

# Capital budgeting & risk

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## OUTLINE

1. Introduction
2. Measurement of project risk
3. Incorporating risk in the capital budgeting decision
4. Assessment of project risk in practice
5. Summary

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## 1. Introduction

"To understand uncertainty and risk is to understand the key business problem -- and the key business opportunity." -- David B. Hertz, 1972.

The capital budgeting decisions that a financial manager makes require analyzing each project's:

1. Future cash flows
2. Uncertainty of future cash flows
3. Value of these future cash flows

When we look at the available investment opportunities, we want to determine which projects will maximize the value of the company and, hence, maximize owners' wealth. That is, we analyze each project, evaluating how much its benefits exceed its costs. The projects that are expected to increase owners' wealth the most are the best ones. In deciding whether a project increases shareholder wealth, we have to weigh its benefits and its costs. The costs are:

- the cash flow necessary to make the investment (the investment outlay) and
- the opportunity costs of using the cash we tie up in this investment.

The benefits are the future cash flows generated by the investment. But we know that anything in the future is uncertain, so we know those future cash flows are not certain. Therefore, for an evaluation of any investment to be meaningful, we must represent how much risk there is that its cash flows will differ from what is expected, in terms of the amount and the timing of the cash flows. Risk is the degree of uncertainty. We can incorporate risk in one of two ways:

- we can discount future cash flows using a higher discount rate, the greater the cash flow's risk, or
- we can require a higher annual return on a project, the greater the cash flow's risk.

And, of course, we must incorporate risk into our decisions regarding projects that maximize owners' wealth. In this reading, we look at the sources of cash flow uncertainty and how to incorporate risk in the capital budgeting decision. We begin by describing what we mean by risk in the context of long-lived

projects. We then propose several commonly used statistical measures of capital project risk. Then we look at the relation between risk and return, specifically for capital projects. And we follow with how risk can be incorporated in the capital budgeting decision and how it is applied in practice.

## A. Risk

**Risk** is the degree of uncertainty. When we estimate (which is the best we can do) what it costs to invest in a given project and what its benefits will be in the future, we are coping with uncertainty. The uncertainty arises from different sources, depending on the type of investment being considered, as well as the circumstances and the industry in which it is operating. Uncertainty may due to:

- Economic conditions -- Will consumers be spending or saving? Will the economy be in a recession? Will the government stimulate spending? Will there be inflation?
- Market conditions -- Is the market competitive? How long does it take competitors to enter into the market? Are there any barriers, such as patents or trademarks that will keep competitors away? Is there sufficient supply of raw materials and labor? How much will raw materials and labor cost in the future?
- Taxes -- What will tax rates be? Will Congress alter the tax system?
- Interest rates -- What will be the cost of raising capital in future years?
- International conditions -- Will the exchange rate between different countries' currencies change? Are the governments of the countries in which the company does business stable?

These sources of uncertainty influence future cash flows. To evaluate and select among projects that will maximize owners' wealth, we need to assess the uncertainty associated with a project's cash flows. In evaluating a capital project, we are concerned with measuring its risk.

### Relevant cash flow risk

Financial managers worry about risk because the suppliers of capital -- the creditors and owners --- demand compensation for taking on risk. They can either provide their funds to your company to make investments or they could invest their funds elsewhere. Therefore, there is an opportunity cost to consider: what the suppliers of capital could earn elsewhere for the same level of risk. We refer to the return required by the suppliers of capital as the cost of capital, which comprises the compensation to suppliers of capital for their opportunity cost of not having the funds available (the time value of money) and compensation for risk.

$$\text{Cost of capital} = \text{Compensation for the time value of money} + \text{Compensation for risk}$$

Using the net present value criterion, if the present value of the future cash flows is greater than the present value of the cost of the project, it is expected to increase the value of the company, and therefore is acceptable. If the present value of the future cash flows is less than the present value of the costs of the project, it should be rejected. And under certain circumstances, using the internal rate of return criterion, if the project's return exceeds the project's cost of capital, the project increases owners' wealth. From the perspective of the company, this required rate of return is what it costs to raise capital, so we also refer to this rate as the cost of capital.

We refer to the compensation for risk as a risk premium -- the additional return necessary to compensate investors for the risk they bear. How much compensation for risk is enough? 2 percent? 4 percent? 10 percent?

