Part III

Market Efficiency

...and Value in an Imperfect Market

You now understand the theory of finance in perfect markets. It is precisely the four perfect market assumptions that have allowed modern finance to become the "science" that it is today. Every important concept of finance has been derived in this perfect markets context first. In fact, with only a few exceptions, most finance formulas used in the real world today are still based on the (false) assumption that the world is perfect!

Fortunately, many financial markets are close to perfect, so the distance between theory and practice in finance is often small. However, it is almost never zero. The real world is definitely dirtier than our perfect one, and you can't just close your eyes and wish you were still in Kansas. Thus, the chapters in this part explain how you can navigate the troubled waters of the real world.

What You Want to Learn in this Part

- In Chapter 11, you will learn not only why the four perfect market assumptions are too good to be true, but also why they are so important. You will learn to think about what happens when individuals have different information, when financial markets are noncompetitive, and when investors or firms have to pay transaction costs and taxes. Sometimes you can adjust the perfect markets formulas explicitly to take market imperfections into account; sometimes you can only do so intuitively.

  Typical questions: What are typical transaction costs, and how do you work with them? How do taxes work? Why are capital gains better than ordinary income? If you have to pay 40% income taxes on interest receipts, the inflation rate is 2% per annum, and your investment promises 5% per annum, how much can you buy in goods tomorrow? Should you take this investment if you can earn 5% in taxable bonds and 3% in tax-exempt municipal bonds?

- In Chapter 12, you will learn about a concept that is not as strict as that of a perfect market: an efficient market. A market is said to be efficient if it uses all available information in the price setting. *All perfect markets are efficient (in equilibrium), but not all efficient markets are perfect.* Whether financial markets are efficient is the question that lies at the heart of "behavioral finance," a field of finance that asks whether individual investor irrationality—doubtlessly present—can be strong enough to influence financial market prices.

  Typical questions: Could it be that market efficiency is not absolute but comes in different degrees? What exactly are the disagreements between classical finance and behavioral finance? What processes can stock prices reasonably follow? Do stock prices follow random walks? What is the signal-to-noise ratio in the context of financial markets? What is an arbitrage? What should you think of market gurus? What can you learn from stock price reactions to events?

11

Market Imperfections

Information/Opinions, Market Depth, Transaction Costs, and Taxes

So far, we have assumed no differences in opinions (and thus information), no transaction costs, no taxes, and a large market with many competitive sellers and buyers—a "perfect market." We discussed uncertainty, risk, and the CAPM (like most finance formulas in the real world) in this framework. They are not just "dead" theory. If the assumptions do not hold, then these very same formulas, used by practitioners and academics alike, might be simply wrong.

Why are the perfect markets assumptions so important? You will learn that it is because they give us one unique, appropriate, expected rate of return—whether you want to borrow someone else's money to finance your projects or lend your money to someone else undertaking projects. Breaking the assumptions causes havoc: Without a unique expected rate of return, the project value depends on the (cash position of the) owner. What does "project value" even mean without a unique price?

Of course, as wonderful as perfect markets are, they do not exist. They are conceptual, not real. For large publicly traded firms, some financial markets can come very close to perfection. For small firms, they almost never do. **Entrepreneurial finance** is really just one example of "financing in imperfect markets."

So, in this chapter, you are leaving our beautiful, frictionless, utopian world. You will have to contemplate how to think about financial questions in the real world. Fortunately, many of your tools (and specifically NPV) still work—remember, for a tool to work in a more complex scenario, it is a minimum sanity condition that it also work in a simpler scenario. The trick of this chapter, then, is to learn how you apply your tools with more caution and to appreciate their limitations.

Dilbert on Internet Startups: 2013-06-01

11.1 Causes and Consequences of Imperfect Markets

So far, we have not distinguished between the cost of capital at which you can borrow money to finance your projects and the rate of return at which you can save money. In "perfect markets," these two rates are the same. Again, this is the purpose of all four perfect markets assumptions. It is only to guarantee one fact on which everything else rests:

Without perfect markets, borrowing and lending rates are not equal.

Perfect markets cause equal borrowing and lending rates.

When this is not the case, the implications are far-reaching. If these rates are not equal, then you cannot move in and out of an investment as often as you like. More fundamentally, even the value of a project stops being unique. Instead, a project may be worth any number in a whole range of possible values. Indeed, the whole concept of one project value may become

Without equal borrowing and lending rates, project market value is not unique.

meaningless. Value can depend on who owns the project, what the tastes of the individuals' relatives are, or even what time of day it is. You could not even claim that the value of a project is its PV. Present value may itself be meaningless. But let's take this one step at a time.

Q 11.1. What does the assumption of a perfect market buy you that would not be satisfied in an imperfect market?

Judging Market Perfection for Intel Shares and Houses

For Intel shares, the perfect market assumptions are not perfectly true, but they are not too far from the truth.

Start by contemplating the four perfect markets assumptions for a stock like Intel:

1. **No differences in opinion:** Recall that this assumption does not mean that there is no uncertainty, but that investors do not disagree about the uncertainty. Objective, rational traders with access to the same kind of information should come to similar conclusions about Intel's value. They should agree on the distribution of prices that Intel shares will likely sell at tomorrow, which in turn defines share value today. For the most part, it is unlikely that rational traders would disagree much about the value of Intel shares—they should realize that it is not very likely that they can predict the price of Intel much better than the market. Any disagreements would likely be minor. Of course, if some traders have insider information, then they could predict tomorrow's price better, and the perfect market would be no more—but trading on inside information is illegal.

2. **Infinitely many investors and firms:** On a typical day in 2016, around 10 million shares of Intel changed hands in about 50,000 transactions, worth about $300 million. This is a lot of buyers and sellers. Thus, Intel shares appear to trade in a competitive market, in which no single buyer or seller influences the price. There are lots of potential buyers willing to purchase the shares for the same price (or maybe just a tiny bit less), and lots of potential sellers willing to sell the shares for the same price (or maybe just a tiny bit more).

3. **No transaction costs:** Trading Intel shares does incur transaction costs, but these are modest. A typical total round-trip transaction cost spread for Intel is about 5 cents on a $50 share price, which is 10 basis points. An institutional trader may even be able to beat this. There are no searching costs for finding out the proper price of Intel shares (it is posted everywhere online), and there are very low costs to locating a buyer or seller.

4. **No taxes:** This may be the most problematic perfect market assumption in this context. Fortunately, we need this assumption of no taxes primarily for one purpose: The return to a seller owning Intel shares should not be different from the rate of return to a buyer. Here is what I mean.

   Consider an extreme example in which Intel starts out at $20 per share and happens to end up at $80 per share two years later. Assume that the capital gains tax rate is 20% and the risk-free discount rate is 5%. How much value is saved if you hold shares for two years versus if you sell them to me midway? If you keep the shares, the taxable capital gains would be on $\$80 - \$20 = \$60$. At a 20% capital gains tax rate, Uncle Sam would collect $12. If you instead trade them to me at $50 after the first year, the capital gains consequences would be on $30 first for you ($20\% \cdot \$30 = \$6$), and then on $30 at the end for me ($6 again). This violates the perfect market assumption, because if you hold the shares for two years, the present value of the tax obligation is $\$12/1.05^2 \approx \$10.88$. If you sell them to me, it is $\$6/1.05 + \$6/1.05^2 \approx \$11.16$. Thus, shares are worth more to you (the seller) if you hold onto them than if you trade them to me (the buyer).

   But the difference in how we value shares is really only in regard to the interest on the interim taxation. It is only 28 cents on a gain of $60. Moreover, this example is extreme

not only in the 300% rate of return, but also in assuming a worst-case taxation scenario. This chapter later explains that many capital gains can be offset by capital losses and that investor tax-timing discretion can further lower taxes. Furthermore, most shares are now held by institutions. Many of these are pension funds, which are entirely tax-exempt and therefore face no tax implications when trading.

The market for Intel shares may indeed be close enough to being perfect to allow you to use perfect markets as a first working assumption.

Unfortunately, not every good is traded in a perfect market. For example, think about selling your house. What is its value? What if your house is in a very remote part of the country, if potential buyers are sporadic, if alternative houses with the same characteristics are rare, or if the government imposes much higher property taxes on new owners (as, e.g., California does)? Intuitively, the value of your house could now depend on the luck of the draw (how many potential buyers are in the vicinity and see the ad, whether a potential buyer wants to live in exactly this kind of house, and so on); your urgency to sell (depending perhaps on whether you have the luxury to turn down a lowball first offer); or whether you need to sell at all (as current owner, you enjoy much lower property taxes, so your house may be worth a lot more to you than to a potential buyer). The value of such a house can be difficult to determine because the market can be far from perfect—and the house value may not even be one unique number.

For real estate, the market is not perfect. Thus, there may not be a unique value.

The range in which possible values lie depends on the degree to which you believe the market is not perfect. For example, if you know that taxes or transaction costs can represent at most 2-3% of the project value, then you know that even if value is not absolutely unique, it is pretty close to unique—possible values sit in a fairly tight range. On the other hand, if you believe that there are few potential buyers for your house, but that some of these potential buyers would purchase the house at much higher prices than others, then it depends on your financial situation as to whether you should accept or decline another buyer's lowball offer.

Use your judgment about market imperfections. Neither buyers nor sellers are assured of a fair price.

Not all financial markets are close to perfect either. Information differences, the unique power of large buyers or large sellers in the market, transaction costs, or special taxes can sometimes play a role. For example, many corporate bonds are traded primarily over-the-counter. Just a small number of financial traders may make a market in them. If you want to buy or sell such a corporate bond, you must call a designated in-house desk trader. These traders are often your only market venue, and they will try to gauge your expertise when negotiating a price with you. You could easily end up paying a lot more for a bond than what you could then sell it back to them just 1 minute later.

Many financial markets are not perfect either.

➤ Over-the-counter, Sect. 7.2, Pg.155.

To repeat—no market, financial or otherwise—is ever "perfectly perfect." However, for some financial instruments, it is very close.

IMPORTANT

For many financial securities—for example, for large, publicly traded stocks—the assumption that the market is perfect is reasonable. For other financial securities and many nonfinancial goods, this assumption is less accurate.

Q 11.2. What is the difference between a perfect market and a competitive market?

Q 11.3. Does a perfect capital market exist in the real world? What is the use of the perfect markets concept?

Perfect Market Assumptions and Violations

The four perfect market assumptions, and how their failures can drive wedges between borrowing and lending rates.

Now think more rigorously about what happens when each of the perfect market assumptions is violated:

1. **No differences in opinion (information):** This assumption means that everyone interprets all uncertainty in the same way in a perfect market. How could this assumption be violated? Here is an example. If your bank believes that there is a 50% chance that you will go bankrupt and default, and you believe that there is only a 10% chance, then your bank will lend you money only if you pay a much higher interest rate than what you will think appropriate. You will then consider your borrowing rate to be too high. Of course, this also breaks the equality of one fair rate at which you can borrow and lend. Your expected rate of return is now lower when you lend than when you borrow.

   To avoid such situations, our perfect markets assumptions include one that posits that *everyone has the same information and agrees on what it means*.

2. **Infinitely many investors and firms:** This assumption really means that the market is very "deep." By itself, the assumption of the presence of many buyers and sellers defines a **competitive market**—one in which no buyer or seller has any unique market power. If buyers or sellers are heterogeneous, then this assumption must be slightly modified. It must be that you can easily find many of the most eager types of buyers and sellers. For example, say a truck is worth more if it is owned by a truck driver. This assumption then states that there must be a large number of truck drivers.

   How could this assumption be violated? If there is only one bank that you can do business with, then this bank will want to exploit its monopoly power. It will charge you a higher interest rate if you want to borrow money than it will pay you if you want to deposit money—and you will have no good alternative.

   To avoid this, our perfect markets assumptions include one that posits that *there are infinitely many buyers and sellers*.

3. **No transaction costs:** Transaction costs here are defined in a very broad sense, and they include indirect costs, such as your time and money to search for the best deal. In a perfect market, you can buy and sell without paying *any* such costs.

   How could this assumption be violated? If it costs $1,000 to process the paperwork involved in a loan, you will incur this cost only if you borrow, but not if you save. Similarly, if it costs you 3 days of work to find the appropriate lender, it means that you will effectively have to pay more than just the borrowing rate. You will have to factor in your 3 days as a cost. Any such transaction costs make your effective borrowing interest rate higher than your effective savings interest rate.

   To avoid this, our perfect markets assumptions include one that posits that *there are zero transaction costs*.

4. **No taxes:** More accurately, this means that there is no distorting government interference (such as government regulation), and that there are no tax advantages or disadvantages to buying or selling securities. Specifically, neither trading of the good nor its possession by one particular owner should change the total tax consequences.

   How could this assumption be violated? If you have to pay taxes on interest earned, but cannot deduct taxes on interest paid, your *de facto* savings rate will be lower than your borrowing rate. Similarly, if the total taxes paid are higher when shares are traded, they could be worth more if they were never traded to begin with. Another violation could be a government regulation requiring you to file lengthy legal documents with the SEC every time you have to sneeze—well, every time you have to execute some transaction.

   To avoid this, our perfect markets assumptions include one that posits that *there are no taxes*.

These four assumptions are actually "overkill," but if they hold, you are safe. Thinking about them helps you judge how close to perfect a given market actually is. However, the real usefulness of the perfect market is *not* that you should believe that it exists in the real world. Instead, its usefulness is that it gives you some simple first-order methods and tools that help you value goods. If these assumptions do not hold, borrowing and lending rates may or may not be similar enough to allow us to still use perfect market tools or variations thereon. (And, as I already mentioned, almost all common real-world finance formulas rely on them.)

If these assumptions are far from the situation in the real world, nothing will work anymore. In fact, markets may cease to function entirely. For example, if you fear that other parties you would be transacting with are *much* better informed than you, you could only lose—the other party would take full advantage of you, selling to you only if the price is too high. If you can avoid it, you should never trade. Such a market collapse may have happened in the market for corporate bonds *for retail investors*. These bonds are traded over-the-counter, which means that the Wall Street trader on the other side of the phone tries to gauge how much an ordinary retail investor actually knows about the correct value of these bonds. As a result, retail investors are so systematically disadvantaged that it makes no sense for them to buy corporate bonds directly. Instead, they are better off buying bond funds, where someone else who does not suffer a knowledge disadvantage (a bond mutual fund) buys and sells corporate bonds on their behalves. Similarly, if transaction costs are extremely high, there may be no market in which anyone could profitably buy or sell. Fortunately, such total market collapses tend to occur only if the perfect market violations are large. With modest violations, the benefits of transacting tend to outweigh the costs to buyers and sellers, and so markets can still function. This is the kind of situation that this chapter considers.

Let's hope the imperfections are not extreme—if they are, the entire market could even disappear.

Q 11.4. Without looking back, state the four perfect market assumptions.

Ambiguous Value in Imperfect Markets

Why is an inequality between borrowing and lending rates so problematic? It is because it breaks the "unique value aspect" of projects. In a perfect market, project value depends *only* on the project, and not on you personally or on your cash position. You can think of this as a clean separation between the concepts of ownership and value. It also leads to the "separation of investments and financing decisions." Project owners can make investment choices based on the quality of the projects themselves, not based on their personal wealth or financing options. Indeed, the NPV formula does not have an input for your identity or current wealth—its only inputs are the project's cash flows and the rate of return on alternative investments.

If savings and investment interest rates differ, the project's value (NPV) can depend on how wealthy the owner is—more generally, on who the owner is.

➤ Investment consumption separation, Sect. 4.1, Pg.56.

For example, assume that you can lend (invest cash) and borrow money (receive cash) at the same 4% in a perfect market. What is the net present value of a project that invests $1,000 today and returns $1,050 next period? It is $9.62. It does not depend on whether you have money or not. If you do not have the $1,000 today, you borrow $1,009.62, invest $1,000, and hand the $1,050 to the lender next year. But if the financial market is imperfect and the borrowing and lending rates are *not* the same, then the value of the project does depend on you, because it depends on your cash holdings. For example, assume that you can lend money (invest cash) at 3% and borrow money (receive cash) at 7%. What is the net present value of a project that invests $1,000 today and returns $1,050 next period?

An example of how project value can depend on your wealth. Consequently, a project's value may no longer be a single dollar figure, but any figure within a dollar range.

- If you have $1,000 and your alternative is to invest your money in the bank, you will get only $1,030 from the bank. You should take the project rather than invest in the bank so that you can earn $20 more.

- If you do not have the $1,000, you will have to borrow $1,000 from the bank to receive $1,050 from the project. But because you will have to pay the bank $1,070, you will lose $20 net. You should not take the project.

The value of the project and your best decision whether to take the project or not now depends on how much cash you have. Consequently, the separation between your project choice and your financial position breaks down. Having to take your current cash holdings into account when making investment choices makes capital budgeting decisions more difficult. In this example, it is fairly easy: If you have a lot of wealth, you should take the project. If you have no cash, you should not take it. But think about projects that have cash inflows and outflows in the future and how your decisions could interact with your own wealth positions in the future. This can become vexingly difficult. You can also see that the project value is no longer unique in imperfect markets. In our example, it could be anything between +$19.42 ($1,050 discounted at 3%) and –$18.69 ($1,050 discounted at 7%). The same ambiguity applies to ownership. Your capital budgeting decision can be different when you already own the project versus when you are just contemplating buying it. Again, your identity matters to the value of the project.

IMPORTANT

If the market is not perfect, the separation of ownership and value breaks down. Therefore, project value is no longer unique. It can depend on who owns the project.

Do You Always Get What You Pay For?

Are there any good deals? Maybe—but how would one even define a good deal in an imperfect market?

Reflect a little on the insight that projects may not have unique values. You surely have heard the saying that "it's only worth what people are willing to pay for it" and the claim that some item "is worth much more than it is being sold for." Which is correct? Are there any good deals? The answer is that both are correct and neither is correct. The first claim is really meaningful only to the extent that markets are *perfect*: If a market is perfect, items are indeed worth exactly what buyers are willing to pay for them. The second claim is meaningful only to the extent that markets are *imperfect*: If a market is imperfect, items have no unique value. Different people can place different values on the item, and some third party may consider an item worth much more than what it was sold for.

