is the NPV of this project? Should Atlantic replace the old machine?

9-4 The Boyd Bottling Company is contemplating the replacement of one of its bottling machines with a newer and more efficient one. The old machine has a book value of $60,000 and a remaining useful life of five years. The firm does not expect to realize any return from scrapping the old machine in five years, but it can sell it now to another firm in the industry for $265,000. The old machine is being depreciated toward a zero salvage value, or by $120,000 per year, using the straight line method.

The new machine has a purchase price of $1,175,000, an estimated useful life and MACRS class life of five years, and an estimated market value of $145,000 at the end of five years. (See Table 9A-2 for MACRS recovery allowance percentages.) It is expected to economize on electric power usage, labor, and repair costs, which will save Boyd $230,000 each year. In addition, the new machine is expected to reduce the number of defective bottles, which will save an additional $25,000 annually. The company's marginal tax rate is 40 percent and it has a 12 percent required rate of return.
a. What initial investment outlay is required for the new machine?
b. Calculate the annual depreciation allowances for both machines, and compute the change in the annual depreciation expense if the replacement is made.
c. What are the incremental operating cash flows in Years 1 through 5?
d. What is the terminal cash flow in Year 5?
e. Should the firm purchase the new machine? Support your answer.
f. In general, how would each of the following factors affect the investment decision, and how should each be treated?
   (1) The expected life of the existing machine decreases.
a. What is Companion's current required rate of return?

b. If the expansion is undertaken, what would be the firm's new beta? What is the new overall required rate of return, and what rate of return must the home computer division produce to leave the new overall required rate of return unchanged?

**Integrative Problems**

9-12 Unilate Textiles is evaluating a new product, a silk/wool blended fabric. Assume that you were recently hired as assistant to the director of capital budgeting, and you must evaluate the new project.

The fabric would be produced in an unused building adjacent to Unilate's Southern Pines, North Carolina plant. Unilate owns the building, which is fully depreciated. The required equipment would cost $200,000, plus an additional $40,000 for shipping and installation. In addition, inventories would rise by $25,000, while accounts payable would go up by $5,000. All of these costs would be incurred at t = 0. By a special ruling, the machinery could be depreciated under the MACRS system as three-year property.

The project is expected to operate for four years, at which time it will be terminated. The cash inflows are assumed to begin one year after the project is undertaken, or at t = 1, and to continue out to t = 4. At the end of the project's life (t = 4), the equipment is expected to have a salvage value of $25,000.

Unit sales are expected to total 100,000 five-yard rolls per year, and the expected sales price is $2.00 per roll. Cash operating costs for the project (total operating costs less depreciation) are expected to total 60 percent of dollar sales. Unilate's marginal tax rate is 40 percent, and its required rate of return is ten percent. Tentatively, the silk/wool blend fabric project is assumed to be of equal risk to Unilate's other assets.

You have been asked to evaluate the project and to make a recommendation as to whether it should be accepted or rejected. To guide you in your analysis, your boss gave you the following set of tasks to complete:

a. Draw a cash flow time line that shows when the net cash inflows and outflows will occur, and explain how the time line can be used to help structure the analysis.

b. Unilate has a standard form that is used in the capital budgeting process; see Table IP9–1. Part of the table has been completed, but you must replace the blanks with the missing numbers. Complete the table in the following steps:

   (1) Complete the unit sales, sales price, total revenues, and operating costs excluding depreciation lines.

   (2) Complete the depreciation line.

   (3) Now complete the table down to net income and then down to net operating cash flows.

   (4) Now fill in the blanks under Year 0 and Year 4 for the initial investment outlay and the terminal cash flows and complete the cash flow time line (net CF). Discuss working capital. What would have happened if the machinery were sold for less than its book value?

c. (1) Unilate uses debt in its capital structure, so some of the money used to finance the project will be debt. Given this fact, should the projected cash flows be revised to show projected interest charges? Explain.
(2) Suppose you learned that Unilate had spent $50,000 to renovate the building last year, expensing these costs. Should this cost be reflected in the analysis? Explain.

(3) Now suppose you learned that Unilate could lease its building to another party and earn $25,000 per year. Should that fact be reflected in the analysis? If so, how?

