CHAPTER 12
Cash Flow Estimation
and Risk Analysis

SOURCE: Andre Jenny/Unicorn Stock Photos
Home Depot Inc. has grown phenomenally over the past decade, and it shows no sign of slowing down. At the beginning of 1990, it had 118 stores, and its annual sales were $2.8 billion. By early 2001, it had more than 1,000 stores, and its annual sales were in excess of $45 billion. Despite concerns of a slowing economy, the company expects to open another 200 stores in fiscal 2001.

Home Depot recently estimated that it costs, on average, $16 million to purchase land, construct a new store, and stock it with inventory. (The inventory costs about $5 million, but about $2 million of this is financed through accounts payable.) Each new store thus represents a major capital expenditure, so the company must use capital budgeting techniques to determine if a potential store’s expected cash flows are sufficient to cover its costs.

Home Depot uses information from its existing stores to forecast new stores’ expected cash flows. Thus far, its forecasts have been outstanding, but there are always risks that must be considered. First, store sales might be less than projected if the economy weakens. Second, some of Home Depot’s customers might in the future bypass it altogether and buy directly from manufacturers through the Internet. Third, new stores could “cannibalize,” that is, take sales away from, existing stores. This last point was made in the July 16, 1999, issue of Value Line:

The retailer has picked the “low-hanging fruit;” it has already entered the most attractive markets. To avoid “cannibalization” — which occurs when duplicative stores are located too closely together — the company is developing complementary formats. For example, Home Depot is beginning to roll out its Expo Design Center chain, which offers one-stop sales and service for kitchen and bath and other remodeling and renovation work . . .

The decision to expand requires a detailed assessment of the forecasted cash flows, including the risk that the forecasted level of sales might not be realized. In this chapter, we describe techniques for estimating a project’s cash flows and their associated risk. Companies such as Home Depot use these techniques on a regular basis to evaluate capital budgeting decisions.
CHAPTER 12

I

CASH FLOW ESTIMATION AND RISK ANALYSIS

The basic principles of capital budgeting were covered in Chapter 11. Given a project’s expected cash flows, it is easy to calculate its payback, discounted payback, NPV, IRR, and MIRR. Unfortunately, cash flows are rarely just given — rather, managers must estimate them based on information collected from sources both inside and outside the company. Moreover, uncertainty surrounds the cash flow estimates, and some projects are riskier than others. In this chapter, we first develop procedures for estimating cash flows associated with capital budgeting projects. Then, we discuss techniques used to measure and take account of project risk. Finally, we introduce the concept of real options and discuss some general principles for determining the optimal capital budget.

ESTIMATING CASH FLOWS

The most important, but also the most difficult, step in capital budgeting is estimating projects’ cash flows — the investment outlays and the annual net cash inflows after a project goes into operation. Many variables are involved, and many individuals and departments participate in the process. For example, the forecasts of unit sales and sales prices are normally made by the marketing group, based on their knowledge of price elasticity, advertising effects, the state of the economy, competitors’ reactions, and trends in consumers’ tastes. Similarly, the capital outlays associated with a new product are generally obtained from the engineering and product development staffs, while operating costs are estimated by cost accountants, production experts, personnel specialists, purchasing agents, and so forth.

It is difficult to accurately forecast the costs and revenues associated with a large, complex project, so forecast errors can be quite large. For example, 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 $7 billion. Similar (or even worse) miscalculations are common in forecasts of product design costs, such as the costs to develop a new personal computer. Further, as difficult as plant and equipment costs are to estimate, sales revenues and operating costs over the project’s life 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, NPV, but it incorrectly estimated the project’s cash flows: Projected revenues were too high, projected costs were too low, and 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. Because of its financial strength, Federal Express was able to absorb losses on the project, but the Zap-Mail venture could have forced a weaker firm into bankruptcy.

The financial staff’s role in the forecasting process includes (1) obtaining information from various 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 managers often become emotionally involved with pet projects and also develop empire-building complexes, both of which lead to cash flow forecasting biases that make bad projects look good — on paper.

It is almost impossible to overstate the problems one can encounter in cash flow forecasts. It is also difficult to overstate the importance of these forecasts. Still, observing the principles discussed in the next several sections will help minimize forecasting errors.

**SELF-TEST QUESTIONS**

What is the most important step in a capital budgeting analysis?
What departments are involved in estimating a project’s cash flows?
What is the financial staff’s role in the forecasting process for capital projects?

**IDENTIFYING THE RELEVANT CASH FLOWS**

The starting point in any capital budgeting analysis is identifying the relevant cash flows, defined as the specific set of cash flows that should be considered in the decision at hand. Analysts often make errors in estimating cash flows, but two cardinal rules can help you avoid mistakes: (1) Capital budgeting decisions must be based on cash flows, not accounting income. (2) Only incremental cash flows are relevant.

Recall from Chapter 2 that free cash flow is the cash flow available for distribution to investors. In a nutshell, the relevant cash flow for a project is the additional free cash flow that the company expects if it implements the project, that is, the cash flow above and beyond what the company could expect if it doesn’t implement the project. The following sections discuss the relevant cash flows in more detail.

**PROJECT CASH FLOW versus ACCOUNTING INCOME**

Recall that free cash flow is calculated as follows:

\[
\text{Free cash flow} = \text{After-tax operating income} + \text{Depreciation} - \text{Capital expenditures} - \text{Change in net operating working capital}
\]

\[
= \text{EBIT}(1-T) + \text{Depreciation} - \text{Capital expenditures} - \left[ \Delta \text{Current assets} - \Delta \text{Spontaneous liabilities} \right].
\]
Just as a firm’s value depends on its free cash flows, the value of a project depends on its free cash flow. We illustrate the estimation of project cash flow later in the chapter with a comprehensive example, but it is important for you to understand that project cash flow differs from accounting income.

**Costs of Fixed Assets**

Most projects require assets, and asset purchases represent negative cash flows. Even though the acquisition of assets results in a cash outflow, accountants do not show the purchase of fixed assets as a deduction from accounting income. Instead, they deduct a depreciation expense each year throughout the life of the asset.

Note that the full costs of fixed assets include any 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 price of the equipment when the project’s cost is being determined. Then, the full cost of the equipment, including shipping and installation costs, is used as the depreciable basis when depreciation charges are being calculated. For example, if a company bought a computer with an invoice price of $100,000 and another $10,000 for shipping and installation, then the full cost of the computer (and its depreciable basis) would be $110,000. Note too that fixed assets can often be sold at the end of a project’s life. If this is the case, then the after-tax cash proceeds represent a positive cash flow. We will illustrate both depreciation and cash flow from asset sales later in the chapter.

**Noncash Charges**

In calculating net income, accountants usually subtract depreciation from revenues. So, while accountants do not subtract the purchase price of fixed assets when calculating accounting income, they do subtract a charge each year for depreciation. Depreciation shelters income from taxation, and this has an impact on cash flow, but depreciation itself is not a cash flow. Therefore, depreciation must be added to net income when estimating a project’s cash flow.

**Changes in Net Operating Working Capital**

Normally, additional inventories are required to support a new operation, and expanded sales tie additional funds up in accounts receivable. However, payables and accruals increase spontaneously as a result of the expansion, and this reduces the 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 operating working capital. If this change is positive, as it generally is for expansion projects, then additional financing, over and above the cost of the fixed assets, will be needed.

Toward the end of a project’s life, inventories will be used but not replaced, and receivables will be collected without corresponding replacements. As these changes occur, the firm will receive cash inflows. As a result, the investment in operating working capital will be returned by the end of the project’s life.
**Interest Expenses Are Not Included in Project Cash Flows**

Recall from Chapter 11 that we discount a project's cash flows by its cost of capital, and that the cost of capital is a weighted average of the costs of debt, preferred stock, and common equity (WACC), adjusted for the project's risk. Moreover, the WACC is the rate of return necessary to satisfy all of the firm's investors—debtholders and stockholders. The discounting process reduces the cash flows to account for the project's capital costs. If interest charges were first deducted and then the resulting cash flows were discounted, this would double count the cost of debt. Therefore, you should not subtract interest expenses when finding a project’s cash flows.

Note that this differs from the procedures used to calculate accounting income. Accountants measure the profit available for stockholders, so interest expenses are subtracted. However, project cash flow is the cash flow available for all investors, bondholders as well as stockholders, so interest expenses are not subtracted. All this is analogous to the procedures used in the corporate valuation model of Chapter 9, where the company’s free cash flows are discounted at the WACC.1

**Incremental Cash Flows**

In evaluating a project, we focus on those cash flows that occur if and only if we accept the project. These cash flows, called incremental cash flows, represent the change in the firm’s total cash flow that occurs as a direct result of accepting the project. Three special problems in determining incremental cash flows are discussed next.

**Sunk Costs**

A sunk cost is an outlay that has already occurred, hence is not affected by the decision under consideration. Since sunk costs are not incremental costs, they should not be included in the analysis. To illustrate, in 2001, Northeast BankCorp was considering the establishment of a branch office in a newly developed section of Boston. To help with its evaluation, Northeast had, back in 2000, hired a consulting firm to perform a site analysis; the cost was $100,000, and this amount was expensed for tax purposes in 2000. Is this 2000 expenditure a relevant cost with respect to the 2001 capital budgeting decision? The answer is no—the $100,000 is a sunk cost, and it will not affect Northeast’s future cash flows regardless of whether or not the new branch is built. It often turns out that a particular project has a negative NPV when all the associated costs, including sunk costs, are considered. However, on an incremental basis,

1 An alternative approach to capital budgeting is to estimate the cash flows that are available for equity holders. Although this produces the same NPV as our approach, we do not recommend it because to apply it correctly requires that we determine the amount of debt and equity for every year of the project's life.
the project may be a good one because the incremental cash flows are large enough to produce a positive NPV on the incremental investment.

**Opportunity Costs**

A second potential problem relates to opportunity costs, which are cash flows that could be generated from an asset the firm already owns provided it is not used for the project in question. To illustrate, Northeast BankCorp already owns a piece of land that is suitable for the branch location. When evaluating the prospective branch, 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 branch 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 Northeast originally paid $50,000 or $500,000 for the property. (What Northeast paid would, of course, have an effect on taxes, hence on the after-tax opportunity cost.)

**Effects on Other Parts of the Firm: Externalities**

The third potential problem involves the effects of a project on other parts of the firm, which economists call externalities. For example, some of Northeast’s customers who would use the new branch are already banking with Northeast’s downtown office. The loans and deposits, hence profits, generated by these customers would not be new to the bank; rather, they would represent a transfer from the main office to the branch. Thus, the net income produced by these customers should not be treated as incremental income in the capital budgeting decision. On the other hand, having a suburban branch would help the bank attract new business to its downtown office, because some people like to be able to bank both close to home and close to work. In this case, the additional income that would actually flow to the downtown office should be attributed to the branch. Although they are often difficult to quantify, externalities (which can be either positive or negative) should be considered.

When a new project takes sales from an existing product, this is often called cannibalization. Naturally, firms do not like to cannibalize their existing products, but it often turns out that if they do not, someone else will. To illustrate, IBM for years refused to provide full support for its PC division because it did not want to steal sales from its highly profitable mainframe business. That turned out to be a huge strategic error, because it allowed Intel, Microsoft, Compaq, and others to become dominant forces in the computer industry. Therefore, when considering externalities, the full implications of the proposed new project should be taken into account.