How do we assess the risk of a project? We begin by recognizing that the assets of a company are the result of its prior investment decisions. What this means is that the company is really a collection or portfolio of projects. So when the company adds another project to its portfolio, should we be concerned only about the risk of that additional project? Or should we be concerned about the risk of the entire

portfolio when the new project is included in it? To see which, let's look at the different dimensions of risk of a project.

## B. Different types of project risk

If we have some idea of the uncertainty associated with a project's future cash flows -- its possible outcomes -- and the probabilities associated with these outcomes, we will have a measure of the risk of the project. But this is the project's risk in isolation from the company's other projects. This is the risk of the project ignoring the effects of diversification and is referred to as the project's total risk, or stand-alone risk.

Since most companies have other assets, the stand-alone risk of the project under consideration may not be the relevant risk for analyzing the project. A company is a portfolio of assets and the returns of these different assets do not necessarily move together; that is, they are not perfectly positively correlated with one another. We are therefore not concerned about the stand-alone risk of a project, but rather how the addition of the project to the company's portfolio of assets changes the risk of the company's portfolio.

Now let's take it a step further. The shares of many companies may be owned by investors who themselves hold diversified portfolios. These investors are concerned about how the company's investments affect the risk of their own personal portfolios. When owners demand compensation for risk, they are requiring compensation for market risk, the risk they can't get rid of by diversifying. Recognizing this, a company considering taking on a new project should be concerned with how it changes the market risk of a company. Therefore, if the company's owners hold diversified investments, it is the project's market risk that is relevant to the company's decision making.

Even though we generally believe that it's the project's market risk that is important to analyze, stand-alone risk should not be ignored. If we are making decisions for a small, closely-held company, whose owners do not hold well-diversified portfolios, the stand-alone risk gives us a good idea of the project's risk. And many small businesses fit into this category.

And even if we are making investment decisions for large corporations that have many products and whose owners are well-diversified, the analysis of stand-alone risk is useful. Stand-alone risk is often closely related to market risk: in many cases, projects with higher stand-alone risk may also have higher market risk. And a project's stand-alone risk is easier to measure than market risk. We can get an idea of a project's stand-alone risk by evaluating the project's future cash flows using statistical measures, sensitivity analysis, and simulation analysis.

## 2. Measurement of project risk

"Take calculated risks. That is quite different from being rash."

-- George S. Patton, 1944.

### A. Statistical measures of cash flow risk

We will look at three statistical measures used to evaluate the risk associated with a project's possible outcomes: the range, the standard deviation, and the coefficient of variation. Let's demonstrate each using new products as examples. Based on experience with our company's current product lines and the market research for new Product A, we can estimate that it may generate one of three different cash flows in its first year, depending on economic conditions:

Economic condition	Cash flow	Probability
Boom	\$10,000	20% or 0.20
Normal	5,000	50% or 0.50
Recession	-1,000	30% or 0.30

Looking at this table we can see there is more than one possible outcome. There are three possible outcomes, each representing a possible cash flow, and its probability of occurring.

Looking at this probability distribution, we see that there is some chance of getting a -\$1,000 cash flow and some chance of getting a +\$10,000 cash flow, though the most likely possibility (the one with the greatest probability) is a +\$5,000 cash flow.

But to get an idea of Product A's risk, we need to know a bit more. The more spread out the possible outcomes, the greater the degree of uncertainty (the risk) of what is expected in the future. We refer to the degree to which future outcomes are "spread out" as **dispersion**. In general, the greater the dispersion, the greater the risk. There are several measures we could use to describe the dispersion of future outcomes. We will focus on the range, the standard deviation, and the coefficient of variation.

### The range

The **range** is a statistical measure representing how far apart the two extreme outcomes of the probability distribution are. The range is calculated as the difference between the best and the worst possible outcomes:

$$\text{Range} = \text{Best possible outcome} - \text{Worst possible outcome}$$

For Product A, the range of possible outcomes is \$10,000 - (-\$1,000) = \$11,000. The larger the range, the farther apart are the two extreme possible outcomes and therefore more risk.

### The standard deviation

Though easy to calculate, the range doesn't tell us anything about the likelihood of the possible cash flows at or between the extremes. In financial decision-making, we are interested in not just the extreme outcomes, but all the possible outcomes.

One way to characterize the dispersion of all possible future outcomes is to look at how the outcomes differ from one another. This would require looking at the differences between all possible outcomes and trying to summarize these differences in a usable measure.