(4) Now assume that the silk/wool blend fabric project would take away profitable sales from Unilate’s cotton/wool blend fabric business. Should that fact be reflected in your analysis? If so, how?

d. Disregard all the assumptions made in part c, and assume there was no alternative use for the building over the next four years. Now calculate the project’s NPV, IRR, and traditional payback. Do these indicators suggest that the project should be accepted?

e. If this project had been a replacement rather than an expansion project, how would the analysis have changed? No calculations are needed; just think about the changes that would have to occur in the cash flow table.

f. Assume that inflation is expected to average five percent over the next four years, that this expectation is reflected in the required rate of return, and that inflation will increase variable costs and revenues by the same relative amount of five percent. Does it appear that inflation has been dealt with properly in the analysis? If not, what should be done, and how would the required adjustment affect the decision?

Problem 9–12 contained the details of a new-project capital budgeting evaluation being conducted by Unilate Textiles. Although inflation was considered in the initial analysis, the riskiness of the project was not considered. The expected cash flows considering inflation as they were estimated in Problem 9–12 (in thousands of dollars) are given in Table IP9–2. Unilate’s required rate of return is ten percent.

You have been asked to answer the following questions:

a. (1) What are the three levels, or types, of project risk that are normally considered?
   (2) Which type is the most relevant?
   (3) Which type is the easiest to measure?
   (4) Are the three types of risk generally highly correlated?

b. (1) What is sensitivity analysis?
   (2) Discuss how one would perform a sensitivity analysis on the unit sales, salvage value, and required rate of return for the project. Assume that each of these variables deviates from its base-case, or expected, value by plus and minus 10, 20, and 30 percent. How would you calculate the NPV, IRR, and the payback for each case?
   (3) What is the primary weakness of sensitivity analysis? What are its primary advantages?

c. Assume that you are confident about the estimates of all the variables that affect the project’s cash flows except unit sales. If product acceptance is poor, sales would be only 75,000 units a year, while a strong consumer response would produce sales of 125,000 units. In either case, cash costs would still amount to 60 percent of revenues. You believe that there is a 25 percent chance of poor acceptance, a 25 percent chance of excellent acceptance, and a 50 percent chance of average acceptance (the base case).

(1) What is the worst-case NPV? The best-case NPV?
**Table IP9-1: Unilate's Silk/Wool Blend Project (thousands of dollars)**

<table>
<thead>
<tr>
<th>END OF YEAR</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit sales (thousands)</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price/unit</td>
<td>$2.00</td>
<td>$2.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total revenues</td>
<td></td>
<td></td>
<td>$200.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Costs excluding depreciation</td>
<td>$120.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depreciation</td>
<td></td>
<td></td>
<td>$36.0</td>
<td>16.8</td>
<td></td>
</tr>
<tr>
<td>Total operating costs</td>
<td>$199.2</td>
<td>$228.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earnings before taxes (EBT)</td>
<td></td>
<td></td>
<td>$44.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taxes</td>
<td>0.3</td>
<td></td>
<td></td>
<td></td>
<td>25.3</td>
</tr>
<tr>
<td>Net income</td>
<td></td>
<td></td>
<td></td>
<td>$26.4</td>
<td></td>
</tr>
<tr>
<td>Depreciation</td>
<td>79.2</td>
<td></td>
<td></td>
<td>36.0</td>
<td></td>
</tr>
<tr>
<td>Incremental operating CF</td>
<td>$79.7</td>
<td></td>
<td></td>
<td></td>
<td>$54.7</td>
</tr>
</tbody>
</table>

| Equipment cost |         |         |         |         |         |
| Installation |         |         |         |         |         |
| Increase in inventory |         |         |         |         |         |
| Increase in accounts payable |         |         |         |         |         |
| Salvage value |         |         |         |         |         |
| Tax on salvage value |         |         |         |         |         |
| Return of net working capital |         |         |         |         |         |
| Cash flow time line (Net CF) | $(260.0) |         |         |         | $89.7   |
| Cumulative CF for payback | (260.0) | (180.3) |         |         | 63.0    |

NPV =
IRR =
Payback =

(2) Use the worst-case, most likely (or base) case, and best-case NPVs and probabilities of occurrence to find the project's expected NPV, standard deviation (\( \sigma_{\text{NPV}} \)), and coefficient of variation (\( \text{CV}_{\text{NPV}} \)).

d. (1) Assume that Unilate's average project has a coefficient of variation (\( \text{CV}_{\text{NPV}} \)) in the range of 1.25 to 1.75. Would the silk/wool blend fabric project be classified as high risk, average risk, or low risk? What type of risk is being measured here?