**Timing of Cash Flow**

We must account properly for the timing of cash flows. Accounting income statements are for periods such as years or months, so they do not reflect exactly when during the period cash revenues or expenses occur. Because of the time...
value of money, capital budgeting cash flows should in theory be analyzed ex-
actly as they occur. Of course, there must be a compromise between accuracy
and feasibility. A time line with daily cash flows would in theory be most accu-
rate, but daily cash flow estimates would be costly to construct, unwieldy to use,
and probably no more accurate than annual cash flow estimates because we
simply cannot forecast well enough to warrant this degree of detail. Therefore,
in most cases, we simply assume that all cash flows occur at the end of every
year. However, for some projects, it may be useful to assume that cash flows
occur at mid-year, or even quarterly or monthly.

**SELF-TEST QUESTIONS**

Why should companies use project cash flow rather than accounting income
when finding the NPV of a project?

How do shipping and installation costs affect the costs of fixed assets and
the depreciable basis?

What is the most common noncash charge that must be added back when
finding project cash flows?

What is net operating working capital, and how does it affect projects’ costs
in capital budgeting?

How does the company get back the dollars it invests in net operating work-
ing capital?

Explain the following terms: incremental cash flow, sunk cost, opportunity
cost, externality, and cannibalization.

Give an example of a “good” externality, that is, one that makes a project
look better.

**EVALUATING CAPITAL BUDGETING PROJECTS**

Up until this point, we have discussed several important aspects of cash flow
analysis, but we have not seen how they affect capital budgeting decisions.
Conceptually, these decisions are straightforward: A potential project creates
value for the firm’s shareholders if and only if the net present value of the in-
cremental cash flows from the project is positive. In practice, however, estimat-
ing these cash flows can be difficult.

Incremental cash flows are affected by whether the project is a new expan-
sion project or a replacement project. A new expansion project is defined as
one where the firm invests in new assets to increase sales. Here the incremen-
tal cash flows are simply the project’s cash inflows and outflows. In effect, the
company is comparing what its value looks like with and without the proposed
project. By contrast, a replacement project occurs when the firm replaces an
existing asset with a new one. In this case, the incremental cash flows are the
firm’s additional inflows and outflows that result from investing in the new asset.
In a replacement analysis, the company is comparing its value if it acquires the new asset to its value if it continues to use the existing asset.2

Despite these differences, the basic principles for evaluating expansion and replacement projects are the same. In each case, the cash flows typically include the following items:

1. **Initial investment outlay.** The initial investment includes the up-front cost of fixed assets associated with the project plus any increases in net operating working capital.

2. **Operating cash flows over the project’s life.** These are the incremental cash inflows over the project’s economic life. Annual operating cash flows equal after-tax operating income plus depreciation. Recall (a) that depreciation is added back because it is a noncash expense and (b) that financing costs (including interest expense) are not included because they are accounted for in the discounting process.

3. **Terminal year cash flows.** At the end of a project’s life, some extra cash flows are frequently received. These include the salvage value of the fixed assets, adjusted for taxes if assets are not sold at their book value, plus the return of the net operating working capital.

For each year of the project’s life, the net cash flow is determined as the sum of the cash flows from each of the three categories. These annual net cash flows are then plotted on a time line and used to calculate the project’s NPV and IRR.

We will illustrate the principles of capital budgeting analysis by examining a new project being considered by Brandt-Quigley Corporation (BQC), a large Atlanta-based technology company. BQC’s research and development department has been applying its expertise in microprocessor technology to develop a small computer designed to control home appliances. Once programmed, the computer will automatically control the heating and air-conditioning systems, security system, hot water heater, and even small appliances such as a coffee maker. By increasing a home’s energy efficiency, the computer can cut costs enough to pay for itself within a few years. Developments have now reached the stage where a decision must be made about whether or not to go forward with full-scale production.

BQC’s marketing vice-president believes that annual sales would be 20,000 units if the units were priced at $3,000 each, so annual sales are estimated at $60 million. The engineering department has reported that the firm would need additional manufacturing capability, and BQC currently has an option to purchase an existing building, at a cost of $12 million, which would meet this need. The building would be bought and paid for on December 31, 2002, and for depreciation purposes it would fall into the MACRS 39-year class.

The necessary equipment would be purchased and installed late in 2002, and it would also be paid for on December 31, 2002. The equipment would fall into the MACRS 5-year class, and it would cost $8 million, including transportation.

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and installation. Moreover, the project would also require an initial investment of $6 million in net operating working capital, which would also be made on December 31, 2002.

The project's estimated economic life is four years. At the end of that time, the building is expected to have a market value of $7.5 million and a book value of $10.908 million, whereas the equipment would have a market value of $2 million and a book value of $1.36 million.

The production department has estimated that variable manufacturing costs would be $2,100 per unit, and that fixed overhead costs, excluding depreciation, would be $8 million a year. Depreciation expenses would be determined in accordance with the MACRS rates (which are discussed in Appendix 12A). BQC's marginal federal-plus-state tax rate is 40 percent; its cost of capital is 12 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 the plant would begin operations on January 1, 2003, the first operating cash flows would occur on December 31, 2003.

Several other points should be noted: (1) BQC is a relatively large corporation, with sales of more than $4 billion, and it takes on many investments each year. Thus, if the computer control project does not work out, it will not bankrupt the company — management can afford to take a chance on the computer control project. (2) If the project is accepted, the company will be contractually obligated to operate it for its full four-year life. Management must make this commitment to its component suppliers. (3) Returns on this project would be positively correlated with returns on BQC's other projects and also with the stock market — the project should do well if other parts of the firm and the general economy are strong.

Assume that you are one of the company's financial analysts, and you must conduct the capital budgeting analysis. For now, assume that the project has the same risk as an average project, and use the corporate weighted average cost of capital, 12 percent.

**Analysis of the Cash Flows**

Capital projects can be analyzed using a calculator, paper, and a pencil, or with a spreadsheet program such as Excel. Either way, you must set the analysis up as shown in Table 12-1 and go through the steps outlined in Parts 1 through 5 of the table. For exam purposes, you will probably have to work problems with a calculator. However, for reasons that will become obvious as you go through the chapter, in practice spreadsheets are virtually always used. Still, the steps involved in a capital budgeting analysis are the same regardless of whether you use a calculator or a computer to “get the answer.”

Table 12-1, which is a printout from the CD-ROM file 12MODEL.xls, is divided into five parts: (1) Input Data, (2) Depreciation Schedule, (3) Net Salvage Values, (4) Projected Net Cash Flows, and (5) Key Output. There are also two extensions, Parts 6 and 7, that deal with risk analysis, which we will discuss later in the chapter when we cover sensitivity and scenario analyses. Note also that the table shows row and column indicators, so cells in the table have designations such as “Cell D33,” which is the location of the cost of the building, found in Part 1, Input Data. If we deleted the row and column
Chapter 12: Cash Flow Estimation and Risk Analysis

Table 12-1: Analysis of a New (Expansion) Project

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
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<td>30</td>
<td>Table 12-1: Analysis of a New (Expansion) Project</td>
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<td>31</td>
<td>Part 1. Input Data (in thousands of dollars)</td>
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<td>32</td>
<td>Building cost (= Depreciable basis)</td>
<td>$12,000</td>
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<tr>
<td>33</td>
<td>Equipment cost (= Depreciable basis)</td>
<td>$8,000</td>
<td>Market value of building in 2006</td>
<td>$7,500</td>
<td></td>
<td></td>
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<tr>
<td>34</td>
<td>Net Operating WC</td>
<td>$6,000</td>
<td>Market value of equip. in 2006</td>
<td>$2,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>35</td>
<td>First year sales (in units)</td>
<td>20,000</td>
<td>Tax rate</td>
<td>40%</td>
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<tr>
<td>36</td>
<td>Growth rate in units sold</td>
<td>0.0%</td>
<td>WACC</td>
<td>12%</td>
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<tr>
<td>37</td>
<td>Sales price per unit</td>
<td>$3.00</td>
<td>Inflation: growth in sales price</td>
<td>0.0%</td>
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<td></td>
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<tr>
<td>38</td>
<td>Variable cost per unit</td>
<td>$2.10</td>
<td>Inflation: growth in VC per unit</td>
<td>0.0%</td>
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<tr>
<td>39</td>
<td>Fixed costs</td>
<td>$8,000</td>
<td>Inflation: growth in fixed costs</td>
<td>0.0%</td>
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<td>40</td>
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<td>41</td>
<td>Table 12-1: Analysis of a New (Expansion) Project</td>
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<tr>
<td>42</td>
<td>Part 2. Depreciation Schedule</td>
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<td>43</td>
<td></td>
<td>Years</td>
<td>Cumulative Depr’n</td>
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<tr>
<td>44</td>
<td>Building Dep’r Rate</td>
<td>1.3%</td>
<td>2.6%</td>
<td>2.6%</td>
<td>2.6%</td>
<td>$1,092</td>
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<td></td>
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<tr>
<td>45</td>
<td>Building Dep’r’n</td>
<td>$156</td>
<td>$312</td>
<td>$312</td>
<td>$312</td>
<td>$1,092</td>
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</tr>
<tr>
<td>48</td>
<td>Equipment Dep’r Rate</td>
<td>20.0%</td>
<td>32.0%</td>
<td>19.0%</td>
<td>12.0%</td>
<td>$6,640</td>
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</tr>
<tr>
<td>49</td>
<td>Equipment Dep’r’n</td>
<td>$1,600</td>
<td>$2,560</td>
<td>$1,520</td>
<td>$960</td>
<td>$6,640</td>
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</tr>
<tr>
<td>50</td>
<td>Ending Book Val: Cost - Cum. Depr’n</td>
<td>6,400</td>
<td>3,840</td>
<td>2,320</td>
<td>$1,360</td>
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<td>51</td>
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<tr>
<td>52</td>
<td>*The indicated percentages are multiplied by the depreciable basis ($12,000 for the building and $8,000 for the equipment)</td>
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<tr>
<td>53</td>
<td>to determine the depreciation expense for the year. See Appendix 12A for a review of MACRS depreciation rates.</td>
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</table>

Indicators, the table would look exactly like the setup for pencil-and-paper calculations.¹ Note also that the first row shown is Row 29; the first 28 rows contain information about the model that we omitted from the text.

Part 1, the Input Data section, provides the basic data used in the analysis. The inputs are really “assumptions”—thus, in the analysis we assume that 20,000 units can be sold at a price of $3 per unit.² Some of the inputs are known with near certainty—for example, the 40 percent tax rate is not likely to change. Others are more speculative—units sold and the variable cost percentage are in this category. Obviously, if sales or costs are different from the assumed levels, then profits and cash flows, hence NPV and IRR, will differ from their projected levels. Later in the chapter, we discuss how changes in the inputs affect the results.

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¹ We first set up Table 12-1 as a “regular” table and did all the calculations with a calculator. We then typed all the labels into a spreadsheet and used the spreadsheet to do the calculations. The “answers” derived were identical. We show the spreadsheet version in Table 12-1, but the only visible difference is that it shows row and column indicators. If you have access to a computer, you might want to look at the model, which is on a file named 12MODEL.xls on the CD-ROM that accompanies this book.