Salespeople may distort the truth and claim great deals.

Thus, when someone claims that a stock or firm is really worth more than he or she is selling it for, there are only a small number of explanations:

1. There may be pure kindheartedness toward any buyer, or a desire by a seller to lose wealth. Not very likely.
2. The seller may not have access to a perfect market to sell the goods. This may make the seller accept a low amount of money for the good, so depending on how you look at it, the good may be sold for more or less than the seller thinks it is worth.
3. The market is perfect and the seller may be committing a conceptual mistake. The good is worth neither more nor less than what it is being sold for—it is worth exactly how much it is being sold for.
4. The seller may be lying and is using this claim as a sales tactic.

Dilbert on Honesty in Sales: 2013-06-16

Q 11.5. Your borrowing rate is 10% per year. Your lending rate is 4% per year. Your project costs $1,000 and will have a rate of return of 8%. Assume you have $900 to invest.

1. Should you take the project?
2. You can think of the $900 as the amount of money that you are not consuming. Say your wealth is $2,000, but in the previous question, you wanted to consume $1,100. Could you still consume this much and take the project? How much could you consume and still want to take the project?

Social Value and Surplus

Buyers get what they pay for in a perfect market. They can "trust" market prices.

Perfect markets are not just privately useful but are also socially useful. If a market is perfect, buyers and sellers need not worry that one deal is better than another—that buying is better than selling, or vice-versa. For example, consider gasoline and imagine that you do not yet know when and where on your road trip you will need to pump more gas. Unlike shares of stock, gas is not the same good everywhere: Gas in one location can be more valuable than gas in another location (as anyone who has ever run out of gas can testify). But in populated areas, the market for gasoline is pretty competitive and close to perfect—there are many buyers (drivers) and sellers (gas stations). This makes it likely that the first gas station you see will have a reasonable price. If you drive by the first gas station and it advertises a price of $3 per gallon, it is unlikely that you will find another gas station within a couple of miles offering the same gas for $2 per gallon or $4 per gallon. Chances are that "the price is fair," or this particular gas station would probably have disappeared by now. (The same applies, of course, in many financial markets, such as those for large company stocks, Treasury bonds, or certain types of mortgages.) As long as the market is very competitive—or better yet, perfect—most deals are likely to be fair deals.

Perfect markets do not mean most buyers and sellers don't care: Perfect markets offer (maximum) surplus for average buyers and sellers.

There is an important conceptual twist here: If you are paying what an item is worth, it does not necessarily mean that you are paying what you *personally* value the good at. For example, if you are running out of gas and you are bad at pushing a 2-ton vehicle, you might very well be willing to pay $10 per gallon—but fortunately, all you need to pay in a competitive market is the market price. The difference between what you personally value a good for and what you pay for it is called your "surplus." Although everyone is paying what the good is worth in a perfect market, most buyers and sellers can come away being better off—only the very last marginal buyer and seller are indifferent.

Q 11.6. Evaluate the following statement: "In a perfect market, no one is getting a good deal. Thus, it would not matter from a social perspective if this market were not available."

11.2 Opinions, Disagreements, and Insider Information

The rest of this chapter will hone in on the four individual imperfections.

What can you do if you think each one of the perfect market assumptions fails? You need to learn both how to judge the degree to which markets are imperfect and how to deal with them as a real-world investor or manager. (Even if there is no unique value, you can still learn how to think about maximizing your own wealth.) The remainder of the chapter thus explores the extent of market imperfections, what can mitigate them, and how you should work when they don't hold.

Information (opinions) is first.

We begin with the effects of disagreements, the violation of the first perfect market assumption that everyone has the same opinion. Like the other assumptions, this works well in some situations and poorly in others.

Expected Return Differences or Promised Return Differences?

Different opinions can lead to disagreements about what the project will pay.

The assumption of no disagreement is only relevant in a world of uncertainty—it would be absurd to believe that differences in opinion could exist if there were no uncertainty. So what happens if the lender and borrower have different information or different judgments about the same information? Most prominently, they could disagree about the default risk. For example, if you have no credit history, then a lender who does not know you might be especially afraid of not receiving promised repayments from you—from the perspective of such a lender, you would be extremely high-risk. Your lender might estimate your appropriate default probability to be 30% and thus may demand an appropriate default premium from you of, say, 10%—an interest rate similar to what credit card vendors are charging. On the other hand, *you* may know that you will indeed return the lender's money, because you know that you will work hard and that you will have the money for sure. In your opinion, a fair and appropriate default premium should therefore be 0%.

Expected rates of return for borrowing and lending now become different.

When your potential lender and you have different opinions, you will face different expected interest rates depending on whether you want to save or borrow. You can use your knowledge from Chapter 6 to work an example to understand the difference between a perfect and an imperfect market scenario.

Do not confuse different promised borrowing/lending rates in perfect markets...

Perfect Markets: Assume that the bank and you agree that you have a 20% probability of default, in which case you will not repay anything. For simplicity, assume risk neutrality and that the appropriate interest rate is 5%. Solving $80\% \cdot r + 20\% \cdot (-100\%) = 5\%$ for the interest rate that you would have to promise yields $r = 31.25\%$. This gives the bank an expected rate of return of 5%. In contrast, the bank is government-insured, so if you deposit your money with it, it would be default-free.

	Promised	Expected
Your Savings Rate	5%	5%
Your Borrowing Rate	31.25%	5%

➤ Credit spreads, Sect. 6.2, Pg.113.

Although your quoted interest rate is higher by the credit spread, if you want to borrow, your cost of capital is still the same 5% either way.

...with different expected borrowing/lending rates in imperfect markets.

Imperfect Markets: Now assume that the bank and you disagree about your default probability. The bank believes that it is 30%—it could be that it has experienced such a default rate for borrowers who seemed to look similar from the perspective of your bank. In contrast, you believe that your default probability is 10%. The bank will therefore quote you an interest rate of $70\% \cdot r + 30\% \cdot (-100\%) = 5\% \Longrightarrow r = 50\%$. Alas, you believe that the expected rate of return at the 50% quoted interest rate is $90\% \cdot 50\% + 10\% \cdot (-100\%) = 35\%$.

	Promised	Expected
Your Savings Rate	5%	5%
Your Borrowing Rate	50% from the bank's perspective	5%
Your Borrowing Rate	50% from your perspective	35%

The disagreements (information differences) are now causing differences in *expected* returns. The borrowing and lending *expected* rates of return are no longer the same. If the bank is wrong, your cost of capital now depends on whether you want to borrow or lend. And even if the bank is right, from your (wrong) perspective, you are still facing different borrowing and lending rates.

IMPORTANT

- The fact that credit spreads reflect a default premium—a difference between the *promised* rate of return and the *expected* rate of return—is not a market imperfection.
- The fact that credit spreads reflect differences in opinion between borrower and lender—a difference about the two assessed *expected* rates of return—is a market imperfection.

Q 11.7. Can there be a difference in the borrowing and lending rates quoted by the bank in perfect markets?

Q 11.8. "If the world is risk-neutral and the market is perfect, then the promised and expected rates of return may be different, but the expected rate of return on all loans should be equal." Evaluate.

Q 11.9. A bond will pay off $100 with probability 99%, and nothing with probability 1% next year. The equivalent appropriate expected rate of return for risk-free bonds is 5%.

1. What is an appropriate promised yield on this bond today?
2. The borrower believes the probability of payoff is 100%. How much money does he believe he has to overpay today?

Covenants, Collateral, and Credit Rating Agencies

Even when borrowers would love to convince their lenders, they may not be able to.

If you are an entrepreneur who wants to start a company, what can you do to reduce your cost of capital? The answer is that it is in your interest to disclose to the lender all the information you can—provided you are the type of entrepreneur who is likely to pay back the loan. You want to reduce the lender's doubt about future repayment. Unfortunately, this can be very difficult. The lender can neither peer into your brain nor give you a good lie detector test. Even after you have done everything possible to reduce the lender's doubts about you (provided your credit history, collateral, and so on), there will still be some residual information differences—they are just a fact of life. To the extent that you can reduce such information differences, your firm will be able to enjoy lower costs of capital. Also, if you as a borrower fail to give your best to convince the lender of your quality, then the lender should assume that you are not an average company but instead the very worst—or else you would have tried to communicate as much as possible.

Good borrowers want to convey credibly to the lender how good they are.

There are at least three important mechanisms that have evolved to alleviate such information differences. The first mechanism is **covenants**, which are contractual agreements that specify upfront what a debtor must do to maintain credit. They can include such requirements as the maintenance of insurance or a minimum corporate value. The second mechanism is **collateral**, which are assets that the creditor can repossess if payments are not made—anything that inflicts pain on the debtor will do. For example, if defaulting debtors were thrown into debtors' prison (as they often were until the nineteenth century), the promise to repay would be more credible and lenders would be more inclined to provide funding at lower rates. Of course, for the unlucky few who just happened to suffer incredibly bad luck ex-post, debtors' prison had some definite drawbacks.

Sumerian Debt Contracts

Among the earliest known collateralized debt contracts is a tablet from Sumeria (Mesopotamia), which promised delivery of silver and gave as security the son of the borrower. (The tablet can be viewed at www.museumofmoney.org/babylon/index.html.) Such contracts are illegal today, but *de facto* "debt slavery" for debts not repaid is still common in many countries, according to the September 2003 issue of *National Geographic*. What do you think about student loans—should students be allowed to declare bankruptcy and walk away from them?

William Goetzmann, Yale University.

Credit rating agencies help lenders estimate the probability of borrower default.

➤ Credit ratings, Sect. 6.2, Pg.114.

The third mechanism to alleviate repayment uncertainty is a credit rating, which is a history of past payments to help assess the probability of future default. This is why you need to give your Social Security number if you want to take out a substantial personal loan—the lender will check up on you. The same is true for large corporations. It may be easier to judge corporate default risk for large companies than personal default risk, but it is still not easy and it costs both time and money. You already learned about these credit ratings in Section 6.2.

Incidentally, bond credit ratings have been historically useless for stock trading strategies.

Unfortunately, although bond rating agencies update their ratings if the condition of the firm changes, the empirical evidence suggests that bond ratings are not very good in helping an investor earn better rates of return. In fact, the ratings seem to respond more to *past* drops in the value of the underlying bonds than vice-versa. The rating agencies seem to be more reactive than proactive. (The poor quality and systematic manipulation of debt ratings by investment banks also played an enabling role in the Great Recession of 2008.)

Don't lose the big picture in the many little problems.

Let me close with a philosophical observation: U.S. and European financial markets are truly amazing. People who would never lend their neighbors a few thousand dollars (fearing that they would not pay it back) have no second thoughts about lending total strangers in anonymous markets their entire lives' savings. It is the combination of the governance of repayments and risk-spreading that has allowed our financial and real markets to develop so well, even in the presence of great uncertainty. It will never be perfectly perfect, of course. Yes, there are problems in the U.S. financial markets, but their relative magnitudes are a lot smaller. By and large, issues of fraud, credit, and trust seem to be under control most of the time. Banks are a vital component of our economic system. In contrast, many hundreds of million of Indians do not have access either to convenient borrowing or saving markets even in the 20s. Many are forced to keep their lives' savings in gold under their mattresses. This leaves them with fewer opportunities and more exposure to theft and corruption.

Q 11.10. What mechanisms can borrowers use to assure lenders? If providing this information is not legally required, will they still volunteer to do so?

11.3 Market Depth and Transaction Costs

The assumption "no market power" is straightforward.

Our second perfect market assumption states that markets are very deep, consisting of many buyers and sellers. If there is only one lender, this lender will have market power over you. Of course, she will exploit her power by charging you a higher borrowing rate and offering you a lower deposit interest rate. Such an extreme form of market power is called a monopoly, but there are many milder forms of such power, too. For example, if you are already shopping in a grocery store, this store has a degree of market power over you. Even if the milk is 3 cents more expensive than in another store, you will still buy the milk where you are. Or say there is only one ATM close to you. In principle, you could get capital from any number of banks, but locally

there is really only this one provider. Fortunately, such uniqueness of capital provision is rarely an important issue in the United States for corporations, especially large ones.

So let's move on to the third perfect markets assumption: the role of transaction costs. Transaction costs drive a wedge between borrowing and lending rates. For example, if it is difficult and costly to administer loans, an investor must charge you a higher borrowing rate than deposit rate just to break even. This is the subject of this section, in which you will learn how corporations and individuals should handle transaction costs.

Transaction costs are this section's main topic.

Typical Costs When Trading Real Goods—Real Estate

When you engage in transactions—that is, purchases or sales—you face costs to facilitate them. One way to think about the magnitude of transaction costs is to compute how much is lost if you decided that you have made a mistake the instant after a purchase, which you now want to undo by reselling. Real estate—most people's biggest asset—is a perfect example to illustrate transaction costs. What does selling or buying a house really cost?

Real estate is an important market in itself. How perfect is it?

Direct costs such as brokerage commissions: Housing transaction costs are so high and so important that they are worth a digression. In the United States, if a house is sold, the seller's broker typically receives 6% of the value of the house as commission (and splits this commission with the buyer's real-estate agent). Thus, if a real-estate agent sells your house for $300,000, her commission is $18,000 (which she usually splits with the buyer's broker). Put differently, without an agent, the buyer and seller could have split the $18,000 between themselves.

Direct transaction costs: a transfer of money.

Although only the seller pays the broker's cost, it makes sense to think of transaction costs in terms of **round-trip costs**—how much worse off you are if you buy and then immediately sell. You would be mistaken if you thought that when you buy a house, you have not incurred any transaction costs because the seller had to pay them—you have incurred an implicit transaction cost in the future when you need to resell your investment. Of course, you usually do not sell assets immediately, so you should not forget about the timing of your future selling transaction costs in your NPV calculations.

Think of transactions in "round-trip" form.

If you borrow to finance the investment, transaction costs may be higher than you think. The real-estate agent earns 6% of the house value, not 6% of the amount of money you put into the house. On a house purchase of $500,000, the typical loan is 80% of the purchase price, or $400,000, leaving you to put in $100,000 in equity. Selling the house the day after the purchase reduces your wealth of $100,000 by the commission of $30,000—for an investment rate of return of –30%. This is not a risk component; it is a pure and certain transaction cost.

House transaction costs are calculated based not on your equity but based on the whole house value—unlike equities for corporate stocks.

How good is your purchase if the house price decreases or increases by 10%? If house prices decline by 10% (or if you overpaid by 10%), the house can only be resold for $450,000, which leaves $423,000 after agent commissions. As the house owner, you are left with $23,000 on a $100,000 investment. A 10% decline in real estate values has reduced your net worth by 77%! In comparison, a 10% increase in real estate values increases the value of the house to $550,000, which means that $517,000 is left after real estate commissions. Your rate of return after this equally-sized magnitude is thus only 17%. If a 10% increase and a 10% decrease are equally likely, your instant expected loss is 30%!

Let's add some price volatility.

In addition to direct agent commissions, there are also many other direct transaction costs. These can range from advertising, to insurance company payments, to house inspectors, to the local land registry, to postage—all of which cost the parties money.

Other direct costs.

Indirect costs such as opportunity costs: Then there is the seller's and buyer's time required to learn as much as possible about the value of the house, and the effort involved to help the agent sell the house. These may be significant costs, even if they involve no cash outlay. If the house cannot be sold immediately but stays empty for a while, the foregone rent is part of the transaction costs. The implicit cost of not having the house put to its best alternative use is called

Indirect transaction costs are the loss of other opportunities.

Real Estate Agents: Who Works for Whom?

Real estate agents are conflicted. If they sell sooner, they can spend their time focusing on other properties. Thus, the typical seller's agent will try to get the seller to reduce the price in order to make a quicker sale. Similarly, the buyer's agent will try to get the buyer to increase the offer. In a financial sense, the buyer's agent is working on behalf of the seller, and the seller's agent is working on behalf of the buyer. Interestingly, Steve Levitt of *Freakonomics* found that when agents sell their own houses, on average, their homes tend to stay on the market for about 10 days longer and sell for about 2% more.

Steve Levitt, University of Chicago.

an **opportunity cost**—the cost of foregoing the next-best choice. Opportunity costs are just as real as direct cash costs.

Typical Costs When Trading Financial Goods—Stocks

Stock transactions also incur direct and indirect costs.

Transactions in financial markets also incur transaction costs. If an investor wants to buy or sell shares, the broker charges a fee, as does the stock exchange that facilitates the transaction. In addition, investors have to consider their time to communicate with the broker to initiate the purchase or sale of a stock as an opportunity cost.

The typical direct transaction costs for stocks are much, much lower than for most other goods.

Direct costs such as brokerage and market maker commissions: Still, the transaction costs for selling financial instruments are much lower than they are for most other goods. Let's look at a few reasons why. First, even if you want to buy (or sell) $1 million worth of stock, some Internet brokers now charge as little as $10 per transaction. Your round-trip transaction, which is a buy and a sale, costs only $20 in broker's commission. In addition, you have to pay the **spread** (the difference between the bid price and the ask price) to the stock exchange. For example, a large company stock like Intel may have a publicly posted price of $50 per share. But you can neither buy nor sell at $50. Instead, the $50 is really just the average of two prices: the **bid price** of $49.92, at which another investor or the exchange's market maker is currently willing to buy shares and the **ask price** of $50.08, at which another investor or the exchange's market maker is currently willing to sell shares. Therefore, you can (probably) purchase shares at $50.08 and sell them at $49.92, a loss of "only" 16 cents, which amounts to round-trip transaction costs of ($49.92 – $50.08)/$50.08 ≈ –0.32%. (Typical market spreads for Intel shares are even lower.) You can compute the total costs of buying and selling 20,000 shares ($1,000,000 worth) of Intel stock as follows:

Financial Round-Trip Transaction		
Purchase 20,000 Shares	Pay $50.08 · 20,000 = $1,001,600	
Add Broker Commission	+$10	= $1,001,610
Sell 20,000 Shares	Receive $49.92 · 20,000 = $998,400	
Subtract Broker Commission	–$10	= $998,390
	Net Round-Trip Transaction Costs	$3,220

This table is not *exactly* correct, though, because the bid and ask prices that the stock exchanges post are valid for only 100 shares. Moreover, some transactions can occur inside the bid-ask spread, but for most large round-trip orders, chances are that you may have to pay more than $50.08 or receive less than $49.92. So 0.32% is probably a bit too small. (In fact, if your trade is large enough, you may even move the publicly posted exchange price away from $50!) Your buy order may have to pay $50.20, and your sell may only get you $49.85. In real life, the true round-trip transaction cost on a $1 million position in Intel shares may be on the order of magnitude of 50 basis points.