An alternative to this is to look at how each possible future outcome differs from a single value, comparing each possible outcome with this one value. A common approach is to use a measure of central location of a probability distribution, the **expected value**.

Let's use  $N$  to designate the number of possible future outcomes,  $x_n$  to indicate the  $n^{\text{th}}$  possible outcome,  $p_n$  to indicate the probability of the  $n^{\text{th}}$  outcome occurring, and  $E(x)$  to indicate the expected outcome. The expected cash flow is the weighted average of the cash flows, where the weights are the probabilities:

$$E(x) = x_1p_1 + x_2p_2 + x_3p_3 + \dots + x_np_n + \dots + x_Np_N$$

$$\text{Expected value} = E(x) = \sum_{n=1}^N p_n x_n$$

The **standard deviation** is a measure of how each possible outcome deviates -- that is, differs -- from the expected value. The standard deviation provides information about the dispersion of possible outcomes because it provides information on the distance each outcome is from the expected value and the likelihood the outcome will occur. The standard deviation is:

$$\text{Standard deviation of possible outcomes} = \sigma(x) = \sqrt{\sum_{n=1}^N p_n(x_n - \varepsilon(x))^2}$$

We begin our calculation of standard deviation by first calculating the expected outcome,  $E(x)$ . In our example, there are three possible outcomes, so  $N = 3$ . Adding the probability-weighted outcome of each of these three outcomes results in the expected cash flow:

$$E(\text{Cash flow for Product A}) = (0.20) \$10,000 + (0.50) \$5,000 + (0.30) \cdot (-\$1,000)$$

$$E(\text{Cash flow for Product A}) = \$2,000 + \$2,500 - \$300$$

$$E(\text{Cash flow for Product A}) = \$4,200$$

The calculations for the standard deviation are provided in Exhibit 1. The standard deviation is a statistical measure of dispersion of the possible outcomes about the expected outcome. The larger the standard deviation, the greater the dispersion and, hence, the greater the risk.

Economic conditions	Cash Flow	Probability	Cash flow times probability	Deviation	Squared deviation	Weighted squared deviation
Boom	\$10,000	20%	\$ 2,000	5,800	33,640,000	6,728,000
Normal	5,000	50%	2,500	800	640,000	320,000
Recession	-1,000	30%	<u>(300)</u>	-5,200	27,040,000	<u>9,112,000</u>
$E(x) = \$4,200$						$\sigma^2 = 15,160,000$
						$\sigma = \$3,893.58$

### The coefficient of variation

The standard deviation provides a useful measure of dispersion. It is a measure of how widely dispersed the possible outcomes are from the expected value. However, we cannot compare standard deviations of different projects' cash flows if they have different expected values.

We can do that with the coefficient of variation, which translates the standard deviation of different probability distributions (because their scales differ) so that they can be compared.

The **coefficient of variation** for a probability distribution is the ratio of its standard deviation to its expected value:

$$\text{Coefficient of variation} = \text{Standard deviation} / \text{Expected value}$$

or

$$\text{Coefficient of variation} = \frac{\sigma_x}{\varepsilon_x}$$

**Example: Expected return and standard deviation**

Consider investing in a project whose possible returns next period and associated probabilities are:

Possible outcome	Probability
-10%	20%
0%	50%
+20%	30%

What is this project's expected return and standard deviation?

First, calculate the expected return:

Possible outcome, $x_i$	Probability, $p_i$	$x_i p_i$
-0.10	0.20	-0.02
0.00	0.50	0.00
0.20	0.30	0.16
		$E(x) = 0.04$

Then, calculate the variance

$x_i - E(x)$	$(x_i - E(x))^2$	$p_i (x_i - E(x))^2$
-0.14	0.0196	0.00392
-0.04	0.0016	0.00080
0.16	0.0256	0.00768
		$\sigma^2(x) = 0.01240$

Variance = 0.01240

Standard deviation = 0.11136 or 11.136%

Risk can be expressed statistically in terms of measures such as the range, the standard deviation, and the coefficient of variation. Now that we know how to calculate and apply these statistical measures, all we need are the probability distributions of the project's future cash flows so we can apply these statistical tools to evaluate a project's risk.

Where do we get these probability distributions? From research, judgment, and experience. We can use sensitivity analysis or simulation analysis to get an idea of a project's possible future cash flows and their risk.

