10

The Capital Asset Pricing Model

What expected rate of return does your project have to offer? The last chapter explained how you can determine the answer if your project is 100% like other assets—such as Treasuries, the stock market, or some other traded financial assets. But what about projects that are more like combinations? How would you judge how much of each asset you would need to mimic your project? And which other assets should you choose as your benchmarking portfolios?

This is the domain of the Capital Asset Pricing Model (CAPM). It comes with a promise that you only have to worry about Treasuries and the stock market (and nothing else) and gives you a formula that relates how much reward your investment project has to offer to compensate your investors for its risk. The risk is the market beta. The formula works for *any* kind of project. You can then use its costs of capital in your NPV calculations.

We will first briefly review what you already know. Then you will learn all about the CAPM. And you will get to apply it—and then, I will have to tell you that although the CAPM is the dominant model in practice, it is not only often poorly applied, but its empirical validity is also miserable even under the best of circumstances. I will put it all in perspective for you.

10.1 What You Already Know

We are still going at the same central question—what is a good opportunity cost of capital?

In this chapter, we will still assume but now lean more heavily on our perfect-market assumptions than we have in recent chapters. Moreover, we will also assume that investors are smart and that they diversify their portfolios to reduce their risk exposures. The types of risk that investors consider toxic can only be the parts that they cannot wash out by diversification and that remain left over even when all assets are just tiny parts of their large overall portfolios.

Not being dummies, collectively, investors snatch up the best projects—those that have low risk and high expected rates of return. In fact, anyone contemplating selling a project with more reward than it deserves would attract a gazillion bidders. Anyone contemplating selling projects with too unfavorable risk contributions for its reward would not receive a single offer. There is really only one correct choice of price. Consequently, what investors purchase in the real world at the correct prices must be subject to some trade-off: Projects that drive up overall portfolio risk must offer higher expected rates of return.

Again, our perspective will be primarily that of the corporate manager, not that of a day trader. From the previous chapter, you know that investors like short-term low-risk project cash

flows (like overnight Treasuries), and dislike long-term unsafe project cash flows (like the stock market). How do you determine how much of your own potential projects should be viewed "like bonds" and how much "like stocks"? This is what the CAPM will do for you—it will give you an answer to "like this much bonds, like this much stocks," and this answer is the "market beta."

We would love an integrated "beautiful" perspective.

These simplifications will leave you with a nice framework: Investors dislike risk and like reward. They care about their overall financial investments portfolio. They are diversified. If you buy into this view, as a corporate manager, you can then infer how external investors judge the risk and reward of your own corporate projects. Investors' reward is their portfolio's expected rate of return. Investors' risk is their *overall* portfolio risk, *not* your project's *own* standard-deviation risk. Your own project's contribution to investors' overall portfolio risk is then best measured by the market beta of your project. Think of beta as a measure of your project's "toxicity." A project that decreases in value when the market decreases in value (and increases when it increases) has a positive market beta. It's toxic—investors don't like it. A project that increases in value when the market decreases in value, and vice-versa, has a negative market beta. It's less toxic—investors like it more. That is, projects with lower market betas help investors (who already otherwise hold market-like portfolios) suffer less overall portfolio risk.

10.2   The Capital Asset Pricing Model (CAPM)

The CAPM gives you the cost of capital if you give it the risk-free rate, the expected rate of return on the market, and your project's market beta.

The **capital asset pricing model** (**CAPM**) gives an appropriate expected rate of return (cost of capital) for each project if you give it the project's single relevant risk characteristics (the market beta); and (just as in the previous chapter) the risk-free rate of return and equity premium. The model states that an investment's cost of capital is lower when it offers better diversification benefits for an investor who holds the overall market portfolio—less required reward for less risk contribution. Market beta is its measure of risk contribution. Projects contributing more risk (market beta) require higher expected rates of return for you to want them; projects contributing less risk require lower expected rates of return. According to the CAPM, nothing but the risk-free rate, the expected equity premium, and the market beta matters. No other financial assets need to be investigated to judge your project.

IMPORTANT

To estimate the required expected rate of return for a project or firm—that is, the cost of capital—according to the CAPM, you need three inputs:

1. The risk-free rate of return, r_F.
2. The expected rate of return on the overall market, $E(r_M)$—or, equivalently, the equity premium $E(r_M) - r_F$.
3. The project's beta with respect to the market, β_i.

The CAPM formula is

$$E(r_i) = r_F + [E(r_M) - r_F] \cdot \beta_i$$

where i is the name of your project and $E(r_i)$ is your project's expected rate of return. All model inputs are forward-looking: the risk-free rate, the equity premium, and the market beta of the asset.

You need to memorize the CAPM formula.

The CAPM formula tells you what investors care about: comovement with the market.

The CAPM specifically ignores the stand-alone risk of your project. That is, investors do not care about your projects' variance, because they are smart enough to diversify away this

idiosyncratic risk. Investors care only about your project's market betas, because it is betas that measure the component of risk that your project contributes and that investors holding the wide market portfolio would not have diversified away.

On a pragmatic level, the CAPM is seductive. It limits your attention to just two benchmark assets. It gives you a coherent universal measure of where projects lie on the spectrum between stocks and bonds. More market beta means "more like stocks," and thus higher expected rates of return ("just like stocks"). Less market beta means "more like bonds," and thus lower expected rates of return ("just like bonds").

Mechanically, it looks sensible.

Without going into detail, economists also love a deep "economic equilibrium model" justification for the CAPM that I will largely spare you. In this view, financial markets are perfect, each and every investor faces the same tradeoffs and uses the model, and each and every asset is priced by it. When all the assumptions are satisfied, it implies mathematically that the CAPM must hold. Necessarily, there could then not be any benchmarks other than the risk-free rate and the stock market, and the only valid measure of risk would be the market beta. This CAPM justification, with its stringent assumptions, is too orthodox and simply not realistic.

There are deeper CAPM rationales that economists call "equilibrium models."

But more important than philosophy, the empirical data soundly rejects the CAPM, as I will explain below in more detail. For now, let me just say that you must still study the CAPM not only because it is conceptually interesting but also because every finance dinosaur in the real world is using it—and, more than likely, (s)he will growl CAPM questions in your job interview.

PS: I was brought up by dinosaurs, too—I got my degrees in the 1980s.

Q 10.1. What are the assumptions underlying the orthodox CAPM? Are the perfect market assumptions among them? Are there more?

The Security Market Line (SML)

Let's first use the CAPM formula as a recipe. If you believe that the risk-free rate is 3% and the expected rate of return on the market is 8%, then the CAPM states that

A first quick use of the CAPM formula.

$$\mathsf{E}(r_i) = 3\% + (8\% - 3\%) \cdot \beta_i = 3\% + 5\% \cdot \beta_i$$
$$\mathsf{E}(r_i) = r_F + [\mathsf{E}(r_M) - r_F] \cdot \beta_i$$

Therefore, a project with a beta of 0.5 should have a cost of capital of $3\% + 5\% \cdot 0.5 = 5.5\%$, and a project with a beta of 2.0 should have a cost of capital of $3\% + 5\% \cdot 2.0 = 13\%$. The CAPM gives the opportunity cost for your investors' capital: If the project with the beta of 2.0 cannot earn this expected rate of return of 13%, you should not take this project and instead return the money to your investors. Your project would add too much risk for its reward. Your investors have better opportunities elsewhere.

The CAPM formula is often graphed as the **security market line** (**SML**), which shows the relationship between the expected rate of return of a project and its beta. Exhibit 10.1 draws a model-perfect security market line for seven assets. Each investment asset (such as a stock or a project) is a point in this coordinate system. Because all assets in our example properly follow the CAPM formula, they must lie on a straight line. The SML is just the graphical representation of the CAPM formula. The slope of this line is the equity premium, $\mathsf{E}(r_M) - r_F$, and the intercept is the risk-free rate, r_F.

The SML is just a graphical representation of the CAPM formula.

Alas, in the real world, even if the CAPM holds, you would not have the data to draw Exhibit 10.1. The reason is that you do not know true expected returns and true expected market betas. Exhibit 10.2 plots a version where you have to rely only on what most investors have and rely on—observable historical data averages. Thus you can only fit an "estimated security market line," not the "true security market line." And you have to hope that your historical

If you know the inputs, the SML is a sharp line; if you estimate them, it is a scatterplot.
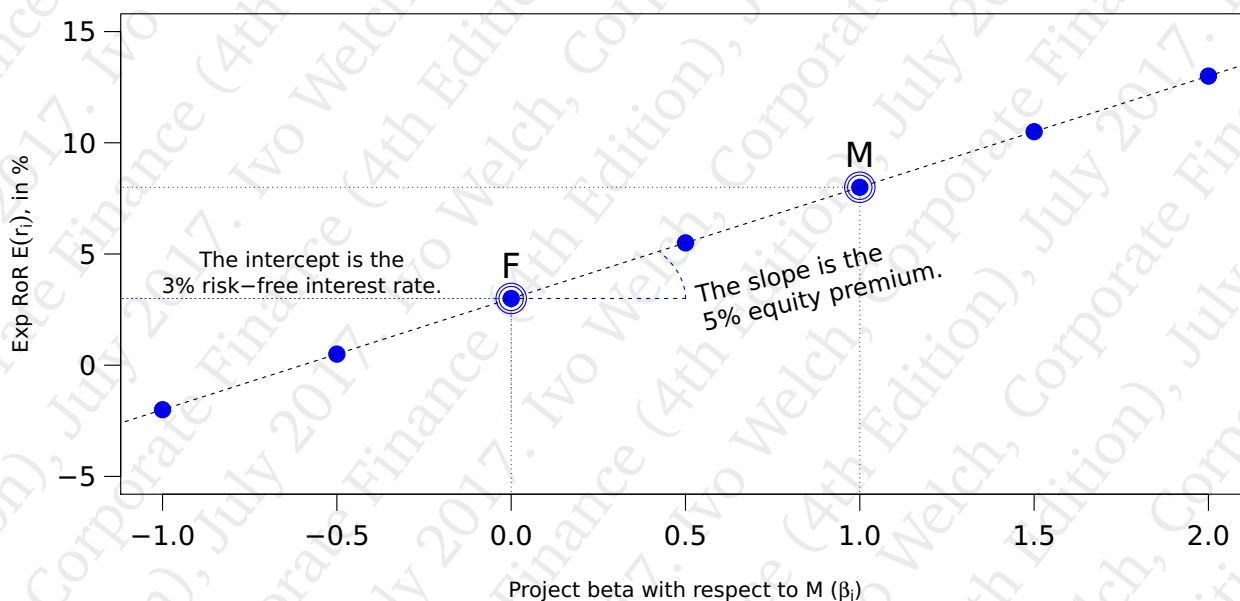
		Investment Asset					
		A	**B**	**F**	**C**	**M**	**D**	**E**
Market Beta	β_i	–1.0	-0.5	0.0	0.5	1.0	1.5	2.0
Expected Rate of Return	$E(r_i)$	–2.0%	0.5%	3.0%	5.5%	8.0%	10.5%	13.0%