² Recall that the sales price is actually $3,000, but for convenience we show all dollars in thousands.
Part 2, which calculates depreciation over the project’s four-year life, is divided into two sections, one for the building and one for the equipment. The first row in each section gives the yearly depreciation rates as taken from Appendix 12A. The second row in each section gives the dollars of depreciation, found as the rate times the asset's depreciable basis, which, in this example, is the initial cost. The third row shows the book value at the end of Year 4, found by subtracting the accumulated depreciation from the depreciable basis.

Part 3 estimates the cash flows the firm will realize when it disposes of the assets. The first row shows the salvage value, which is the sales price the company expects to receive when it sells the assets four years hence. The second row shows the book values at the end of Year 4; these values were calculated in Part 2. The third row shows the expected gain or loss, defined as the difference between the sales price and the book value. As explained in notes c and d to Table 12-1, gains and losses are treated as ordinary income, not capital gains or losses. Therefore, gains result in tax liabilities, and losses produce tax liabilities.

Note again that if an asset is sold for exactly its book value, there will be no gain or loss, hence no tax liability or credit. However, if an asset is sold for other than its book value, a gain or loss will be created. For example, BQC’s building will have a book value of $10,908, but the company only expects to realize $7,500 when it is sold. This would result in a loss of $3,408. This indicates that the building should have been depreciated at a faster rate — only if depreciation had been $3,408 larger would the book and market values have been equal. So, the Tax Code stipulates that losses on the sale of operating assets can be used to reduce ordinary income, just as depreciation reduces income. On the other hand, if an asset is sold for more than its book value, as is the case for the equipment, then this signifies that the depreciation rates were too high, so the gain is called “depreciation recapture” by the IRS and is taxed as ordinary income.
TABLE 12-1  Analysis of a New (Expansion) Project  
Part 4

| Credits, that are equal to the gain or loss times the 40 percent tax rate. Taxes paid and tax credits are shown on the fourth row. The fifth row shows the after-tax cash flow the company expects when it disposes of the asset, found as the expected sales price minus the tax liability or plus the credit. Thus, the firm expects to net $8,863 from the sale of the building and $1,744 from the equipment, for a total of $10,607.

Next, in Part 4, we use the information developed in Parts 1, 2, and 3 to find the projected cash flows over the project's life. Five periods are shown, from Year 0 (2002) to Year 4 (2006). The cash outlays required at Year 0 are the negative numbers in the first column, and their sum, —$26,000, is shown at the bottom. Then, in the next four columns, we calculate the operating cash flows. We begin with sales revenues, found as the product of units sold and the sales price.
EVALUATING CAPITAL BUDGETING PROJECTS

Next, we subtract variable costs, which were assumed to be $2.10 per unit. We then deduct fixed operating costs and depreciation to obtain taxable operating income, or EBIT. When taxes (at a 40 percent rate) are subtracted, we are left with net operating profit after taxes, or NOPAT. Note, though, that we are seeking cash flows, not accounting income. Sales are presumably for cash (or else receivables are collected promptly), and both taxes and all costs other than depreciation must be paid in cash. Therefore, each item in the “Operating Cash Flow” section of Part 4 represents cash except depreciation, which is a noncash charge. Thus, depreciation must be added back to obtain the project’s cash flows from operations. The result is the row of operating cash flows shown toward the bottom of Part 4, on Row 96.

When the project’s life ends, the company will receive the “Terminal Year Cash Flows” as shown in the column for Year 4 in the lower part of the table, on rows 98, 99, and 100. First, note that BQC invested $6,000 in net operating working capital—inventories plus accounts receivable—at Year 0.

---

Notice that in Part 1, Input Data, we show a growth rate in unit sales, and inflation rates for the sales price, variable costs, and fixed costs. BQC anticipates that unit sales, the sales price, and costs will be stable over the project’s life; hence, these variables are all set at zero. However, nonzero values can be inserted in the input section to determine the effects of growth and inflation. Incidentally, the inflation figures are all specific for this particular project—they do not reflect inflation as measured by the CPI. The expected CPI inflation is reflected in the WACC, and it is not expected to change over the forecast period.
INTRODUCTION TO PROJECT RISK ANALYSIS

Up to now we have simply assumed that projects will produce a given set of cash flows, and we then analyzed those cash flows to decide whether to accept or reject the project. Obviously, though, cash flows are not known with certainty. We now turn to risk in capital budgeting, examining the techniques firms use to determine a project’s risk and then to decide whether its profit potential is worth the risk.

Recall from Chapter 10 that there are three distinct types of risk: stand-alone risk, corporate risk, and market risk. Given that the firm’s primary objective is to maximize stockholder value, what ultimately matters is the risk that a project imposes on stockholders. Because stockholders are generally diversified, market risk is theoretically the most relevant measure of risk. Corporate risk is also important for these three reasons:

MAKING THE DECISION

Part 5 of the table shows the standard evaluation criteria — NPV, IRR, MIRR, and payback — based on the cash flows shown on Row 102. The NPV is positive; the IRR and MIRR both exceed the 12 percent cost of capital, and the payback indicates that the project will return the invested funds in 3.23 years. Therefore, on the basis of the analysis thus far, it appears that the project should be accepted. Note, though, that we have been assuming that the project is about as risky as the company’s average project. If the project were judged to be riskier than average, it would be necessary to increase the cost of capital, which might cause the NPV to become negative and the IRR and MIRR to drop below the then-higher WACC. Therefore, we cannot make a final “go, no-go” decision until we evaluate the project’s risk, the topic of the next section.

SELF-TEST QUESTIONS

What three types of cash flows must be considered when evaluating a proposed project?

Define the following terms: new expansion project and replacement project.

INTRODUCTION TO PROJECT RISK ANALYSIS

As operations wind down in Year 4, inventories will be sold and not replaced, and this will provide cash. Similarly, accounts receivable will be collected and not replaced, and this too will provide cash. The end result is that the firm will recover its $6 million investment in net operating working capital during the last year of the project’s life. In addition, when the company disposes of the building and equipment at the end of Year 4, it will receive cash as estimated in Part 3 of the table. Thus, the total terminal year cash flow amounts to $16,607 as shown on Row 100. When we sum the columns in Part 4, we obtain the net cash flows shown on Row 102. Those cash flows constitute a cash flow time line, and they are then evaluated in Part 5.
1. Undiversified stockholders, including the owners of small businesses, are more concerned about corporate risk than about market risk.

2. Empirical studies of the determinants of required rates of return \((k)\) generally find that both market and corporate risk affect stock prices. This suggests that investors, even those who are well diversified, consider factors other than market 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 their stock prices, and this makes corporate risk significant.

For these three reasons, corporate risk is important even if a firm’s stockholders are well diversified.

### SELF-TEST QUESTIONS

What are the three types of project risk?
Why are (1) market and (2) corporate risk both important?

### TECHNIQUES FOR MEASURING STAND-ALONE RISK

Why should a project’s stand-alone risk be important to anyone? In theory, this type of risk should be of little or no concern. However, it is actually of great importance for two 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 market 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. Because of this high correlation, stand-alone risk is generally a good proxy for hard-to-measure corporate and market risk.

The starting point for analyzing a project’s stand-alone risk involves determining the uncertainty inherent in its cash flows. To illustrate what is involved, consider again Brandt-Quigley Corporation’s appliance control computer project that we discussed above. Many of the key inputs shown in Part 1 of Table 12-1 are subject to uncertainty. For example, sales were projected at 20,000 units to be sold at a net price of $3,000 per unit. However, actual unit sales will almost certainly be somewhat higher or lower than 20,000, and the sales price will probably turn out to be different from the projected $3,000 per unit. In
effect, the sales quantity and price estimates are really expected values based on probability distributions, as are many of the other values that were shown in Part 1 of Table 12-1. 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 actual value of the variable in question and thus 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 probability distribution and, thus, the project’s stand-alone risk. In the following sections, we discuss three techniques for assessing a project’s stand-alone risk: (1) sensitivity analysis, (2) scenario analysis, and (3) Monte Carlo simulation.

**Sensitivity Analysis**

Intuitively, we know that many of the variables that determine a project’s cash flows could turn out to be different from the values used in the analysis. We also know that a change in a key input variable, such as units sold, will cause the NPV to change. **Sensitivity analysis** is a technique that indicates how much NPV will change in response to a given change in an input variable, other things held constant.

Sensitivity analysis begins with a *base-case* situation, which is developed using the *expected* values for each input. To illustrate, consider the data given back in Table 12-1, in which projected income statements for Brandt-Quigley’s computer project were shown. The values used to develop the table, including unit sales, sales price, fixed costs, and variable costs, are the most likely, or base-case, values, and the resulting $5.166 million NPV shown in Table 12-1 is called the **base-case NPV.** Now we ask a series of “what if” questions: “What if unit sales fall 15 percent below the most likely level?” “What if the sales price per unit falls?” “What if variable costs are $2.50 per unit rather than the expected $2.10?” Sensitivity analysis is designed to provide the decision maker with answers to questions such as these.

In a sensitivity analysis, each variable is changed by several percentage points above and below the expected value, holding all other variables constant. Then a new NPV is calculated using each of these values. Finally, the set of NPVs is plotted to show how sensitive NPV is to changes in each variable. Figure 12-1 shows the computer project’s sensitivity graphs for six of the input variables. The table below the graph gives the NPVs that were used to construct the graph. The slopes of the lines in the graph 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.* From the figure and the table, we see that the project’s NPV is very sensitive to changes in the sales price and variable costs, fairly sensitive to changes in the growth rate and units sold, and not very sensitive to changes in fixed costs and the cost of capital.

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

Before we move on, we should note that spreadsheet computer programs such as Excel are ideally suited for performing sensitivity analysis. We used the model developed in Table 12-1 to conduct the analyses represented in Figure 12-1; it
generated the NPVs and then drew the graphs. To conduct such an analysis by hand would be extremely time consuming.

**Scenario Analysis**

Although sensitivity analysis is probably the most widely used risk analysis technique, it does have limitations. For example, we saw earlier that the computer project’s NPV is highly sensitive to changes in the sales price and the variable cost per unit. Those sensitivities suggest that the project is risky. Suppose, however, that Home Depot or Circuit City was anxious to get the new computer product and would sign a contract to purchase 20,000 units per year for four
years at $3,000 per unit. Moreover, suppose Intel would agree to provide the principal component at a price that would ensure that the variable cost per unit would not exceed $2,100. Under these conditions, there would be a zero probability of high or low sales prices and input costs, so the project would not be at all risky in spite of its sensitivity to those variables.

We see, then, that we need to extend sensitivity analysis to deal with the probability distributions of the inputs. In addition, it would be useful to vary more than one variable at a time so that we could see the combined effects of changes in the variables. Scenario analysis provides these extensions — it brings in the probabilities of changes in the key variables, and it allows us to change more than one variable at a time. In a scenario analysis, the financial analyst begins with the base case, or most likely set of values for the input variables. Then, he or she asks marketing, engineering, and other operating managers to specify a worst-case scenario (low unit sales, low sales price, high variable costs, and so on) and a best-case scenario. Often, the best case and worst case are defined as having a 25 percent probability of conditions being that good or bad, with a 50 percent probability that the base-case conditions will occur. Obviously, conditions could actually take on other values, but parameters such as these are useful to get people focused on the central issues in risk analysis.