(2) Based on common sense, how highly correlated do you think the project would be to the firm's other assets? (Give a correlation coefficient, or range of coefficients, based on your judgment.)

(3) How would this correlation coefficient and the previously calculated \( \sigma \) combine to affect the project's contribution to corporate, or within-firm, risk? Explain.

e. (1) Based on your judgment, what do you think the project's correlation coefficient would be with respect to the general economy and thus with returns on "the market"?
Table IPS-2

<table>
<thead>
<tr>
<th>Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment in:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed assets</td>
<td>$(240)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net working capital</td>
<td>(20)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit sales (thousands)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Sales price (dollars)</td>
<td>$2.100</td>
<td>$2.205</td>
<td>$2.315</td>
<td>$2.431</td>
<td></td>
</tr>
<tr>
<td>Total revenues</td>
<td>$210.0</td>
<td>$220.5</td>
<td>$231.5</td>
<td>$243.1</td>
<td></td>
</tr>
<tr>
<td>Cash operating costs (60%)</td>
<td>(126.0)</td>
<td>(132.3)</td>
<td>(138.9)</td>
<td>(145.9)</td>
<td></td>
</tr>
<tr>
<td>Depreciation</td>
<td>(79.2)</td>
<td>(108.0)</td>
<td>(36.0)</td>
<td>(16.8)</td>
<td></td>
</tr>
<tr>
<td>Earnings before taxes (EBT)</td>
<td>$4.8</td>
<td>$(19.8)</td>
<td>$36.6</td>
<td>$80.4</td>
<td></td>
</tr>
<tr>
<td>Taxes (40%)</td>
<td>(1.9)</td>
<td>7.9</td>
<td>(22.6)</td>
<td>(32.2)</td>
<td></td>
</tr>
<tr>
<td>Net income</td>
<td>$2.9</td>
<td>$(11.9)</td>
<td>$34.0</td>
<td>$48.2</td>
<td></td>
</tr>
<tr>
<td>Plus depreciation</td>
<td>79.2</td>
<td>108.0</td>
<td>36.0</td>
<td>16.8</td>
<td></td>
</tr>
<tr>
<td>Net operating cash flow</td>
<td>$82.1</td>
<td>$96.1</td>
<td>$70.0</td>
<td>$65.0</td>
<td></td>
</tr>
<tr>
<td>Salvage value</td>
<td>25.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tax on SV (40%)</td>
<td>(10.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recovery of NWC</td>
<td>20.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net cash flow</td>
<td>$(260)</td>
<td>$82.1</td>
<td>$96.1</td>
<td>$70.0</td>
<td>$100.0</td>
</tr>
<tr>
<td>Cumulative cash flow for payback:</td>
<td>(260.0)</td>
<td>(177.9)</td>
<td>(81.8)</td>
<td>(11.8)</td>
<td>88.2</td>
</tr>
</tbody>
</table>

NPV at 10% cost of capital = $15.0
IRR = 12.6%

(2) How would correlation with the economy affect the project's market risk?

f. (1) Unilaterally adds or subtracts three percentage points to the overall required rate of return to adjust for risk. Should the project be accepted?

(2) What subjective risk factors should be considered before the final decision is made?

g. Define scenario analysis and simulation analysis, and discuss their principal advantages and disadvantages. (Note that you have already done scenario analysis in part c.)

h. (1) Assume that the risk-free rate is ten percent, the market risk premium is six percent, and the new project's beta is 1.2. What is the project's required rate of return on equity based on the CAPM?

(2) How does the project's market risk compare with the firm's overall market risk?

(3) How does the project's stand-alone risk compare with that of the firm's average project?

(4) Briefly describe how you would estimate the project's beta. How feasible do you think that procedure actually would be in this case?

(5) What are the advantages and disadvantages of focusing on a project's market risk?
Computer-Related Problem

Work the problem in this section only if you are using the computer problem diskette.