An example of how low transaction costs in stock can be is illustrated by an extremely large trade in a very liquid security that occurred on Thursday, November 30, 2006, at 12:12pm. Kirk Kerkorian, a billionaire investor, sold 5% of GM (a block of 28 million shares) at $29.25 per share (or about $820 million)—almost to the penny for the price that GM shares were trading at on the NYSE. Upon receiving the news, the GM stock price dropped to $28.49—but within 1 hour, it had recovered and even reached $29.50. And since then, stock markets have become even more competitive. Don't you find it remarkable how the sale of even very large blocks of shares seems to barely move the stock price?

An example of how stunningly low stock transaction costs can be.

You may sometimes read about **high-frequency traders** (**HFT**), who run algorithms to strategically pick off pennies because they have a nano-second earlier access to trading. Whether this is a problem or not can be debated, but if it ever was, it is going away. There are now dozens of HFTs competing against one another for the business of buying and selling shares from the rest of us. They have almost surely competed away much of their possible excess profits. Moreover, new exchanges with better market structures are also appearing. Even if this game was rigged a few years ago, it's no longer a major concern today.

HFT — High Frequency Traders?

Indirect costs such as opportunity costs: Investors do not need to spend a lot of time to find out the latest price of the stock: It is instantly available from many sources (e.g., from YAHOO! FINANCE). The information research costs are very low: Unlike a house, the value of a stock is immediately known. Finally, buyers can be found practically instantaneously, so search and waiting costs are also very low. In contrast, count on many anxiety-ridden waiting months when you want to sell your house.

The typical indirect transaction costs (opportunity costs) for stocks are also very low.

Comparing Stock Transaction Costs To Housing Transaction Costs

Let's compare the transaction costs in buying and selling financial securities to those of a house. Aside from the direct real estate broker fees of 6% (for the $100,000 equity investment in the $500,000 house, this comes to $30,000 for a round-trip transaction), you must add the other fees and waiting time. Chances are that you will be in for other transaction costs—say, another $10,000.

Compared to other economic assets...

Cost Type	Explanation	Real Estate (House)	Financial Security (Stock)
Direct	Typical round-trip commission, etc.	≥6%	0-1%
Search/Research	Time to determine fair price	High	Zero
Search/Liquidity	Time waiting to find buyer	Variable	Zero

And houses are just one example: Many transactions of physical goods or labor services (but not all) can incur similarly high transaction costs.

In contrast, if you want to buy or sell 100 shares in, say, Microsoft stock, your transaction costs are relatively low. Because there are many buyers and many sellers, financial transaction costs are comparably tiny. Even for a $100,000 equity investment in a medium-sized firm's stock, the transaction costs are typically only about $300–$500. It may not be a perfectly correct assumption that the market for trading large stocks is perfect, but it is not far off. It certainly is convenient to assume that financial transaction costs are zero. For an individual buying and selling ordinary stocks only rarely (a **buy-and-hold** investor), a zero-transaction-cost assumption is often quite reasonable. But if you are a **day trader**—someone who buys and sells stocks daily—our perfect market assumption would be inappropriate.

...financial securities have such low transaction costs that they can be assumed to be almost zero for buy-and-hold investors.

Q 11.11. What would you guess are the transaction costs for a round-trip transaction of $10,000 in Microsoft shares, in percentage and in absolute terms?

Q 11.12. List important transaction cost components, both direct and indirect.

Transaction Costs in Returns and Net Present Values

The ultimate rule.

As an investor, you usually care about rates of return *after* all transaction costs have been taken into account, not about pre-transaction-cost rates of return from quoted prices. Let's work out how you should take these transaction costs on both sides (buy and sell) into account.

Rates of return: Work with after-transaction-cost rates.

Return to our housing example. If you purchase a house for \$1,000,000 and you sell it to the next buyer at \$1,100,000 through a broker, your rate of return is not 10%. At selling time, the broker charges you a 6% commission. There are also some other costs that reduce the amount of money you receive, not to mention your many opportunity costs. Say these costs amount to \$70,000 in total. In addition, even when you purchased the house, you most likely had to pay some extra costs (such as an escrow transfer fee) above and beyond the \$1,000,000—say, \$5,000. Your rate of return would therefore not be \$1,100,000/\$1,000,000 – 1 = 10%, but only

$$\text{r} = \frac{(\$1{,}100{,}000 - \$70{,}000) - (\$1{,}000{,}000 + \$5{,}000)}{(\$1{,}000{,}000 + \$5{,}000)} \approx 2.5\%$$

$$\text{Rate of Return} = \frac{\text{Dollars Returned after Transaction Costs} - \text{Dollars Invested after Transaction Costs}}{\text{Dollars Invested after Transaction Costs}}$$

Note how the \$5,000 must be added to, not subtracted from, the price you originally paid. The price you paid was ultimately higher than \$1,000,000. The \$5,000 works against you. Incidentally, in order to make their returns look more appealing, many professional fund managers quote their investors' rates of return before taking their own fees (transaction costs) into account. They add a footnote at the bottom that satisfies the lawyers so that you cannot sue the fund for having been misled—you are supposed to know how to adjust the returns to take these transaction costs into account.

Net present value: Work with after-transaction-cost cash flows and with after-transaction opportunity costs of capital.

How do you take care of transaction costs in present value calculations? This is relatively straightforward. In the example, you put in \$1,005,000 and receive \$1,030,000—say, after one year:

$$\text{NPV} = -\$1{,}005{,}000 + \frac{\$1{,}030{,}000}{1 + \text{Opportunity Cost of Capital}}$$

The only thing you must still take care of is to quote your opportunity cost of capital also in after-transaction cost terms. You may not be able to get a 10% rate of return in comparable investments either, because you may also be required to pay a transaction cost on them. In this case, assume that your alternative investment with equal characteristics in the financial markets (not the housing markets) would earn an 8% per year rate of return, but with a 50-basis-point transaction cost. Your project would then have an appropriate NPV of

$$\text{NPV} = -\$1{,}005{,}000 + \frac{\$1{,}030{,}000}{1.075} \approx -\$46{,}860$$

Q 11.13. Compute your after-transaction-costs rate of return on buying a house for \$1,000,000 if you have to pay 0.5% transaction fees up front (to cover various escrow fees); and then pay a 6% broker's commission (plus 2% in waiting costs) at the end of one year when you sell (on the then selling price of the house). Assume a \$4,000/month effective dividend of enjoying living in the house. Assume that your opportunity cost of capital (not the bank-quoted interest rate) is 7% per year. At what rate of capital appreciation would the NPV be zero if you resold the house after one year?

The Value of Liquidity

When *future* transaction costs influence your upfront willingness to buy an asset, proper pricing gets even more interesting and complex. You might not want to purchase a house even if you *expect* to recoup your transaction costs, because you dislike the fact that you do not know whether it will be easy or hard to resell. After all, if you purchase a stock or bond instead, you know you can resell without much of a transaction cost whenever you want.

Anticipating future transaction costs, buyers demand a higher rate of return for more illiquid investments.

What would make you want to take the risk of sitting on a house for months without being able to sell it? To get you to buy a house would require the seller to compensate you. The seller would have to offer you a **liquidity premium**—an extra expected rate of return to compensate you for your willingness to hold an asset that you may find difficult to convert into cash if a need were to arise. The liquidity analogy comes from physics. In the same way that physical movement is impeded by physical friction, economic transactions are impeded by transaction costs.

"Liquidity" is a common analogy that finance has borrowed from physics.

Housing may be an extreme example, but liquidity effects appear to be important everywhere, even in financial markets with their low transaction costs. (Some financial markets are generally considered low-friction, or even close to frictionless.) Even finance professors and the best fund managers do not yet fully understand liquidity premiums, but we do know that they can be very important. In financial crises, like 2008, liquidity seems to have been the only thing that was really important. Let's look at some examples of where liquidity premiums seem to play important roles.

Liquidity (or lack thereof) is super-important in most markets, but we do not fully understand it yet.

Treasury Bonds

Believe it or not, even Treasuries have differences in liquidity! The most recently issued Treasury of a particular maturity is called **on-the-run**. These bonds account for more than half of the total daily trading volume, yet less than 5% of the outstanding market cap. Every bond trader who wants to trade a bond with roughly this maturity focuses on this particular bond. This makes it easier to buy and sell the on-the-run bond compared to a similar but not identical **off-the-run** bond. In 2016, the typical on-the-run bond traded for about 5 basis points less than the equivalent off-the-run Treasury. In other words, you would have been able to buy the off-the-run bond at a much lower price than the on-the-run bond.

Even Treasuries have differences in liquidity: on-the-run and off-the-run bonds.

The reason why you might want to buy the on-the-run bond, even though it had a higher price, would be that you could resell it much more quickly and easily than the equivalent off-the-run bond. Of course, as the date approaches when this 10-year bond is about to lose its on-the-run designation and another bond is about to become the on-the-run 10-year bond, the old on-the-run premium drops in value.

On-the-run is more liquid.

In a perfect world, there should be no difference between these two types of bonds. Yet when a two-year bond is on-the-run, its bid-ask spread is on average about 1 basis point lower, and it offers on average 0.6 basis points less in yield. For a ten-year bond, both the bid-ask spread and the yield difference between the on-the-run and off-the-run Treasury are usually about 3 basis points. This can only be explained by an investor preference for the immediate liquidity of the current on-the-run bond.

Investors prefer on-the-run bonds because of their immediate liquidity.

Liquidity Provision As a Business: Market Making

You can think of a market maker on an exchange as someone who is providing liquidity. As a retail investor, you can sell your securities to the market maker in an instant, and it is up to the market maker to find some other investor who wants to hold it long term. To provide this liquidity, the market maker earns the bid-ask spread—a part of the liquidity premium.

Market = Liquidity Provider.

The provision of liquidity in markets of any kind is a common business. For example, you can think of antique stores or used car dealerships as liquidity providers that try to buy cheap (being

Liquidity provision is an essential business.

a standby buyer) and sell expensive (being a standby seller). Being a liquidity provider can require big risks and capital outlays. If it were easy, everyone could do it—and then competition would ensure that there would be no more money in liquidity provision!

Liquidity Runs

Liquidity crises are extremely interesting.

The most remarkable empirical regularity about liquidity, however, is that every few years, investors in all markets suddenly seem to prefer only the most liquid securities. This is called a **flight to quality** or **run on liquidity**. In such situations, the spreads on almost all bonds—regardless of whether they are Latin American, European, corporate, mortgage-related, and so on—relative to Treasuries tend to widen all at the same time.

How the liquidity run in the 2008 Great Recession spread.

In early 2008, with the Great Recession, the U.S. economy was facing just such a run on liquidity. It started in the mortgage sector, then spread to many other bonds. Every fund and bank was afraid that its investors would pull their lines of credit. Thus, they themselves were pulling back all lines of credit that they had extended to their clients (often other banks and funds). Many were selling even highly rated securities for low prices (sometimes fire-sale prices), just to avoid being caught themselves in an even worse liquidity run. There were many extremely curious pricing oddities during the 2008 liquidity run, but they were difficult to exploit by arbitrageurs (because no one would trust lending them the money to execute these arbitrages). For example, two-year bonds issued by a federal government agency, GNMA, and thus always fully backed by the federal government, traded at a full 200 basis points higher than the equivalent Treasuries.

If you are liquid in a liquidity crisis, you can earn a lot of money.

Selling liquidity in order to collect the liquidity premium is also a very common method for Wall Street firms and hedge funds to make money—perhaps even *the* most common. If you know you will not need liquidity at sudden notice or that you want to hold bonds to maturity, it can make sense to buy less-liquid securities to earn the liquidity premium. A sample strategy might be to buy illiquid corporate bonds, financed with cheaper borrowed money. Most of the time, this strategy makes modest amounts of money consistently—except when a flight to liquidity occurs and liquidity spreads widen. Exactly such a situation led to the collapse of a well-known hedge fund named Long-Term Capital Management (LTCM) in 1998. After Russia defaulted on its debt, the spreads on almost every bond widened—the average corporate bond spread in the United States rose from about 4% to about 8% in one week! LTCM simply could not find any buyers for its large holdings of non-Treasury bonds. On the other hand, those funds that could hold onto their positions throughout the crisis or that provided extra liquidity (buying securities that were now very cheap) did extremely well when liquidity returned to normal and their illiquid securities went back up in price. The same fate probably befell many financial firms in the Great Recession. Their own financiers demanded their money back quickly, but there was no liquid market to unwind positions quickly.

Q 11.14. What is the difference between a liquidity premium and a transaction cost?

11.4 Taxes

The art of taxation consists in so plucking the goose as to get the most feathers with the least hissing. Jean-Baptiste Colbert

Dilbert on tax code: 2013-04-06

Certainty? In this world nothing is certain but death and taxes. Benjamin Franklin

Dilbert on Writing the Tax Code: 2013-04-10

Our fourth violation of market perfection is taxes. They are pervasive and are often an economically large component of project returns. The actual tax code itself is very complex, and its details change every year, but the basics have remained in place for a long time and are similar in most countries. Let me summarize briefly what you need to know for this book.

Only a sketch of the complex tax code.

The Basics of (Federal) Income Taxes

The **Internal Revenue Service** (**IRS**) taxes individuals and corporations similarly. (There are some differences, but we don't have the space to discuss them.) Gross income is adjusted by a set of allowable deductions into taxable income, and a (progressive) tax rate is applied. **Before-tax expenses** (deductions) are better for taxpayers than **after-tax expenses**. For example, if you earn $100,000 and there was only one 40% bracket, a $50,000 before-tax expense would leave you

The tax code basics have been simple and stable, but the details are complex and ever-changing.

$$(\$100{,}000 - \$50{,}000) \cdot (1 - 40\%) \quad = \quad \$30{,}000$$

$$\text{Before-Tax Net Return} \cdot (1 - \text{Tax Rate}) \quad = \quad \text{After-Tax Net Return}$$

while the same $50,000 as an after-tax expense would leave you with only

$$\$100{,}000 \cdot (1 - 40\%) - \$50{,}000 \quad = \quad \$10{,}000$$

Perhaps the most important deductible items for both corporations and individuals are interest payments, although individuals can deduct them only for mortgages. In addition, there are some other deductions such as pension contributions. There are also some nonprofit investors (such as pension funds) that are entirely tax-exempt.

➤ Other tax shelters, Sect. 18.7, Pg.504.

The tax code categorizes income into four different classes: ordinary income, interest income, dividend income, and capital gains. The tax rates on these classes differ, as does the ability to apply deductions on them to reduce the income tax burden.

Among the four classes of income, dividends receipts and capital gains are the two best in terms of tax treatment.

Ordinary income applies to most income that is not derived from financial investments (such as wages). Individuals are allowed only very few deductions on ordinary income, and the tax rate is the highest. The highest marginal Federal income tax rate was 39.6% in 2016. Most U.S. states also have an income tax, which can add up to another 10-15% on top of the Federal rate.

Interest income is basically treated like ordinary income.

Dividend income from shares in qualifying U.S. corporations are taxed at a lower rate, often about half that of ordinary income.

Capital gains on assets owned for one year or more are taxed at the lower rates, just like dividends. (Assets held for less than one year are taxed essentially at the same rate as ordinary income.) In addition, your capital losses are deductible against your capital gains. And unlike any other income, which is taxed every year, both short-term and long-term capital gains are taxed only when realized. Moreover, if you have moved for one year to a state with no income taxes, then you can realize your capital gain without paying state income tax—even if the appreciation itself has occurred mostly while you were living in a high-income tax state. (It is no accident that many senior citizens have been moving to Florida to avoid state income tax on their accumulated capital gains.)

From the perspective of an investor, capital gains are preferable to dividend income, and both are preferable to interest and ordinary income.

The difference between marginal and average tax rates.

The **average tax rate** (the ratio of paid taxes to taxable income) is lower than the **marginal tax rate** (the rate on the last dollar of income), because lower marginal tax rates are applied to your first few dollars of income in the progressive U.S. tax system. For example, in 2016, the first $9,275 were taxed at 10%, the next $28,374 at 15%, and so on. Thus, ignoring a variety of subsequent adjustments, if you earned $30,000, you would have paid taxes of

$$\text{Tax} = 10\% \cdot \$9{,}275 + 15\% \cdot (\$30{,}000 - \$9{,}275) \approx \$4{,}036$$

Therefore, your marginal tax rate—the one applicable to your last dollar of income—was 15%, while your average tax rate was about 13.5%. Economists almost always work only with marginal tax rates, because they are relevant to your earning a little more or less. For large corporations, the distinction is often minor, because beginning at around $100,000 of income, the federal tax rate is about 34% (as of 2016). A corporation that earns or loses $10 million has an average tax rate that is, for all practical purposes, the same as its marginal tax rate.

The tax picture here is rather incomplete.

Of course, there are also other important taxes, such as state income taxes, Social Security and Medicare taxes, property taxes, sales taxes, and so on. In recent years, an alternative tax system, the **alternative minimum tax** (**AMT**), has become as important as the standard federal income tax system. Because the AMT categorizes most income the same way, we won't distinguish between the standard income tax and the alternative minimum tax. If you have to file in multiple states, the details can become hair-raisingly complex. Professional athletes have to pay taxes in every state in which they have played a game, for example. Some retailers have to handle hundreds of (sales) tax authorities in the United States alone. It gets worse when multiple countries are involved. If you find yourself in such a situation, may the Force be with you!