The best-case, base-case, and worst-case values for BQC’s computer project are shown in Table 12-2, along with plots of the data. If the product is highly successful, then the combination of a high sales price, low production costs, high first year sales, and a strong growth rate in future sales will result in a very high NPV, $144 million. However, if things turn out badly, then the NPV would be −$38.3 million. The graphs show the very wide range of possibilities, indicating that this is indeed a very risky project. If the bad conditions materialize, this will not bankrupt the company — this is just one project for a large company. Still, losing $38 million would certainly not help the stock price.

The project is clearly risky, and that suggests that its cost of capital is higher than the firm’s WACC of 12 percent, which is applicable to an average-risk project. BQC generally adds 3 percentage points to the corporate WACC when it evaluates projects deemed to be risky, so it recalculate the NPV using a 15 percent cost of capital. That lowered the base-case NPV to $2,877,000 from $5,166,000. Thus, the project is still acceptable by the NPV criterion.

Scenario analysis provides useful information about a project’s stand-alone risk. However, it is limited in that it considers only a few discrete outcomes (NPVs), even though there are an infinite number of possibilities. We briefly describe a more complete method of assessing a project’s stand-alone risk in the next section.

**Monte Carlo Simulation**

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. While Monte Carlo simulation is considerably more complex than scenario analysis, simulation software packages make this process manageable. Many of these packages are included as add-ons to spreadsheet programs such as *Microsoft Excel*.

In a simulation analysis, the computer begins by picking at random a value for each variable — sales in units, the sales price, the variable cost per unit, and
so on. Then those values are combined, and the project's NPV is calculated and stored in the computer's memory. Next, a second set of input values is selected at random, and a second NPV is calculated. This process is repeated perhaps 1,000 times, generating 1,000 NPVs. The mean and standard deviation of the set of NPVs is determined. The mean, or average value, is used as a measure of the project's expected profitability, and the standard deviation (or coefficient of variation) is used as a measure of the project's risk.

**TABLE 12-2 Scenario Analysis (Dollars in Thousands)**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Probability</th>
<th>Sales Price</th>
<th>Unit Sales</th>
<th>Variable Costs</th>
<th>Growth Rate</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best case</td>
<td>25%</td>
<td>$3.90</td>
<td>26,000</td>
<td>$1.47</td>
<td>30%</td>
<td>$144,024</td>
</tr>
<tr>
<td>Base case</td>
<td>50%</td>
<td>3.00</td>
<td>20,000</td>
<td>2.10</td>
<td>0</td>
<td>5,166</td>
</tr>
<tr>
<td>Worst case</td>
<td>25%</td>
<td>2.10</td>
<td>14,000</td>
<td>2.73</td>
<td>-30%</td>
<td>(38,315)</td>
</tr>
</tbody>
</table>

Expected NPV = Sum, probability times NPV = $29,010
Standard deviation (calculated in Excel model) = $68,735
Coefficient of variation = Standard deviation/Expected NPV = 2.37

**NOTE:** The scenario analysis calculations were performed in the Excel model, 12MODEL.xls.

There are several Monte Carlo simulation software packages available that work as add-ons to popular PC spreadsheet programs. A demo version of one, called @RISK, can be downloaded from [http://www.palisade.com/html/risk.html](http://www.palisade.com/html/risk.html).
A recent survey of executives in Australia, Hong Kong, Indonesia, Malaysia, the Philippines, and Singapore asked several questions about their companies’ capital budgeting practices. The study yielded some interesting results, which are summarized here.

**TECHNIQUES FOR EVALUATING CORPORATE PROJECTS**

Consistent with evidence on U.S. companies, most companies in this region evaluate projects using IRR, NPV, and payback. IRR use ranged from 86 percent (in Hong Kong) to 96 percent (in Australia) of the companies. NPV use ranged from 81 percent (in the Philippines) to 96 percent (in Australia). Payback use ranged from 81 percent (in Indonesia) to 100 percent (in Hong Kong and the Philippines).

**TECHNIQUES FOR ESTIMATING THE COST OF EQUITY CAPITAL**

Recall from Chapter 10 that three basic approaches can be used to estimate the cost of equity: CAPM, dividend yield plus growth rate (DCF), and cost of debt plus a risk premium. The use of these methods varied considerably from country to country (see Table A).

We noted in Chapter 11 that the CAPM is used most often by U.S. firms. (See the Industry Practice box in Chapter 11 entitled, “Techniques Firms Use to Evaluate Corporate Projects” on page 531.) Except for Australia, this is not the case for Asian/Pacific firms, who instead more often use the other two approaches.

**TECHNIQUES FOR ASSESSING RISK**

Finally, firms in these six countries rely heavily on scenario and sensitivity analyses to assess project risk. They also use decision trees (which we discuss later in this chapter) and Monte Carlo simulation, but less frequently than the other techniques (see Table B).

PROJECT RISK CONCLUSIONS

Monte Carlo simulation is useful, but it is a relatively complex procedure. Therefore, a detailed discussion is best left for advanced finance courses.

SELF-TEST QUESTIONS

List two reasons why, in practice, a project’s stand-alone risk is important.

Differentiate between sensitivity and scenario analyses. What advantage does scenario analysis have over sensitivity analysis?

What is Monte Carlo simulation?

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

These questions do not have easy answers. From a theoretical standpoint, well-diversified investors should be concerned only with market risk and managers should be concerned only with stock price maximization, and these two factors should lead to the conclusion that market (beta) risk ought to be given...
INCORPORATING PROJECT RISK AND CAPITAL STRUCTURE INTO CAPITAL BUDGETING

Capital budgeting can affect a firm’s market risk, its corporate risk, or both, but it is extremely difficult to quantify either type of risk. Although it may be possible to reach the general conclusion that one project is riskier than another, it is difficult to develop a really good quantitative measure of project risk. This makes it difficult to incorporate differential risk into capital budgeting decisions.

Two methods are used to incorporate project risk into capital budgeting. One is called the certainty equivalent approach. Here all cash flows that are not known with certainty are scaled down, and the riskier the flow, the lower its certainty equivalent value. The other method, and the one we focus on, is the risk-adjusted discount rate approach, under which differential project risk is dealt with by changing the discount rate. Average-risk projects are discounted 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 may be appropriate to give stand-alone and corporate risk more weight than financial theory suggests. Note also that the CAPM ignores bankruptcy costs, even though such costs can be substantial, and the probability of bankruptcy depends on a firm’s corporate risk, not on its beta risk. Therefore, 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 market risk.

Although it would be nice to reconcile these problems and to measure project risk on some absolute scale, the best we can do in practice is to estimate 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 market 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 market risk, and vice versa for projects with low corporate risk.7
at the firm’s average cost of capital, higher-risk projects are discounted at a higher cost of capital, and lower-risk projects are discounted at a rate below the firm’s average cost of capital. Unfortunately, there is no good 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.

As a final consideration, capital structure must also be taken into account if a firm finances different assets in different ways. For example, one division might have a lot of real estate that is well suited as collateral for loans, whereas some other division might have most of its capital tied up in specialized machinery, which is not good collateral. As a result, the division with the real estate might have a higher debt capacity than the division with the machinery, hence an optimal capital structure that contains a higher percentage of debt. In this case, the financial staff might calculate the cost of capital differently for the two divisions.8

**Self-Test Question**

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

**Incorporating Real Options into the Capital Budgeting Decision**

Capital budgeting analysis is in many respects straightforward. A project is deemed acceptable if it has a positive NPV, where the NPV is calculated by discounting the estimated cash flows at the project’s risk-adjusted cost of capital. However, things often get more complicated in the real world. One complication is that many projects include a variety of embedded real options that dramatically affect their value. For example, companies often have to decide not only if they should proceed with a project, but also when they should proceed with the project. In many instances, this choice can radically affect the project’s NPV.

**Decision Trees to Evaluate Investment Timing Options**

Assume that BQC is considering a project that requires an initial investment of $5 million at the beginning of 2002 (or \( t = 0 \)). The project will generate positive net cash flows at the end of each of the next four years (\( t = 1, 2, 3, \) and \( 4 \)), but the size of the yearly cash flows will depend critically on what happens to market conditions in the future. Figure 12-2 illustrates two decision trees that diagram the problem at hand. As shown in the top section, Panel a, there is a 50 percent probability that market conditions will be strong, in which case the

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8 We will say more about the optimal capital structure and debt capacity in Chapter 13.
BQC is considering a proposed expansion project. The project requires an initial investment of $5,000,000, and it has an economic life of four years. The project’s yearly cash flows will depend on market conditions. BQC is deciding whether to turn down the project, to proceed with it today, or to wait a year before making the decision. Currently, there is a 50% probability that the market will be good and a 50% probability it will be bad. If the decision is postponed for a year, the market’s condition will be known. Given the project’s risk, all cash flows are discounted at 14%.

### a. Proceed with the Project Today

<table>
<thead>
<tr>
<th>YEAR</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th><strong>NPV</strong></th>
<th><strong>PROBABILITY</strong></th>
<th><strong>PRODUCT (NPV x PROBABILITY)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Investment:</td>
<td>-5M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market is good (50% probability)</td>
<td>+2.5M</td>
<td>+2.5M</td>
<td>+2.5M</td>
<td>+2.5M</td>
<td>$2,284,280.76</td>
<td>0.5</td>
<td>$1,142,140</td>
<td></td>
</tr>
<tr>
<td>Market is bad (50% probability)</td>
<td>+1.5M</td>
<td>+1.5M</td>
<td>+1.5M</td>
<td>+1.5M</td>
<td>-629,431.54</td>
<td>0.5</td>
<td>-314,715</td>
<td></td>
</tr>
</tbody>
</table>

Expected NPV = $827,425

**Value of expected NPV in 2002 = $1,142,140 \times 0.5 \times \frac{1}{1.14} = $1,001,877.**

### b. Wait a Year to See if the Market Is Good or Bad, Then Invest Only if the Market Is Good

<table>
<thead>
<tr>
<th>YEAR</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th><strong>NPV</strong></th>
<th><strong>PROBABILITY</strong></th>
<th><strong>PRODUCT (NPV x PROBABILITY)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wait: Spend $0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market is good (50% probability)</td>
<td>-5M</td>
<td>+2.5M</td>
<td>+2.5M</td>
<td>+2.5M</td>
<td>+2.5M</td>
<td>$2,284,280.76</td>
<td>0.5</td>
<td>$1,142,140</td>
<td></td>
</tr>
<tr>
<td>Market is bad (50% probability)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Expected NPV = $1,142,140

The expected value for the project is found as a weighted average of the NPVs of the two possible outcomes, with the weights being the probabilities.
for each outcome. With a 50 percent probability for each branch, the expected value of the project, if it is undertaken today, is $827,425, as shown in the last column of Panel a in Figure 12-2. Since the project has a positive NPV, it appears that the company should proceed with it, even though there is a 50–50 chance that it will actually turn out to be a loser.