9-14 Use the computerized model in the File C9 to work this problem. Golden State Bakers Inc. (GSB) has an opportunity to invest in a new dough machine. GSB needs more productive capacity, so the new machine will not replace an existing machine. The new machine costs $260,000 and will require modifications costing $15,000. It has an expected useful life of ten years, will be depreciated using the MACRS method over its five-year class life, and has an expected salvage value of $12,500 at the end of Year 10. (See Table 9A-2 for MACRS recovery allowances for percentages.) The machine will require a $22,500 investment in net working capital. It is expected to generate additional sales revenues of $125,000 per year. But its use will also increase annual cash operating expenses by $55,000. GSB's required rate of return on projects is ten percent and its marginal tax rate is forty percent. The machine's book value at the end of Year 10 will be zero, so GSB will have to pay taxes on the $12,500 salvage value.

a. What is the NPV of this expansion project? Should GSB purchase the new machine?

b. Should GSB purchase the new machine if it is expected to be used for only five years and then sold for $31,250? (Note that the model is set up to handle a five-year life; you need only enter the new life and salvage value.)

c. Would the machine be profitable if revenues increased by only $195,000 per year? Assume a ten-year project life and a salvage value of $12,500.

d. Suppose that revenues rose by $125,000 but that expenses rose by $65,000. Would the machine be acceptable under these conditions? Assume a ten-year project life and a salvage value of $12,500.

---

**Online Essentials**

- [http://cespl.psy.orl.gov/mc/mc.html](http://cespl.psy.orl.gov/mc/mc.html) : Computational Science Education Project

  This site provides an electronic book that includes an introduction to Monte Carlo simulation.

- [http://www.studyfinance.com](http://www.studyfinance.com) : studyfinance.com

  This site provides tutorials relating to capital budgeting, including how marginal cash flows are computed for replacement decisions.

- [http://www.teachmefinance.com](http://www.teachmefinance.com) : TeachMeFinance.com

  This site contains tutorials related to a number of the topics covered in this chapter, including capital budgeting, cash flows, probability distributions, and standard deviation.


  This site provides the U.S. Code that defines depreciable assets, depreciation rates, and so on. Publication 946 defines depreciation, describes the depreciation process, gives the MACRS rates, and so forth. You can get more information by using the search function, keying in the phrase "Modified Accelerated Cost Recovery System," and then looking at the various publications.
Suppose a firm buys a milling machine for $100,000 and uses it for five years, after which it is scrapped. The cost of the goods produced by the machine each year must include a charge for using machine and reducing its value, and this charge is called depreciation. In this appendix we review some of the depreciation concepts covered in your accounting course.

Companies often calculate depreciation one way when figuring taxes and another way when reporting income to investors: many use the straight line method for stockholder reporting (or "book" purposes), but they use the fastest rate permitted by law for tax purposes.

According to the straight line method used for stockholder reporting, you normally would take the cost of the asset, subtract its estimated salvage value, and divide the net amount by the asset's useful economic life. For an asset with a five-year life that costs $100,000 and has a $12,500 salvage value, the annual straight line depreciation charge is \((100,000 - 12,500)/5 = 17,500\). Note, however, as we discuss later in this appendix, that salvage value is not considered for tax depreciation purposes.

For tax purposes, Congress changes the permissible tax depreciation methods from time to time. Prior to 1954, the straight line method was required for tax purposes, but in 1954 accelerated methods (double declining balance and sum-of-years' digits) were permitted. Then, in 1981, the old accelerated methods were replaced by a simpler procedure known as the Accelerated Cost Recovery System (ACRS). The ACRS system was changed again in 1986 as a part of the Tax Reform Act, and it is now known as the Modified Accelerated Cost Recovery System (MACRS).

**Tax Depreciation Life** For tax purposes, the entire cost of an asset is expensed over its depreciable life. Historically, an asset's depreciable life was determined by its estimated useful economic life; it was intended that an asset would be fully depreciated at approximately the same time that it reached the end of its useful economic life. However, MACRS totally abandoned that practice and set simple guidelines that created several classes of assets, each with a more-or-less arbitrarily prescribed life called a recovery period or class life. The MACRS class life bears only a rough relationship to the expected useful economic life.

A major effect of the MACRS system has been to shorten the depreciable lives of assets, thus giving businesses larger tax deductions and thereby increasing their cash flows available for reinvestment. Table 9A-1 describes the types of property that fit into the different class life groups, and Table 9A-2 sets forth the MACRS recovery allowances (depreciation rates) for selected classes of investment property.