Exhibit 10.1: *The Security Market Line With Perfect Knowledge.* This graph plots the CAPM relation $E(r_i) = r_F + [E(r_M) - r_F] \cdot \beta_i = 3\% + (8\% - 3\%) \cdot \beta_i$, where β_i is the beta of an individual asset with respect to the market. In this graph, we assume that the risk-free rate is 3% and the equity premium is 5%. Each point is one asset (such as a stock, a project, or a mutual fund). The point M could be the value-weighted market portfolio or any any other security with a $\beta_i = 1$. F could be the risk-free asset or any other security with a $\beta_i = 0$.

data has provided good, unbiased estimates of the true forward-looking market beta and true forward-looking expected rates of return. (Both are big assumptions!) If the fitted line looks straight, you would not immediately throw out the CAPM. In any case, any workable version of the CAPM in real life can only state that there should roughly be a linear relationship between the data-estimated market betas and the data-estimated expected rates of return, just as drawn in Exhibit 10.2.

Q 10.2. The risk-free rate is 4%. The expected rate of return on the market is 7%. What is the appropriate cost of capital for a project that has a beta of 3?

Q 10.3. The risk-free rate is 4%. The expected rate of return on the market is 12%. What is the cost of capital for a project that has a beta of 3?
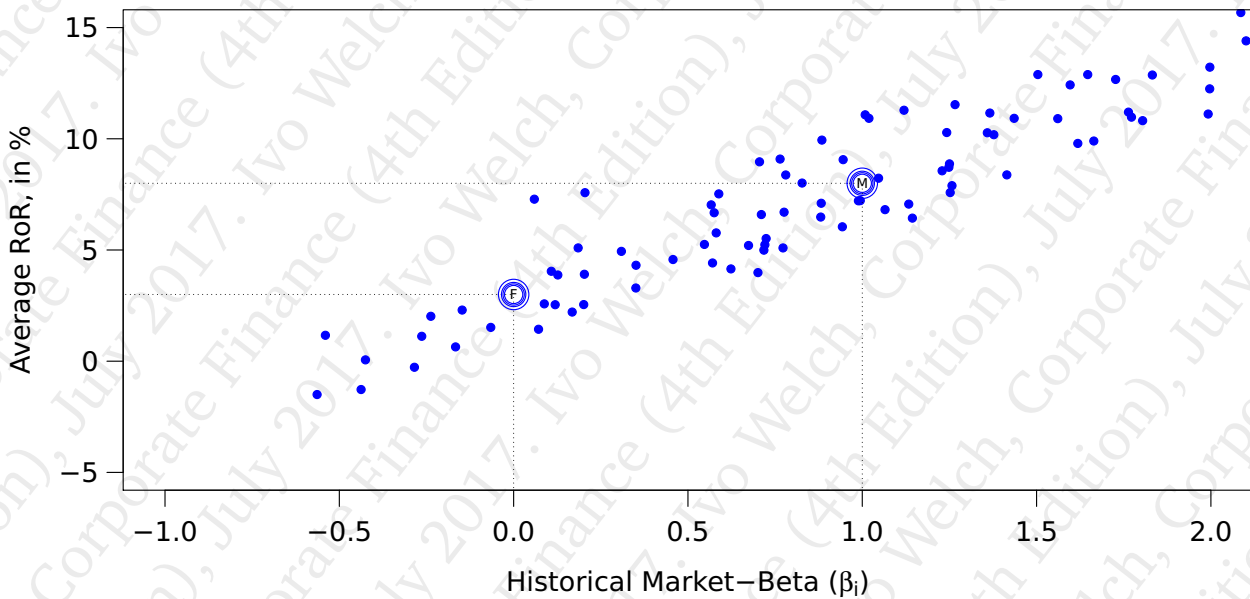
Exhibit 10.2: *The Security Market Line in an Ideal CAPM World.* This plot shows what you are, at best, confronted with: You don't know expected returns and betas. All you know are historical average returns and historical betas that are usually just data statistics. You then hope that these are unbiased representations of the underlying true historical mean returns and historical betas. In turn, you then further hope that these are also representative of future expected returns and future betas. There is always hope.

Q 10.4. The risk-free rate is 4%. The expected rate of return on the market is 12%. What is the cost of capital for a project that has a beta of –3? Does this make economic sense?

Q 10.5. Is the real-world SML with historical data a perfectly straight line?

Q 10.6. The risk-free rate is 4%. The expected rate of return on the market is 7%. A corporation intends to issue publicly traded bonds that *promise* a rate of return of 6% and offer an *expected* rate of return of 5%. What is the implicit beta of the bonds?

Q 10.7. Draw the SML if the risk-free rate is 5% and the equity premium is 9%.

Q 10.8. What is the equity premium, both mathematically and intuitively?

The CAPM in the Present Value Formula

If you take the CAPM at face value, it gives you a good denominator for the NPV formula, the opportunity cost of capital, $E(r)$:

$$\text{NPV} = C_0 + \frac{E(C_1)}{1 + E(r_1)} + \frac{E(C_2)}{1 + E(r_2)} + \cdots$$

Together, the CAPM and the NPV formulas tell you that cash flows that correlate more with the overall market are of less value to your investors and therefore require higher expected rates of return ($E(r)$) in order to pass muster (well, to pass the hurdle rate, which is determined by the alternative opportunities that your model presumes your investors have).

The CAPM is called an **asset-pricing model**, even though it is most often expressed in terms of a required expected rate of return rather than in terms of an appropriate asset price. Fortunately, though messy, the two are equivalent—you can always work with the CAPM return first, and then discount the expected cash flow into an appropriate price. A given expected rate of return implies a given price. (If you do not know the fair price, you will have to take two aspirins [or something more hallucinogenic] and work with a more difficult version of the CAPM formula. It is called **certainty equivalence** [CEV] and is explained in the companion chapter.)

Equity and Asset Betas

As in Section 9.5, it is important that you always distinguish between asset costs of capital and equity costs of capital. Whatever worked there with the overall costs of capital also works here with market betas. Done. You can skip the rest of this section, or endure a few more examples.

Assume that the risk-free rate is 4% and the equity premium is 5%. You own a \$100 million project with an asset beta of 2.0 that you can finance with \$20 million of risk-free debt. Truly risk-free debt always has a beta of 0. To find your equity beta, write down the formula for your asset beta (firm beta):

$$\beta_{\text{Firm}} = \underbrace{\left(\frac{\text{Debt value}}{\text{Firm value}}\right)}_{20\%} \cdot \underbrace{\beta_{\text{Debt}}}_{(0)} + \underbrace{\left(\frac{\text{Equity value}}{\text{Firm value}}\right)}_{80\%} \cdot \underbrace{\beta_{\text{Equity}}}_{(\beta_{\text{Equity}})} = 2.0$$

Solve this to find that your market beta of equity is 2.5. It is this market beta of equity that you would find reported on YAHOO! FINANCE. You would not want to base your hurdle rate for your entire firm's typical average project on your equity beta: Such a mistake would recommend you use a hurdle rate of $E(r_i) = r_F + [E(r_M) - r_F] \cdot \beta_i = 4\% + 5\% \cdot 2.5 = 16.5\%$. This would be too high. Instead, you should require your average projects to return $E(r_i) = 4\% + 5\% \cdot 2.0 = 14\%$.

	20% Debt	80% Equity	100% Project
Beta	0.0	2.5	2.0
⇒ Cost of Capital	4%	16.5%	14.0%

In both cases, the capitalization-weighted average of debt and equity is always the overall project asset.

Conversely, if your project is private but the potential future owners are well-diversified, you may have to find its hurdle rate by looking at public comparables. Let's presume you find a similarly sized firm with a similar business that YAHOO! FINANCE lists with a beta of 4, or perhaps better yet, the firm's industry. Remember that financial websites always list only the equity beta. The CAPM tells you that the expected rate of return on the equity is $4\% + 5\% \cdot 4 = 24\%$. However, this is not necessarily the hurdle rate for your project. When you look further on

YAHOO! FINANCE, you may notice that your comparable is financed with 90% debt and 10% equity. (If the comparable had very little debt, a debt beta of 0 might have been a good assumption, but unfortunately, in this case it is not.) Corporate debt rarely has good historical return data that would allow you to estimate a debt beta. Consequently, practitioners often estimate the expected rate of return on debt via debt comparables based on the credit rating. Say your comparable's debt is rated BB and say that BB bonds have offered *expected* rates of return of 100 basis points above the Treasury. (This might be 200 basis points *quoted* above the Treasury). With the Treasury standing at 4%, you would estimate the comparable's cost of capital on debt to be 5%. The rest is easy. The expected rate of return on your project should be

$$\mathsf{E}(r_{\text{Project}}) = 90\% \cdot 5\% + 10\% \cdot 24\% = 6.9\%$$
$$= w_{\text{Debt}} \cdot \mathsf{E}(r_{\text{Debt}}) + w_{\text{Equity}} \cdot \mathsf{E}(r_{\text{Equity}})$$

This would make a good hurdle rate estimate for your project.

Does Risk Reduction Create Value?

In the 1960s and 1970s, many firms became **conglomerates**, that is, companies with widely diversified and often unrelated holdings. Can firms add value through such diversification? The answer is "usually no." Diversification indeed reduces the standard deviation of the company's rate of return (diversified companies are less risky). Yet, in a perfect market, your investors can just as well diversify risk for themselves. They don't need the firm to do it for them. This is a more important insight than what follows. Again: if investors can do it without the firm, the firm cannot add value by doing it for them.