However, suppose BQC’s managers can wait until next year, when more information will be available about market conditions, before making the decision. The best guess today is that the project has a 50–50 chance of generating $2.5 million or $1.5 million, hence ending up with a positive or a negative NPV. However, one year from now the company will be better able to estimate whether market conditions will be good or bad. To keep things simple, assume that if the company waits a year, the project’s initial investment will still be $5 million, the annual cash flows will still be $2.5 or $1.5 million, but the firm will know for sure whether the market is strong or weak.

Should BQC proceed with the project today, or should it wait a year? In many respects, this decision is similar to choosing among mutually exclusive projects. When comparing two mutually exclusive projects that are both profitable, you should select the one with the highest net present value. In BQC’s case, the mutually exclusive choice is between investing in the project today and waiting a year before deciding whether or not to make the investment. The company should select the strategy with the highest expected net present value.

If the company proceeds today, the project’s estimated NPV is $827,425. If it waits a year, there is a 50 percent chance that the annual net cash flows will be $2.5 million, which at a 14 percent cost of capital, produces an NPV of $2,284,280.76. However, there is also a 50 percent chance that the annual net cash flows will be only $1.5 million, which translates into an NPV of $\text{-}629,431.54. However, under the “Wait” strategy, BQC would know which market condition existed, and it would make the decision to “Go” if conditions were good and make a “No Go” decision if they were bad. Under the No Go decision, no investment is made, hence the NPV will be zero. Thus, if BQC waits a year, there is a 50 percent probability the project will be undertaken, in which case the NPV will be $2,284,280.76, and there is a 50 percent probability the project will not be undertaken, in which case the NPV will be zero. This is illustrated in Panel b of Figure 12-2. As we see in the last column of Panel b in Figure 12-2, the expected NPV under the Wait option is $1,142,140.

Note, though, that all the cash flows under the Wait case are deferred for one year, hence the Wait case NPV is as of a year from now, in 2003 rather than 2002 as in the “Proceed Immediately” case. Therefore, to make the NPVs comparable, we must discount the Wait NPV back for one year to find the project’s value in today’s dollars. The PV of the Wait NPV, discounted at the 14 percent cost of capital, is shown in the lower right part of the figure to be $1,001,877. Since this number exceeds the NPV based on investing today, the analysis suggests that the company should wait to develop the project.

Note that we used 14 percent as the discount rate for both the Proceed Immediately and Wait analyses. Is this reasonable? Probably not. If we wait, we will have a much better idea of market demand. Indeed, in our simplified example, we have implicitly assumed that there is no uncertainty whatever about the cash flows if we wait a year. Therefore, it would be reasonable to discount the cash flows in Panel b of Figure 12-2 at a rate lower than 14 percent, which was the rate used for high-risk projects. A good case could be made for using 10 percent, the rate for low-risk projects, in the Wait case. Of course, a lower
discount rate would cause the Wait NPV to be even higher, thus reinforcing the case for waiting.

**Other Considerations**

When making Proceed Immediately versus Wait decisions, financial managers need to consider several factors. First, if a firm like BQC decides to wait, it may lose any strategic advantages associated with being the first competitor to enter a new line of business, and this could alter the cash flows. On the other hand, as we saw in the above example, waiting enables the company to avoid costly mistakes. In general, the more uncertainty there is about future market conditions, the more attractive it becomes to wait, but this risk reduction can be offset by the loss of the “first mover advantage.”

**Other Examples of Embedded Options**

In addition to the investment timing option, many projects also include a variety of other embedded strategic options. Some examples are given below.

**Growth/Expansion Options**

Many projects, if undertaken, will enable the company to pursue other profitable projects down the road. These projects contain **growth/expansion options**. In some cases, a project that appears to have a negative NPV may still be attractive if it opens the door to new products or new markets. For example, many accounting, banking, and other types of firms have opened offices in Hong Kong, even though the offices do not appear to be profitable, because they want to prepare for possible entry into the vast China market. Likewise, movie picture producers may go ahead with a movie that they suspect may not fully cover its costs if they anticipate that there is some chance that the movie will lead to a profitable sequel. Similarly, a company may decide to build a larger headquarters facility than it currently needs because it recognizes that there is a chance it will want to expand headquarters staff over time.

**Abandonment/Shutdown Options**

After undertaking a project, managers may have the option to abandon or shut down the project if it is later found to be unprofitable. **Abandonment options** can reduce a project’s loss potential, and this can both increase expected cash flows and reduce project risk. Therefore, including abandonment possibilities in the capital budgeting decision can increase a proposed project’s expected NPV. Coca-Cola’s “New Coke” is an example of an abandonment situation. Shortly after its launch, it became apparent that the product would never be the money-maker Coke had anticipated. Note that Coca-Cola faced risks when it embarked on the project: Future operating cash flows and abandonment values might be lower than expected. Coca-Cola benefited by avoiding the “downside” losses that would have occurred due to the lower-than-anticipated operating cash flows by terminating the New Coke project. In general, the opportunity to abandon projects allows companies to limit downside losses.
Flexibility Options

It is often worth spending money today if it allows you to maintain flexibility over time. These investments contain **flexibility options**. For example, consider a situation where two competing technologies are vying to become the industry standard. Assume that BQC is developing a product whose design depends critically on which of the two competing technologies wins out. BQC might be better off spending more on product development if the added expenditures give the company the flexibility to use either technology. Similarly, a computer company might invest more in a plant to produce lap top computers if the extra investment meant that the plant would be flexible enough to produce desk top computers should demand turn out to be stronger in that segment of the market.

**Self-Test Questions**

What is a decision tree, and how is it used in capital budgeting?

Briefly illustrate an investment timing option.

Identify some examples of projects with embedded options.

Explain why the following statement is true: “In general, the more uncertainty there is about future market conditions, the more attractive it may be to wait.”

The Optimal Capital Budget

So far we have described various factors that managers consider when they evaluate individual projects. For planning purposes, managers also need to forecast the total amount of investment in order to determine how much capital must be raised. While every firm goes through this process in its own unique way, there are some commonly used procedures for estimating the optimal capital budget. We use Citrus Grove Corporation, a producer of fruit juices, to illustrate how this process works in practice.

**Step 1.** The financial vice-president obtains an estimate of her firm’s overall composite WACC. As we discussed in Chapter 10, this composite WACC is based on market conditions, the firm’s capital structure, and the riskiness of its assets. Citrus Grove’s projects are roughly similar from year to year in terms of their risks.

**Step 2.** The corporate WACC is scaled up or down for each of the firm’s divisions to reflect the division’s capital structure and risk characteristics. Citrus Grove, for example, assigns a factor of 0.9 to its stable low-risk fresh citrus juice division, but a factor of 1.1 to its more exotic fruit juice group. Therefore, if the corporate cost of capital is determined to be 10.50 percent, the cost for the citrus juice division is 0.9(10.50%) = 9.45%, while that for the exotic juice division is 1.1(10.50%) = 11.55%.
Step 3. Financial managers within each of the firm’s divisions estimate the relevant cash flows and risks of each of their potential projects. The estimated cash flows should explicitly consider any real options embedded in the projects, which includes any opportunities to repeat the project at a later date. Then, within each division, projects are classified into one of three groups—high risk, average risk, and low risk—and the same 0.9 and 1.1 factors are used to adjust the divisional cost of capital estimates. (A factor of 1 would be used for an average-risk project.) For example, a low-risk project in the citrus juice division would be assigned a cost of capital of $0.9(9.45\%) = 8.51\%$, while a high-risk project in the exotic juice division would have a cost of $1.1(11.55\%) = 12.71\%$.

Step 4. Each project’s NPV is then determined, using its risk-adjusted cost of capital. The optimal capital budget consists of all independent projects with positive NPVs plus those mutually exclusive projects with the highest positive NPVs.

In estimating its optimal capital budget, we assumed that Citrus Grove will be able to obtain financing for all of its profitable projects. This assumption is reasonable for large, mature firms with good track records. However, smaller firms, new firms, and firms with dubious track records may have difficulties raising capital, even for projects that the firm concludes have positive NPVs. In such circumstances, the size of the firm’s capital budget may be constrained. This circumstance is called capital rationing. In such situations capital is scarce, and it should be used in the most efficient way possible. Procedures are available for allocating capital so as to maximize the firm’s aggregate NPV subject to the constraint that the capital rationing ceiling is not exceeded. However, due to its complexity, the details of this process are best left for advanced finance courses.

The four steps outlined above also assume that the accepted projects have, on average, about the same debt-carrying capacity as the firm’s existing assets. If this is not true, the corporate WACC determined in Step 1 will not be correct, and it will have to be adjusted.

The procedures discussed in this section cannot be implemented with much precision, but they do force the firm to think carefully about each division’s relative risk, about the risk of each project within the divisions, and about the relationship between the total amount of capital raised and the cost of that capital. Further, the process forces the firm to adjust its capital budget to reflect capital market conditions. If the costs of debt and equity rise, this fact will be reflected in the cost of capital used to evaluate projects, and projects that would be marginally acceptable when capital costs were low would (correctly) be ruled unacceptable when capital costs become high.

**Self-Test Questions**

Explain how a financial manager might estimate his or her firm’s optimal capital budget.

In estimating the optimal capital budget, what assumption is typically made concerning the amount of capital that can be raised?

What is capital rationing?
Throughout the book, we have indicated that the value of any asset depends on the amount, timing, and riskiness of the cash flows it produces. In this chapter, we developed a framework for analyzing a project's cash flows and risk. Given a set of inputs, we can use the techniques described back in Chapter 11 to evaluate whether projects should be accepted or rejected. In addition, in this chapter we briefly introduced real options and discussed the procedures for estimating the optimal capital budget.

- The most important (and most difficult) step in analyzing a capital budgeting project is estimating the incremental after-tax cash flows the project will produce.
- Project cash flow is different from accounting income. Project cash flow reflects: (1) cash outlays for fixed assets, (2) the tax shield provided by depreciation, and (3) cash flows due to changes in net operating working capital. Project cash flow does not include interest payments.
- In determining incremental cash flows, opportunity costs (the cash flows foregone by using an asset) must be included, but sunk costs (cash outlays that have been made and that cannot be recouped) are not included. Any externalities (effects of a project on other parts of the firm) should also be reflected in the analysis.
- Cannibalization occurs when a new project leads to a reduction in sales of an existing product.
- Capital projects often require an additional investment in net operating working capital (NOWC). An increase in NOWC must be included in the Year 0 initial cash outlay, and then shown as a cash inflow in the final year of the project.
- The incremental cash flows from a typical project can be classified into three categories: (1) initial investment outlay, (2) operating cash flows over the project's life, and (3) terminal year cash flows.
- Since stockholders are generally diversified, market risk is theoretically the most relevant measure of risk. Market, or beta, risk is important because beta affects the cost of capital, which, in turn, affects stock prices.
- 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 its employees, customers, suppliers, and community.
- Sensitivity analysis is a technique that shows how much a project’s 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 that uses a computer to simulate future events and thus to estimate the profitability and riskiness of a project.
The risk-adjusted discount rate, or project cost of capital, is the rate used to evaluate a particular project. It is based on the corporate WACC, which is increased for projects that are riskier than the firm’s average project but decreased for less risky projects.