Estimates of cash flows are based on assumptions about the economy, competitors, consumer tastes and preferences, construction costs, and taxes, among a host of other possible assumptions. One of the first things we have to consider about our estimates is how sensitive they are to these assumptions. For example, if we only sell two million units instead of three million units in the first year, is the project still profitable? Or, if Congress increases the tax rates, will the project still be attractive?

We can analyze the sensitivity of cash flows to change in the assumptions by using re-estimating the cash flows for different scenarios. Sensitivity analysis, also called scenario analysis, is a method

of looking at the possible outcomes, given a change in one of the factors in the analysis. Sometimes we refer to this as "what if" analysis -- "what if this changes", "what if that changes", ..., and so on.

**Tools that can be used to evaluate total risk**

**Sensitivity analysis** (also called **scenario analysis**) is the examination of possible cash flows and returns on an investment when one uncertain element is altered ("what if?" analysis).

Sensitivity analysis illustrates the effects of changes in assumptions. But because sensitivity analysis focuses only on one change at a time or different sets of variations at a time, it is not very realistic. We know that not one, but many factors can change throughout the life of the project. In the case of the Williams project, there are a number of assumptions built into the analysis that are based on uncertainty, including the sales prices of the building and equipment in five years and the entrance of competitors no sooner than five years. And you can use your imagination and envision any new product and the attendant uncertainties regarding many factors including the economy, the company's competitors, and the price and supply of raw material and labor.

Sensitivity analysis becomes unmanageable if we start changing two factors at the same time (change more than two and it's even worse). A manageable approach to changing two or more factors at the same time is computer simulation. **Simulation analysis** is the analysis of cash flows and returns on investments when more than one uncertain element is considered (allowing more than one probability distribution to enter the picture). Simulation analysis allows the financial manager to develop a probability distribution of possible outcomes, given a probability distribution for each variable that may change.

Simulation analysis is more realistic than sensitivity analysis because it introduces uncertainty for many variables in the analysis. But if you use your imagination, this analysis may become complex since there are interdependencies among many variables in a given year and interdependencies among the variables in different time periods.

However, simulation analysis looks at a project in isolation, ignoring the diversification effects of projects, focusing instead on a single project's total risk. And simulation analysis also ignores the effects of diversification for the owners' personal portfolio. If owners hold diversified portfolios, then their concern is how a project affects their portfolio's risk, not the project's total risk.

## Demonstration of simulation analysis

Suppose that we are making an investment of \$80 million in the equipment for a new product. Through research with our marketing and production management, we have determined the expected price and cost per unit, as well as the number of units to produce and sell. Along with these estimates, we have a standard deviation that gives us an idea of the uncertainty associated with these estimates.

For simplicity, we have assumed that these three variables – price, cost, and number of units – are distributed normally with the mean and standard deviations provided by the company's management. From the accounting department, we have an estimate of the range of possible tax rates during the product's life; we've assumed a uniform distribution for these rates.

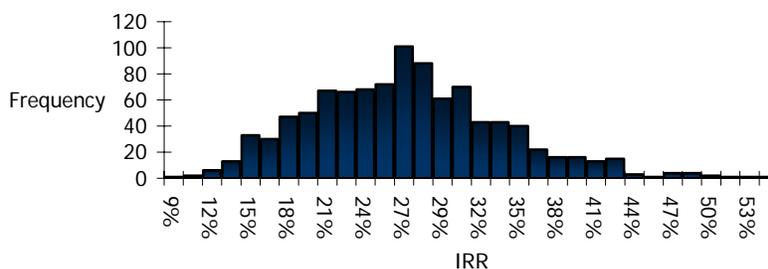
This analysis has produced the following:

Variable	Number of units	Price per unit	Expense per unit	Tax rate	
Mean	10,000,000	\$14	\$0.75	Minimum	35%
Standard deviation	1,000,000	\$2	\$0.05	Maximum	45%

We assume that the product will be produced and sold for the foreseeable future.

Using Microsoft Excel<sup>®1</sup>, we simulated 1,000 draws (that is, 1,000 random selections from each of the four variables' distributions) using the above information and calculated the product's internal rate of return for each of these draws. The spreadsheet consists of distribution specifications and the results of the random draws.<sup>2</sup>

The result is a distribution of possible internal rates of return for the product, as depicted in the histogram.