Consider Table 9A-1 first. The first column gives the MACRS class life, while the second column describes the types of assets that fall into each category. Property classified with lives equal to or greater than 27.5 years (real estate) must be depreciated by the straight line method, but assets classified in the other categories can be depreciated either by the accelerated method using rates shown in Table 9A-2 or by an alternate straight line method.

As we saw earlier in the chapter, higher depreciation expenses result in lower taxes, hence higher cash flows. Therefore, because a firm has the choice of using the alternate straight line rates or the accelerated rates shown in Table 9A-2, most elect to use...
five years, after each year must
gage is called de-
ps, covered in
is and another hod for stock-
mitted by law
you normally divide the net
life that costs
ation charge-er in this ap-
methods from purposes, but
-digits) were
simpler pro-
CII system
own as the
spensed over-
d by its esti-
epreciated at
e life. How-
that created
called a re-
ship to
ible lives of
their cash-
 that fit re-
ecovery al-
while the
erty clas-
cipreciated by
alternate
taxes, the al-

Table 9A-1  Major Classes and Asset Lives for MACRS

<table>
<thead>
<tr>
<th>CLASS</th>
<th>TYPE OF PROPERTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-year</td>
<td>Certain special manufacturing tools.</td>
</tr>
<tr>
<td>5-year</td>
<td>Automobiles, light-duty trucks, computers, and certain special manufacturing equipment.</td>
</tr>
<tr>
<td>7-year</td>
<td>Most industrial equipment, office furniture, and fixtures.</td>
</tr>
<tr>
<td>10-year</td>
<td>Certain longer-lived equipment, and many water vessels.</td>
</tr>
<tr>
<td>15-year</td>
<td>Certain land improvement, such as shrubbery, fences, and roads; service station buildings.</td>
</tr>
<tr>
<td>20-year</td>
<td>Farm buildings</td>
</tr>
<tr>
<td>27.5-year</td>
<td>Residential rental real property such as apartment buildings.</td>
</tr>
<tr>
<td>39-year</td>
<td>All nonresidential real property, including commercial and industrial buildings.</td>
</tr>
</tbody>
</table>

Table 9A-2  Recovery Allowance Percentages for Personal Property

<table>
<thead>
<tr>
<th>Ownership Year</th>
<th>3-Year</th>
<th>5-Year</th>
<th>7-Year</th>
<th>10-Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>33%</td>
<td>20%</td>
<td>14%</td>
<td>10%</td>
</tr>
<tr>
<td>2</td>
<td>45%</td>
<td>32%</td>
<td>25%</td>
<td>18%</td>
</tr>
<tr>
<td>3</td>
<td>15%</td>
<td>19%</td>
<td>17%</td>
<td>14%</td>
</tr>
<tr>
<td>4</td>
<td>7%</td>
<td>12%</td>
<td>13%</td>
<td>12%</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>11%</td>
<td>9%</td>
<td>9%</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>6%</td>
<td>9%</td>
<td>7%</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td>9%</td>
<td>7%</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>4%</td>
<td>7%</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td>7%</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td>6%</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

NOTE: These recovery allowance percentages were taken from the Internal Revenue Service Web site, which is http://www.irs.ustreas.gov. The percentages are based on the 200 percent declining balance method prescribed by MACRS, with a switch to straight line depreciation at some point in the asset's life. For example, consider the five-year recovery allowance percentages. The straight line percentage would be 20 percent per year, so the 200 percent declining balance multiplier is 2.0(20%) = 40% = 0.4. However, because the half-year convention applies, the MACRS percentage for Year 1 is 20 percent. For Year 2, 80 percent of the depreciable basis remains to be depreciated, so the recovery allowance percentage is 0.40(80%) = 32%, and so on. Although the tax tables carry the allowance percentages to two decimal places, we have rounded to the nearest whole number for ease of illustration.

the accelerated rates. The yearly recovery allowance, or depreciation expense, is determined by multiplying each asset's depreciable basis by the applicable recovery percentage shown in Table 9A-2. Calculations are discussed in the following sections.
Half-Year Convention  Under MACRS, the assumption generally is made that property is placed in service in the middle of the first year. Thus, for three-year class life property, the recovery period begins in the middle of the year the asset is placed in service and ends three years later. The effect of the half-year convention is to extend the recovery period one more year, so three-year class life property is depreciated over four calendar years, five-year property is depreciated over six calendar years, and so on. This convention is incorporated into Table 9A–2’s recovery allowance percentages.7

Depreciable Basis  The depreciable basis is a critical element of MACRS because each year’s allowance (depreciation expense) depends jointly on the asset’s depreciable basis and its MACRS class life. The depreciable basis under MACRS is equal to the purchase price of the asset plus any shipping and installation costs. The basis is not adjusted for salvage value.