Real options exist when managers can influence the size and riskiness of a project’s cash flows by taking different actions during or at the end of the project’s life.

Many projects include a variety of embedded options that can dramatically affect the true NPV. Examples of embedded options include (1) the option to accelerate or delay a project, (2) “growth options” that might enable a firm to pursue other profitable future projects, (3) the option to abandon or shut down the project, and (4) “flexibility” options that allow a firm to modify its operations over time.

Projects whose capital outlays are made in stages over several years are often evaluated using decision trees. Decision trees are also useful for identifying real options, which, in turn, may materially affect a project’s true NPV.

An investment timing option involves not only the decision of whether to proceed with a project but also the decision of when to proceed with it. This opportunity to affect a project’s timing can dramatically change its estimated value.

If an investment creates the opportunity to make other potentially profitable investments that would not otherwise be possible, then the investment is said to contain a growth option.

The abandonment option is the ability to abandon a project if the operating cash flows and/or abandonment value turn out to be lower than expected. It reduces the riskiness of a project and increases its value.

A flexibility option is the option to modify operations depending on how conditions develop during a project’s life, especially the type of output produced or the inputs used.

For planning purposes, managers need to forecast the total dollar amount that will be required to fund the acceptable projects, or the total capital budget for the planning period. They need this information to determine how much capital will have to be raised.

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

**QUESTIONS**

12-1 Operating cash flows rather than accounting profits are listed in Table 12-1. What is the basis for this emphasis on cash flows as opposed to net income?

12-2 Explain why sunk costs should not be included in a capital budgeting analysis, but opportunity costs and externalities should be included.

12-3 Explain how net operating working capital is recovered at the end of a project’s life, and why it is included in a capital budgeting analysis.

12-4 Define (a) simulation analysis, (b) scenario analysis, and (c) sensitivity analysis. If AT&T were considering two investments, one calling for the expenditure of $200 million to develop a satellite communications system and the other involving the expenditure of $12,000 for a new truck, on which one would the company be more likely to use simulation analysis?
12-5 What factors should a company consider when it decides whether to invest in a project today or to wait until more information becomes available?

12-6 In general, do timing options make it more or less likely that a project will be accepted today?

12-7 If a company has an option to abandon a project, would this tend to make the company more or less likely to accept the project today?

**SELF-TEST PROBLEMS**  (SOLUTIONS APPEAR IN APPENDIX B)

**ST-1**

Define each of the following terms:

- Relevant cash flow
- Incremental cash flow; sunk cost; opportunity cost; externalities; cannibalization
- Change in net operating working capital; new expansion project
- Replacement project
- Sensitivity analysis
- Base-case NPV
- Scenario analysis
- Worst-case scenario; best-case scenario; base case
- Monte Carlo simulation
- Risk-adjusted discount rate
- Real options; decision tree; investment timing option
- Growth/expansion option; abandonment option; flexibility option
- Capital rationing

**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 3-year class. (See Table 12A-2 for MACRS recovery allowance percentages.) It will be sold after 3 years for $20,000, and it will require an increase in net operating 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 federal-plus-state tax rate is 40 percent.

a. What is the company’s net investment if it acquires the earthmover? (That is, what are the Year 0 cash flows?)

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

c. What is the terminal cash flow?

d. If the project’s cost of capital is 10 percent, should the earthmover be purchased?

e. Suppose that the firm’s management is unsure about the savings in before-tax operating costs and the earthmover’s salvage value.

(1) What is the earthmover’s net present value if the savings in before-tax operating costs increase by 15 percent above the firm’s original expectations? Would this change the firm’s decision to acquire the earthmover from the decision made in part d?

(2) What is the earthmover’s net present value if the earthmover’s salvage value increases by 10 percent above the firm’s original expectations? Assume no other change in data from the original problem. Would this change the firm’s decision to acquire the earthmover from the decision made in part d?

f. Suppose the firm’s capital budgeting manager suggests that the firm do a scenario analysis for this project because of the sensitivities of both the equipment’s cost savings and its salvage value. After an extensive analysis, he comes up with the following probabilities and values for the scenario analysis:

<table>
<thead>
<tr>
<th>SCENARIO</th>
<th>PROBABILITY</th>
<th>BEFORE-TAX SAVINGS</th>
<th>SALVAGE VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worst case</td>
<td>30%</td>
<td>$15,000</td>
<td>$18,000</td>
</tr>
<tr>
<td>Base case</td>
<td>40</td>
<td>20,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Best case</td>
<td>30</td>
<td>25,000</td>
<td>24,000</td>
</tr>
</tbody>
</table>

What is the project’s expected net present value (NPV), the standard deviation of the NPV, and the coefficient of variation of the NPV?
The staff of Heymann Manufacturing has estimated the following net cash flows and probabilities for a new manufacturing process:

<table>
<thead>
<tr>
<th>YEAR</th>
<th>P = 0.2</th>
<th>P = 0.6</th>
<th>P = 0.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>($100,000)</td>
<td>($100,000)</td>
<td>($100,000)</td>
</tr>
<tr>
<td>1</td>
<td>20,000</td>
<td>30,000</td>
<td>40,000</td>
</tr>
<tr>
<td>2</td>
<td>20,000</td>
<td>30,000</td>
<td>40,000</td>
</tr>
<tr>
<td>3</td>
<td>20,000</td>
<td>30,000</td>
<td>40,000</td>
</tr>
<tr>
<td>4</td>
<td>20,000</td>
<td>30,000</td>
<td>40,000</td>
</tr>
<tr>
<td>5</td>
<td>20,000</td>
<td>30,000</td>
<td>40,000</td>
</tr>
<tr>
<td>5*</td>
<td>0</td>
<td>20,000</td>
<td>30,000</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 cost of capital for an average-risk project is 10 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, 2 percentage points are added to the firm’s cost of capital. Similarly, if the coefficient of variation is less than 0.8, 1 percentage point is deducted from the cost of capital. What is the project’s cost of capital? Should Heymann accept or reject the project?

### STARTER PROBLEMS

12-1 **Investment outlay**

Truman Industries is considering an expansion project. The necessary equipment could be purchased for $9 million, and the project would also require an initial $3 million investment in net operating working capital. The company’s tax rate is 40 percent. What is the project’s initial investment outlay?

12-2 **Operating cash flow**

Eisenhower Communications is trying to estimate the first-year operating cash flow (at \( t = 1 \)) for a proposed project. The financial staff has collected the following information:

- Projected sales: $10 million
- Operating costs (excluding depreciation): 7 million
- Depreciation: 2 million
- Interest expense: 2 million

The company faces a 40 percent tax rate. What is the project’s operating cash flow for the first year (\( t = 1 \))? 

12-3 **Net salvage value**

Kennedy Air Lines is now in the terminal year of a project. The equipment originally cost $20 million, of which 80 percent has been depreciated. Kennedy can sell the used equipment today to another airline for $5 million, and its tax rate is 40 percent. What is the equipment’s after-tax net salvage value?
Hampton Manufacturing estimates that its WACC is 12 percent if equity comes from retained earnings. However, if the company issues new stock to raise new equity, it estimates that its WACC will rise to 12.5 percent. The company believes that it will exhaust its retained earnings at $3,250,000 of capital due to the number of highly profitable projects available to the firm and its limited earnings. The company is considering the following seven investment projects:

<table>
<thead>
<tr>
<th>PROJECT</th>
<th>SIZE</th>
<th>IRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$750,000</td>
<td>14.0%</td>
</tr>
<tr>
<td>B</td>
<td>1,250,000</td>
<td>13.5</td>
</tr>
<tr>
<td>C</td>
<td>1,250,000</td>
<td>13.2</td>
</tr>
<tr>
<td>D</td>
<td>1,250,000</td>
<td>13.0</td>
</tr>
<tr>
<td>E</td>
<td>750,000</td>
<td>12.7</td>
</tr>
<tr>
<td>F</td>
<td>750,000</td>
<td>12.3</td>
</tr>
<tr>
<td>G</td>
<td>750,000</td>
<td>12.2</td>
</tr>
</tbody>
</table>

Assume that each of these projects is independent and that each is just as risky as the firm’s existing assets. Which set of projects should be accepted, and what is the firm’s optimal capital budget?

Refer to Problem 12-4. Now assume that Projects C and D are mutually exclusive. Project D has an NPV of $400,000, whereas Project C has an NPV of $350,000. Which set of projects should be accepted, and what is the firm’s optimal capital budget?

Refer to Problem 12-4. Assume again that each of the projects is independent but that management decides to incorporate project risk differentials. Management judges Projects B, C, D, and E to have average risk, Project A to have high risk, and Projects F and G to have low risk. The company adds 2 percentage points to the cost of capital of those projects that are significantly more risky than average, and it subtracts 2 percentage points from the cost of capital for those that are substantially less risky than average. Which set of projects should be accepted, and what is the firm’s optimal capital budget?

The problems included in this section are set up in such a way that they could be used as multiple-choice exam problems.

Worldwide Technologies encounters significant uncertainty in its sales volume and price with its primary product. The firm uses scenario analysis to determine an expected NPV, which it then uses in its capital budget. The base-case, best-case, and worst-case scenarios and probabilities are provided in the following table. What is this product’s expected NPV, standard deviation, and coefficient of variation?

<table>
<thead>
<tr>
<th>SCENARIO</th>
<th>PROBABILITY OF OUTCOME</th>
<th>UNIT SALES VOLUME</th>
<th>SALES PRICE</th>
<th>NPV (IN 000’s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worst case</td>
<td>0.30</td>
<td>10,800</td>
<td>$6,480</td>
<td>−$10,800</td>
</tr>
<tr>
<td>Base case</td>
<td>0.50</td>
<td>18,000</td>
<td>7,560</td>
<td>+23,400</td>
</tr>
<tr>
<td>Best case</td>
<td>0.20</td>
<td>23,400</td>
<td>7,920</td>
<td>+50,400</td>
</tr>
</tbody>
</table>

Huang Industries is considering a proposed project for its capital budget. The company estimates that the project’s NPV is $12 million. This estimate assumes that the economy and market conditions will be average over the next few years. The company’s CFO, however, forecasts that there is only a 50 percent chance that the economy will be
average. Recognizing this uncertainty, she has also performed the following scenario analysis:

<table>
<thead>
<tr>
<th>ECONOMIC SCENARIO</th>
<th>PROBABILITY OF OUTCOME</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recession</td>
<td>0.05</td>
<td>($70 million)</td>
</tr>
<tr>
<td>Below average</td>
<td>0.20</td>
<td>(25 million)</td>
</tr>
<tr>
<td>Average</td>
<td>0.50</td>
<td>12 million</td>
</tr>
<tr>
<td>Above average</td>
<td>0.20</td>
<td>20 million</td>
</tr>
<tr>
<td>Boom</td>
<td>0.05</td>
<td>30 million</td>
</tr>
</tbody>
</table>

What is the project's expected NPV, its standard deviation, and its coefficient of variation?