Diversification reduces risk, but does not create value.

As in the previous section, we can elaborate about this in the context of the CAPM. However, the basic idea should hold in any reasonable framework, e.g., if projects have different cash flow horizons and thus different costs of capital. Thus, you can consider it "done" and you can skip this section, too, if you already fully understand this. Otherwise, endure the example.

For example, if your $900 million firm ABC (e.g., with a beta of 2 and a risk of 20%) is planning to take over the $100 million firm DEF (e.g., with a beta of 1 and also a risk of 20%), the resulting firm is worth $1 billion. ABC + DEF indeed has an idiosyncratic risk lower than 20% if the two firms are not perfectly correlated, but your investors (or a mutual fund) could just have held 90% of their portfolios in ABC and 10% in DEF and thereby achieved the very same diversification benefits. If anything, a merger takes away your investors' freedom: They no longer have the ability to buy, say, 50% of their portfolios in ABC and 50% in DEF. (In a CAPM world, this does not matter.) The CAPM makes it explicit that the cost of capital does not change unduly. Say both firms follow the CAPM pricing formula, and say that the risk-free rate is 3% and the equity premium is 5%,

A specific diversification example worked out for you, in which projects are priced fairly, and diversification neither creates nor destroys value.

$$\mathsf{E}(r_{\text{ABC}}) = 3\% + 5\% \cdot 2 = 13\%$$
$$\mathsf{E}(r_{\text{ABC}}) = r_F + [\mathsf{E}(r_M) - r_F] \cdot \beta_{\text{ABC}}$$

and

$$\mathsf{E}(r_{\text{DEF}}) = 3\% + 5\% \cdot 1 = 8\%$$
$$\mathsf{E}(r_{\text{DEF}}) = r_F + [\mathsf{E}(r_M) - r_F] \cdot \beta_{\text{DEF}}$$

The newly formed company will have an expected rate of return (cost of capital) of

$$E(r_{ABC + DEF}) = 90\% \cdot 13\% + 10\% \cdot 8\% = 12.5\%$$
$$E(r_{ABC + DEF}) = w_{ABC} \cdot E(r_{ABC}) + w_{DEF} \cdot E(r_{DEF})$$

and a market beta of

$$\beta_{ABC + DEF} = 90\% \cdot 2 + 10\% \cdot 1 = 1.9$$
$$\beta_{ABC + DEF} = w_{ABC} \cdot \beta_{ABC} + w_{DEF} \cdot \beta_{DEF}$$

The merged company will still follow the CAPM,

$$E(r_{ABC + DEF}) = 3\% + 5\% \cdot 1.9 = 12.5\%$$
$$E(r_{ABC + DEF}) = r_F + [E(r_M) - r_F] \cdot \beta_{ABC + DEF}$$

Its cost of capital has not unduly increased or declined. In an ideal [CAPM] world, no value has been added or destroyed—even though ABC + DEF will have a risk lower than the 20% per annum that its two constituents had.

Deconstructing Quoted Rates of Return

As in Section 9.6, the asset-pricing model provides just the expected rate of return, not the quoted rate of return. If you look at the example there again, you could view it as applying in the current context, too. The CAPM merely pins down the sources of the 75% and 25% expected debt equity components. Replace these 75/25 proportions with a beta of 0.25, and you really have the same example.

Short-Term and Long-Term Projects?

Although the CAPM formally recognizes only one SML in theory, we use different risk-free rates for different project horizons in practice. Thus, short-term projects would have lower costs of capital than long-term projects. For example, you might assess, say, a 3% equity premium; and using the prevailing yield curve in 2016, you might assess

	β_i:	–2	–1	0	1	2	3
Short-Term Projects	$E(r_i) = 1\% + 3\%$	1%	2%	3%	4%	5%	6%
Long-Term Projects	$E(r_i) = 3\% + 3\%$	–3%	0%	3%	6%	9%	12%

where the 1% is the 1-year Treasury and the 3% is the 30-year Treasury. Recall that we are not sure whether we should use the same equity premium (here 3%) for both near and far project cash flows. It is due to ignorance that we typically use the same equity-premium estimate regardless of term.

Nerdnote: If the CAPM truly held, long-term bonds would have higher expected rates of return than short-term bonds, and this could be explained exactly by their positive market beta. Alas, long-term bonds have had negative market betas for a few decades now. Nobody knows why. However, be aware that applying the CAPM to long-term bonds would so obviously contradict reality that few are tempted to use it in this context Instead, everyone uses adjusted yield-curve estimates.

Q 10.9. A corporate bond with a beta of 0.2 will pay off next year with 99% probability. The risk-free rate is 3% per annum, and the equity premium is 5% per annum.

1. What is the price of this bond?
2. What is its promised rate of return?
3. Decompose the bond's quoted rate of return into its components.

Q 10.10. Going to your school has total additional and opportunity costs of $30,000 *this year and upfront*. With 90% probability, you are likely to graduate from your school. If you do not graduate, you have lost the entire sum. Graduating from the school will increase your 40-year lifetime annual salary by roughly $5,000 per year, but more so when the market rate of return is high than when it is low. For argument's sake, assume that your extra-income beta is 1.5. Assume the risk-free rate is 3%, and the equity premium is 5%. What is the value of your education?

10.3 Estimating the Extra Input: Market Beta

We already discussed estimating the risk-free rate and equity premium in the previous chapter and beta estimation in the chapter before. Because beta is the only novel aspect relative to benchmarking, let's discuss it a little more. Beta tells you how the rate of return of your project fluctuates with that of the overall market. Unlike the previous two inputs, which are the same for every project in the economy, the beta input depends on your own specific project characteristics: Different projects have different betas.

> Unlike the risk-free rate and the equity premium, beta is specific to each project.

Just as with the risk-free rate and the expected rate of return on the stock-market (or equivalently, the equity premium) in Chapter 9, investors are really interested in the *future* market betas of your projects and not in their historical market betas. No one really cares about the past for its own sake. But as usual, you often have no choice other than to rely on estimates, and these are usually based largely on statistical analysis of historical data. Although any estimates of future betas from historical betas tend to be better than estimates of the future equity premium from historical equity premiums, beta estimates are still not too reliable—especially over long horizons. The reason is that stock returns are very noisy, and the unobserved underlying true betas themselves also tend to move around. It's like shooting without a viewfinder at a moving target—not as good as shooting at a fixed target, but not as bad as shooting without a view. *C'est la vie.*

> The CAPM has three inputs. We will cover them in detail.

Market Beta Estimation Based on Historical Data

The basic mechanics of finding the historical market beta for a project with historical rates of return is easy. You run a **market-model** regression. The independent variable is the rate of return on the stock market. The dependent variable is the rate of return on your project. It is also good practice to subtract the risk-free T-bill rate from both your project's and the stock market's rates of return. Any statistical software package (and common computer spreadsheet programs like Excel or Openoffice) can readily calculate the coefficients a and b in the market-model regression:

> Ways to estimate beta.

$$\underbrace{(r_{\text{Project}} - r_F)}_{\text{y variable}} = a + b \cdot \underbrace{(r_{\text{Market}} - r_F)}_{\text{x variable}}$$

The slope b is the market beta. It's a good thing that we use b as a symbol instead of β, because the b that the regression spits out is only an estimate of a true beta (β), and not the true and unknowable beta itself.

Historical market beta to forward market beta

This is only the basics. To get a better forward-looking market beta estimate, you should do the following:

1. Use daily stock returns, not monthly stock returns.

2. Use about two years' worth of data. Between one and five years of data will do.

3. "Shrink" your first-pass market beta by 30-40% towards 1, depending on the timing of the cash flow that you intend to use it on:

< 1 Year	$(1 - 0.3) \times b + 0.3 \times 1$
> 5 Years	$(1 - 0.4) \times b + 0.4 \times 1$

This 0.3 (or 0.4) factor is used partly because it reduces historical outliers, and partly because true market betas drift over long horizons. If you want, you can shrink beta by another 10% if your project and firm are small.

For example, if your statistical software gives you a first-pass market-beta estimate for your project of 2.0, and you want to estimate a CAPM cost of capital for a project cash flow in 1 year, then use $(1 - 0.3) \times 2.0 + 0.3 = 1.7$. If you want to estimate it for a project cash flow in 10 years, use 1.6. If your first-pass estimate is -1.0, and the cash flow is in 1 year, use $(1 - 0.3) \times -1.0 + 0.3 = -0.4$.

It does not matter much which particular stock market index you use as your independent variable. The S&P 500 with or without dividends is fine. There are also other more sophisticated methods, but the above three guidelines cover the most important basics. It is unlikely that you can improve much on them. These market betas are as good as they are going to get.

What not to do!

In practice, you may encounter two common estimation practices that dramatically worsen the quality of estimated market betas. So let me warn you:

1. If you have good daily data, do not estimate market beta with monthly return data. (And if you have no choice [as, for example, with hedge funds, which report rates of return only monthly], then shrink more—think 50-60%, not 30-40%.)

2. If you have your firm's own stock returns, do not use industry portfolio returns as stand-ins for your firm. Although industry betas move less than stock-specific betas and thus seem appealing, in reality industry betas are much worse predictors for stocks than the stocks' own market betas.

If you see either practice, tell the dinosaur using them that the mammals are taking over and they'd better evolve and adapt!

Nerdnote: If you want to estimate future market-beta even better, then shrink not towards 1, but towards a smaller constant, like 0.6-0.8, if your firm and project are small.

Market Beta Estimation Based on Theoretical Consideration

As a corporate manager, you are rarely interested in the market beta of an industry or even a stock. Usually, you are interested in the market beta of a potential project. Sometimes, your firm may not even be publicly traded, so you would not have any historical price data to begin with. In this case, corporate CAPM users sometimes rely on economic intuition rather than historical statistics. To see the logic, rearrange the CAPM formula. Now, do you think your project cash flows and its future project values (which are influenced by changes in the economy) are likely to move more or less with the overall stock market (and possibly the overall economy)?