The height of this distribution is the number of draws (out of the possible 1,000 replications) for which the IRR fell into the range of IRRs depicted in the horizontal axis. In terms of risk, the wider the dispersion of possible IRRs relative to the expected IRR, the greater the product's risk.

## 3. Measuring a project's market risk

If we are looking at an investment in a share of stock, we could look at that stock's returns and the returns of the entire market over the same period of time as a way of measuring its market risk. While this is not a perfect measurement, it at least provides an estimate of the sensitivity of that particular stock's returns as compared to the returns of the market as a whole. But what if we are evaluating the market risk of a new product? We can't look at how that new product has affected the company's stock return! So what do we do?

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<sup>1</sup> To perform this analysis, we use Microsoft Excel's Random Number Generator in the Data Analysis program to perform the simulation given our specified distributions of all the variable factors.

<sup>2</sup> For an explanation of how to use Microsoft Excel<sup>®</sup> in simulation, go to <http://office.microsoft.com/en-us/assistance/HA011118931033.aspx>

Though we can't look at a project's returns and see how they relate to the returns on the market as a whole, we can do the next best thing: estimate the market risk of the stock of another company whose only line of business is the same as the project's risk. If we could find such a company, we could look at its stock's market risk and use that as a first step in estimating the project's market risk.

Let's use a measure of market risk, referred to as beta and represented by  $\beta$ .  $\beta$  is a measure of the sensitivity of an asset's returns to change in the returns of the market.  $\beta$  is an elasticity measure: if the return on the market increases by 1 percent, we expect the return on an asset with a  $\beta$  of 2.0 to increase by 2 percent, if the return on the market decreases by 1 percent, we expect the returns on an asset with a  $\beta$  of 1.5 to decrease by 1.5 percent, and so on. The **asset beta**, therefore, is a measure of the asset's market risk. To distinguish the beta of an asset from the beta we used for a company's stock, we refer to an asset's beta as  $\beta_{\text{asset}}$  and the beta of a company's stock as  $\beta_{\text{equity}}$ .

## A. Market risk and financial leverage

If a company has no debt, the market risk of its common stock is the same as the market risk of its assets. This is to say the beta of its equity,  $\beta_{\text{equity}}$ , is the same as its asset's beta,  $\beta_{\text{asset}}$ .

**Financial leverage** is the use of fixed payment obligations, such as notes or bonds, to finance a company's assets. The greater the use of debt obligations, the more financial leverage and the more risk associated with cash flows to owners. So, the effect of using debt is to increase the risk of the company's equity. If the company has debt obligations, the market risk of its common stock is greater than its assets' risk (that is,  $\beta_{\text{equity}}$  greater than  $\beta_{\text{asset}}$ ), due to financial leverage. Let's see why.

Consider an asset's beta,  $\beta_{\text{asset}}$ . This beta depends on the asset's risk, not on how the company chose to finance it. The company can choose to finance it with equity only, in which case  $\beta_{\text{equity}}$  greater than  $\beta_{\text{asset}}$ . But what if, instead, the company chooses to finance it partly with debt and partly with equity? When it does this, the creditors and the owners share the risk of the asset, so the asset's risk is split between them, but not equally because of the nature of the claims. Creditors have seniority and receive a fixed amount (interest and principal), so there is less risk associated with a dollar of debt financing than a dollar of equity financing of the same asset. So the market risk borne by the creditors is different than the market risk borne by owners.

Let's represent the market risk of creditors as  $\beta_{\text{debt}}$  and the market risk of owners as  $\beta_{\text{equity}}$ . Since the asset's risk is shared between creditors and owners, we can represent the asset's market risk as the weighted average of the company's debt beta,  $\beta_{\text{debt}}$ , and equity beta,  $\beta_{\text{equity}}$ :

$$\beta_{\text{asset}} = \beta_{\text{debt}} \left( \frac{\text{proportion of assets}}{\text{financed with debt}} \right) + \beta_{\text{equity}} \left( \frac{\text{proportion of assets}}{\text{financed with equity}} \right)$$

$$\beta_{\text{asset}} = \beta_{\text{debt}}\omega_{\text{debt}} + \beta_{\text{equity}}\omega_{\text{equity}}$$