Sale of a Depreciable Asset  If a depreciable asset is sold, the sale price (salvage value) minus the then-existing undepreciated book value is added to operating income and taxed at the firm’s marginal tax rate. For example, suppose a firm buys a five-year class life asset for $100,000 and sells it at the end of the fourth year for $25,000. The asset’s book value is equal to $100,000(0.11 + 0.06) = $17,000. Therefore, $25,000 − $17,000 = $8,000 is added to the firm’s operating income and is taxed.

Depreciation Illustration  Assume that Unilate Textiles buys a $150,000 machine that falls into the MACRS five-year class life asset and places it into service on March 15, 2000. Unilate must pay an additional $30,000 for delivery and installation. Salvage value is not considered, so the machine’s depreciable basis is $180,000. (Delivery and installation charges are included in the depreciable basis rather than expensed in the year incurred.) Each year’s recovery allowance (tax depreciation expense) is determined by multiplying the depreciable basis by the applicable recovery allowance percentage. Thus, the depreciation expense for 2000 is 0.20($180,000) = $36,000, and for 2001 it is 0.32($180,000) = $57,600. Similarly, the depreciation expense is $34,200 for 2002, $21,600 for 2003, $19,800 for 2004, and $10,800 for 2005. The total depreciation expense over the six-year recovery period is $180,000, which is equal to the depreciable basis of the machine.

As noted previously, most firms use straight line depreciation for stockholder reporting purposes but MACRS for tax purposes. For these firms, for capital budgeting, MACRS should be used because in capital budgeting, we are concerned with cash flows, not reported income.

Problem

depreciation effects 9A–1  Christina Manning, great granddaughter of the founder of Manning Tile Products and current president of the company, believes in simple, conservative

7The half-year convention also applies if the straight line alternative is used, with half of one year’s depreciation taken in the first year, a full year’s depreciation taken in each of the remaining years of the asset’s class life, and the remaining half-year depreciation taken in the year following the end of the class life. You should recognize that virtually all companies have computerized depreciation systems. Each asset’s depreciation pattern is programmed into the system at the time of its acquisition, and the computer aggregates the depreciation allowances for all assets when the accountants close the books and prepare the financial statements and tax returns.
is made that tree-year class set is placed in to extend the reciated over--
irs, and so on. percentages? 

because each reciable basis 1 to the par-
isis not ad-
orice (salvage ating income vs a five-year $25,000. The, $25,000 -
00 machine ce on March tion. Salvage Delivery and ensed in the : determined percentage. d for 2001 it 00 for 2002, secation ex-depreciable

holder ret- gest, cash flows,

is conservative

one year's de-
 3 years of the he end of the tion systems, if one use the books

accounting. In keeping with her philosophy, she has decreed that the company shall use alternative straight line depreciation, based on the MACRS class lives, for all newly acquired assets. Your boss, the financial vice presidents and the only nonfamily officer, has asked you to develop an exhibit that shows how much this policy costs the company in terms of market value. Ms. Manning is interested in increasing the value of the firm's stock because she fears a family stockholder revolt that might remove her from office. For your exhibit, assume that the company spends $100 million each year on new capital projects, that the projects have on average a ten-year class life, that the company has a nine percent cost of debt, and that its marginal tax rate is 34 percent. (Hint: Show how much the total NPV of the projects in an average year would increase if Manning used the standard MACRS recovery allowances.)

APPENDIX 9B

Comparing Projects with Unequal Lives

Two procedures used to compare capital projects with unequal lives are (1) the replacement chain (common life) method and (2) the equivalent annual annuity method. Suppose the company we followed throughout the chapter, HEP, is planning to modernize its production facilities; and, as a part of the process, it is considering either a conveyor system (Project C) or some forklift trucks (Project F) for moving materials from the parts department to the main assembly line. Both the expected net cash flows and the NPVs for these two mutually exclusive alternatives are shown in Figure 9B-1.