IMPORTANT

- Remember that there are some tax-exempt investors, such as pension funds.
- You must understand how income taxes are computed (the principles, not the details), how to find the marginal tax rate, how to compute the average tax rate, and why the average tax rate is usually lower than the marginal tax rate.
- Expenses that can be paid from before-tax income are better than expenses that must be paid from after-tax income. Specifically, interest expenses are tax-deductible and thus better for the taxpayer.
- Capital gains and secondarily dividend income enjoy preferential tax treatment for the recipient, relative to interest and ordinary income.

Q 11.15. Is it better for the taxpayer to have a before-tax or an after-tax expense? Why?

Q 11.16. What types of income do taxpayers prefer? Why?

Q 11.17. Why is the marginal tax rate usually lower than the average tax rate?

The Effect of Taxes on Rates of Return

How does finance work if there are income taxes? Mechanically, taxes are similar to transaction costs—they take a "cut," which makes investments less profitable. One difference between them is that income taxes are higher on more profitable transactions, whereas plain transaction costs are the same whether you made or lost money. And, of course, taxes often have many more nuances. A second and perhaps more important difference is that taxes are often orders of magnitude bigger and thus more important than ordinary transaction costs—except in illustrative textbook examples. For many investors and corporations, tax planning is an issue of first-order importance.

Taxes are on profits, not on values or sales. Nevertheless, they are often much larger than transaction costs.

In the end, all investors should care about is after-tax returns, not before-tax returns. It should not matter whether you receive \$100 that has to be taxed at 50% or whether you receive \$50 that does not have to be taxed. This leads to a recommendation analogous to that for transaction costs—*work only in after-tax money*. For example, say you invest \$100,000 in after-tax money to earn a return of \$160,000. Your marginal tax rate is 25%. Taxes are on the net return of \$60,000, so your after-tax net return is

Taxable investors (unlike tax-exempt investors) care about after-tax inflows and outflows.

$$\begin{array}{ccc} 75\% \cdot \$60{,}000 & = & \$45{,}000 \\ (1-\tau) \cdot \text{Before-Tax Net Return} & = & \text{After-Tax Net Return} \end{array}$$

(The tax rate is commonly abbreviated with the Greek letter τ, tau.) In addition, you will receive your original investment back, so your after-tax rate of return is

$$r_{\text{after tax}} = \frac{\$145{,}000 - \$100{,}000}{\$100{,}000} = 45\%$$

Tax-Exempt Bonds and the Marginal Investor

In the United States, interest paid on bonds issued by smaller governmental entities is legally tax-exempt. (The Constitution's authors did not want to have the federal government burden states' or local governments' efforts to raise money.) If you own one of these bonds, you do not need to declare the interest on your federal income tax forms, and sometimes not even on your state's income tax form, either. (The arrangement differs from bond to bond.) The most prominent tax-exempt bonds are often just called **municipal bonds**, or **munis** for short. As their name suggests, many are issued by municipalities such as the City of Los Angeles (CA) or the City of Canton (OH). State bonds are also categorized as muni bonds, because they are also exempt from federal income tax. Unfortunately, unlike the U.S. Treasury, municipalities can and have gone bankrupt, so their bonds may not fully repay. (For example, Orange County California prominently defaulted in December 1994.) Still, many muni bonds are fairly safe AAA credit. Tax-exempt bonds are often best compared to taxable corporate bonds with similar bond ratings. The difference between the prevailing interest rates on equally risky taxable and tax-exempt bonds allows us to determine the effective tax rate in the economy.

State and municipal bonds' interest payments are legally exempt from (federal) income taxes.

For example, on June 20, 2016, Bonds Online reported

	2 Year	10 Year	20 Year
Tax-Exempt Muni, A	0.7%	1.7%	2.7%
Corporate Bonds, A	1.1%	2.7%	4.0%
Treasury	0.7%	1.6%	2.0%

In June 2016, taxable bonds offered 133 basis points per annum above munis. An investor in the 35% tax bracket should have preferred the tax-exempt muni bond.

Would tax-exempt or corporate 10-year bonds be better for *you*? Well, it depends. For argument's sake, ignore default. If you invested \$100 into munis at a 1.7% interest rate, you

would receive \$1.70 of interest at year's end and Uncle Sam would get none of it. You would prefer the corporate bond. If you invested \$100 in corporate bonds, you would receive \$2.70. If your federal income tax rate is 0%, you would clearly prefer the \$2.70 to the \$1.70. However, if your marginal tax rate is 39.6%, Uncle Sam would collect $\$2.70 \cdot 39.6\% \approx \$1.07$ and leave you with $\$2.70 \cdot (1-39.6\%) \approx \$1.63$. Because \$1.70 is better than the \$1.63, you would prefer the tax-exempt bond.

Investors above a critical tax rate should prefer the muni bond.

In economics, almost everything that is important is "on the margin." Thus, economists like to think about a hypothetical marginal investor. This is an investor whose marginal income tax rate is such that she would be exactly indifferent between buying the tax-exempt bond and the taxable bond. Using the same calculations, for the 20-year bond, the marginal investor has a tax rate of

$$2.7\% = (1-\tau_{\text{marginal}}) \cdot 4.0\% \quad \Leftrightarrow \quad \tau_{\text{marginal}} = 1 - \frac{2.7\%}{4.0\%} \approx 32.5\%$$

$$r_{\text{after tax}} = (1-\tau_{\text{marginal}}) \cdot r_{\text{before tax}} \quad \Leftrightarrow \quad \tau_{\text{marginal}} = 1 - \frac{r_{\text{after tax}}}{r_{\text{before tax}}}$$

Any investor with a marginal income tax rate above 32.5% (such as a high-income retail investor) should prefer the tax-exempt bond. Any investor with a marginal income tax rate below 32.5% (such as your tax-exempt 401K) should prefer the taxable bond. When economists think more generally about how assets are priced, they also use this tax rate as the effective economy-wide one.

Q 11.18. What were the marginal investor's tax rates on 2-year and 10-year bonds in June 2016?

Q 11.19. If your tax rate is 20%, what interest rate do you earn in after-tax terms if the before-tax interest rate is 6%?

Q 11.20. If the marginal investor's tax rate is 30% and taxable bonds offer a rate of return of 6%, what rate of return do equivalent muni bonds offer?

Taxes in Net Present Values

You should only care about your own after-tax cash flows.

Again, as with transaction costs, you should take care to work only with cash in the same units—here, this means cash that you can use for consumption. Again, it should not matter whether you receive \$100 that has to be taxed at 50% or whether you receive \$50 that does not have to be taxed. As far as NPV is concerned, you should compute everything in after-tax dollars. This includes all cash flows, whether they occur today or tomorrow, and whether they are inflows or outflows.

IMPORTANT

Perform all NPV calculations in *after-tax* money. This applies both to the expected cash flows and to the opportunity cost of capital.

You must compute the after-tax opportunity cost of capital.

Unfortunately, you cannot simply discount before-tax cash flows with the before-tax cost of capital (wrong!) and expect to come up with the same result as when you discount after-tax cash flows with the after-tax cost of capital (right!).

For example, consider a project that costs \$10,000 and returns \$13,000 next year. Your tax rate is 40%, and 1-year equivalently risky bonds return 25% if their income is taxable and 10% if their income is not taxable. First, you must decide what your opportunity cost of capital is. Section 11.4 showed that if you invest \$100 into taxables, you will receive \$125 but the IRS will confiscate $(\$125-\$100)\cdot 40\% = \$10$. You will thus own \$115 in after-tax wealth. Tax-exempts grow only to \$110, so you prefer the taxable bond—it is the taxable equally risky bond that determines your opportunity cost of capital. Your equivalent after-tax rate of return is therefore 15%. This 15% is your after-tax "opportunity" cost of capital—it is your best alternative use of capital elsewhere.

Your opportunity cost of capital depends on your own tax rate.

Return to your \$10,000 project now. You know that your taxable project returns 30% taxable (\$3,000), while taxable bonds return 25% (\$2,500), so NPV should tell you to take this project. Uncle Sam will confiscate $40\%\cdot\$3{,}000 = \$1{,}200$, leaving you with \$11,800. Therefore, the NPV of your project is

$$\text{NPV} = -\$10{,}000 + \frac{\$11{,}800}{1+15\%} \approx \$260.87 \quad \text{(after-tax cash flows and after-tax cost of capital)}$$

$$C_0 + \frac{E(C_1)}{1+E(r_1)}$$

You must discount your after-tax expected cash flows with your after-tax opportunity cost of capital.

It makes intuitive sense: If you had invested money into the bonds, you would have ended up with \$11,500. Instead, you will end up with \$11,800—the \$300 difference occurring next year. Discounted, the \$261 seems intuitively correct. Of course, there are an infinite number of ways of getting *incorrect* solutions, but let me point out a few. None of the following calculations that use the before-tax expected cash flows (and try different discount rates) give the same correct result of \$260.87:

Here are incorrect shortcut attempts, working with before-tax cash flows and/or before-tax costs of capital.

$$\text{NPV} \neq -\$10{,}000 + \frac{\$13{,}000}{1+25\%} = \$400 \quad \text{(taxable cash flows, taxable cost of capital)}$$

$$\text{NPV} \neq -\$10{,}000 + \frac{\$13{,}000}{1+15\%} \approx \$1{,}304.35 \quad \text{(taxable cash flows, after-tax cost)}$$

$$\text{NPV} \neq -\$10{,}000 + \frac{\$13{,}000}{1+10\%} \approx \$1{,}818.18 \quad \text{(taxable cash flows, muni-tax-exempt cost)}$$

You have no choice: To get the correct answer of \$260.87, *you cannot work with before-tax expected cash flows*. Instead, you need to go through the exercise of carefully computing after-tax cash flows and discounting with your after-tax opportunity cost of capital.

You know that computing after-tax cash flows is a pain. Can you at least compare two *equally* taxable projects in terms of their before-tax NPV? If one project is better than the other in before-tax terms, is it also better in after-tax terms? If yes, then you could at least do relative capital budgeting with before-tax project cash flows. This may or may not work, and here is why. Compare project SAFE, which costs \$1,000 and will provide \$1,500 this evening; and project UNSAFE, which costs \$1,000 and will provide either \$500 or \$2,500 this evening with equal probability. The expected payout is the same, and the cost of capital is practically 0% for 1 day. If you are in the 20% marginal tax bracket, project SAFE will leave you with \$500 in *taxable* earnings. The IRS will collect $20\%\cdot(\$1{,}500-\$1{,}000) = \$100$, leaving you with +\$400 in after-tax net return. Project UNSAFE will either give you \$1,500 or –\$500 in *taxable* earnings.

In some, but not all, situations, you can compare two projects based on their before-tax NPVs.

- If the project succeeds, you would send $\$1{,}500\cdot 20\% = \$300$ to the IRS. If the project fails, and if you can use the losses to offset gains from projects elsewhere, you would send $\$500\cdot 20\% = \$100$ *less* to the IRS (because your taxable profits elsewhere would be reduced). In this case, projects SAFE and UNSAFE would have the same expected tax costs and after-tax cash flows: $\frac{1}{2}\cdot\$300 + \frac{1}{2}\cdot(-\$100) = \$100$.

- If you drop into a different tax bracket, say, 25%, when your (additional) net income is $1,000 higher, then project UNSAFE becomes less desirable than project SAFE. For the $1,500 income, the first $500 would still cost you $100 in tax, but the remaining $1,000 would cost you $250. Thus, your project's marginal tax obligation would be either $350 or –$100, for an expected tax burden of $125. (The same logic applies if your losses would make you fall into a lower tax bracket—the UNSAFE project would become less desirable, because the tax reduction would be worth less.)
- If you have no capital gains elsewhere that you can reduce with the UNSAFE project capital loss, then the UNSAFE project would again be worth less. Corporations can ask for a tax refund on old gains, so the unrealized tax loss factor is less binding than it is for individuals, who may have to carry the capital loss forward until they have sufficient income again to use it—if ever.

Thus, whether you can compare projects on a before-tax basis depends on whether you have perfect symmetry in the applicable marginal tax rates across projects. If you do, then the project that is more profitable in after-tax terms is also more profitable in before-tax terms. This would allow you to simply compare projects by their before-tax NPVs. If gains and losses face different taxation—either because of tax bracket changes or because of your inability to use the tax losses elsewhere—then you cannot simply choose the project with the higher before-tax NPV. You will have to go through the entire after-tax NPV calculations and compare them.

IMPORTANT

You can only compare projects on a before-tax NPV basis if the tax treatment is absolutely symmetric. This requires consideration of your overall tax situation.

Two more tax-adjusting corporate valuation methods, WACC and APV, unfortunately have to wait.

You now know how to discount projects in the presence of income taxes. However, you do not yet know how to compute the proper discount rate for projects that are financed by debt and equity, because debt and equity face different tax consequences. Unfortunately, you will have to wait until Chapter 18 before we can do a good job discussing the two suitable methods—called adjusted present value (APV) and the weighted average cost of capital (WACC)—to handle differential taxation for different corporate securities.

Q 11.21. You have a project that costs $50,000 and will return $80,000 in 3 years. Your marginal capital gains tax rate on the $30,000 gain will be 37.5%. Treasuries pay a rate of return of 8% per year; munis pay a rate of return of 3% per year. What is the NPV of your project?

Q 11.22. You are in the 33.3% tax bracket. A project will return $14,000 in 1 year for a $12,000 investment—a $2,000 net return. The equivalent tax-exempt bond yields 15%, and the equivalent taxable bond yields 20%. What is the NPV of this project?

Q 11.23. It is not uncommon for individuals to forget about taxes, especially when investments are small and payoffs are large but rare. Say you are in the 30% tax bracket. Is the NPV of a $1 lottery ticket that pays off taxable winnings of $10 million with a chance of 1 in 9 million positive or negative? How would it change if you could buy the lottery ticket with before-tax money?

Tax Timing

In many situations, the IRS does not allow reinvestment of funds generated by a project without an interim tax penalty. This can be important when you compare one long-term investment to multiple short-term investments that are otherwise identical. For example, consider a farmer in the 40% tax bracket who buys grain (seed) that costs \$300 and that triples in value every year.

It is often better if you are taxed only at the very end, rather than in the interim.

- If the IRS considers this farm to be *one long-term two-year project*, the farmer can use the first harvest to reseed, so \$300 seed turns into \$900 in one year and then into a \$2,700 harvest in two years. Uncle Sam considers the profit to be \$2,400 and so collects taxes of \$960. The farmer is left with an after-tax cash flow of \$2,700 – \$960 = \$1,740.
- If the IRS considers this production to be *two consecutive 1-year projects*, then the farmer's after-tax profits are lower. He ends up with \$900 at the end of the first year. Uncle Sam collects 40% · (\$900 – \$300) = \$240, leaving the farmer with \$660. Replanted, the \$660 grows to \$1,980, of which the IRS collects another 40% · (\$1,980 – \$660) = \$528. The farmer is left with an after-tax cash flow of \$1,980 – \$528 = \$1,452.

The discrepancy between \$1,740 and \$1,452 is due to the fact that the long-term project can avoid the interim taxation. Similar issues arise whenever an expense can be reclassified from "reinvested profits" (taxed, if not with some credit at reinvestment time) into "necessary maintenance."

Q 11.24. Assume that your marginal tax rate is 25%. Assume that the IRS would tax payments only when made. (Sorry, in real life, the IRS nowadays does tax zero-bonds even when they do not yet pay out anything.)

1. What is the future value of a 10-year zero-bond priced at a YTM of 10%? How much does the IRS get to keep?
2. What is the future value of a 10-year annual level-coupon bond priced at a YTM of 10%, assuming that coupons are immediately reinvested at the same 10%?
3. What would it be worth to you today to be taxed only at the end (via the zero-bond) and not in the interim (via the coupon bond)? Which is better?

11.5 Entrepreneurial Finance

Now that you understand how to work with market imperfections, for what types of firms do they matter most? Market imperfections are probably mild for large, publicly traded corporations. These types of firms typically face only modest interest rate spreads between their (risky) borrowing and lending rates. Of course, their *promised* borrowing interest rates are a little higher than what they can receive investing their money in Treasury bonds. Yet, given that they still have some possibility of going bankrupt, large firms' required *expected* borrowing costs of capital are probably fairly close to the *expected* rates of return they could earn if they invested in bonds with characteristics similar to the bonds that they themselves have issued. Thus, large public corporations can often pretend to live in a reasonably perfect market. This also means that they have the luxury of separating their project choices from their financial needs.

For large companies, a perfect market assumption with equal borrowing and lending rates is reasonable.

➤ Altman study of bond default rates, Sect. 6.2, Pg.114.

In the world of individuals, entrepreneurs, and small companies, however, it is quite plausible that the costs of capital are often higher than equivalent expected savings interest rates. In fact, the most important difference between "ordinary corporate finance" and "entrepreneurial finance" is the degree to which their capital markets are perfect. Almost all entrepreneurs find it very difficult to convey credibly their intent and ability to pay back loans. And any credit that entrepreneurs receive is usually also very illiquid: Lenders cannot easily convert it into cash,

For entrepreneurs, a perfect market assumption is problematic.

should the need arise. Therefore, they demand a high liquidity spread, too. Many entrepreneurs even end up having to resort to financing projects with credit cards, which may charge 1,000 basis points or more above Treasury.

The expected costs of capital are often very high for entrepreneurs needing capital.

In sum, small firms often face extraordinarily high differentials between expected borrowing and lending rates. Entrepreneurs' high borrowing costs can thus prevent them from taking many projects that they would have undertaken if they had the money already on hand. Cash-on-hand can become a prime determinant of all their decisions. More established firms or wealthier entrepreneurs should optimally take more projects than poorer entrepreneurs. Yes, the world is not fair.

➤ Separation of Decisions, Sect. 4.1, Pg.56.

Be careful: Don't believe entrepreneurial claims! Often, high borrowing rates are just promised, not expected.