But interest on debt is deducted to arrive at taxable income, so the claim that creditors have on the company's assets does not cost the company the full amount, but rather the after-tax claim, so the burden of debt financing is actually less due to interest deductibility. Further, the beta of debt is generally assumed to be zero (that is, there is no market risk associated with debt). It can then be shown that the relation between the asset beta and the equity beta is:

$$\beta_{\text{asset}} = \beta_{\text{equity}} \left[ \frac{1}{\left( 1 + \left( (1 - \tau) \frac{\text{debt}}{\text{equity}} \right) \right)} \right]$$

This means that an asset's beta is related to the company's equity beta, with adjustments for financial leverage. You'll notice that if the company does not use debt,  $\beta_{\text{equity}} = \beta_{\text{asset}}$  and if the company does use debt,  $\beta_{\text{equity}} < \beta_{\text{asset}}$ .

Therefore, we can translate a  $\beta_{\text{equity}}$  into a  $\beta_{\text{asset}}$  by removing the company's financial risk from its  $\beta_{\text{equity}}$ . As you can see in equation above, to do this we need to know:

- the company's marginal tax rate;
- the amount of the company's debt financing; and
- the amount of the company's equity financing.

The process of translating an equity beta into an asset beta is referred to as "unlevering" since we are removing the effects of financial leverage from the equity beta,  $\beta_{\text{equity}}$ , to get a beta for the company's assets,  $\beta_{\text{asset}}$ .

### Using a pure-play

A company with a single line of business is referred to as a **pure-play**. Selecting the company or companies that have a single line of business, where this line of business is similar to the project's, helps in estimating the market risk of a project. We estimate a project's asset beta by starting with the pure-play's equity beta. We can estimate the pure-play's equity beta by looking at the relation between the returns on the pure-play's stock and the returns on the market. Once we have the pure-play's equity beta, we can then "unlever" it by adjusting it for the financial leverage of the pure-play company.

#### Examples of pure plays

Company	Industry	$\beta_{\text{equity}}$
7-Eleven	Convenience stores	0.75
Universal Corporation	Tobacco	0.60
POSCO	Steel producer	1.00
American Water Works	Water utility	0.45

Source: *Value Line Investment Survey*

Suppose a pure-play company has the following financial data:

$$\begin{aligned} \beta_{\text{equity}} &= 1.1 \\ \text{Debt} &= \$3,914 \text{ million} \\ \text{Equity} &= \$4,468 \end{aligned}$$

Its asset beta,  $\beta_{\text{asset}}$ , is 0.6970:

$$\beta_{\text{asset}} = 1.1 \left[ \frac{1}{\left( 1 + \left( (1 - 0.34) \frac{\$3,914}{\$4,468} \right) \right)} \right] = 0.6970$$

Because many U.S. corporations whose stock's returns are readily available have more than one line

#### Example: Levering and unlevering betas

Calculate the asset beta for each of the following companies:

Company	Marginal tax rate	Debt	Equity	$\beta_{\text{equity}}$
Company A	40%	\$100	\$200	1.5
Company B	30%	\$100	\$400	1.5
Company C	40%	\$100	\$200	1.0

Solution:

$$\begin{aligned} \beta_{\text{asset}} \text{ for Company A} &= 1.1538 \\ \beta_{\text{asset}} \text{ for Company B} &= 1.2766 \\ \beta_{\text{asset}} \text{ for Company C} &= 0.7692 \end{aligned}$$

of business, finding an appropriate pure-play company may be difficult. Care must be taken to identify those that have lines of business similar to the project's.

### Try it! Asset betas

Calculate the asset beta for each of these companies:

Company	Tax rate	Debt	Equity	$\beta_{\text{equity}}$
3M	35%	\$10.33 billion	\$55.51 billion	0.90
Amazon.com	35%	\$3.45 billion	\$16.18 billion	1.70
Sprint Nextel	35%	\$49.54 billion	\$70.88 billion	1.15
Walt Disney Company	35%	\$29.95 billion	\$52.90 billion	1.35
Yahoo!	35%	\$2.08 billion	\$47.13 billion	1.90

Note: Tax rate is assumed.

Source of data: Yahoo! Finance and Value Line Investment Survey

**Bottom line:** We can't estimate the relevant, market risk of a project because this is not measurable directly. What we can do is use the market risk of a company in a similar, single line of business and then uses that company's stock beta – with some adjustments for differing financial leverage – to estimate the beta for the project. With this beta, we can then estimate the cost of capital for the project.