Holmes Manufacturing Company is considering the purchase of a new machine for $250,000 that will reduce manufacturing costs by $90,000 annually. Holmes will use the 3-year MACRS accelerated method to depreciate the machine, and it expects to sell the machine at the end of its 5-year operating life for $23,000. (See Table 12A-2 for MACRS recovery allowance percentages.) The firm will need to increase net operating working capital by $25,000 when the machine is installed, but required operating working capital will return to the original level when the machine is sold after 5 years. Holmes' marginal tax rate is 40 percent, and it uses a 10 percent cost of capital to evaluate projects of this nature.

a. What is the project's NPV?

b. Assume the firm is unsure about the savings to operating costs that will occur with the new machine's acquisition. Management believes these savings may deviate from their base-case value ($90,000) by as much as plus or minus 20 percent. What is the NPV of the project under both situations?

c. Suppose the firm's chief financial officer suggests that the firm do a scenario analysis for this project because of concerns raised about data assumptions, particularly the operating cost savings, the new machine's salvage value, and the net operating working capital (NOWC) requirement. After an extensive analysis, she arrives with the following probabilities and values for the scenario analysis:

<table>
<thead>
<tr>
<th>SCENARIO</th>
<th>PROBABILITY</th>
<th>COST SAVINGS</th>
<th>SALVAGE VALUE</th>
<th>NOWC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worst case</td>
<td>0.35</td>
<td>$72,000</td>
<td>$18,000</td>
<td>$30,000</td>
</tr>
<tr>
<td>Base case</td>
<td>0.35</td>
<td>90,000</td>
<td>23,000</td>
<td>25,000</td>
</tr>
<tr>
<td>Best case</td>
<td>0.30</td>
<td>108,000</td>
<td>28,000</td>
<td>20,000</td>
</tr>
</tbody>
</table>

What is the project's expected net present value, its standard deviation, and its coefficient of variation?

Twain Hotels is interested in developing a new hotel in Tokyo. The company estimates that the hotel would require an initial investment of $20 million. Twain expects that the hotel will produce positive cash flows of $3 million a year at the end of each of the next 20 years. The project's cost of capital is 12 percent.

a. What is the project's net present value?

b. While Twain expects the cash flows to be $3 million a year, it recognizes that the cash flows could, in fact, be much higher or lower, depending on whether the Japanese government imposes a large hotel tax. One year from now, Twain will know whether the tax will be imposed. There is a 25 percent chance that the tax will be imposed, in which case the yearly cash flows will be only $2.4 million. At the same time, there is a 75 percent chance that the tax will not be imposed, in which case the yearly cash flows will be $3.2 million. Twain is deciding whether to proceed with the hotel today or to wait 1 year to find out whether the tax will be imposed. If Twain waits a year, the initial investment will remain at $20 million. Assume that all cash flows are discounted at 12 percent. Should Twain proceed with the project today or should it wait a year before deciding?
PROBLEMS

12-11  
New project analysis  
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 3-year class, would be sold after 3 years for $60,000. (See Table 12A-2 for MACRS recovery allowance percentages.) Use of the equipment would require an increase in net operating 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 federal-plus-state tax rate is 40 percent.

a. What is the net cost of the spectrometer? (That is, what is the Year 0 net cash flow?)
b. What are the net operating cash flows in Years 1, 2, and 3?
c. What is the terminal cash flow?
d. If the project’s cost of capital is 12 percent, should the spectrometer be purchased?

12-12  
New project analysis  
The Harris 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 your firm. The machine falls into the MACRS 3-year class, and it would be sold after 3 years for $65,000. (See Table 12A-2 for MACRS recovery allowance percentages.) The machine would require an increase in net operating 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. Harris’s marginal tax rate is 35 percent.

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

12-13  
Risky cash flows  
The Butler-Perkins Company (BPC) must decide between two mutually exclusive investment projects. Each project costs $6,750 and has an expected life of 3 years. Annual net cash flows from each project begin 1 year after the initial investment is made and have the following probability distributions:

<table>
<thead>
<tr>
<th>PROJECT A</th>
<th>PROJECT B</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROBABILITY</td>
<td>NET CASH FLOWS</td>
</tr>
<tr>
<td>0.2</td>
<td>$6,000</td>
</tr>
<tr>
<td>0.6</td>
<td>6,750</td>
</tr>
<tr>
<td>0.2</td>
<td>7,500</td>
</tr>
</tbody>
</table>

BPC has decided to evaluate the riskier project at a 12 percent rate and the less risky project at a 10 percent rate.

a. What is the expected value of the annual net cash flows from each project? What is the coefficient of variation (CV)? (Hint: \( \sigma_B = 5,798 \) and \( CV_B = 0.76 \).)
b. What is the risk-adjusted NPV of each project?
c. If it were known that Project B’s cash flows were negatively correlated with other cash flows of the firm whereas Project A’s cash flows were positively correlated, how would this knowledge affect the decision? If Project B’s cash flows were negatively correlated with gross domestic product (GDP), would that influence your assessment of its risk?

12-14  
Scenario analysis  
Your firm, Agrico Products, is considering the purchase of a tractor that will have a net cost of $36,000, will increase pre-tax operating cash flows before taking account of depreciation effects by $12,000 per year, and will be depreciated on a straight-line basis over 5 years at the rate of $7,200 per year, beginning the first year. (Annual cash flows will be $12,000, before taxes, plus the tax savings that result from $7,200 of depreciation.) The board of directors is having a heated debate about whether the tractor will actually last 5 years. Specifically, Elizabeth Brannigan insists that she knows of some tractors that have lasted only 4 years. Philip Glasgo agrees with Brannigan, but he argues that most tractors do give 5 years of service. Laura Evans says she has known some to last for as long as 8 years.
Given this discussion, the board asks you to prepare a scenario analysis to ascertain the importance of the uncertainty about the tractor's life. Assume a 40 percent marginal federal-plus-state tax rate, a zero salvage value, and a cost of capital of 10 percent. (Hint: Here straight-line depreciation is based on the MACRS class life of the tractor and is not affected by the actual life. Also, ignore the half-year convention for this problem.)

The Scampini Supplies Company recently purchased a new delivery truck. The new truck costs $22,500, and it is expected to generate net after-tax operating cash flows, including depreciation, of $6,250 per year. The truck has a 5-year expected life. The expected year-end abandonment values (salvage values after tax adjustments) for the truck are given below. The company's cost of capital is 10 percent.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>ANNUAL OPERATING CASH FLOW</th>
<th>ABANDONMENT VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>($22,500)</td>
<td>—</td>
</tr>
<tr>
<td>1</td>
<td>6,250</td>
<td>17,500</td>
</tr>
<tr>
<td>2</td>
<td>6,250</td>
<td>14,000</td>
</tr>
<tr>
<td>3</td>
<td>6,250</td>
<td>11,000</td>
</tr>
<tr>
<td>4</td>
<td>6,250</td>
<td>5,000</td>
</tr>
<tr>
<td>5</td>
<td>6,250</td>
<td>0</td>
</tr>
</tbody>
</table>

a. Should the firm operate the truck until the end of its 5-year physical life; if not, what is its optimal economic life?
b. Would the introduction of abandonment values, in addition to operating cash flows, ever reduce the expected NPV and/or IRR of a project?

The Bush Oil Company is deciding whether to drill for oil on a tract of land that the company owns. The company estimates that the project would cost $8 million today. Bush estimates that once drilled, the oil will generate positive net cash flows of $4 million a year at the end of each of the next 4 years. While the company is fairly confident about its cash flow forecast, it recognizes that if it waits 2 years, it would have more information about the local geology as well as the price of oil. Bush estimates that if it waits 2 years, the project would cost $9 million. Moreover, if it waits 2 years, there is a 90 percent chance that the net cash flows would be $4.2 million a year for 4 years, and there is a 10 percent chance that the cash flows will be $2.2 million a year for 4 years. Assume that all cash flows are discounted at 10 percent.

a. If the company chooses to drill today, what is the project's net present value?
b. Would it make sense to wait 2 years before deciding whether to drill?

SPREADSHEET PROBLEM

Webmasters.com has developed a powerful new server that would be used for corporations' Internet activities. It would cost $10 million to purchase the equipment necessary to manufacture the server, and $3 million of net operating working capital would be required. The servers would sell for $24,000 per unit, and Webmasters believes that variable costs would amount to $17,500 per unit. The company's fixed costs would also rise by $1 million per year. It would take 1 year to purchase the required equipment and set up operations, and the server project would have a life of 4 years. Conditions are expected to remain stable during each year of the operating life; that is, unit sales, sales price, and costs would be unchanged. If the project is undertaken, it must be continued for the entire 4 years. Also, the project's returns are expected to be highly correlated with returns on the firm's other assets. The firm believes it could sell 1,000 units.

The equipment would be depreciated over a 5-year period, using MACRS rates as described in Appendix 12A. The estimated market value of the equipment at the end of the project's 4-year life is $500,000. Webmasters' federal-plus-state tax rate is 40 percent. Its cost of capital is 10 percent for average-risk projects, defined as projects with
a coefficient of variation of NPV between 0.8 and 1.2. Low-risk projects are evaluated with a WACC of 8 percent, and high-risk projects are evaluated at 13 percent.

a. Develop a spreadsheet model and use it to find the project's NPV, IRR, and payback. (Hint: You might want to modify the model on file 12MODEL.xls rather than create an entirely new model.)

b. Now conduct a sensitivity analysis to determine the sensitivity of NPV to changes in the sales price, variable costs per unit, and number of units sold. Set these variables' values at 10 percent and 20 percent above and below their base-case values. Include a graph in your analysis.

c. Now conduct a scenario analysis. Assume that there is a 25 percent probability that “best-case” conditions, with each of the variables discussed in part b being 20 percent better than its base-case value, will occur. There is a 25 percent probability of “worst-case” conditions, with the variables 20 percent worse than base, and a 50 percent probability of base-case conditions.

d. If the project appears to be more or less risky than an average project, find its risk-adjusted NPV, IRR, and payback.

e. On the basis of information in the problem, would you recommend that the project be accepted?
necessities as the firm strives to maximize shareholder value by generating free cash flows. To answer the following questions, first refer to Coca-Cola’s 1999 annual report at http://www.cocacola.com/annualreport/1999. Click on message to shareowners, scroll down to the full index, and click on management’s discussion and analysis.

a. How does Coca-Cola define its business?
b. Briefly discuss Coca-Cola’s liquidity position and capital resources. How are these factors expected to influence Coca-Cola’s ability to meet its financial targets?
c. How does Coca-Cola define free cash flow (FCF)? What was Coca-Cola’s free cash flow in 1999?
d. How does the 1999 free cash flow compare with that in 1998? What are some reasons for the difference?
e. As a multinational corporation, Coca-Cola faces a number of additional risks, including exchange rate risk. How has Coca-Cola prepared for the European Union’s new common currency, the Euro? What effect is the Euro expected to have on Coca-Cola’s consolidated financial statements?

ALLIED FOOD PRODUCTS

12-19 Capital Budgeting and Cash Flow Estimation

After seeing Snapple’s success with noncola soft drinks and learning of Coke’s and Pepsi’s interest, Allied Food Products has decided to consider an expansion of its own in the fruit juice business. The product being considered is fresh lemon juice. Assume that you were recently hired as assistant to the director of capital budgeting, and you must evaluate the new project.