However, be careful in the real world before you believe the claims of entrepreneurs. Entrepreneurs also tend to have notoriously overoptimistic views of their prospects. Even venture capital—the financing vehicle for many high-tech entrepreneurial ventures—may advertise rates of return of 30% per year or more, but they seem to have managed to return only a couple of percentage points above the risk-free rate over the last 30 years *on average*. Adjusting for the correct default rates may actually mean that entrepreneurs face only high *promised* borrowing costs, not high *expected* borrowing costs. Thus, the large quoted spread between entrepreneurs' borrowing and lending rates, which is really all that you can easily observe, likely has a large component that is due not to information disagreements but simply to credit risk.

The courts apply an ad hoc discount to the values of entrepreneurial companies based on their limited access to capital.

This issue of how to deal with market imperfections for small firms also arises frequently in the courts, where a cost-of-capital estimate is necessary to compute the value for an entrepreneurial enterprise—for example, for purposes of assessing the inheritance tax or resolving disputes among former business partners. (Such valuation services are an important revenue business for many finance professors and consulting firms.) It has become customary and court-sanctioned to compute first the value of an equivalent publicly traded business or company as if it faced a perfect market, and then to apply a **private discount** of around 10% to 30% to this hypothetical private firm value in order to reflect its limited access to capital. The amount of this discount is ad hoc, but it is better than no attempt at all.

Q 11.25. What are the two possible reasons why entrepreneurs often have to finance their projects with credit cards, which can charge interest rates as high as 1,000 basis points above Treasury?

11.6 Deconstructing Quoted Rates of Return—Imperfect Market Premiums

Adding Market Imperfection Permia.

In Sections 6.2 and 9.6, you learned that you could decompose quoted rates of return into a time premium, a default premium, and a risk premium. Market imperfections can create additional premiums.

➤ Default Premium Deconstruction, Sect. 6.2, Pg.113.

➤ Risk Premium Deconstruction, Sect. 9.6, Pg.208.

$$\begin{aligned}\text{Promised Rate of Return} &= \text{Time Premium} + \text{Default Premium}\\ &\quad + \text{Risk Premium} + \text{Imperfect Market Premiums}\\ \text{Expected Rate of Return} &= \underbrace{\text{Time Premium} + \text{Risk Premium}}_{\text{provided by the CAPM}}\\ &\quad + \text{Imperfect Market Premiums}\end{aligned}$$

Quantifying imperfect market premiums is not easy, but we will try anyway. Unfortunately, there is not much that can be said about one of the imperfect market premiums—the premium compensating for differences in opinions. The nature of information disagreements is that they are idiosyncratic. But this does not mean that they are unimportant. As noted earlier,

imperfections can be so large, even in financial markets, that they may destroy a financial market's viability. Fortunately, the other three imperfections—taxes, transaction costs, and shallow markets—create premiums that are often a little easier to quantify than the premium associated with information disagreements.

Tax differences are often modest across assets in the *same* class. However, when there are assets that are treated differently from a tax perspective, the one with the worse treatment has to offer a higher rate of return. For example, municipal bonds are excluded from federal taxation. Therefore, non-municipal bonds have to offer a higher rate of return relative to these tax-exempt bonds. Similarly, unlike federal Treasury bonds, the holders of corporate bonds are subject to state income taxes. This means that corporate bonds need to pay a premium relative to Treasuries—a **tax premium**.

Tax premiums are usually similar within the same "asset class."

Transaction costs and deep markets also play important roles. The resulting premiums are often lumped under the general term "liquidity premiums." The idea is that when given a choice between a very liquid security (that you can resell in an instant to many different investors in case you need money) and a very illiquid security, you will demand an extra rate of return to buy the less liquid one. We can thus extend our earlier premiums analysis to the following:

Let me expand the imperfect market premium into its component premiums.

$$\begin{aligned}
\text{Promised Rate of Return} &= \text{Time Premium} + \text{Default Premium} + \text{Risk Premium} \\
&\quad + \text{Liquidity Premium} + \text{Tax Premium} \\
\text{Actual Earned Rate} &= \text{Time Premium} + \text{Default Realization} + \text{Risk Premium} \\
&\quad + \text{Liquidity Premium} + \text{Tax Premium} \\
\text{Expected Rate of Return} &= \text{Time Premium} + \text{Expected Risk Premium} \\
&\quad + \text{Liquidity Premium} + \text{Tax Premium}
\end{aligned}$$

Again, there could be other premiums that should go into this formula, such as information premiums or bond contract feature premiums. I omit them because I don't have empirical evidence to show you. In addition, our concept of a clean decomposition is a little problematic in itself, because these premiums overlap. For example, it is quite possible that there are covariance-risk aspects to liquidity. (In other words, it could be that liquidity spreads increase when the market goes down, which would mean that they have a positive market beta.) Thus, a part of the quoted spread could be considered either as a risk premium or as a liquidity premium. Nevertheless, the basic decomposition in the above formulas is useful.

➤ Credit Ratings, Sect. 6.2, Pg.114.

Let's go back to corporate bonds. You already learned in Section 6.2 that many corporate bonds have significant default risk, which means that they have to offer a default premium (relative to Treasuries, of course). Let me now tell you that, depending on credit rating, they have market betas between about 0.1 (investment-grade bonds) and 0.5 (junk bonds). This means that junk bonds may have to offer meaningfully large premiums to compensate investors for market risk, but for investment-grade bonds, any beta premium would be trivial.

Corporate bonds: CAPM-type market covariance risk may matter for junk bonds but would be trivial for AAA-grade bonds.

However, many corporate bonds are difficult to resell quickly—most have to be traded over-the-counter, and not on an organized exchange. Therefore, they have to offer their buyers a liquidity premium. Finally, corporate bonds are subject to state income taxes. This means that they have to offer a tax premium.

Liquidity premiums could be high for all types of risky bonds. Tax premiums are probably similar among all taxable bonds.

Historical Performance

Differences in expected rates of return by credit rating suggest that riskier and less liquid bonds earn more than safer bonds—but not as much as it seems.

In the Ed Altman study you first saw in Section 6.2, the historical average rates of return on corporate bonds from 1971 to 2003 were as follows:

The typical investment-grade bond promised about 200 basis points above the equivalent Treasury bond. However, investors ended up with only about 20-40 basis points above the Treasury. Thus, about 170 basis points was the default premium.

The typical junk bond promised a spread of about 500 basis points per annum above the 10-year Treasury bond. However, investors ended up with a spread of "only" about 220 basis points. The default premium was therefore about 280 basis points.

This suggests that the default premium is the most important premium in stated corporate bond yields. Only about 20-40 basis points for investment-grade and about 220 basis points for junk bonds still remain to be explained by the sum of the risk, liquidity, trading, tax, and other premiums.

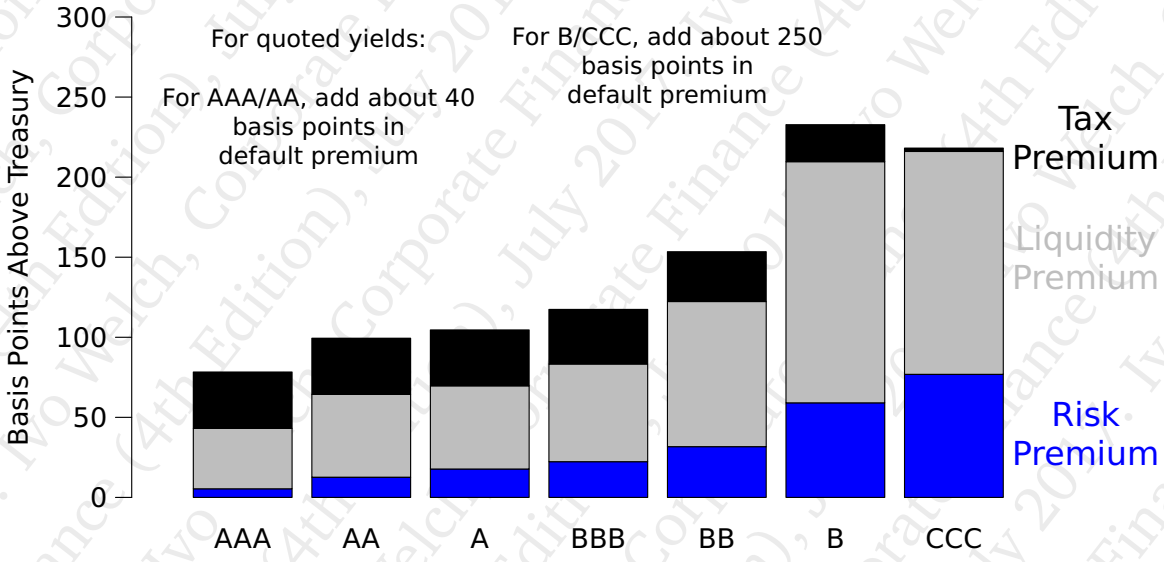

Exhibit 11.1: *The Components of Expected Rates of Return in Corporate Bonds, 1985-2003.* These are estimates of *expected* yield premiums for long-term corporate bonds. For highly rated bonds, the liquidity and tax premiums are much larger than the risk premium. For very low-rated bonds, the liquidity premium becomes relatively more important, followed by the risk premium and then the tax premium. To obtain stated (quoted) bond yields, you would have to add the default premium. The time premium has been taken out because all spreads are relative to the prevailing time-equivalent Treasury yield. For example, the average AAA bond would have quoted 7.2% when the average Treasury bond yielded 6%. The default premium would have added about 40 basis points, with the remaining 80 basis points having been compensation for risk, liquidity, and taxes. Original source: De Jong and Driessen, 2005.

Exhibit 11.1 decomposes expected rates of return into market risk premiums, liquidity premiums, and tax premiums.

De Jong and Driessen produced a similar study on bonds from 1985 to 2003. Unlike Altman, they decomposed the *average* (expected) rates of return into a liquidity risk premium, a market risk premium, and a tax premium. Exhibit 11.1 shows that about 40 basis points for AAA and 250 basis points for CCC bonds were pure default premiums that you would not have earned on average. With betas of around 0.1, the market risk premium was negligibly small for AAA and AA bonds, but then was higher for CCC-rated bonds, accounting for as much as 1% yield per year. The liquidity premium was about 50 basis points for highly rated bonds, and 100-150 basis points for junk bonds. Incidentally, many institutional investors are only allowed to hold investment-grade bonds. Thus, dropping from investment grade to speculative grade incurs a large liquidity penalty. You can see this in the sudden and unusually steep rise in yield for BB and B bonds. Over the last 10 years, this "step-up" has been even more dramatic. Finally, the state income tax premium was about 20-30 basis points for all bonds, except for the CCC bonds (which may simply be a data glitch).

A third piece of evidence is more informal. Since 1991, Vanguard has sold its VFITX government bond fund, its VFICX investment grade corporate bond fund, and its VWEHX junk-bond corporate bond fund. All three buy and hold intermediate-term bonds, with maturities and durations of about 5-6 years. A typical quoted spread over VFITX was about 130 bp for VFICX and 400 bp for VWEHX. Yet, from 2006 to 2016—that is including the Great Recession—VFICX beat VFITX by a more modest 80bp (6.1% vs. 5.3%) and VWEHX beat VFITX by 120 bp. After taxes on distributions, these realized performance spreads shrink to 20 bp and –20 bp. You read this correctly—over the last 10 years, taxable investors holding government bonds did no worse than investors holding high-yield junk bonds, despite the much higher risk and much higher promised yields on the latter.

Q 11.26. An AAA-rated bond promising to pay \$100,000 costs \$90,090. Time-equivalent Treasuries offer 8%.

1. Let's assume for a moment—just for this question—that the financial markets are neither risk-neutral nor perfect. What can you say about other premia in the AAA bond's quoted interest rate? (These premiums will be explained in future chapters; they include the risk premium, the default premium, and the liquidity premium.)
2. Let's assume for a moment that the financial markets are now risk-neutral. What can you say about other premiums in the AAA quoted interest rate? (These premiums will be explained in future chapters; they include the risk premium, the default premium, and the liquidity premium.)
3. Assuming that the liquidity premium is 0.5%, what can you say about the risk premium, the default premium, and the liquidity premium?

Q 11.27. How important are the various premiums for investment-grade bonds and junk bonds? (Omit the time premium.)

11.7 Multiple Effects: How to Work Novel Problems

Life is tough—it does not always offer simple solutions.

➤ Inflation, Sect. 5.2, Pg.82.

Of course, in the messy real world, you can suffer many problems (such as inflation, transaction costs, disagreements, sole potential buyers, and taxes) all at once, not just in isolation. In fact, there are so many possible real-world problems that no one can possibly give you a formula for each one. Thus, it is important that you approach the real world keeping a multitude of issues in mind.

If you get lucky, you may get good estimates ignoring market inefficiencies altogether. Adjust a little maybe just intuitively.

1. Ask yourself in a given situation whether the assumption of a perfect market is reasonably appropriate. For example, in the case of large and possibly tax-exempt companies, you may consider it reasonable to get away with assuming a perfect market, and just work out the "perfect market" answer—a simple NPV, for example. Then think about the direction in which market imperfections would push you, judge the magnitude, and make an intuitive adjustment. You can thereby often work out a good answer without the enormous complications that the perfectly correct answer would require.

You must learn how to think for yourself. I can now only teach you the method, not the solution.

2. If you conclude that you are a long way from home (i.e., from a perfect market), then you must first determine which market imperfections are most important. Then you must work out a good solution by yourself. If you had hoped for the one magic bullet that tells you how to solve every different kind of problem you might encounter, I have to disappoint you. There are just too many possibilities, and the task is often hard. Probably the best way to answer such new and thorny questions is to internalize the method of "thinking by numerical example." You really must be able to work out formulas for yourself when you need them.

Solving a Problem with Inflation and Taxes

Now work an example of how both taxes and inflation could interact.

For example, let's see how you could approach a situation with both taxes and inflation. Always start by making up some numbers you find easy to work with. Let's say you are considering an investment of \$100. Further, assume that you will earn a 10% rate of return on your \$100 investment and Uncle Sam will take $\tau = 40\%$ (or \$4 on your \$10 return). Therefore, you get \$110 before taxes but end up with only \$106 in nominal terms. What you have just calculated is

$$\begin{aligned} \$100 \cdot [1 + 10\% \cdot (1 - 40\%)] &= \$106 \\ C_0 \cdot \left[1 + r_{\text{nominal,before tax}} \cdot (1 - \tau)\right] &= C_1 \end{aligned}$$

Now you need to determine what your \$106 is really worth, so you must introduce inflation. Pick some round number, say, a rate of $\pi = 5\%$ per annum. Consequently, in purchasing power, the \$106 is worth:

$$\begin{aligned} \frac{\$106}{1 + 5\%} &\approx \$100.95 \\ \frac{C_1}{1 + \pi} &= P_0 \end{aligned}$$

Your after-tax, post-inflation, real rate of return is $\$100.95/\$100 - 1 = 0.95\%$. Knowing the numerical result, you need to translate your numbers into a formula. You computed

$$\begin{aligned} r_{\text{after tax, real}} &= \frac{\$100.95 - \$100}{\$100} = \frac{\frac{\$100 \cdot [1+10\% \cdot (1-40\%)]}{1+5\%} - \$100}{\$100} \\ &= \frac{10\% \cdot (1 - 40\%) - 5\%}{1 + 5\%} \approx 0.95\% \\ r_{\text{after tax, real}} &= \frac{P_0 - C_0}{C_0} = \frac{\frac{C_0 \cdot [1 + r_{\text{nominal,before tax}} \cdot (1-\tau)]}{1+\pi} - C_0}{C_0} \\ &= \frac{r_{\text{nominal,before tax}} \cdot (1 - \tau) - \pi}{1 + \pi} \end{aligned} \tag{11.1}$$

This is, of course, not a formula that anyone remembers. However, it is a useful illustration of how you should approach and simplify complex questions—numerical example first, formula second.

Taxes on Nominal Returns?

Here is an interesting question: If the real rate of return remains constant, does it help or hurt an investor if inflation goes up? Let's assume that the real rate of return is a constant 20%. If inflation is 50%, then the nominal rate of return is 80% (because $(1+50\%)\cdot(1+20\%) = 1+80\%$): You get \$180 for a \$100 investment. Now add income taxes to the tune of 40%. The IRS sees \$80 in interest, taxes \$32, and leaves you with \$48. Your \$148 will thus be worth $\$148/(1+50\%) \approx \$98.67$ in real value. Instead of a 20% increase in real purchasing power when you save money, you now suffer a $\$98.67/\$100 - 1 \approx -1.3\%$ change in real purchasing power. Despite a high real interest rate, Uncle Sam ended up with more, and you ended up with less purchasing power than you started with. The reason is that although Uncle Sam claims to tax only interest gains, you can actually lose in *real* terms because the interest tax is on *nominal* interest payments. Contrast this with the same scenario without inflation. In this case, if the real rate of return were still 20%, you would have earned \$20, Uncle Sam would have taxed you \$8, and you could have kept \$112 in real value.

If the real interest rate stays constant, does inflation hurt an investor? Yes, because taxes are assessed on nominal returns.

IMPORTANT

If real before-tax interest rates remain constant, because the IRS taxes nominal returns, not real returns, you get the following results:

- Higher inflation and interest rates hurt *taxable* savers.
- Higher inflation and interest rates help *taxable* borrowers.

(Economic forces of demand and supply for capital may therefore have to adjust, so that real rates of return increase when inflation increases.)

For much of postwar U.S. history, real rates of return on short-term government bonds have indeed been *negative* for taxed investors.

Yikes.

Q 11.28. Assume that you have both taxes and inflation. You are in the 20% tax bracket, and the inflation rate is 5% per year. A 1-year project offers you \$3,000 return for a \$20,000 investment. Taxable bonds offer a rate of return of 10% per year. What is the NPV of this project? Extra credit if you can derive the formula yourself!

Q 11.29. (Advanced) Assume that the inflation rate is 100% per year and the nominal rate of interest is 700% per year. (This was also our apples example from Section 5.2.) Now, assume that there is also a 25% default rate. That is, 1 in 4 apples are returned with worms inside and will therefore not be sellable (and be worth \$0). What is your real rate of return? What is the formula?