We see that Project C, when discounted at a 15 percent required rate of return, has the higher NPV and thus appears to be the better project, in spite of the fact that Project F has the higher IRR.

**Figure 9B-1** Expected Net Cash Flows for Project C and Project F

**PROJECT C:**

<table>
<thead>
<tr>
<th>0</th>
<th>$k = 15%$</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net $\Delta C$, $(40,000)$</td>
<td>13,000</td>
<td>8,000</td>
<td>14,000</td>
<td>12,000</td>
<td>11,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$NPV_C$ at 15% = $5,374$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$IRR_C = 19.7%$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PROJECT F:**

<table>
<thead>
<tr>
<th>0</th>
<th>$k = 15%$</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net $\Delta C$, $(20,000)$</td>
<td>7,000</td>
<td>13,000</td>
<td>12,000</td>
<td></td>
</tr>
<tr>
<td>$NPV_F$ at 15% = $3,807$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$IRR_F = 25.2%$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Replacement Chain (Common Life) Approach  Although the analysis in Figure 9B-1 suggests that Project C should be selected, this analysis is incomplete, and the decision to choose Project C actually is incorrect. If we choose Project F, we will have the opportunity to make a similar investment in three years, and if cost and revenue conditions continue at the Figure 9B-1 levels, this second investment will also be profitable. However, if we choose Project C, we will not have this second investment opportunity. Therefore, to make a proper comparison of Projects C and F, we could apply the replacement chain (common life) approach; that is, we could find the NPV of Project F over a six-year period and then compare this extended NPV with the NPV of Project C over the same six years.

The NPV for Project C as calculated in Figure 9B-1 is already over the six-year common life. For Project F, however, we must expand the analysis to include the replacement of F in Year 3, resulting in the following six-year cash flow time line:

<table>
<thead>
<tr>
<th>Year</th>
<th>Cash Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>(20,000)</td>
</tr>
<tr>
<td>1</td>
<td>7,000</td>
</tr>
<tr>
<td>2</td>
<td>12,000</td>
</tr>
<tr>
<td>3</td>
<td>(20,000)</td>
</tr>
<tr>
<td>4</td>
<td>7,000</td>
</tr>
<tr>
<td>5</td>
<td>13,000</td>
</tr>
<tr>
<td>6</td>
<td>12,000</td>
</tr>
</tbody>
</table>

Extended life NPV of Project F at 15% = $6,310.

Here we make the assumption that Project F's cost and annual cash inflows will not change if the project is repeated in three years, and that HEP's required rate of return will remain at 15 percent. Project F's extended NPV is $6,310. This is the value that should be compared with Project C's NPV, $5,374. Because Project F's "true" NPV is greater than that of Project C, Project F should be selected.

Equivalent Annual Annuity Approach  Although the preceding example illustrates why an extended analysis is necessary if we are comparing mutually exclusive projects with different lives, the arithmetic is generally more complex in practice. For example, one project might have a six-year life versus a ten-year life for the other. This would require a replacement chain analysis over 30 years, the lowest common denominator of the two lives. In such a situation, it is often simpler to use a second procedure, the equivalent annual annuity (EAA) method, which involves three steps:

1. Find each project's NPV over its initial life. In Figure 9B-1, we found NPV_C = $5,374 and NPV_F = $3,807.
2. Find the constant annuity cash flow (the equivalent annual annuity [EAA]) that has the same present value as each project's NPV. For Project F, here is the time line:

---

We also could set up Project F's extended time line as follows:

1. The Stage 1 NPV is $3,807.
2. The Stage 2 NPV is also $3,807, but this value will not accrue until Year 3, so its value today, discounted at 15 percent, is $2,503.
3. The extended life NPV is thus $3,807 + $2,503 = $6,310.
To find the value of EAA, with a financial calculator, enter $-3,807$ as the PV,  
$I = k = 15$, and $N = 3$, and solve for PMT. The answer, $1,667$, represents the  
cash flow stream, which, when discounted back three years at 15 percent, has a  
present value equal to Project F's original NPV of $3,807$. The payment figure  
we found, $1,667$, is called the project's "equivalent annual annuity (EAA)." The  
EAA for Project C was found similarly to be $1,420$. Thus, Project C has an  
NPV that is equivalent to an annuity of $1,420$ per year, while Project F's NPV  
is equivalent to an annuity of $1,667$.