The lemon juice would be produced in an unused building adjacent to Allied’s Fort Myers plant; Allied 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 time 0. By a special ruling, the machinery could be depreciated under the MACRS system as 3-year property.

The project is expected to operate for 4 years, at which time it will be terminated. The cash inflows are assumed to begin 1 year after the project is undertaken, or at time 1, and to continue out to time 4. At the end of the project’s life (time 4), the equipment is expected to have a salvage value of $25,000.

Unit sales are expected to total 100,000 cans per year, and the expected sales price is $2.00 per can. Cash operating costs for the project (total operating costs less depreciation) are expected to total 60 percent of dollar sales. Allied’s tax rate is 40 percent, and its weighted average cost of capital is 10 percent. Tentatively, the lemon juice project is assumed to be of equal risk to Allied’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 questions.

a. Draw a 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. Allied has a standard form that is used in the capital budgeting process; see Table IC12-1. 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) Fill in the blanks under Year 0 for the initial investment outlay.
(2) Complete the table for unit sales, sales price, total revenues, and operating costs excluding depreciation.
(3) Complete the depreciation data.
(4) Now complete the table down to operating income after taxes, and then down to net cash flows.
(5) Now fill in the blanks under Year 4 for the terminal cash flows, and complete the net cash flow line. Discuss net operating working capital. What would have happened if the machinery were sold for less than its book value?
c. (1) Allied 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 Allied 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 Allied could lease its building to another party and earn $25,000 per year. Should that fact be reflected in the analysis? How?
(4) Now assume that the lemon juice project would take away profitable sales from Allied’s fresh orange juice business. Should that fact be reflected in your analysis? If so, how?
TABLE IC12-1

Allied’s Lemon Juice Project (Total Cost in Thousands)

<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>
</table>

I. INVESTMENT OUTLAY
- Equipment cost
- Installation
- Increase in inventory
- Increase in accounts payable
- Total net investment

II. OPERATING CASH FLOWS
- Unit sales (thousands) 100
- Price/unit $ 2.00 $ 2.00
- Total revenues $200.0
- Operating costs excluding depreciation $120.0
- Depreciation 36.0 16.8
- Total costs $199.2 $228.0
- Operating income before taxes $44.0
- Taxes on operating income 0.3 25.3
- Operating income after taxes $26.4
- Depreciation 79.2 36.0
- Operating cash flow $ 0.0 $ 79.7 $ 54.7

III. TERMINAL YEAR CASH FLOWS
- Return of net operating working capital
- Salvage value
- Tax on salvage value
- Total termination cash flows

IV. NET CASH FLOWS
- Net cash flow ($260.0)
- $ 89.7

V. RESULTS
- NPV =
- IRR =
- MIRR =
- Payback =

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d. Disregard all the assumptions made in part c, and assume there was no alternative use for the building over the next 4 years. Now calculate the project’s NPV, IRR, MIRR, and regular 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?

Think about the changes that would have to occur in the cash flow table.
f. Assume that inflation is expected to average 5 percent over the next 4 years; that this expectation is reflected in the WACC; and that inflation will increase variable costs and revenues by the same percentage, 5 percent. Does it appear that inflation has been dealt with properly in the
TABLE IC12-2

<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></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Investment in:</strong></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 operating working capital</td>
<td>(20)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Unit sales (thousands)</strong></td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td><strong>Sales price (dollars)</strong></td>
<td>$2.100</td>
<td>$2.205</td>
<td>$2.315</td>
<td>$2.431</td>
<td></td>
</tr>
<tr>
<td><strong>Total revenues</strong></td>
<td>$210.0</td>
<td>$220.5</td>
<td>$231.5</td>
<td>$243.1</td>
<td></td>
</tr>
<tr>
<td><strong>Cash operating costs (60%)</strong></td>
<td>126.0</td>
<td>132.3</td>
<td>138.9</td>
<td>145.9</td>
<td></td>
</tr>
<tr>
<td><strong>Depreciation</strong></td>
<td>79.2</td>
<td>108.0</td>
<td>36.0</td>
<td>16.8</td>
<td></td>
</tr>
<tr>
<td><strong>Operating income before taxes</strong></td>
<td>$ 4.8</td>
<td>($ 19.8)</td>
<td>$ 56.6</td>
<td>$ 80.4</td>
<td></td>
</tr>
<tr>
<td><strong>Taxes on operating income (40%)</strong></td>
<td>1.9</td>
<td>(7.9)</td>
<td>22.6</td>
<td>32.1</td>
<td></td>
</tr>
<tr>
<td><strong>Operating income after taxes</strong></td>
<td>$ 2.9</td>
<td>($ 11.9)</td>
<td>$ 34.0</td>
<td>$ 48.3</td>
<td></td>
</tr>
<tr>
<td><strong>Plus depreciation</strong></td>
<td>79.2</td>
<td>108.0</td>
<td>36.0</td>
<td>16.8</td>
<td></td>
</tr>
<tr>
<td><strong>Operating cash flow</strong></td>
<td>$ 82.1</td>
<td>$ 96.1</td>
<td>$ 70.0</td>
<td>$ 65.1</td>
<td></td>
</tr>
<tr>
<td><strong>Salvage value</strong></td>
<td>25.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Tax on SV (40%)</strong></td>
<td>(10.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Recovery of NOWC</strong></td>
<td>20.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Net cash flow</strong></td>
<td>($260)</td>
<td>$ 82.1</td>
<td>$ 96.1</td>
<td>$ 70.0</td>
<td>$100.1</td>
</tr>
<tr>
<td><strong>Cumulative cash flows for payback:</strong></td>
<td>(260.0)</td>
<td>(177.9)</td>
<td>(81.8)</td>
<td>(11.8)</td>
<td>88.3</td>
</tr>
<tr>
<td><strong>Compounded inflows for MIRR:</strong></td>
<td>109.2</td>
<td>116.3</td>
<td>77.0</td>
<td>100.1</td>
<td></td>
</tr>
<tr>
<td><strong>Terminal value of inflows:</strong></td>
<td>402.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NPV at 10% cost of capital</strong></td>
<td>$15.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>IRR</strong></td>
<td>= 12.6%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MIRR</strong></td>
<td>= 11.6%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

analysis? If not, what should be done, and how would the required adjustment affect the decision? You can modify the numbers in the table to quantify your results.

Although inflation was considered in the initial analysis, the riskiness of the project was not considered. The expected cash flows, considering inflation (in thousands of dollars), are given in Table IC12-2. Allied’s overall cost of capital (WACC) is 10 percent.

You have been asked to answer the following questions.

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

h. (1) What is sensitivity analysis?
(2) Discuss how one would perform a sensitivity analysis on the unit sales, salvage value, and cost of capital 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. Explain how you would calculate the NPV, IRR, MIRR, and payback for each case.
(3) What is the primary weakness of sensitivity analysis? What are its primary advantages?
i. Assume that you are confident about the estimates of all the variables that affect the 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?
(2) Use the worst-, most likely (or base), and best-case NPVs, with their probabilities of occurrence, to find the project’s expected NPV, standard deviation, and coefficient of variation.

j. (1) Assume that Allied’s average project has a coefficient of variation (CV) in the range of 1.25 to 1.75. Would the lemon juice 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 with 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.

k. (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”?
(2) How would correlation with the economy affect the project’s market risk?

l. (1) Allied typically adds or subtracts 3 percentage points to the overall cost of capital to adjust for risk. Should the lemon juice project be accepted?
(2) What subjective risk factors should be considered before the final decision is made?

m. In recent months, Allied’s group has begun to focus on real option analysis.
(1) What is real option analysis?
(2) What are some examples of projects with embedded real options?
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 must include a charge for the machine, and this charge is called depreciation. In the following sections, we review some of the depreciation concepts covered in accounting courses.

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. Under the straight-line method used for stockholder reporting, one normally takes the cost of the asset, subtracts its estimated salvage value, and divides the net amount by the asset’s useful economic life. For an asset with a 5-year life, which 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); a 1993 tax law made further changes in this area.

Note that U.S. tax laws are very complicated, and in this text we can only provide an overview of MACRS designed to give you a basic understanding of the impact of depreciation on capital budgeting decisions. Further, the tax laws change so often that the numbers we present may be outdated before the book is even published. Thus, when dealing with tax depreciation in real-world situations, current Internal Revenue Service (IRS) publications or individuals with expertise in tax matters should be consulted.

**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 investment. Table 12A-1 describes the types of property that fit into the different class life groups, and Table 12A-2 sets forth the MACRS recovery allowance percentages (depreciation rates) for selected classes of investment property.

Consider Table 12A-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 in the 27.5- and 39-year categories (real estate) must be depreciated by the straight-line method, but 3-, 5-, 7-, and 10-year property (personal property) can be depreciated either by the accelerated method using the rates shown in Table 12A-2 or by an alternate straight-line method.¹

As we saw earlier in the chapter, higher depreciation expenses result in lower taxes, hence higher cash flows. Therefore, since a firm has the choice of using the alternate straight-line rates or the accelerated rates shown in Table 12A-2, most elect to use 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 12A-2. Calculations are discussed in the following sections.

### Half-Year Convention

Under MACRS, the assumption is generally made that property is placed in service in the middle of the first year. Thus, for 3-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 out one more year, so 3-year class life property is depreciated over four calendar years, 5-year property is depreciated over six calendar years,

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¹ As a benefit to very small companies, the Tax Code also permits companies to expense, which is equivalent to depreciating over one year, up to $20,000 of equipment for 2000 and $24,000 for 2001. Thus, if a small company bought one asset worth up to $20,000, it could write the asset off in the year it was acquired. This is called “Section 179 expensing.” We shall disregard this provision throughout the book.
and so on. This convention is incorporated into Table 12A-2’s recovery allowance percentages.2

**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 (which is the estimated market value of the asset at the end of its useful life) regardless of whether accelerated or the alternate straight-line method is used.

**Sale of a Depreciable Asset**

If a depreciable asset is sold, the sales price (actual 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 5-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) = $100,000(0.17) = $17,000. Therefore, $25,000 – $17,000 = $8,000 is added to the firm’s operating income and is taxed.

**Depreciation Illustration**

Assume that Allied Food Products buys a $150,000 machine that falls into the MACRS 5-year class life and places it into service on March 15, 2002. Allied 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 2002 is 0.20($180,000) = $36,000, and for 2003 it is 0.32($180,000) = $57,600. Similarly, the depreciation expense is $34,200 for 2004, $21,600 for 2005, $19,800 for 2006, and $10,800 for 2007. 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 above, 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. The reason is that, in capital budgeting, we are concerned with cash flows, not reported income. Since MACRS depreciation is used for taxes, this type of depreciation must be used to determine the taxes that will be assessed against a particular project. Only if the depreciation method used for tax purposes is also used for capital budgeting will the analysis produce accurate cash flow estimates.

**Problem**

Cate Rzasa, great-granddaughter of the founder of Rzasa Tile Products and current president of the company, believes in simple, conservative 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-president 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. Rzasa 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 10-year class life, that the company has a 9 percent cost of debt, and that its tax rate is 35 percent. (Hint: Show how much the NPV of projects in an average year would increase if Rzasa used the standard MACRS recovery allowances.)