Q 11.30. (Advanced) Assume there is a 10% nominal rate of return, a tax rate of 40%, and an inflation rate of 5%. (In the taxes-and-inflation example from Formula 11.1 we worked out that the post-inflation, after-tax rate of return was 0.95%.) Now, add a default rate, d, of 2%, where all money is lost (–100% return). What is the real, post-inflation, after-tax, post-default rate of return? (Hint: Losses are tax-deductible, too. Assume that the default rate reduces the nominal rate of return (on which taxes are charged) because you do not just take 1 such loan, but 1 million, which practically assures you of the exact default rate without any sampling variation.)

Q 11.31. If the private sector is a net saver (e.g., leaving the public sector as a net borrower), does Uncle Sam have an incentive to reduce or increase inflation?

Summary

This chapter covered the following major points:

- If markets are perfect, there are infinitely many buyers and sellers, no disagreements (opinions), no transaction costs, and no taxes.
- In perfect markets, *promised* borrowing and lending rates can be different, but *expected* borrowing and lending rates cannot. In imperfect markets, even *expected* borrowing and lending rates can be different.
- If markets are not perfect, capital budgeting decisions can then depend on the cash position of the project owner. NPV and interest rate computations can still be used, although you have to exert special care in working with correct and meaningful inputs (especially for the cost of capital). This is usually best done by thinking in terms of concrete examples first, then translating them into formulas later.
- Transaction costs can be direct (such as commissions) or indirect (such as search or waiting costs). It is often useful to think of round-trip transaction costs.
- Financial assets' transaction costs tend to be very low, so that it is reasonable in many (but not all) circumstances just to ignore them.
- In the real world, buyers often prefer more liquid investments. To induce them to purchase a less liquid investment may require offering them some additional expected rate of return.
- Many financial markets have such low transaction costs and are often so liquid that they are believed to be close to perfect—there are so many buyers and so many sellers that it is unlikely that you would pay too much or too little for an asset. Such assets are likely to be worth what you pay for them.
- The tax code is complex. For the most part, individuals and corporations are taxed similarly. You must understand the following:
  - How income taxes are computed (the principles, not the details)
  - The fact that expenses that can be paid from before-tax income are better than expenses that must be paid from after-tax income
  - How to compute the average tax rate
  - How to obtain the marginal tax rate
  - That capital gains enjoy preferential tax treatment
  - Why the average and marginal tax rates differ, and why the marginal tax rate is usually higher than the average tax rate
- Taxable interest rates can be converted into equivalent tax-exempt interest rates, given the appropriate marginal tax rate.
- Tax-exempt bonds are usually advantageous for investors in high-income tax brackets. You can compute the critical tax rate for the investor who is indifferent between the two.
- You should do all NPV calculations with after-transaction-cost and after-tax cash flows and costs of capital.
- Long-term projects often suffer less interim taxation than short-term ones.
- Entrepreneurial finance can be viewed as the finance of imperfect markets. Small and startup firms suffer market imperfections more than large and established firms.
- Market imperfections are often responsible for large differences in required costs of capital. Limited diversification, liquidity, tax premia, etc., can be responsible for higher costs of capital for many projects. Their magnitude can be much higher than the CAPM-type risk premia that compensate investors for cash-flow covariance with the stock market.
- Quoted rates of return on financial instruments contain not only the time premium, default premium, and risk premium, but also many imperfect market premiums (such as tax premiums and liquidity premiums). For many bonds, the CAPM-style risk premium is very small compared to other premiums.
- The IRS taxes nominal returns, not real returns. This means that higher inflation rates are bad for savers and good for borrowers.

Keywords

AMT, 258. After-tax expense, 257. Alternative minimum tax, 258. Ask price, 252. Average tax rate, 258. Before-tax expense, 257. Bid price, 252. Buy-and-hold, 253. Collateral, 249. Competitive market, 244. Covenants, 249. Day trader, 253. Entrepreneurial finance, 241. Flight to quality, 256. HFT, 253. High-frequency traders, 253. IRS, 257. Internal Revenue Service, 257. Liquidity premium, 255. Marginal tax rate, 258. Muni, 259. Municipal bond, 259. Off-the-run, 255. On-the-run, 255. Opportunity cost, 252. Private discount, 264. Round-trip costs, 251. Run on liquidity, 256. Spread, 252. Tax premium, 265.

Answers

Q 11.1 In a perfect market, borrowing and lending rates are identical. An important implication of equal borrowing and lending rates is that there is a unique price for which a product would be selling (which we can then call its value).

Q 11.2 A competitive market is only one of the four conditions of a perfect market.

Q 11.3 There is no perfect capital market in this world. However, the concept of a perfect market helps you evaluate what departures from a perfect market really mean—and even what kind of departures you should be thinking about.

Q 11.4 The perfect market assumptions are: (a) no differences in information, (b) no market power, (c) no transaction costs, and (d) no taxes.

Q 11.5 For the \$1,000 cost project:

1. You would have to borrow \$100 at an interest rate of 10% in order to take the project. If you take the project, you will therefore have $\$1{,}000 \cdot 1.08 - \$110 = \$970$ next period. If instead you invest \$900 at the 4% savings rate, you will receive only \$936. You should definitely take the project.
2. There is a trade-off between investing a smaller sum in the bank and a larger sum in the project now. Say you invest I. If you put it into the bank, you receive $\mathrm{I} \cdot (1 + 4\%) = \mathrm{I} \cdot 1.04$. If you put I into the project, you receive $\$1{,}000 \cdot 1.08$ from the project, and borrow (\$1,000–I) at an interest rate of 10%. Therefore, you must solve

$$\mathrm{I} \cdot 1.04 = \$1{,}000 \cdot 1.08 - (\$1{,}000 - \mathrm{I}) \cdot 1.1$$

The solution is $\mathrm{I} \approx \$333.33$, which means that if you want to consume more than \$1,666.67, you should not take the project. Check: [1] If you consume \$1,700, you have a remaining \$300 to invest. The bank would pay \$312 next year. The project would pay off \$1,080, but you would have to borrow \$700 and pay back \$770, for a net of \$310. You should not take the project. [2] If you consume \$1,600, you have a remaining \$400 to invest. The bank would pay \$416 next year. The project would pay off \$1,080, but you would have to borrow \$600 and pay back \$660, for a net of \$420. You should take the project.

Q 11.6 False. A perfect market is still socially valuable, because sellers and buyers receive surpluses. The buyer surplus is the difference between the value that the good has to a particular buyer and the price at which this buyer can acquire it. (A similar argument applies to the seller—the non-marginal producer can sell the good for a higher dollar amount than it costs to provide the good.) It is only the "marginal" buyer and seller that get no surplus. All inframarginal buyers and sellers are better off.

Q 11.7 Yes, banks can quote different borrowing and lending rates even in a perfect market! Stated interest rates include a default premium. A perfect market is about equality of *expected* rates, not about equality of *promised* rates.

Q 11.8 True. In a perfect and risk-neutral market, the default rates may be quite different, but the expected rates of return on all investments should be the same.

Q 11.9 For the bond that pays \$100 99% of the time:

1. The expected payoff is \$99. The discounted expected payoff is $\$99/1.05 \approx \$94.286$. The promised yield is therefore $\$100/\$94.286 - 1 \approx 6.06\%$.
2. This borrower would believe the value to be $\$100/1.05 \approx \$95.238$. Therefore, the borrower believes he has to overpay by about 95 cents.

Q 11.10 Covenants, collateral, and credit ratings are all common mechanisms to aid the lender in determining the probability of default. Even if disclosure is not required, good borrowers would still want to do so. Therefore, no bank would trust a borrower who is not disclosing as much information as possible. To get credit, it is in the interest of the borrower to volunteer information.

Q 11.11 Microsoft is a large stock, just like Intel. Therefore, a round-trip transaction would probably cost a bid-ask spread of between 0.1% and 0.3%. On a \$10,000 investment, the bid-ask cost would be around \$20, and broker fees would probably be around \$10 to \$30 with a discount broker. Thus, \$50 (or 0.5%) is a reasonable estimate.

Q 11.12 Direct transaction cost components: broker costs, market maker or exchange costs (bid-ask spread), and other cash expenses (e.g., advertising costs and postage). Indirect transaction cost components: time taken to do research and/or searching for a buyer or seller, opportunity costs, anxiety, and so on.

Q 11.13 For this house transaction cost question, you first need to assume a proper discount rate for the \$4,000/month rent. At a 7% effective interest rate per year, your true monthly rate is $1.07^{1/12} - 1 \approx 0.5654\%$ per month). A reasonable assumption to value the rent stream is as a 1-year annuity, whose value is $\$4{,}000/r \cdot [1 - 1/(1+r)^{12}] \approx \$46{,}281$ today. Therefore,

$$-(\$1{,}000{,}000 + \$5{,}000) + \$46{,}281 + \frac{x \cdot (1 - 8\%)}{1.07} = 0$$

Solve this to $x \approx \$1{,}115{,}031$, so your capital appreciation must be 11.5% per annum for this project to be zero NPV for you.

Q 11.14 A liquidity premium is an upfront lower price to compensate you for transaction costs later on. This can allow you to earn a higher expected rate of return on the investment.

Q 11.15 A taxpayer prefers to have a before-tax expense, because it reduces the amount that Uncle Sam considers as income, which Uncle Sam would then want to tax.

Q 11.16 The first preference of taxpayers is to receive income in the form of capital gains (especially as long-term capital gains, which is usually under the control of the taxpayer). Their second preference is to receive income in the form of dividends. Both are much better forms of income than interest income or ordinary income. They are both taxed at lower rates under the U.S. tax code. (In 2016, long-term capital gains and qualifying dividends were taxed at 20% for tax payers in the 39.6% tax bracket. In addition, capital gains can most easily be offset by capital losses elsewhere, and there is no interim taxation before the capital gains realization.)

Q 11.17 The marginal tax rate is usually *not* lower but higher. The average tax rate is usually lower, because the first few dollars of income are taxed at lower tax rates.

Q 11.18 For the 2-year bonds, $1 - 0.7/1.1 \approx 36\%$; for the 10-year bonds, $1 - 1.7/2.7 \approx 37\%$.

Q 11.19 For every \$100, you receive \$6. Uncle Sam takes 20% of \$6, or \$1.20. Your after-tax rate of return is $\$4.80/\$100 = 4.8\%$. You could have also computed $(1 - 20\%) \cdot 6\% = 4.8\%$ directly.

Q 11.20 If the marginal investor's tax rate is 30% and taxable bonds offer a rate of return of 6%, then munis should offer $r = 70\% \cdot 6\% = 4.2\%$ to earn the marginal investor the same after-tax income.

Q 11.21 First, you need to compute your best opportunity cost of capital if you do not take your project.

- The Treasury will pay \$108 before tax. You could therefore earn $\$108 - 0.375 \cdot \$8 = \$105$ after taxes. This is an after-tax rate of return of 5%.
- The muni will pay only \$103 after taxes. This is an after-tax rate of return of 3%.

Comparing the two, your opportunity cost of capital—that is, your best investment opportunity elsewhere—is 5% *in after-tax terms*. Now, move on to your project. You will have to pay \$11,250 in taxes on \$30,000, so you will have \$18,750 net return left after taxes, which comes to an after-tax amount of \$80,000–\$11,250 = \$68,750. Your project NPV is therefore $-\$50{,}000 + \$68{,}750/1.05^3 \approx +\$9{,}389$. This is a great project!

Q 11.22 Your opportunity cost of capital is determined by the tax-exempt bond, because $66.67\% \cdot 20\% < 15\%$. Your project's \$2,000 will turn into $66.67\% \cdot \$2{,}000 \approx \$1{,}334$ after-tax earnings, or \$13,334 after-tax cash flow. Therefore, your NPV is $-\$12{,}000 + \$13{,}334/(1 + 15\%) \approx -\$405.22$. Check: The after-tax rate of return of the project's cash flow is $\$13{,}334/\$12{,}000 - 1 \approx 11.11\%$. This is less than 15%. You are better off investing in tax-exempt bonds.

Q 11.23 The \$1 is paid from after-tax income, so leave it as is. The \$10 million is taxed, so you will only receive \$7 million. With a 1 in 9 million chance of winning, the expected payoff is $\$7{,}000{,}000 \cdot 1/9{,}000{,}000 + \$0 \cdot 8{,}999{,}999/9{,}000{,}000 \approx 78$ cents. Therefore, the NPV is negative for any cost of capital. If you could pay with before-tax money, the ticket would cost you only 70 cents in terms of after-tax money, so for interest rates below $\$0.7778/\$0.70 - 1 \approx 11.1\%$ or so, the lottery would be a positive-NPV investment. (This assumes that you are risk-neutral, on average, for such a small idiosyncratic investment.)

Q 11.24 For comparing the zero bonds and coupon bonds, assume that you start with \$1,000 of money:

1. The 10% zero-bond would have a single before-tax payout of $\$1{,}000 \cdot 1.10^{10} \approx \$2{,}593.74$, for which the IRS would collect $\$1{,}593.74 \cdot 25\% \approx \$398.44$ in year 10. This means that you would keep an after-tax zero-bond payout of \$2,195.30.
2. The 10% coupon bond has an after-tax rate of return of 7.5% per annum, because it is always taxed at 25% in the very same year. Reinvestment yields an after-tax rate of return of 7.5% (\$75 in the first year on \$1,000). After 10 years, you are left with $\$1{,}000 \cdot 1.075^{10} \approx \$2{,}061.03$.
3. The tax savings on the zero-bond are \$134 in 10 years. Therefore, the zero-bond is better.

Q 11.25 Entrepreneurs pay interest rates as high as 1,000 basis points for one of two reasons: First, default rates are high. (This is not necessarily a difference in expected rates of return.) Second, market imperfections (especially information differences about default probabilities and liquidity premiums) are high. Banks cannot easily determine which entrepreneurs are for real and which ones will go bankrupt and take the bank's money with them. The entrepreneurs may or may not be better at knowing whether their inventions will work. (This can be a market imperfection.)

Q 11.26 For this bond:

1. The total promised rate of return is $\$100{,}000/\$90{,}090 - 1 = 11\%$. The time premium is the Treasury yield of 8%, which leaves 3%. The sum of the three remaining premiums (risk, default, liquidity) would be 3%. You cannot deconstruct the three without more information.
2. Risk-neutrality means that the risk premium would be zero. Therefore, you now know the default premium and liquidity premium sum to 3%.
3. Risk-neutrality means that the risk premium would be zero. You now know the liquidity premium, too. This means that the default premium is 2.5%.

Q 11.27 From Altman's evidence: The default premium seems more important than the other non-time premiums. From de Jong's evidence, ranking the remaining premiums: For investment-grade bonds, the liquidity and tax premiums seem to explain most of the return above the Treasury. Risk premiums are very small. For junk bonds, liquidity and risk premiums can become large. The risk premium is typically still lower than the liquidity premium. The tax premium becomes relatively small.

Q 11.28 What is your after-tax rate of return on taxable bonds? \$100 will grow to \$110 at a 10% interest rate before tax, minus the 20% that Uncle Sam collects. Uncle Sam takes $1.1 \cdot \$100 = \$110$, subtracts \$100, and then leaves you with only 80% thereof:

$$r_{\text{after tax}} = \frac{80\% \cdot (\$110 - \$100)}{\$100} = 8\%$$

$$r_{\text{after tax}} = \frac{(1-\tau) \cdot (C_1 - C_0)}{C_0}$$

where τ is your tax rate of 20%. $(C_1 - C_0)/C_0$ is the before-tax rate of return, so this is just

$$r_{\text{after tax}} = 80\% \cdot 10\% = 8\%$$
$$= (1-\tau) \cdot r_{\text{before tax}}$$

Now, in before-tax terms, your project offers a 15% rate of return. In after-tax terms, the project offers $80\% \cdot \$3{,}000 = \$2{,}400$ net return. On your investment of \$20,000, this is a 12% after-tax rate of return. (On the same \$20,000, the taxable bond would offer only $80\% \cdot (\$22{,}000 - \$20{,}000) = \$1{,}600$ net return (8%). So, you know that the NPV should be positive.) Therefore, the project NPV is

$$\text{NPV} = -\$20{,}000 + \frac{\$20{,}000 + 80\% \cdot (\$23{,}000 - \$20{,}000)}{1 + 8\%}$$
$$\approx \$740.74$$

$$\text{NPV} = C_0 + \frac{C_0 + (1-\tau) \cdot (C_1 - C_0)}{1 + r_{\text{after tax}}}$$

You can now easily substitute any other cash flows or interest rates into these formulas to obtain the NPV. Note that everything is computed in nominal dollars, so you do not need the information about the inflation rate! (And you needed it in nominal, because taxes are computed based on nominal gains, not real gains.)

Q 11.29 First, a simple version of the answer: Your one real apple becomes eight nominal pseudo-apples (at 700%), which is four real apples after 100% inflation. One goes bad, so you are left with three apples, i.e., a rate of return of 200%. Now, the more complete version: Your numeraire is one apple (1a) that costs \$1. You will get \$8 in nominal terms, next year $(a \cdot (1 + r_{\text{nominal,before tax}}) = a \cdot (1 + 700\%) = 8 \cdot a)$. This will buy apples that cost \$2 each $((1+\pi) = (1 + 100\%) = \$2)$, that is, four apples $(a \cdot (1 + r_{\text{nominal,before tax}})/(1+\pi) = 1a \cdot (1+700\%)/(1+100\%) = 4a)$. However, one of the apples (d = 25%) is bad, so you will get only three apples $(a_1 = a_0 \cdot (1 + r_{\text{nominal,before tax}})/(1+\pi) \cdot (1-d) = 1 \cdot a_0 \cdot (1+700\%)/(1+100\%) \cdot 75\% = 3 \cdot a_0)$. Therefore, the real rate of return is $(a_1 - a_0)/a_0$, or

$$r_{\text{real,after tax,post default}} = \frac{(1a \cdot \frac{1+700\%}{1+100\%} \cdot 75\%) - 1a}{1a}$$
$$= 300\% - 1 = 200\%$$

$$r_{\text{real,after tax,post default}} = \frac{[1a \cdot \frac{1+r_{\text{nominal,before tax}}}{1+\pi} \cdot (1-d)] - 1a}{1a}$$

The "1a" of course cancels, because the formula applies to any number of apples or other goods.