Turn the formula around to help contemplate beta

$$E(r_{\text{Project}}) = r_F + [E(r_M) - r_F] \cdot \beta_{\text{project}} \quad \Longleftrightarrow \quad \beta_{\text{Project}} = \frac{E(r_{\text{Project}}) - r_F}{E(r_M) - r_F}$$

The right side of this formula helps translate your intuition into a beta estimate. What rate of return (above the risk-free rate) will your project have if the market were to have +10% or −10% rate of return (above the risk-free rate)? Clearly, such guesswork is difficult and error-prone—but it can occasionally provide a market-beta estimate when no other is available. But be aware that such estimates are almost always poor.

If you do not believe me that your estimate is going to be so bad that you may as well just go back to the peer benchmarks from Chapter 9, then I dare you to try. Randomly pick five stocks from YAHOO! FINANCE. Do not peek at their market betas. Explain to me what they should be, and then check your claims against their actual market betas. If you can accurately assess which market betas are far from 1, then you are a better intuitive economist than I am. In fact, I have almost no economic intuition as to why entire asset classes, such as long-term bonds, have had negative market betas over the last 20 years and positive market betas before then.

Don't be so confident!

Moreover, *please* stand back and think for a moment what you are really doing here. If you are dealing with a new project that has never seen the light of day and that has no historical data, would you even want to use the CAPM? And are you a fully diversified owner who cares only about market-risk and not about idiosyncratic project risk, and who has access to a perfectly competitive capital market? If you are an entrepreneur, I would like to meet you. I have never met such an entrepreneur. (And, are you even convinced so far that the CAPM is a good description of real life—something for which I have shown you zero evidence up to this point? All that you know so far is that the inputs are difficult to estimate.)

Do you even want beta for a project without historical stock returns?

Q 10.11. According to the CAPM formula, a zero-beta asset should have the same expected rate of return as the risk-free rate. Can a zero-beta asset still have a positive standard deviation? Does it make sense that such a risky asset would not offer a higher rate of return than a risk-free asset in a world in which investors are risk-averse?

Q 10.12. A comparable firm (with similar size and business) has a YAHOO! FINANCE-listed equity beta of 2.5 and a debt/asset ratio of 2/3. Assume that the debt is risk-free.

1. Estimate the equity beta for your firm if your projects have similar betas, but your firm will carry a debt/asset ratio of 1/3.

2. If the risk-free rate is 3% and the equity premium is 2%, then what should you use as your firm's hurdle rate?

3. What do investors demand as the expected rate of return on the comparable firm's equity and on your own equity?

Q 10.13. You own a stock portfolio that has a market beta of 2.4, but you are getting married to someone who has a portfolio with a market beta of 0.4. You are three times as wealthy as your future significant other. What is the beta of your joint portfolio?

10.4   Neutralizing Equity-Premium Uncertainty?!

Do you recall my claim that the risk-free rate and the equity premium were the two most important numbers in finance, regardless of whether you are using the CAPM or not? Well, you also want to know the market-beta for the same reason. It is an extremely useful number, too.

It is very easy to short the stock market (e.g., using an S&P 500 future or ETX). This allows you to "innoculate" or "hedge" your project against overall stock-market risk. Just short the right amount of stock, which is exactly the ratio that market beta gives you. For example, if you have $100 million invested in an asset with a market beta of 3, you can short $3 \cdot \$100 = \$300$ million in the market and thereby reduce your market risk to zero. If the stock market happens to go down by 1%, you would expect (a) your project to go down by 3% but (b) your hedge to go up by the same $3 \cdot 1\%$. The CAPM formula even suggests that your equity-premium estimate is now irrelevant.

However, a short market position can also increase the variance of your project outcomes: You may end up in a scenario in which your own project underperforms and the stock market outperforms. You may even go bankrupt because of it. Your project's idiosyncratic-risk component and your errors in estimating betas now become more important. This is not a problem if your project owners are highly diversified, and your particular project is just a tiny fraction of their wealth that they don't care a great deal about. Yet, it is a problem if they are not; or if you, as the corporate manager, care about your one specific project a great deal (or if there are bankruptcy costs, as you will learn in Chapter 19).

Putting this together, from your perspective as the CEO of one small company in a large market, you can render a degenerate version of the CAPM formula to be nearly true by definition. If you are shorting the correct full amount of stock market, it won't matter whether you are overestimating or underestimating the equity premium. The limits to this strategy are your estimation uncertainty about beta and your idiosyncratic risk tolerance. In the real world, a full short may neither be possible nor desirable. If you do not immunize your company against market risk, then it matters to you what the equity-risk premium is—and whether the CAPM is right in the first place.

You may object that you would not want to short the stock market—betting against the market was historically not a smart maneuver. But, as a CFO, do you really know better whether you should be long or short the stock market? If it is fairly priced, so be it. Leave this choice to your investors. If they want to bet on or against the overall stock market, they do not need you to do it for them. You are only "abusing" the insights of the CAPM to avoid or at least reduce your ignorance about your project's best cost of capital estimate.

10.5   Is the CAPM the Right Model?

The CAPM Assumptions Are Not Innocuous

Although the CAPM edifice is reasonable, it does not mean that this edifice "obviously" holds. The CAPM model leans a lot more on the perfect-market assumptions (and then some) than our earlier chapters did.

Are most financial markets really so perfect? Do most investors really hold diversified stock market portfolios? Do they really care *only* about risk and reward in their financial-asset portfolios and nothing else?

Stand back for a moment. How can the CAPM perspective fail? Consider the following examples:

Nerdnote: The strategy of neutralizing the market works only for a single company. If every firm did it, it would change the investment opportunity set.

- If you own a house, chances are that much of your current wealth is invested in the equity portion of your house, and you are not as diversified as you should be. You should then try to find stocks that reduce your house risk exposure, not stocks that reduce your financial market risk exposure. You should like stocks that go up when your house value goes down.

- If you are under 40 years of age, chances are that much of your lifetime wealth is in your human capital. It is not diversified. And only you can invest easily in *your* education: I cannot. You need to hedge *your* career, not mine. You should like stocks that go up when the value of your expertise goes down.

- If you are a tech engineer and work in Silicon Valley, you should short technology stocks as a hedge against their tanking. Conversely, you should not mind losing in your financial portfolio when technology stocks boom (and you end up rich from your employer's stock options, anyway). Yet many engineers in Silicon Valley are so irrationally overconfident, excited, and/or convinced of technology and their (stock-picking) abilities that they end up buying mostly technology stocks for their portfolios, instead. They double up rather than hedge. It's worked so far, but just wait...

- Do firms really live in near-perfect capital markets? Entrepreneurs often need to scratch together whatever capital they can. If they cannot easily find many capital providers, they may have to pay much higher costs of capital than suggested by the CAPM. And they may be forced to invest most of their own wealth—to the point of bankrupting themselves if their projects fail.

- Entrepreneurs are notorious for staking their entire life's savings on their startups. They are hardly ever diversified and usually highly liquidity constrained.

So, even though the theoretical CAPM assumptions are nice, their applicability is actually quite narrow—it considers a scenario in which all investors do not care about anything but the risk and return in the financial markets, and they all have (largely) the same investments and investment opportunities. Don't think the CAPM *has* to be true just because it seems reasonable at first glance.

The Scientific Evidence for the CAPM Is Negative

What if every investor were to choose portfolios for his or her own personal reasons and not with the same perspective—some looking to hedge their houses, others their job, others their industry, others their product's failure? Then it may well be that some assets offer higher or lower expected rates of return than suggested by the CAPM—the CAPM would not hold. In this case, corporate managers really should not rely on the CAPM. Instead, they should stick to a more holistic approach or the less ambitious peer benchmark approach from Chapter 9. Sadly, this always turns out to be good advice in real life: You should not use the CAPM. It does not work. Use the benchmark approach instead.

What equilibrium?

In defense of the CAPM, it is true that the stock market has outperformed bonds. This is evidence that investors have indeed been rewarded for taking on more risk, at least across these two asset classes. However, within the asset class of stocks, the empirical evidence shows that higher market-beta stocks did not have higher average rates of return in the past than lower market-beta stocks. It's not just that benchmarks other than the equity premium *also* matter; it's that beta itself does not seem to matter. Using a market-beta of 1 on every project (the ultimate shrinkage) would not have done harm.

The stock market has done well...

I can summarize decades worth of academic work in two sentences: At best, the empirical evidence is inconclusive about whether the CAPM should be discarded. At worst, it is conclusive and the CAPM should be completely discarded. Consequently, the common corporate use of the CAPM to obtain hurdle rates across projects is based only on wishful thinking, not on empirical evidence.
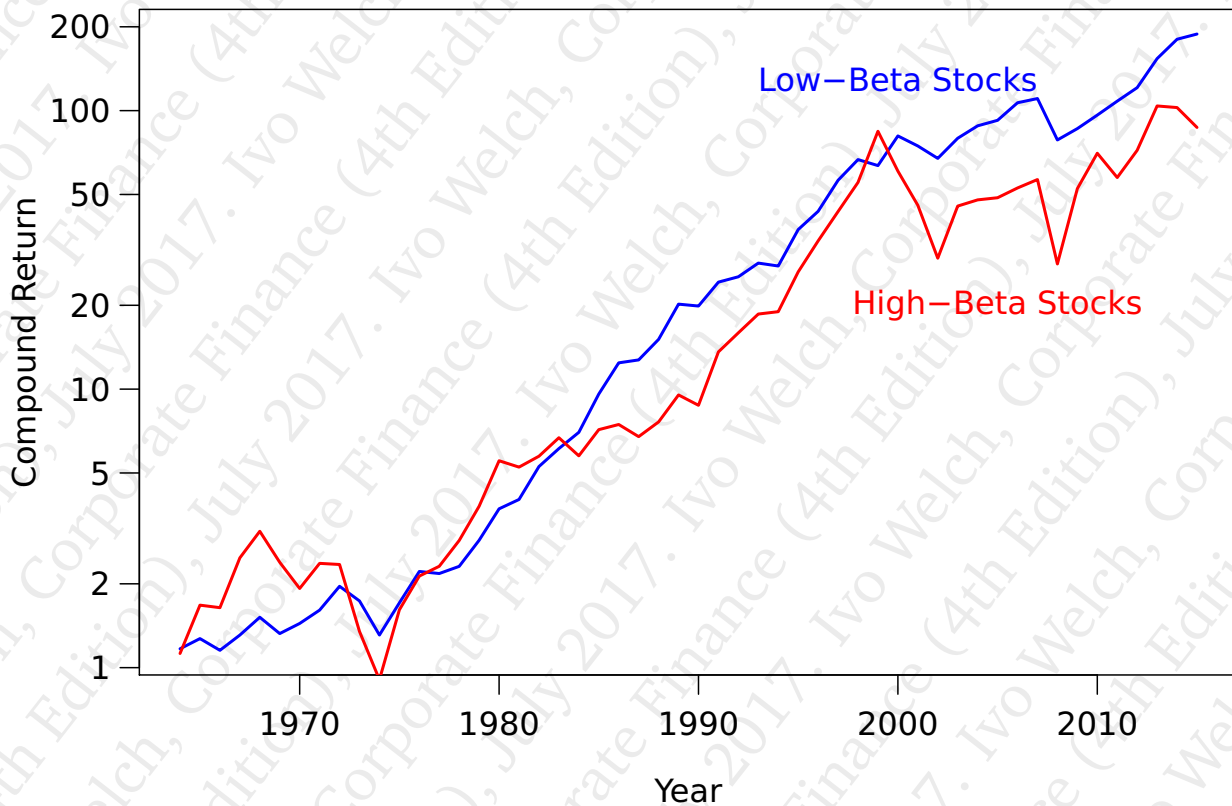
Beta, schmeta.