## 4. Incorporating risk in the capital budgeting decision

In using the net present value method to value future cash flows, we know that the discount rate should reflect the project's risk. In using the internal rate of return method, we know that the hurdle rate -- the minimum rate of return on the project -- should reflect the project's risk. Both the net present value and the internal rate of return methods, therefore, depend on using a cost of capital that reflects the project's risk.

### A. Risk-adjusted rate

The cost of capital is the cost of funds (from creditors and owners). This cost is the return required by these suppliers of capital. The greater the risk of a project, the greater the return required, and hence, the greater the cost of capital.

The cost of capital can be viewed as the sum what suppliers of capital demand for providing funds if the project were risk-free plus compensation for the risk they take on.

The compensation for the time value of money includes compensation for any anticipated inflation. We typically use a risk-free rate of interest, such as the yield on a long-term U.S. Treasury bond, to represent the time value of money.

The compensation for risk is the extra return required because the project's future cash flows are uncertain. If we assume that the relevant risk is the stand-alone risk (say, for a small, closely-held business), investors would require a greater return, the greater the project's stand-alone risk. If we assume that the relevant risk is the project's market risk, investors would require a greater return, the greater the project's market risk.

### B. Return required for the project's market risk

Now let's explain how to determine the premium for bearing market risk. We do this by first specifying the premium for bearing the average amount of risk for the market as a whole and then, using our measure of market risk, fine tune this to reflect the market risk of the asset. The **market risk premium** for the market as a whole is the difference between the average expected market return,  $r_m$ , and the risk-free rate of interest,  $r_f$ . If you bought an asset whose market risk was the same as that as the market as a whole, you would expect a return of  $r_m - r_f$  to compensate you for market risk.

Next, let's adjust this market risk premium for the market risk of the particular project by multiplying it by that project's asset beta,  $\beta_{\text{asset}}$ :

$$\text{Compensation for market risk} = \beta_{\text{asset}} (r_m - r_f).$$

This is the extra return necessary to compensate for the project's market risk. The asset beta fine-tunes the risk premium for the market as a whole to reflect the market risk of the particular project. If we then add the risk-free interest rate, we arrive at the cost of capital:

$$\text{Cost of capital} = r_f + \beta_{\text{asset}} (r_m - r_f)$$

Suppose the expected risk-free rate of interest is 4 percent and the expected return on the market as a whole is 10 percent. If the asset beta is 2.00, this means that if there is a 1 percent change in the market risk premium, we expect a 2 percent change in the return on the project. In this case, the cost of capital is 16 percent:

$$\text{Cost of capital} = 0.04 + 2.00 (0.10 - 0.04) = 0.16 \text{ or } 16\%$$

If asset beta is 0.75, instead, the cost of capital is 8.5 percent:

$$\text{Cost of capital} = 0.04 + 0.75 (0.10 - 0.04) = 0.085 \text{ or } 8.5\%$$

If we are able to gauge the market risk of a project, we estimate the risk-free rate and the premium for market risk and put them together. But often we are not able to measure the market risk, nor even the risk-free rate. So we need another way to approach the estimation of the project's cost of capital.

### C. Adjusting the company's cost of capital

Another way to estimate the cost of capital for a project without estimating the risk premium directly is to use the company's average cost of capital as a starting point. The average cost of capital is the company's marginal cost of raising one more dollar of capital -- the cost of raising one more dollar in the context of all the company's projects considered altogether, not just the project being evaluated. We can adjust the average cost of capital of the company to suit the perceived risk of the project:

- If a new project being considered is riskier than the average project of the company, the cost of capital of the new project is greater than the average cost of capital.
- If the new project is less risky, its cost of capital is less than the average cost of capital.
- If the project is as risky as the average project of the company, the new project's cost of capital is equal to the average cost of capital.

As you can tell, altering the company's cost of capital to reflect a project's cost of capital requires judgment. How much do we adjust it. If the project is riskier than the typical project do we add 2 percent? 4 percent? 10 percent? There is no prescription here. It depends on the judgment and experience of the decision maker. But this is where we can use the measures of a project's stand-alone risk to help form that judgment.

## 5. Assessment of project risk in practice

Most U.S. companies consider risk in some manner in evaluating investment projects. But considering risk is usually a subjective analysis as opposed to the more objective results obtainable with simulation or sensitivity analysis.