Q 11.30 Instead of 10%, you earn only $98\% \cdot 10\% + 2\% \cdot (-100\%) = 7.8\%$. Translated into a formula, this is $(1-d) \cdot r_{\text{nominal,before tax}} + d \cdot (-100\%) = r_{\text{nominal,before tax}} - d \cdot (1 + r_{\text{nominal,before tax}}) = 10\% - 2\% \cdot (1 + 10\%) = 7.8\%$. Now, using the formula from Page 268,

$$r_{\text{after tax, real, post default}} = \frac{V_0 - C_0}{C_0}$$
$$= \frac{\frac{C_0 \cdot [1 + r_{\text{nominal,before tax}} \cdot (1-\tau)]}{1+\pi} - C_0}{C_0}$$
$$= \frac{r_{\text{nominal,before tax}} \cdot (1-\tau) - \pi}{1+\pi}$$

replace the nominal interest rate $r_{\text{nominal,before tax}}$ with the default reduced nominal rate $r_{\text{nominal,before tax}} - d \cdot (1 + r_{\text{nominal,before tax}})$, so the new formula is

$$r_{\substack{\text{post default,}\\ \text{after tax, real}}} = \frac{V_0 - C_0}{C_0}$$
$$= \frac{\frac{C_0 \cdot [1 + (r_{\text{nominal,before tax}} - d \cdot (1 + r_{\text{nominal,before tax}})) \cdot (1-\tau)]}{1+\pi} - C_0}{C_0}$$
$$= \frac{(r_{\text{nominal,before tax}} - d \cdot (1 + r_{\text{nominal,before tax}})) \cdot (1-\tau) - \pi}{1+\pi}$$
$$= \frac{7.8\% \cdot (1 - 40\%) - 5\%}{1 + 5\%} \approx -0.30\%$$

Q 11.31 Uncle Sam would benefit from an increase in inflation, because he taxes nominal rates of return, not real rates of return. In the real world, interest rates would also have to rise to compensate private savers for this extra "tax" on money.

End of Chapter Problems

Q 11.32. Evaluate whether supermarkets operate in perfect markets.

Q 11.33. What are the perfect market assumptions?

Q 11.34. Your borrowing rate is 15% per year. Your lending rate is 10% per year. The project costs $5,000 and has a rate of return of 12%.

1. Should you take the project if you have $2,000 to invest?
2. If you have $3,000 to invest?
3. If you have $4,000 to invest?

Q 11.35. An entrepreneur is quoted a loan rate of 12% at the local bank, while the bank pays depositors 6% per annum.

1. If in bankruptcy the entrepreneur will not pay back anything, but otherwise everything will be repaid, then what does the bank believe the probability of failure to be?
2. What is the quoted default premium?
3. Compute the expected default premium. (Note that when you lose all your money plus the default premium, your rate of return can be below –100%. This is not only reasonable but necessary to get an average default premium that is what it should be.)

Q 11.36. "If the world is risk-neutral, then the promised and expected rates of return may be different but the expected rates of return on all loans should be equal." Evaluate.

Q 11.37. Go to the Edgar page on the SEC's website. Look up the *El Torito* company (also *Real Mex Restaurants, Inc*) S-4 filing on 2004-06-09. Describe the covenants and requirements to which El Torito is obligated. (Note: This may take a while, but reading this S-4 will introduce you to how these agreements look in the real world.)

Q 11.38. The bid quote on a corporate bond is $212; the ask is $215. You expect this bond to return its promised 15% per annum for sure. In contrast, T-bonds offer only 6% per annum but have no spread. If you have to liquidate your position in 1 month, what would a $1 million investment be worth in either instrument? Which instrument should you buy?

Q 11.39. Look up on a financial website what the cost of a round-trip transaction on $10,000 worth of shares in Exxon Mobil Corp would cost you today.

Q 11.40. You have discovered an investment strategy that can beat the market by 300 basis points per year. Assume that the stock market is expected to return 9% per annum. Unfortunately, to implement your strategy, you will have to turn over your portfolio three times a year. Think of this as rebalancing (selling and buying) 25% of your portfolio every month. You have very good traders, who can execute trades at a cost of only 7.5 cents per transaction (15 cents round-trip) on a $30 stock. Does this strategy make sense?

Q 11.41. A day trader has $10 million in assets. She buys and sells 30% of her portfolio every day. Assume that this day trader is very good and incurs single round-trip transaction costs of only 10 cents on a $30 stock. Roughly, by how much does this day trader's strategy have to beat the benchmark in order to make this a profitable activity? Assume that the trader could earn $200,000 in equivalent alternative employment and that there are 252 trading days per year.

Q 11.42. Search online for the current federal income tax rates on the four different types of income for individual taxpayers and corporate taxpayers.

1. What are these rates?
2. Assume that a corporation has just earned $2 million in ordinary income, $1 million in interest income, and $3 million in realized long-term capital gains (net). Focusing only on the basics and ignoring deductions, what is its tax obligation? What are its marginal tax rates? What is its average tax rate?
3. Assume that you (an individual) have just earned $2 million in ordinary income, $1 million in interest income, and $3 million in realized long-term capital gains (net). Focusing only on the basics and ignoring deductions, what is your income tax obligation? What is your marginal tax rate? What is your average tax rate?
4. How much would your state income tax, Social Security, and Medicare add to your tax bill? Is your state income tax payment a before-tax or an after-tax expense?

Q 11.43. If your tax rate is 40%, what interest rate do you earn in after-tax terms if the before-tax interest rate is 6%?

Q 11.44. On September 28, 2007, tax-exempt AAA-rated 10-year muni bonds traded at a yield of 3.99%. Corporate 10-year AAA-rated bonds traded at 5.70%. What was the marginal investor's tax rate?

Q 11.45. Go to the Vanguard website and look up VWITX and VBIIX.

1. What is the current yield from the tax-exempt Vanguard bond fund?
2. What is your state income tax treatment?
3. How does it compare to the most similar Vanguard taxable bond fund?
4. What tax rate would an investor have to suffer in order to be indifferent between the two bond funds?

Q 11.46. Consider a real estate project that costs $1,000,000. Thereafter, it will produce $60,000 in taxable ordinary income before depreciation every year. Favorable tax treatment means that the project will produce $100,000 in tax depreciation write-offs each year for 10 years (nothing thereafter). For example, if you had $500,000 in ordinary income in year 2 without this project, you would now have only $400,000 in ordinary income instead. At the end of 10 years, you can sell this project for $800,000. All of this $800,000 will be fully taxable as write-up at your capital gains tax rate of 20%. If your ordinary income tax is 33% per annum, if taxable bonds offer a rate of return of 8% per annum, and if tax-exempt munis offer a rate of 6% per annum, what would be the NPV of this project?

Q 11.47. You are in the 25% tax bracket. A project will return $20,000 next year for a $17,000 investment—a $3,000 net return. The equivalent tax-exempt bond yields 14%, and the equivalent taxable bond yields 20%. What is the NPV of this project?

Q 11.48. The lottery gives you a 1 in 14 million chance of winning the jackpot. It promises $20 million to the lucky winner. A ticket costs $1. Alas, the lottery forgot to mention that winnings are paid over 20 years (with the first $1 million payment occurring immediately), that inflation is 2% per year, and that winnings are taxable. Is the lottery a good investment? (Assume that you are in a 40% marginal income tax bracket and that the appropriate nominal discount rate is 10% per year.)

12

Perfect and Efficient Markets, and Classical and Behavioral Finance

How Trustworthy are Market Prices?

This chapter explains the concept of an efficient market, which is not as strict as but closely linked to that of a perfect market. A market is said to be efficient if it does not ignore available information. To illuminate perfect and efficient markets, this chapter also explains arbitrage, an essential concept of finance, without which no study of finance would be complete. We then discuss the consequences of the concepts: What do efficient and/or perfect markets mean for predicting stock performance? How should you interpret the success of famous investors? And how can you use the concept of efficient markets to run an event study to help assess the valuation impact of big corporate events?

12.1 Market Efficiency

A perfect market sets up stiff competition among many investors. This forces them to use all available information as well as they possibly can. This is called **market efficiency**: a situation in which prices reflect *all* available information. In a fully efficient market, you should not be able to use any available information to predict future returns better than the market can.

Market efficiency means the market uses all available information in setting the price.

IMPORTANT

A price is called **efficient** if the market has set the price correctly as if it were using *all* available information. (PS: It is not necessary that any investor has all the information.)

> Warning: Market efficiency is a different concept from mean-variance efficiency (the efficient frontier), which was used in the context of portfolio optimization. Economists love "efficiency" and thus use the term in many contexts.

➤ Mean-variance efficiency, Sect. 8.2, Pg.171.

Exhibit 12.1 illustrates an efficient market. Suppose the market considers an expected rate of return of 10% on ABC stock to be a fair rate of return, given ABC's characteristics. This figure of 10% could come, for instance, from the CAPM. Market efficiency then pins down the relationship between the best estimate of the price next year and the price today. In our example, if the market expects ABC to trade for $55 next year, it should set the price today at $50. The market would not be efficient if it had set today's price at $49 or $51. You can turn this around, too. You should not be able to locate information that tells you today when/if/that the true expected

An example: ABC's price today is based on the best estimate of future characteristics, obtained from a model like the CAPM.

value tomorrow is really \$60 (for an expected rate of return of 20%) or \$50 next year (for an expected rate of return of 0%). If you could find information telling you authoritatively that a better estimate of next year's price is \$60 (or \$50), then ABC's stock would be mispriced. A market that has overlooked your information would not be efficient.

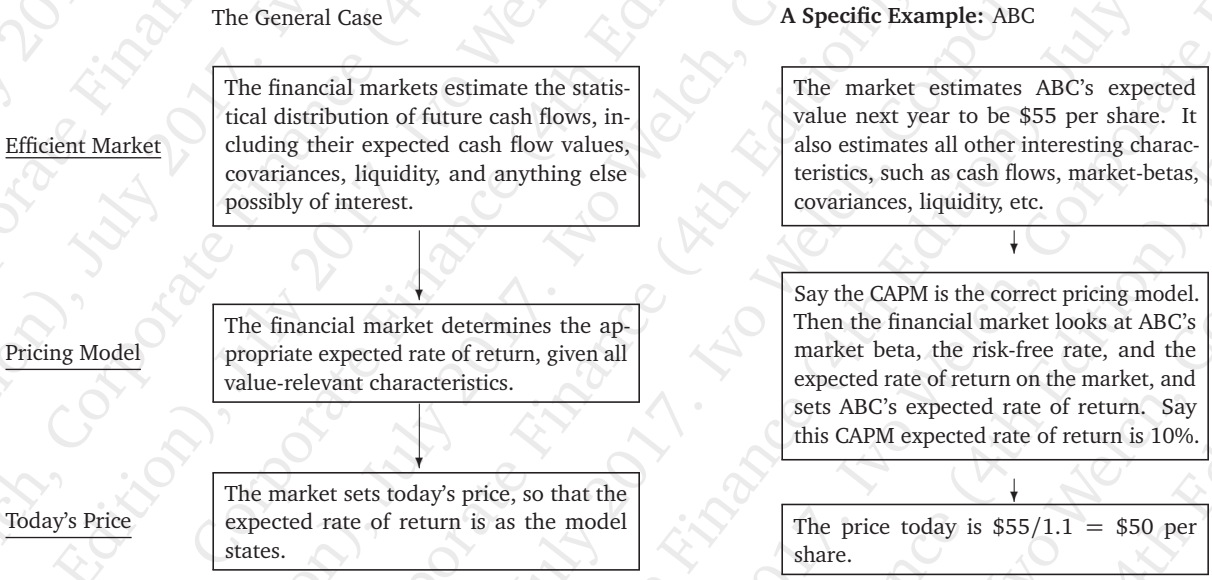

Exhibit 12.1: *Market Efficiency and Pricing Model.* The critical question is *If you saw a price of, say, \$45.83 today, what would you conclude has gone wrong?* Is it the market or the model?

What is the model? What is the information set?

The practical use of the "efficient markets" concept begs two questions:

1. Where does the figure of 10% come from? It has to come from some model that tells you what rate of return ABC should have to offer given its characteristics, such as risk, liquidity, and so on. The CAPM is such a model (though only a modestly successful one). Without a good model of what you should expect the rate of return to be, market efficiency is too vague a concept to be meaningful.
2. If the market is not perfect and different investors have different information, then exactly what information set are we talking about? If you are ABC's CEO, then you may have more information than the public. You may know whether the SEC will open an investigation against you and whether you have the next new hit drink in the lab right now. You could know whether \$50 today is too high or too low. Put differently, the market may be efficient with respect to publicly available information, but it need not be efficient with respect to insider information.

If you find the expected rate of return is really 20%: (a) Your 10% model could be wrong; (b) the market was not efficient.

What should you conclude if you can determine authoritatively that the expected rate of return is really 20%? (This can happen either if you determine that the expected payoff is \$60, not \$55, or if the expected payoff is \$55, but today's price is \$45.83.) You could now draw one of two conclusions:

1. The CAPM is not the correct model. Instead, the market followed some other pricing model and wanted to set the expected rate of return for ABC at 20% in the first place.

2. The stock market is not efficient.

Can you see why market efficiency is so difficult to prove or reject? If you wish to proclaim a belief in market efficiency, and if you then find empirically that prices are not what your model predicted, you would simply proclaim that it was your model for the appropriate expected returns in your financial market that was wrong, not that the market was inefficient. It was your fault, not the market's. You just have to go back and search more—possibly forever—until you find the right pricing model.

Is market efficiency so difficult to disprove that it becomes a "faith"?

Short-Term versus Long-Term Market Efficiency

Over long horizons (say, 1 year or longer), market efficiency is extremely difficult to disprove. The reason is that no one knows exactly what the correct model of pricing is—the CAPM may often be a reasonable model, but it is not infallible and its estimates are rarely accurate in practice. We are not sure whether a stock like ABC should earn 10%, 20%, or 30% a year. This renders market efficiency a concept that in practice often evades empirical testing. It is also why market efficiency is sometimes (unfairly) disparaged as being more religion than science. Based on the existing long-run evidence, some reasonable analysts conclude that financial markets are generally efficient (and our [CAPM] pricing model is wrong); and other reasonable analysts conclude that financial markets are generally not efficient.

Practically useful? Rarely over very long horizons, where efficiency is often more a matter of faith.

Of course, in extreme circumstances, market efficiency can be a useful claim even on such long horizons. We know that no reasonable model of financial markets should give investors great bets like "+$1 million with 99% probability" and "–$1 with 1% probability." Expected returns this high would be way out of line with *any* reasonable pricing model. Even expected rates of return of 100% per year would surely be unreasonable for (most) stocks. Of course, few people doubt that the stock market is, to such a first approximation, efficient—we all know that you just can't earn that much. But there is a large gray zone where it is difficult to distinguish between model error and market inefficiency. Because no one knows for sure what the correct model of expected stock returns is, no one can tell you affirmatively whether the stock market set the price of ABC stock so as to offer investors an expected rate of return on ABC of, say, 10% a year or 12% a year.

Okay, let me qualify this for long horizons.

However, over short horizons (say, a day or so), market efficiency is a surprisingly useful concept. The reason is that over a single day it does not matter as much whether you believe the expected rate of return on ABC is 0%, 10%, or 20% per annum. Even on the high end of 20% per annum, the expected rate of return is still only about 5 basis points per day. Roughly speaking, regardless of whether you believe in the CAPM or not, you should expect day-to-day returns to be just a tiny bit above 0%. You should attribute most daily price movements to random fluctuations, presumably caused by unpredictable news of changes in the economic environment. However, if you can predict day-to-day stock movements (and you have thousands of days of historical stock returns to work with), then chances are that you would not blame the pricing model. Instead, you would probably conclude that the market is not efficient.

Practically useful? Definitely yes over short horizons.

IMPORTANT

- Over short time intervals (say, days), market efficiency is a very powerful concept. The expected rate of return should be tiny. If it is different, the market is probably inefficient.
- Over long time intervals (say, months or years), it is difficult to pin down what the appropriate expected rate of return is. This makes it difficult to disentangle errors in the pricing model from market inefficiency.
- Prices should move only when there is news about future cash flows or discount rate changes, where news is defined as the unanticipated component of new information that is arriving. Such news can be firm-specific or market-wide.

Relation to Perfect Market

Perfect market ⇒ efficient market.

Although the efficient market concept is different from the perfect market concept, the two are intimately linked—in fact, so much so that they are often casually confused. The reason is that if a market is perfect, economic forces drive it instantly toward market efficiency. Put differently, if a market were perfect but inefficient, everyone would want to earn great returns and trade the same way. It would be too easy to become rich. Market prices would instantly adjust to prevent this. Therefore, if a market is perfect, it is inevitably also efficient.

Efficient market ⇏ perfect market.

The converse is not true, however. It is quite possible for an imperfect market—for example, one in which there are taxes or different opinions—to be efficient. You could even (crudely) think of market efficiency as the result of the trades of many investors with many different information sets (opinions). The market price is the outcome at which investors no longer wish to trade further. Appropriately weighted, one half believes the market price is too low; the other half believes it is too high. Of course, efficiency should be contemplated market by market. It is probable that some financial markets are efficient while others are not. The closer a market is to being perfect, the more likely it is to being efficient.

Efficient market is a weak facsimile of "same information."

Another way to understand the difference is to compare assumptions. Of the four perfect-market assumptions, only one has any overlap with and bearing on the efficient-market concept: the one regarding "same information set and opinions." And even the information requirements are weaker. It is not necessary that all investors have the same information and opinion (as in the perfect-market setting), just that the market price is the same "as if" the market itself had access to all the information at once. So, a market can be efficient even when investors know different bits and pieces of information and/or to have different opinions, just as long as the market-price is the same that it would be if they were all sharing their information and opinions.