Exhibit 10.3: *Portfolio Performance of High-Beta and Low-Beta Stocks.* This graph plots the compound performance of portfolios formed from the lowest-quintile beta stocks and the highest-quintile beta stocks. If the CAPM had been right, higher-beta stocks should have offered higher expected performance. Alas, they did not.
Original Data Source: Ken French's Website.

Huh? WTH? Did you really read me right?

Yes you did. Don't use the CAPM. The evidence is against it.

It does not take a PhD to see this (though it takes many to hide it). You won't find this kind of figure in other textbooks that want to obscure the truth.

A famous finance professor, Ken French, estimates market betas for stocks each year, forms one portfolio of the quintile of stocks with the lowest betas, and another of those with the highest betas. He posts the data for everyone to see. Exhibit 10.3 plots the performance of these two portfolios. The high-beta portfolio should be toxic and thus require and deliver higher average rates of return than the low-beta portfolio. Alas, not only is the high-beta portfolio not statistically significantly superior, it isn't even superior. Low-beta stocks have outright outperformed high-beta stocks.

In Defense of the Use of the CAPM

If the evidence is against the CAPM, then why do we finance professors torture you with it? We may indeed have sadistic streaks (as our PhD students can testify), but this is not why. This "why" is much easier to answer than how stocks are priced in the real world or what the best estimate of the appropriate hurdle rates for your project should be.

Across **asset classes:** Stocks had higher average rates of return than bonds. In this sense, high-beta assets offered higher average returns than low-beta assets. At least in this super-rough asset-class version, market beta works reasonably well. Higher-beta asset classes tended to have higher average rates of return.

Impeccable intuition: The CAPM shines through its simplicity and focus on diversification. It gets executives away from the false notion that public investors care about the idiosyncratic risk of projects that they can diversify away. Thus, corporate diversification into a conglomerate for its own sake can reduce its own risk but not market risk. It cannot add value. Investors can diversify themselves. They don't need the firm to do it for them.

Strong Belief: Many instructors and practitioners find the CAPM to be so plausible that they are willing to live with the "absence of CAPM evidence." They do not take this absence to mean "evidence of CAPM absence" (paraphrasing Rumsfeld). Thus, they adopt the CAPM based on faith and not on evidence—actually, more like despite evidence. If you do this, you must be aware that this is what you are doing.

Stand-in for Expected Cash Flow Default: The CAPM often assigns higher costs of capital to projects that are more likely to fail. If you have not fully adjusted your expected cash flow estimates downwards to adjust for failure (a common human error), the CAPM cost of capital often helps to impose a higher hurdle rate on riskier cash flows. It's a crutch.

Stand-in for Imperfect-Market Factors: The CAPM often assigns higher costs of capital to projects that do not satisfy the perfect-market assumptions and that face higher costs of capital. Again, this can accidentally result in better cost-of-capital estimates not *because* of the CAPM, but *despite* the CAPM. It's the other crutch.

Such a Great Idea: The CAPM is so intuitive and appealing that it would be "rediscovered" again and again by those who were not forced to learn it. Those who cannot remember the past are condemned to repeat it

Everyone uses it: The CAPM is *the* standard. Exhibit 10.4 shows that 73% of the CFOs reported that they always or almost always use the CAPM. (And use of the CAPM was even more common among large firms and among CFOs with an MBA.) No alternative method was used very often. Consequently, you have no choice but to understand the CAPM model well—*if you will work for a corporation, then the CAPM is the benchmark model that your future employer will likely use and will expect you to understand well*. Chances are that you will be interrogated about it in your job interview.

Again, the CAPM is simply *the* standard. The CAPM is also used as a benchmark by many investors (e.g., to rate their investment managers), government regulatory commissions, courts (in tort cases), and so on. It is literally the dominant, if not the only, widely used model to estimate the cost of capital. There is even a whole section on the CFA exam about the CAPM!

Alternatives—please stand up: The famous sociologist Lewin wrote that "there is nothing more practical than a good theory." If not the CAPM, then what else? There are alternatives, but none are universally accepted. My own recommendation is to go with the benchmarking approach from the previous chapter.

Market Hedging: Even if the market beta does not measure the average rate of return, it does guide managers about how much market risk they face—and, if they so desire, how to neutralize it and focus on their real expertise.
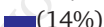
Method	Usage Frequency	Usage Recommendation	Explained in
CAPM	(73%)	With Caution	Chapter 9
	(87%)	Mukhlynina and Nyborg (2016)	
Historical Average Returns	(39%)	Rarely	Chapter 8
Modified CAPM	(34%)	With Caution	Chapter 9
Backed Out from Gordon Model	(16%)	Occasionally	Chapter 3
Whatever Investors Tell Us	(14%)	Occasionally	Chapter 2

Exhibit 10.4: *CFO Valuation Techniques for the Cost of Capital.* Rarely means "usually no, and often used incorrectly." Not reported, use of the CAPM is more common among managers with an MBA—and in firms who rely on consultants who in turn use the CAPM. Original Source: John Graham and Campbell Harvey, 2001.

Do you want a bedtime story that "the world is ok" in order to be able to go to sleep, or the tough truth?

Be aware that my treatment of the CAPM in an introductory corporate finance textbook borders on heresy. Most textbooks still make the CAPM their centerpiece. They do this not because the authors believe in it, but because it is dogma that new finance students (and many old finance professors) are too fragile to deserve the hard truth. I am sorry—I wish I could have told you a happy bedtime story about how the world is nice and orderly, too. But it would have been a lie.

"Cost of Capital" Expert Witnessing

When Congress tried to force the "Baby Bells" (the split-up parts of the original AT&T) to open up their local telephone lines to competition, it decreed that the Baby Bells were entitled to a fair return on their infrastructure investment—with fair return to be measured by the CAPM. (The CAPM is either the *de facto* or legislated standard for measuring the cost of capital in many other regulated industries, too.) The estimated value of the telecommunication infrastructure in the United States is about $10 to $15 billion. A difference in the estimated equity premium of 1% may sound small, but even in as small an industry as local telecommunications, it meant about $100 to $150 million a year—enough to hire hordes of lawyers and valuation consultants opining in court on the appropriate equity premium. Some of my colleagues bought nice houses with the legal fees.

I did not get the call. I lack the ability to keep a straight face while stating that "the equity premium is exactly *x* point *y* percent," which was an important qualification for being such an expert. In an unrelated case in which I did testify, the opposing expert witness even explicitly criticized my statement that my cost-of-capital estimate was an imprecise range—unlike me, he could provide an exact estimate, and it was 11% per year!   *Baby-Bell History: Bradford Cornell, UCLA*

If you must use it...

Never make the following errors, please.

If you still want to use the CAPM, here is my advice. As a corporate executive, you should always first think hard about why and when you want to use the CAPM. Think about whether it is useful for your own cost-of-capital estimates. Think about whether the CAPM errors seem too large to be useful for your particular needs. And understand what you are getting. Do simpler benchmarks first—do they agree with the CAPM estimate?

Accuracy: The CAPM is a poor model if you want precision. If you believe that CAPM expected rates of return should be calculated with any digits after the decimal point, then you are deluded. Please realize that, at best, the CAPM can offer only expected rates of return that are of the "right order of magnitude," plus or minus a few percentage points, perhaps.

Actually, if accuracy is important, you are in trouble. Finance does not have *any* models that can offer precision. ortunately, you may not have to be good at estimating value; you may just need to be better than your competitors. Always remember that valuation is as much an art as it is a science. And you wouldn't be the first corporate executive who just happened to be saved by Lady Luck, even if the bet was not a particularly good one.

Don't expect accuracy and don't use it for financial investing.

➤ F,
Pg.??.

Investment purposes: If you are not a corporate executive looking to determine your project hurdle rate, but a financial investor looking for good investments from the universe of financial instruments, and with an ability to shift your money around every day, then please do not use the CAPM. Although the CAPM offers the correct intuition that wide diversification needs to be an important part of *any* good investment strategy, there *are* better investment strategies than just investing in the overall market index. These are discussed in advanced investments courses.

Avoid using the CAPM for short-term financial investment purposes.

Please do not confuse the CAPM with the mean-variance framework discussed in Chapter 8. Mean-variance optimization is an asset-selection technique for your individual portfolio, and it works, regardless of whether or not the CAPM holds.

➤ Mean-variance optimization in detail,
Sect. 8.2, Pg.171.

Longer-Term Differences: If you are a corporate executive, be especially cautious of discount rates for expected cash flows far in the future. Look at your cost of capital more holistically. Remember that the CAPM has two terms.

➤ Corporate Time-Varying Costs of Capital,
Sect. 5.5, Pg.99.