Companies that use discounted cash flow techniques, such as internal rate of return and net present value methods, tend to use a single cost of capital. But using a single cost of capital for all projects can be hazardous.

Suppose you use the same cost of capital for all your projects. If all of them have the same risk and the cost of capital you are using is appropriate for this level of risk, no problem. But what if you use the same cost of capital but your projects each have different levels of risk?

Suppose you use a cost of capital that is the cost of capital for the company's average risk project. What happens when you apply discounted cash flow techniques, such as the net present value or the internal rate of return, and use this one rate? You will end up:

- rejecting profitable projects (which would have increased owners' wealth) that have risk below the risk of the average risk project because you discounted their future cash flows too much, and
- accepting unprofitable projects whose risk is above the risk of the average project, because you did not discount their future cash flows enough.

Companies that use a risk-adjusted discount rate usually do so by classifying projects into risk classes by the type of project. For example, a company with a cost of capital of 10 percent may use a 14 percent cost of capital for new products and a much lower rate of 8 percent for replacement projects. Given a set of costs of capital, the financial manager need only figure out what class a project belongs to and then apply the rate assigned to that class.

Companies may also make adjustments in the cost of capital for factors other than the type of project. For example, companies investing in projects in foreign countries will sometimes make an adjustment for the additional risk of the foreign project, such as exchange rate risk, inflation risk, and political risk.

The cost of capital is generally based on an assessment of the company's overall cost of capital. First, the company evaluates the cost of each source of capital -- debt, preferred stock, and common equity. Then each cost is weighted by the proportion of each source to be raised. This average is referred to as the weighted average cost of capital (WACC).

There are tools available to assist the decision-maker in measuring and evaluating project risk. But much of what is actually done in practice is subjective. Judgment, with a large dose of experience is used more often than scientific means of incorporating risk. Is this bad? Well, the scientific approaches to measurement and evaluation of risk depend, in part, on subjective assessments of risk, the probability distributions of future cash flows and judgments about market risk. So it is possible that by-passing the more technical analyses in favor of completely subjective assessment of risk may result in cost of capital estimates that better reflect the project's risk. But then again it may not. The proof may be in the pudding, but it is difficult to assess the "proof" since we cannot tell how well companies could have done had they used more technical techniques!

## 6. Summary

To screen and select among investment projects, the financial manager must estimate future cash flows for each project, evaluate the riskiness of those cash flows, and evaluate each project's contribution to the company's value and, hence, to owners' wealth. The financial manager has to evaluate future cash flows -- cash flows that are estimates, which mean they are uncertain. The financial manager must also to incorporate of risk into the analysis of projects to identify which ones maximize owners' wealth.

Statistical measures that can be used to evaluate the risk of a project's cash flows are: the range, the standard deviation, and the coefficient of variation. Sensitivity analysis and simulation analysis are tools that can be used in conjunction with the statistical measures, to evaluate a project's risk. Both techniques give us an idea of the relation between a project's return and its risk. However, since the company is itself a portfolio of projects and it is typically assumed that owners hold diversified portfolios, the relevant risk of a project is not its stand-alone risk, but rather how it affects the risk of owners' portfolios, its market risk.

Risk is typically figured into our decision-making by using a cost of capital that reflects the project's risk. The relevant risk for the evaluation of a project is the project's market risk, which is also referred to as the asset beta. This risk can be estimated by looking at the market risk of companies in a single line of business similar to that of the project, a pure-play. An alternative to finding a pure-play is to classify projects according to the type of project (e.g. expansion) and assign costs of capital to each project type according to subjective judgment of risk.

Most companies adjust for risk in their assessment of the attractiveness of projects. However, this adjustment is typically done by evaluating risk subjectively and ad hoc adjustments to the company's cost of capital to arrive at a cost of capital for a particular project.

## 7. Solutions to Try it!

### Asset betas

Company	$\beta_{\text{equity}}$	Debt/equity	$\left[ \frac{1}{\left( 1 + \left( (1 - \tau) \frac{\text{debt}}{\text{equity}} \right) \right)} \right]$	$\beta_{\text{asset}}$
3M	0.90	0.18609	0.89209	0.80288
Amazon.com	1.70	0.21323	0.87827	1.49306
Sprint Nextel	1.15	0.69893	0.68761	0.79076
Walt Disney Company	1.35	0.56616	0.73099	0.98684
Yahoo!	1.90	0.04413	0.97212	1.84702

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