3. Assuming that continuous replacements can and will be made each time a  
project's life ends, these EAA's will continue on out to infinity; that is, they will  
constitute perpetuities. Recognizing that the value of a perpetuity is $V = PMT/k$,  
we can find the net present values of the infinite EAA's of Projects C and F as  
follows:

\[
\text{Infinite horizon NPV}_C = \frac{1,420}{0.15} = \$9,467.
\]

\[
\text{Infinite horizon NPV}_F = \frac{1,667}{0.15} = \$11,113.
\]

In effect, the EAA method assumes that each project, if taken on, will be replaced  
each time it wears out and will provide cash flows equivalent to the calculated annuity  
value. The PV of this infinite annuity is then the infinite horizon NPV for the project.  
Because the infinite horizon NPV of F exceeds that of C, Project F should be  
accepted. Therefore, the EAA method leads to the same decision rule as the replacement  
chain method—accept Project F.

The EAA method often is easier to apply than the replacement chain method, but  
the replacement chain method is easier to explain to decision makers. Still, the two  
methods always lead to the same decision if consistent assumptions are used. Also, note  
that Step 3 of the EAA method is not really necessary—we could have stopped after  
Step 2 because the project with the higher EAA will always have the higher NPV over  
any common life if the same required rate of return is used for the projects.

When should we worry about unequal life analysis? As a general rule, the unequal  
life issue (1) does not arise for independent projects, but (2) can arise if mutually  
exclusive projects with significantly different lives are being evaluated. However, even for  
mutually exclusive projects, it is not always appropriate to extend the analysis to a  
common life. This should only be done if there is a high probability that the projects will  
actually be replicated beyond their initial lives.

We should note several potentially serious weaknesses inherent in this type of  
unequal life analysis: (1) If inflation is expected, then replacement equipment will have a  
higher price, and both sales prices and operating costs will probably change. Thus, the  
static conditions built into the analysis would be invalid. (2) Replacements that occur  
down the road would probably employ new technology, which in turn might change  
the cash flows. This factor is not built into either replacement chain analysis or the
EAA approach. (3) It is difficult enough to estimate the lives of most projects, so estimating the lives of a series of projects is often just a speculation. (4) If reasonably strong competition is present, the profitability of projects will be eroded over time, and that would reduce the need to extend the analysis beyond the projects’ initial lives.

In view of these problems, no experienced financial analyst would be too concerned about comparing mutually exclusive projects with lives of, say, eight years and ten years. Given all the uncertainties in the estimation process, such projects, for all practical purposes, would be assumed to have the same life. Still, it is important to recognize that a problem does exist if mutually exclusive projects have substantially different lives. When we encounter such problems in practice, we build expected inflation or possible efficiency gains directly into the cash flow estimates and then use the replacement chain approach (but not the equivalent annuity method). The cash flow estimation is more complicated, but the concepts involved are exactly the same as in our example.

Problems

unequal lives 9B-1 Keenan Clothes Inc. is considering the replacement of its old, fully depreciated knitting machine. Two new models are available: Machine 190-3, which has a cost of $190,000, a three-year expected life, and after-tax cash flows (labor savings and depreciation) of $87,000 per year; and Machine 360-6, which has a cost of $360,000, a six-year life, and after-tax cash flows of $98,306 per year. Knitting machine prices are not expected to rise because inflation will be offset by cheaper components (microprocessors) used in the machines. Assume that required rate of return appropriate for evaluating the machines is 14 percent.

a. Should the firm replace its old knitting machine, and, if so, which new machine should it use?

b. Suppose the firm’s basic patents will expire in nine years, and the company expects to go out of business at that time. Assume further that the firm depreciates its assets using the straight line method, that its marginal tax rate is 40 percent, and that the used machines can be sold at their book values. Under these circumstances, should the company replace the old machine? Explain.

unequal lives 9B-2 Zappe Airlines is considering two alternative planes. Plane A has an expected life of five years, will cost $100, and will produce net cash flows of $30 per year. Plane B has a life of ten years, will cost $132, and will produce net cash flows of $25 per year. Zappe plans to serve the route for ten years. Inflation in operating costs, airplane costs, and fares is expected to be zero, and the company’s required rate of return is 12 percent. By how much would the value of the company increase if it accepted the better project (plane)? Assume all costs and cash flows are in millions of dollars.