The first term is the risk-free rate, which applies to all projects, regardless of beta. Fortunately, this one is easy. You should use higher costs of capital for cash flows that will occur in the more distant future. And you have a great estimate of the premium that long-term projects need to offer over short-term projects, based on the Treasury yield curve. You don't even need historical estimates: you can use the prevailing Treasury yield curve. *Use it! It works!*

It is the second term (the beta multiplied by the risk-premium)—i.e., your beta risk-adjustment—that you must be especially suspicious about. If your cash flows will occur in many years, be modest. Do not overstate the risk assessment from the CAPM. Cut down extreme estimates. Shrink and shrink again (towards the average rate of return on risky investments). (Of course, do not forget to be similarly humble in your expected cash flow estimates.) Fortunately, you may be ok:

- As a corporate manager, compare the cost of capital on *your equity* vs. the cost of capital on *your debt* for your long-term cash flows. With an equity premium based on the performance of stocks vs. long-term Treasuries of about 1-2% from 1970 to today, it may not matter so much whether your project A has a beta of 0.8 and your project B has a beta of 1.2. The implied cost-of-capital difference between these two projects of under $(1.2 - 0.8) \cdot 2\% \approx 1\%$/year is already small and probably swamped by your expected cash flow estimation error.

- For long-term cash flows, your best estimate of your equity market betas should be tilted much more towards 1 than what you think your market beta is today. Thus, if you fit your historical market beta to be 0.5 for A and 1.5 for B today, you may well want to use a market beta shrunk to around 0.9 for A and 1.1 for B if those equity cash flows will occur in 10-20 years. Think about this: A and B would now have a different implied cost of equity capital of $0.2 \cdot 2\% \approx 0.4\%$. This is way below your noise-and-uncertainty threshold.

  But let's continue. Say your projects are partly debt-financed, too. Now you need to calculate asset market betas rather than equity market betas. Let's say both

Asset betas are often even closer to 1—and they often give CAPM estimates some (sorely needed) time-stability.

projects have 50% debt that is almost risk-free. Then your asset beta would be $0.5 \cdot 0.0 + 0.5 \cdot 0.9 = 0.45$ for A and $0.5 \cdot 0.0 + 0.5 \cdot 1.1 = 0.55$ for B. Now you have a project cost-of-capital difference $(0.55 - 0.45) \cdot 2\% \approx 0.2\%$ between A and B.

How does this expected rate-of-return difference between A and B compare to your own uncertainty about your projects' relative expected cash flows? Does the CAPM beta risk-adjustment really matter much in light of your uncertainty?

In sum, cash flows in the more distant future and cash flows that are more risky should likely be discounted more, as already explained in Chapter 9. But be humble about your capabilities in trying to distinguish between projects that are similar along time and asset-class dimensions.

The estimated CAPM cost of capital for long-term cash flows is fragile.

Taking Advantage of CAPM Violations

The CAPM leans heavily on equilibrium market forces that are really quite weak.

Do investors have arbitrage opportunities if the CAPM fails? Absolutely not. The universe remains aligned even if the CAPM does not hold, and even in a perfect market.

Q: What happens if a stock offers too much or too little expected rate of return? A: Investor stampedes towards or away from the stock.

What would happen in the CAPM if one stock offered more than its appropriate expected rate of return? Its price would be too low. It would be too good a deal. Investors would immediately flock to it, and because there would not be enough of this stock in the economy, investors would bid up its price. This would lower its expected rate of return. The price of the stock would settle at the correct CAPM expected rate of return. Conversely, what would happen if one stock offered less than its due expected rate of return? Investors would not be willing to hold enough of this stock: The stock's price would be too high, and its price would fall. Neither situation should happen in a CAPM world.

Assets not priced according to the CAPM do not allow you to make money for nothing. However, they could imply good deals.

Is this an arbitrage—a "free money" situation? No! When stocks do not follow the CAPM formula, buying them remains risky. Yes, some stocks would offer a higher or lower expected rate of return and thus seem to be too good or too bad a deal, attracting too many or too few investors. (Or, the investors may not even flock towards better deals, perhaps because they have other needs, perhaps because they are asleep at the switch.) But these stocks would remain risky bets, and investors would want to buy just a little more or less. No investor could earn risk-free profits. There would be no arbitrage here. The market forces working on correcting any CAPM mispricing are just modest.

Maybe for some...

And also remember that there are good reasons why the CAPM would not hold in the first place. For example, as we have discussed, it relies heavily on many perfect-market assumptions. If investors are taxed or liquidity-constrained (that is, they cannot easily diversify, e.g., because the firm is a startup or family firm) or do not agree on the inputs, then it is quite plausible that some firms or even sectors (such as "value firms" or "growth firms") would offer higher or lower expected rates of return than the CAPM suggests. But not all is lost. It may mean that if *you* are an investor with CAPM preferences, you can do a little better than holding the overall market portfolio by tilting your market-like portfolio just a little towards stocks that offer higher expected rates of return than suggested by the CAPM formula and just a little away from stocks that offer lower expected rates of return.

10.6 Good CAPM Alternatives and Perspectives

You have already learned in the previous chapter about the principal alternative to the CAPM—benchmarking. The CAPM is really based on similar ideas, but it has just gone one step too far. It is too overconfident.

Madness: One Step Beyond. Can models be overconfident?

CAPM vs. Benchmarking: Widening and Narrowing Concepts

The CAPM both generalizes and narrows the idea of benchmarking. The generalization is that market beta is a more universal and objective measure of how equity-like any investment asset is than subjective judgment. It works for any asset—be it bond, stock, one specific stock or fund, equity options, gold, art, etc. The narrowing is that the CAPM is very specific about the fact that it is market beta—and market beta alone—that is the benchmark of the risk that investors care about. No other factors or exposure to other factors matter.

The CAPM goes one step too far. Stocks do seem to give higher average returns than bonds, but betas do not seem to predict higher expected returns.

- If the CAPM model is correct, then using more benchmark portfolios (à la Chapter 9) than just the stock market would still be just fine. Each benchmark portfolio would be priced according to the CAPM and lie on the SML. It is merely a convenience of the CAPM that you do not *have to* worry about these benchmark portfolios. If you do use these other benchmarks, fine. If you do not, fine, too. You will still find the same proper expected rate of return.

- If the CAPM model is incorrect, then by using it, you would have gone one step too far. You could easily get the wrong answer. For example, say, investors do not care about market risk (and market beta), but only about, say, oil risk, computer technology risk, and biotech risk. It could be the case that because the market portfolio contained some of these risks, it provided a higher expected rate of return. But it would really matter now whether your project and market beta come from oil risk (which gives you higher expected rate of return) or, say, gold risk (which does not). The CAPM would give you the right answer only if your project happened to have the same proportions as the market portfolio in its exposures.

  What you really need are the benchmark portfolios that matter as your comparison. Of course, unlike the CAPM, the benchmark portfolio method would be harder to use: What are good benchmarks? But benchmarking would still work in principle—just as long as you give this method all the right benchmark portfolios!

My Personal Opinion about Costs of Capital

Now I will give you my own educated opinion about good project cost-of-capital estimates. Different finance professors will come to different conclusions, so do not take my opinion as the gospel.

Solid Inference

The following expected-return premia are rock-solid:

- There definitely is a time value of money.
- There definitely is a term structure. Long-term cash flows usually require higher costs of capital than short-term cash flows. Your investors can earn higher expected rates of return elsewhere for longer-term commitments.
- There definitely is a credit component. Assets have to make up for higher probabilities of default with higher promised yields—that is, higher yields when they succeed.

We have not covered the following yet. It will be explained in Chapter 11.

What is solid empirical evidence?

➤ Market Imperfections, Chapter 11, Pg.241.

- Market imperfections play important roles. There are many kinds. Here are a few examples. There seems to be a liquidity premium. Assets that can be quickly liquidated (especially in general market crashes like 1987 or 2008) are more expensive, and different asset classes seem to have different degrees of liquidity. Because of their collateral, mortgage debt tends to have lower costs of capital than general bonds. Firms with less access to capital markets, such as startups, seem to pay higher costs of capital, although adjusting for default makes this difficult to measure. Investors pay more in personal income tax for interest receipts than they do for capital gains, which makes equities relatively more desirable and reduces their after-tax income. Sentiment and agency considerations also seem to play important roles in equity trading. Many of these market imperfections embody some concepts of risk, but it is not the market beta. Interestingly, courts agree with imperfect-market views. They allow as much as a 20-30% discount for the value of privately held assets relative to publicly traded peers. We may not know what the costs of capital for small, privately held firms are, but we do know that they are usually much higher.

Uncertain Inference

I wish I knew the equity risk premium—and for a lot of different reasons. The CAPM is only one of them. Benchmarking is another. Alas, I am not so confident that I have a good assessment. We are dealing with finance (with estimated probabilities), not physics (with known probabilities).

Market beta times equity premium is probably small, after other premia.

After taking into account the premia just mentioned (which includes premia that are sometimes included in and have to be captured by the risk premium, but which I already have in my number), the remaining risk premium—especially over longer horizons—is probably relatively small (1-2%). However, we do not know for sure. Our uncertainty is much larger than our certainty about its magnitude. And you need to realize that betas for cash flows far into the future are much closer to 1 than historical regressions would suggest. The "CAPM" beta-metric for measuring the project's risk impact and expected rate of return is only of modest importance.

Use reasonable risk adjustments—a little bit of beta, a little bit of idiosyncratic risk, a little bit more heuristic finesse.

So what would I do if I was not constrained by my boss? My best alternative cost-of-capital recommendation would start out just like the CAPM: As the first term in a formula, I would recommend that you use the rate of return on bonds of similar maturity as the cash flow that you want to value. Usually, this means that you assign higher costs of capital to cash flows farther in the future. It is only on the second term—the equity risk-adjustment—that I would tinker. Instead of the (shrunk) CAPM market beta multiplied by some historical equity premium (of 1-3%/year geometric above long-term Treasuries), I would recommend a more holistic approach.

- Take into consideration that projects with high volatility and/or with high leverage are more risky. The equity on these projects probably requires a higher expected rate of return to keep your investors happy. Realize that projects with higher idiosyncratic risk are also usually the same projects about which executives tend to be most overly optimistic. (Check again: are you sure your expected cash flows in the NPV numerator are not overconfident?!)

- Take into consideration whether you and your owners are well-diversified. If you are not, then you should require higher rates of return on riskier projects. In this case, it is not "beta risk" that matters, but "total risk."

- Take into consideration that your investors may "like" growth firms and are often willing to pay higher prices and thus accept lower average rates of return for some such projects. If they are willing to give you money at lower expected rates of return, take it!

There is probably little harm if you calculate a (repeatedly shrunk) CAPM market beta and apply it to a relatively low equity premium (say, 2%/year) for some heuristic orientation. Assess whether any other non-CAPM cost-of-capital assessments seem reasonably similar to such a CAPM assessment. In this sense, the CAPM can still be informative.

If Forced

And if my boss forced me into the CAPM approach, what would I do?

- If I ran a large firm with good access to capital markets and I needed to evaluate a typical medium-term project, I would assume an equity premium of 1-3% per annum and apply this to the equity components of all my long-term cash flows. The exception would be projects for which I would have strong prior knowledge that their market betas would be very extreme—say, below –1 or greater than 3 (and I would then shrink those betas further to, say, 0 and 1.5, respectively, to account for long-term uncertainty about betas). I would consider long-term corporate debt to have a higher cost of capital than equivalent Treasuries, but a lower cost of capital than my own equity—the latter primarily because debt provides a corporate income tax shield (as you will learn in Chapter 18) and not because the equity premium over long-term corporate bonds is high.

- Deviating from the CAPM, if I ran a startup firm, I would assume a cost of capital of 2% to 6% above the *expected* rate of return on my uncollateralized debt. The expected rate of return on my equity could be very high—it could even be in the double digits. (This higher rate reflects the fact that more volatile cash flows and firms that struggle with more market imperfections must pay higher costs of capital.) Risk definitely plays a role, but not in the strict CAPM market-beta sense. Alternatively, I would abandon NPV-based models altogether and try to estimate what other similar projects are offering their investors. This is the route we take in Chapter 15.

And I would never use any of my schemes here (or the CAPM) for the pricing of bonds, derivatives, or other extreme kinds of projects.

Am I the only professor who recommends against using the CAPM? No. Many do in private, and even more do when their own money is on the line. Most are afraid to admit to our collective ignorance in front of students but prefer to proclaim knowledge (and teach the beauty that is the CAPM). Let me appeal to a higher authority for backup: Eugene Fama, the most famous finance professor alive, winner of a Nobel prize, and partly responsible for the original spread of the CAPM, nowadays strongly recommends against it. His view is that using the CAPM expected rate of return as your cost of capital in an NPV calculation effectively divides one bad uncertain number by another bad uncertain number. This practice convolutes errors and uncertainty about expected cash flows in the numerator with errors and uncertainty about expected returns in the denominator. If you get lucky, your errors cancel. If not, they do not. Yikes! Gene prefers comparables.

Conclusion

IMPORTANT

- The CAPM is *the* benchmark model in the real world. Most corporations use it.
- Every interviewer will expect you to understand the CAPM. Regardless of whether the model holds or not, you have to know it.
- The empirical evidence suggests that the CAPM is not a great model for predicting expected rates of return.
- The first CAPM term (the time adjustment) seems to hold better than the second CAPM term (the risk adjustment).
- Market betas tend to revert back towards 1. This requires you to shrink ordinary OLS beta estimates very aggressively towards 1.

- The geometric equity premium above long-term Treasuries (for evaluating long-term cash flows) has been—and is unlikely to be more in the future than—2-3% per annum.
- The CAPM never offers great accuracy.
- Mean-variance optimization (Section 8.2) works even if the CAPM does not.
- Peer portfolio benchmarking (Chapter 9) works regardless of whether the CAPM does or does not work.
- You may or may not want to immunize your project against equity-premium risk and estimation uncertainty, using its beta estimate. Immunized projects have much clearer cost-of-capital benchmarks than unimmunized projects.

Q 10.14. Does the empirical evidence suggest that the CAPM is correct?

Q 10.15. If the CAPM is wrong, why do you need to learn it?

Q 10.16. Is the CAPM likely to be more accurate for a project where the beta is very high, one where it is very low, or one where it is zero?

Q 10.17. To value an ordinarily risky project, that is, a project with a beta in the vicinity of about 1, what is the relative contribution of your personal uncertainty (lack of knowledge) about (a) the risk-free rate, (b) the equity premium, (c) the beta, and (d) the expected cash flows? Consider both long-term and short-term investments. Where are the trouble spots?

Summary

This chapter covered the following major points:

- The CAPM provides an "opportunity cost of capital" for investors, which corporations can use as the cost of capital in the NPV formula. The CAPM formula is

$$E(r_i) = r_F + [E(r_M) - r_F] \cdot \beta_i$$

Thus, there are three inputs: the risk-free rate of return (r_F), the expected rate of return on the market ($E(r_M)$), and the project's or firm's market beta (β_i). Only the latter is project-specific.

- The line plotting expected rates of return against market beta is called the security market line (SML).

- The CAPM provides an expected rate of return, consisting of the time premium and the risk premium. It ignores the default premium. In the NPV formula, the default risk and default premium work through the expected cash flow in the numerator, not through the expected rate of return (cost of capital) in the denominator.

- For r_F, you should use bonds that match the timing of your project's cash flows. Thus, cash flows farther in the future often require higher opportunity costs of capital. Even if you do not believe in the CAPM, term adjustment is important.

- The expected rate of return on the stock market is a critical CAPM input if the project's market beta is high—but this equity premium is difficult to guess. There are many guesstimation methods, but no one really knows which one is best. Reasonable estimates for the equity premium ($E(r_M) - r_F$) can range from about 1% to 8% per annum, although 2-3% seems most common for cash flows more than a few years into the future.

- There are a number of methods to estimate market beta. Don't be too confident in betas far from 1, especially for long-term project cash flows.

- If you combine a short position in the stock market with a positive-beta project, the combined project is a lot easier to price than a project with a positive beta.

It neutralizes the effect of model and equity-premium errors.

- Never believe the CAPM blindly. Its estimates are poor. Use them more for "general direction" than as "accurate guides." Think compass, not GPS.

- Even though its estimates are poor, understand the CAPM well. Everyone will expect you to.

This negative perspective on the CAPM is so uncommon in a textbook (but not among the experts actually studying the models) that it is important that you don't misunderstand what this chapter says. So let's end this chapter with a FAQ:

- **Q**: Should riskier cash flows not require higher promised rates of return?

    A: Riskier projects have to promise higher rates of return, i.e., offer higher default premiums. This is not the same as higher risk premiums in the CAPM sense. In NPV applications, make sure to reflect the default risk in the expected cash flow numerator. Riskier projects need to pay off a lot more when they succeed, just to make up for the fact that they fail more often.

- **Q**: Should long-term and therefore riskier cash flows not require higher expected rates of return?

    A: Long-term projects command term premiums. Thus, in NPV applications, you should usually use higher required costs of capital for more distant cash flows. You should not use the CAPM for this. The U.S. Treasury Yield Curve gives you a working first estimate about how much extra premium that long-term cash flows should require above short-term cash flows.

- **Q**: Besides leverage structure and term, should riskier stocks and corporate cash flows have higher expected discount rates?

    A: Maybe, but be careful. First, make it modest. Don't be too overconfident in your ability to judge equity risks. If you can judge the risks well, make sure your estimates first flow into your expected cash flows in the NPV numerator. Second, don't be too wedded to the CAPM for the extra "risk-premium kicker." Instead, combine your cost-of-capital estimate with judgment-based and other risk measures, such as volatility (especially if your owners are not fully diversified).

Preview of the Chapter Appendix in the Companion

The appendix to this chapter explains:

- How the "certainty equivalence value" (CEV) allows you to use the CAPM for projects that you are not buying at the appropriate equilibrium price. For example, you would need the CEV to work out how to value an inheritance that will be higher if the economy does well. (Just because the inheritance is "free" to *you* does not mean that there is a zero value to it.)

- How to use the CEV formula to estimate the value of a project for which you have historical cash flows, but no market value information.

- How the CAPM is derived from the fact that the optimal portfolio is always the combination of two portfolios, one of which may be the risk-free asset.

- What a few more CAPM alternatives are and how to use them. The first alternative is the APT (arbitrage pricing theory) and its relative, the Intertemporal CAPM. The second alternative is a "Fama-French"-style model, which uses factors such as value, growth, momentum, investment, and robustness. This Fama-French model seems to predict better than any alternatives, but it is less grounded in theory (or, you may say, reason) than the former. It also often gives counterintuitive results—e.g., that small-growth stocks are safer than large-value stocks and therefore that managers should use *lower* discount rates on, say, risky tech ventures.

Keywords

Asset-pricing model, 218.   CAPM, 214.   Capital asset pricing model, 214.   Certainty equivalence, 218.   Conglomerate, 219.   Market-model, 221.   SML, 215.   Security market line, 215.

Answers

Q 10.1 Yes, the perfect market is an assumption underlying the CAPM. In addition,

1. Investors are rational utility maximizers.
2. Investors care only about overall portfolio mean rate of return and risk at one given point in time.
3. All parameters are known (not discussed until later in the chapter).
4. All assets are traded. Every investor can buy every asset.

Q 10.2 With $r_F = 4\%$ and $E(r_M) = 7\%$, the cost of capital for a project with a beta of 3 is $E(r) = r_F + [E(r_M) - r_F] \cdot \beta_i = 4\% + (7\% - 4\%) \cdot 3 = 13\%$.

Q 10.3 With $r_F = 4\%$ and $E(r_M) = 12\%$, the cost of capital for a project with a beta of 3 is $E(r) = r_F + [E(r_M) - r_F] \cdot \beta_i = 4\% + (12\% - 4\%) \cdot 3 = 28\%$.

Q 10.4 With $r_F = 4\%$ and $E(r_M) = 12\%$, the cost of capital for a project with a beta of –3 is $E(r) = r_F + [E(r_M) - r_F] \cdot \beta_i = 4\% + (12\% - 4\%) \cdot (-3) = -20\%$. Yes, it does make sense that a project can offer a negative expected rate of return. Such projects are such great investments that you would be willing to expect losses on them, just because of the great insurance that they are offering.

Q 10.5 No—the real-world SML is based on historical data and not true expectations. It would be a scatterplot of historical risk and reward points. If the CAPM holds, a straight, upward-sloping line would fit them best.

Q 10.6 Write down the CAPM formula and solve $E(r_i) = r_F + [E(r_M) - r_F] \cdot \beta_i = 4\% + (7\% - 4\%) \cdot \beta_i = 5\%$. Therefore, $\beta_i = 1/3$. Note that we are ignoring the promised rate of return.

Q 10.7 The security market line is
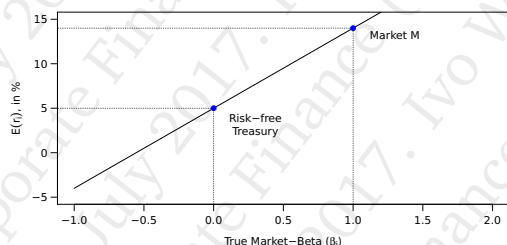
Q 10.8 The equity premium, $E(r_M) - r_F$, is the premium that the market expects to offer on the risky market above and beyond what it offers on Treasuries.

Q 10.9 It does not matter what you choose as the per-unit payoff of the bond. If you choose $100, you expect it to return $99.

1. Thus, the price of the bond is $PV = \$99/(1 + [3\% + 5\% \cdot 0.2]) \approx \$95.19$.
2. Therefore, the promised rate of return on the bond is $\$100/\$95.19 - 1 \approx 5.05\%$.
3. The risk-free rate is 3%, so this is the time premium (which contains any inflation premium). The (expected) risk premium is 1%. The remaining 1.05% is the default premium.

Q 10.10 The cost needs to be discounted with the current interest rate. Because payment is upfront, this cost is $30,000 now! The appropriate expected rate of return for cash flows (of your earnings) is $3\% + 5\% \cdot 1.5 = 10.5\%$. You can now use the annuity formula to determine the PV if you graduate:

$$\frac{\$5,000}{10.5\%} \cdot \left[1 - \left(\frac{1}{1 + 10.5\%} \right)^{40} \right] \approx \$47,619 \cdot 98.2\%$$
$$\approx \$46,741.46$$

With 90% probability, you will do so, which means that the appropriate risk-adjusted and discounted cash flow is about $42,067.32. The NPV of your education is therefore about $12,067.32.

Q 10.11 Yes, a zero-beta asset can still have its own idiosyncratic risk. And, yes, it is perfectly kosher for a zero-beta asset to offer the same expected rate of return as the risk-free asset. The reason is that investors hold gazillions of assets, so the idiosyncratic risk of the zero-beta asset will just diversify away.

Q 10.12 This is an asset beta versus equity beta question. Because the debt is almost risk-free, we can use $\beta_{Debt} \approx 0$.

1. First, compute an unlevered asset beta for your comparable with its debt-to-asset ratio of 2 to 3. This is $\beta_{Asset} = w_{Debt} \cdot \beta_{Debt} + w_{Equity} \cdot \beta_{Equity} = (2/3) \cdot 0 + (1/3) \cdot 2.5 \approx 0.833$. Next, assume that your project has the same asset beta, but a smaller debt-to-asset ratio of 1 to 3, and compute your own equity beta: $\beta_{Asset} = w_{Debt} \cdot \beta_{Debt} + w_{Equity} \cdot \beta_{Equity} \Rightarrow 0.833 \approx (1/3) \cdot 0 + (2/3) \cdot \beta_{Equity} \Rightarrow \beta_{Equity} = 1.25$.
2. With an asset beta of 0.83, your firm's asset hurdle rate should be $E(r_i) = 3\% + 2\% \cdot 0.83 \approx 4.7\%$.
3. Your comparable's equity expected rate of return would be $E(r_{Comps\,Equity}) = 3\% + 2\% \cdot 2.5 = 8\%$. Your own equity's expected rate of return would be $E(r_{Your\,Equity}) = 3\% + 2\% \cdot 1.25 = 5.5\%$

Q 10.13 Your combined happy-marriage beta would be $\beta_{\text{Combined}} = (3/4) \cdot 2.4 + (1/4) \cdot 0.4 = 1.9$.

Q 10.14 No, the empirical evidence suggests that the CAPM does not hold. The most important violation seems to be that value firms had market betas that were low, yet average returns that were high. The opposite was the case for growth firms.

Q 10.15 Even though the CAPM is empirically rejected, it remains the benchmark model that everyone uses in the real world. Moreover, even if you do not trust the CAPM itself, at the very least it suggests that covariance with the market could be an important factor.

Q 10.16 The CAPM should work very well if beta is about 0. The reason is that you do not even need to guess the equity premium if this is so.

Q 10.17 For short-term investments, the expected cash flows are most critical to estimate well (see Section 4.1 on Page 57). In this case, the trouble spot (d) is really all that matters. For long-term projects, the cost of capital becomes relatively more important to get right, too. The market betas and risk-free rates are usually relatively low maintenance (though not trouble-free), having only modest degrees of uncertainty. The equity premium will be the most important problem factor in the cost-of-capital estimation. Thus, the trouble spots for long-term projects are (b) and (d).

End of Chapter Problems

Q 10.18. What are the assumptions underlying the CAPM? Are the perfect market assumptions among them? Are there more?

Q 10.19. If the CAPM holds, then what should you do as a manager if you cannot find projects that meet the hurdle rate suggested by the CAPM?

Q 10.20. In a perfect world (and in the absence of externalities, which would imply that projects influence other projects), should you take only the projects with the highest NPV?

Q 10.21. Write down the CAPM formula. Which are economy-wide inputs, and which are project-specific inputs?

Q 10.22. The risk-free rate is 6%. The expected rate of return on the stock market is 8%. What is the appropriate cost of capital for a project that has a beta of 2?

Q 10.23. The risk-free rate is 6%. The expected rate of return on the stock market is 10%. What is the appropriate cost of capital for a project that has a beta of –2? Does this make economic sense?

Q 10.24. Draw the SML if the true expected rate of return on the market is 6% per annum and the risk-free rate is 2% per annum. What would the figure look like if you were not sure about the expected rate of return on the market?

Q 10.25. A junk bond with a beta of 0.4 will default with 20% probability. If it does, investors receive only 60% of what is due to them. The risk-free rate is 3% per annum and the risk premium is 5% per annum. What is the price of this bond, its promised rate of return, and its expected rate of return?

Q 10.26. What would it take for a bond to have a larger risk premium than default premium?

Q 10.27. A corporate zero-bond promises 7% in one year. Its market beta is 0.3. The equity premium is 4%; the equivalent Treasury rate is 3%. What is the appropriate bond price today?

Q 10.28. Explain the basic schools of thought when it comes to equity premium estimation.

Q 10.29. If you do not want to estimate the equity premium, what are your alternatives to finding a cost-of-capital estimate?

Q 10.30. Explain in 200 words or less: What are reasonable guesstimates for the market risk premium and why?

Q 10.31. Should you use the same risk-free rate of return both as the CAPM formula intercept and in the equity premium calculation, or should you assume an equity premium that is independent of investment horizon?

Q 10.32. Should a negative-beta asset offer a higher or a lower expected rate of return than the risk-free asset? Does this make sense?

Q 10.33. An unlevered firm has an asset market beta of 1.5. The risk-free rate is 3%. The equity premium is 4%.

1. What is the firm's cost of capital?

2. The firm refinances itself. It repurchases half of its stock with debt that it issues. Assume that this debt is risk-free. What is the equity beta of the levered firm?

3. According to the CAPM, what rate of return does the firm have to offer to its *creditors*?

4. According to the CAPM, what rate of return does the firm have to offer to its *levered equity holders*?

5. Has the firm's weighted average cost of capital changed?

Q 10.34. Download daily stock market data for Intel and the S&P 500 for calendar year 2016 from YAHOO! FINANCE.

1. What was Intel's plain stock-market-model regression beta in your sample?

2. What was Intel's shrunk stock-market beta? Use a shrinkage factor of 0.5 towards a market beta of 1.0 and your just-calculated estimate.

3. How does this compare to the Intel market beta on YAHOO! FINANCE?

4. If Intel had a debt-equity ratio of 1-to-2 and its debt was close to risk-free, what was its asset beta? (Hint: To determine the debt-to-asset ratio, make up an example in which a firm has a 30% D/E ratio.)

Q 10.35. A peer firm in a comparable business has an equity beta of 2.5 and a debt-equity ratio of 2. The debt is almost risk-free. Estimate the beta for your equity if projects have constant betas, but your firm will carry a debt-equity ratio of 1/2. (Hint: To translate a debt-equity ratio into a debt-asset ratio, make up an example.)

Q 10.36. A Fortune 100 firm is financed with $15 billion in debt and $5 billion in equity. Its historical equity beta has been 2. If the firm were to increase its leverage from $15 billion to $18 billion and use the cash to repurchase shares, what would you expect its levered equity beta to be?

Q 10.37. The prevailing risk-free rate is 5% per annum. A competitor to your own firm, though publicly traded, has been using an overall project cost of capital of 12% per annum. The competitor is financed by $1/3$ debt and $2/3$ equity. This firm has had an estimated equity beta of 1.5. What is it using as its equity premium estimate?

Q 10.38. Apply the CAPM. Assume the risk-free rate of return is the current yield on 5-year bonds. Assume that the market's expected rate of return is 3% per year above this. Download five years of daily rate-of-return data on four funds: NAESX, VLACX, VUVLX, and VWUSX.

- What were the historical average rates of return?

- What were the historical market betas?

- What were the historical market betas, adjusted (shrunk) toward 1 by averaging with 1?

- How do these estimates compare to the market beta estimates of the financial website from which you downloaded the data?

- Does it appear as if these funds followed a CAPM-like relationship?

Q 10.39. Draw some possible security markets lines (SML's) that would not be consistent with the CAPM. On the x axis, put the true market beta. On the y axis, put the true expected rate of return.

Q 10.40. Does the empirical evidence suggest that the CAPM is correct?

Q 10.41. Why do you need to understand the CAPM?

Q 10.42. Under what circumstances is the CAPM a good model to use? What are the main arguments in favor of using it? When is it not a good model?

Q 10.43. If you use the CAPM, explain for what kinds of projects it is important to get accurate equity-premium estimates.