Transaction costs are often culprits in keeping prices from their efficient levels.

Perhaps the most important perfect market assumption driving prices toward efficiency is the absence of transaction costs. Without them, it is easy for you and other investors to trade on any information that the market has not yet incorporated in the stock price—and thereby earn an unusually good expected rate of return. However, the no-free-lunch axiom applies here, too. High transaction costs would make it more likely that you could expect to find violations of efficient markets. But if it is very expensive to trade and if the market is therefore not efficient and does not respond to news immediately, it would also be very difficult for you to take advantage of such inefficiencies.

Investor competition pushes markets toward efficiency.

Here is a practical example of how any market inefficiency would disappear quickly in a perfect market: What would you do if you learned that the market always goes down on rainy days and up on sunny ones? It is unlikely that the average investor requires extra return to hold stocks on sunny days—and, even if the average investor does, it is enough for you if you are not among them. You would never buy stocks when the weather forecast predicts that rain is coming. Instead, you would only buy stocks when the weather forecast predicts that the sun will shine. Investors like yourself—and there are of course many such investors in perfect markets—would rapidly bid up the prices before the sun shone, so that the prices would no longer systematically go up on sunny days. The end result is that if markets are efficient, then you should not be able to earn abnormally good sunny-day returns—at least not this easily. In a reasonable world, to earn higher expected rates of return, you must be willing to take on something that other investors are reluctant to take on—such as higher portfolio risk. Today's weather alone should not do it. (Interestingly, academics do disagree on whether the weather in New York City has a small influence on stock returns. Some papers claim it does, so that the market is inefficient. Others dispute this, claiming the historical correlation is spurious and disappears if the statistical tests are done correctly. All agree that the weather influence is small, however.)

Prices should be generally efficient even in a nonperfect financial market. Who would be willing to hold overpriced stuff?

Conversely, it is easier to believe that markets are *not* (or less) efficient if transaction costs are high. But even if the market is not perfect, market inefficiencies should still raise eyebrows. For example, let's say that the appropriate rate of return on ABC was still 10% and the price was

still $50. Alas, when you run a few regressions, you learn that the expected future price is not really $55 but $51. (The true expected rate of return would thus not be 10%, but 2%.) In a perfect market, some investors may want to short some ABC and use the shorting proceeds to buy another stock. This may not be possible if the market is imperfect and the costs of going short are too high. However, this leaves the question of why investors who already own ABC shares would not want to sell them ASAP. They would not incur the shorting transaction costs and would avoid the then lower-than-appropriate rate of return. (Maybe they are asleep?! Or maybe even the non-short related plain selling transaction costs are too high?!) Such "economic self-interested behavior" adds to the "third-party investor pressure" in driving markets toward efficient pricing, even in a market that is imperfect.

➤ Shorting stocks, Sect. 7.2, Pg.155.

IMPORTANT

- If a market is perfect, market forces should drive it strongly and quickly toward efficiency.
- If a market is not perfect, self-interested individual behavior should still drive it toward efficiency. But this force is much weaker, and third-party traders may not be able to aid in the process.

Market Efficiency in Modern Financial Markets

In the United States, the financial markets for Treasuries, large corporate stocks, index mutual funds, currencies, and others, seem reasonably close to perfect and thus efficient. They are definitely very competitive. There are millions of buyers and sellers, thousands of tax-exempt investors, and modest transaction costs, and it seems unlikely that some investors have real inside information. It is difficult to believe that you or I could outsmart the prices in such markets. After all, thousands of other traders are likely equally as smart. They would flock to good bargains and avoid bad bargains along with us. Of course, the smaller the firm, the less perfect and the less efficient the market in its stock is likely to be. Many small stocks on the NASDAQ exchange trade only rarely, and they can have large transaction costs:

You can reasonably assume that markets are efficient for large corporate stocks.

- The bid-ask spread is often high.
- The posted bid-ask spread is only guaranteed for 100 shares—if you want to trade more shares, the price is likely to move against you.
- Commissions can be high.
- Shorting small stocks can be very costly when compared to the ideal of a perfect world in which you have full access to the proceeds (e.g., to earn interest).

➤ Bid-ask spread, Sect. 11.3, Pg.252.

In a round-trip transaction, you will face the first three issues once when you buy and once when you sell. Thus, it is unlikely that small stocks will immediately and fully reflect all information appropriately. The historical prices you see posted may be "stale" and may not even reflect the price that would have applied if you had wanted to trade. Market efficiency is never white or black, but always a shade of gray—just as it is for perfect markets. Large, liquid S&P 100 stocks are pretty close to efficient; small NASDAQ stocks may not be.

The fact that large-firm stock markets are pretty efficient means that, by and large, you can trust these financial markets to get asset values about right—at least within the limits of the typical transaction costs—and to get it right *immediately*. As an investor, would you not rather face an inefficient market? If it were inefficient, you might be able to find some good bets (opportunities that earn unusually high expected rates of return). But it would not all be gravy. In an inefficient market, you could not rely on market prices being fair—they could be inappropriately too high or too low. You would never really know whether you are overpaying or underpaying. Investing would be a very messy business. You might have to spend a lot of time

The advantage of an efficient market: Prices can be trusted.

➤ Great bets, Sect. 12.4, Pg.291.

"Trading Places" and Citrus Futures

The 1983 hit comedy *Trading Places*, starring Dan Akroyd and Eddie Murphy, centers around the trading of orange juice frozen concentrate **futures contracts**. (A future is a contract that specifies terms to buy or sell a commodity in the future—in this case, oranges.) If it is going to rain or if there is a frost, oranges will be scarcer and the futures price will rise. You can learn more about futures contracts at the website of the *Chicago Mercantile Exchange* at http://www.cme.com.

In a 1984 paper in the *American Economic Review*, Richard Roll found that these citrus futures contracts predict whether the U.S. Weather Service's forecast for central Florida temperatures is too high or too low. It is a great example of how financial markets help aggregate information better than the best nonfinancial institution. This should not surprise you. After all, there is a lot of money at stake!

and money to determine whether prices are fair. The advantage of efficient markets is that if you hold a portfolio of many large and liquid stocks, you do not have to spend a lot of time and money to perform **due diligence** in order to determine whether stocks are fairly priced. All you need to do is to make sure you are appropriately diversified to meet your risk-reward preference. And you can probably accomplish this goal by buying just a few large index-mimicking mutual funds.

Q 12.1. What does it mean for a market to be efficient?

Q 12.2. As a believer in efficient markets, what would you likely answer when heretics claim that they can reject market efficiency because they have found assets that pay too much for their risk?

Q 12.3. Is market efficiency a more powerful concept over long or short horizons?

Q 12.4. How does an efficient market differ from a perfect market?

Q 12.5. Is it more or less likely for a financial market to be efficient when transaction costs are low?

Q 12.6. Would you expect the market for the dollar-euro exchange rate to be more or less perfect and efficient than the NYSE?

How to Get Squeezed and Lose Money Even When You Are Right

Even in cases where it is probable that the market mispriced stocks, such as technology stocks during the famous "Internet bubble" at the turn of the millennium, it was almost impossible for an individual investor to take advantage of the market inefficiency. Believe me, I know.

In 1998, I shorted Netscape. I believed that Netscape's browser was about to be taken to the cleaners by Microsoft's Internet Explorer. I was right on my prediction—but in February 1999, AOL paid a lot of money to acquire Netscape. Not satisfied with one mistake, I proceeded to my next mistake. I believed Yahoo (YHOO) was worth less than what it was trading for. I speculated that it would go down. After I had lost more than three times my original investment, I realized that I had to either close my bet or risk going bankrupt. Consequently, I terminated my bet. Yes, I would have been right in the end and made a lot of money if I had held on longer, but I simply could not afford the risk (and mental anguish) any longer. I learned from this episode—after 15 years as a financial economist—that even if the stock market is irrational and even if it overvalues a stock by three times, it can also be irrational enough to overvalue it by yet another three times.

Later on, I found out that I was not alone. The most reprinted article in the history of *Fortune* magazine was "Mr. Buffett on the Stock Market," from November 22, 1999, in which famed financier Warren Buffett warned about the overvaluations of tech stocks and Internet stocks. Like me, Buffett had suffered from years of poor performance (and from yet another quarter of misery to follow), as Internet stocks reached ever higher.

Not everyone believes there was a bubble. The book's website (book.ivo-welch.info) has an impromptu email conversation between myself and Eugene Fama (perhaps the most famous finance professor alive and a strong defender of market efficiency). This will give you an authentic impression of the ongoing dialogue among finance professors.

12.2 Market Efficiency Beliefs and Behavioral Finance

Classical versus behavioral finance.

A firm belief in efficient markets is what defines a school of thought known as **classical finance**, an outgrowth of the school of **rational economics**. This belief is that the evidence supports the **efficient market hypothesis**, or **EMH**, which holds that all securities are priced efficiently. In contrast, another school of thought, often dubbed **behavioral finance**, posits that markets sometimes do *not* use all available information. Depending on how strong a believer in classical finance versus behavioral finance you are, you may believe that there are no especially good trading opportunities, few trading opportunities, or plenty of trading opportunities. Both camps agree, however, that market perfection plays a crucial role in determining whether a particular market is efficient or not.

Many large financial markets in the United States are probably close to efficient.

Almost all financial economists, regardless of camp, believe in basic market efficiency for large markets and liquid securities. No respectable economist believes that it is easy to get very rich trading on easily available information. Instead, the disagreement is, loosely, about whether stock markets are "99% efficient" or "97% efficient." Classical finance believes in the former, behavioral finance in the latter. Of course, you can trade millions of dollars in large-firm stocks or market indexes relatively easily and at low transaction costs. Thus, it does not require huge efficiency violations for behavioral finance economists to be right and for classical finance economists to be wrong. Exploiting just the tiny—say, $100\% - 97\% = 3\%$—violations from market efficiency could make you a star investor. (This is also not coincidentally why so many fund managers publicly proclaim their faith in behavioral finance.) However, don't take me too literally here—the 99% versus 97% is an analogy, and there is really a spectrum of beliefs in market efficiency among economists and fund managers. Now, although you should realize that any classification scheme really identifies just segments on a continuous line, you can still try to classify financial economists and investors by their faiths in efficiency. Let's look at some such classifications.

The Traditional Classification

The traditional classification of market efficiency is about the type of information needed to beat the market.

The traditional definition of market efficiency focuses on information. In the traditional classification, market efficiency comes in three strengths: weak, semistrong, and strong.

Weak market efficiency says that all information in past prices is reflected in today's stock prices so that **technical analysis** (trading based solely on historical price patterns) cannot be used to beat the market. Put differently, the market is the best technical analyst.

Semistrong market efficiency says that all public information is reflected in today's stock prices, so that neither **fundamental trading** (based on underlying firm fundamentals, such as cash flows or discount rates) nor technical analysis can be used to beat the market. Put differently, the market is both the best technical and fundamental analyst.

Strong market efficiency says that all information, both public and private, is reflected in today's stock prices, so that nothing—not even private insider information—can be used to beat the market. Put differently, the market is the best analyst and cannot be beat.

Many finance professors no longer believe in perfect efficiency.

In this traditional classification, all finance professors nowadays believe that most financial markets are not strong-form efficient: Insider trading may be illegal, but it works. However, arguments rage on as to which markets are semistrong-form efficient or even weak-form efficient, and even for large and liquid financial markets (such as large firms traded on the NYSE or NASDAQ, or some options on the CBOE). Finance professors regularly publish claims that some new rule would have outperformed reasonable average rates of return historically, often by large margins. Prominently among them are some particular forms of momentum strategies (buying stocks that have gone up and selling stocks that have gone down over the last year) and value strategies (buying boring old-economy stocks, selling glamorous high-growth new-economy stocks). These strategies would have offered "excess returns" as high as 1-2% per month.

Why do many trading strategies seem to have worked historically?

Market efficiency champions quickly point out that many of these strategies' returns were **spurious**: They disappeared almost as quickly as they were discovered, and they probably were never real to begin with. Also, many of these trading strategies would have required such high transaction costs that they would not have been profitable in the real world. That is, even if prices had not incorporated all information, thus leaving the market inefficient, they may have been well within the bounds of transaction costs. Yet some trading strategies, such as momentum or value, do seem to have produced large historical excess returns even after transaction costs. One good question is whether they will continue to work. (Personally, I am not claiming that they will or will not work in the future.) A second good question raised by EMH proponents is what part of these strategy returns was appropriate compensation for risk (not captured by the CAPM) and thus not excessive to begin with.

The returns to collecting information must be in "balance" with their costs.

One conceptual question that had vexed academics for a long time was how markets could be efficient to begin with. After all, if there is no money to be made, why would anyone bother collecting information on firms? And if no one bothers to collect information on them, how can the market incorporate all information and thus be efficient? Eventually, a resolution to this puzzle was offered by Grossman and Stiglitz. They argued that markets can never be 100% efficient—they can only be, say, "99%" efficient. In equilibrium, good information collectors should earn just about enough trading profits to break even on their costs of information collecting. On the margin, the expected costs of learning and trading on more information are exactly equal to the expected trading profits. The informed investors earn this money trading against **noise traders**, who do not collect information and who may trade for idiosyncratic reasons (e.g., to pay for tuition).

Q 12.7. Which form of market efficiency do momentum trading strategies seem to violate?

The Fundamentals-Based Classification and Behavioral Finance

My preferred taxonomy of market efficiency is based on how much prices deviate from value.

I prefer an alternative classification of market efficiency, which divides economists based on their belief in whether prevailing market prices reflect underlying values:

A true believer would argue that financial prices always reflect the best net present value estimate of all future cash flows. This means that stock prices should change correctly if and only if news about fundamentals (cash flows or discount rates) appears.

A firm believer would argue that financial prices may sometimes deviate from the appropriate best estimate of future cash flows. However, transaction costs make it practically impossible for investors to find unusually good bets.

A mild believer would also argue that financial prices may sometimes deviate from the appropriate best estimate of future cash flows. However, unlike a firm believer, a mild believer would argue that there are occasions when it is possible to exploit this misvaluation. This would result in the occasional unusually good bet. Usually, the profitabilities of such bets should remain within economically reasonable magnitudes—a couple of percentage points a year on the high side. Mild believers thus think that smart fund managers can offer investors slightly better bets, but nothing more. There are no guarantees.

A nonbeliever would argue that financial prices regularly deviate from the appropriate value, and to an extent that allows investors to obtain great bets fairly routinely.

These classes are progressively weaker along the market efficiency dimension. For example, a firm believer need not be a true believer. Firm belief can be the right club to join if financial price changes are indeed unpredictable, but not because of news about fundamentals. There could be unrelated noise in stock price changes, especially in the short run. A mild believer need not be a firm believer: Transaction costs may be low enough to permit great trading strategies based on efficient markets violations. A nonbeliever need not be a mild believer: Financial markets may just beg to be exploited. This classification is related to but not the same as the earlier classification. For example, it is possible that markets do not reflect all fundamental information, yet stock returns are unpredictable.

There is even some really weird but dramatic evidence against market efficiency.

Occasionally, there is evidence that refutes even the truest of believers—but this is rare. The most dramatic example occurred in 2000, when the network company 3COM spun off the PDA company Palm. Widely reported in the press at the time, 3COM retained 95% of Palm's stock—and announced that each shareholder of 3COM would soon receive 1.525 shares of Palm. After the IPO, Palm closed at \$95.06 per share. Therefore, 3COM should have been worth at least $1.525 \cdot \$95.06 \approx \$145$. Instead, 3COM shares closed at \$81.81. (It was impossible to exploit this discrepancy, because it was impossible to find Palm shares to short. Palm shares later enjoyed an almost uninterrupted fall in price, down to less than \$2 per share by 2003.)

This evidence as a whole suggests that the financial markets are usually somewhere between mildly and firmly efficient.

Where do most finance professors sit in this classification of beliefs? Virtually no academic is a perpetual nonbeliever, and only a very few remain in the "true believer" camp. Instead, most finance professors are somewhere between the "mild believer" camp (the center of behavioral finance) and the "firm believer" camp (the center of classical finance). The debates between the two more extreme sides of these camps—the more "classical rational economists" and the more "behavioral economists"—are intellectually exciting. After all, bringing new evidence to bear on these disagreements is the process by which we learn more.

Buyer beware: Here is my own opinion.

Let me tell you my personal view. I sit right in the middle between the two schools of thought, somewhere in the firm-to-mild camp. In my view, most investors believe that they are smarter than they are—that they can predict when stocks are going to go up or down. This is why I believe that trading in the stock market seems so (inexplicably) active. Some pundits like to call this "investor psychology." However, I also believe that ordinary individual investors are unlikely to be able to find rate-of-return patterns in the stock market that earn high excess returns. A very few sophisticated funds may be able to earn systematically a few basis points extra per year.

➤ Evidence on Fund Performance, Sect. 12.5, Pg.299.

But these funds are scarce. Even after decades of academic research that has tried to identify better-performing funds, we have usually found that only about half of all funds outperform the market and half underperform the market—even before fund transaction costs.

Behavioral Finance

One final note: Pundits love to talk about investor psychology. And it is indeed the case that individuals suffer from many cognitive biases. For example, Nobel-prizing winning research has argued that investors are "loss-averse," which induces them to make mistakes. It is very plausible that loss aversion influences their stock trading patterns. But it is not so plausible that loss aversion necessarily influences stock prices. There are two problems. The first is that different investors would have started out at different investment levels. They would thus suffer from loss aversion relative to different starting points. This means that, in the aggregate, prices would not necessarily behave as if investors are loss-averse. The second is that, if prices were badly set because of investor loss aversion (or most other behavioral mistakes), a few smart investors would try to take advantage of this behavioral bias. They would quickly drive prices back to where they would look like random walks.

Q 12.8. If you believe that market values do not always perfectly reflect underlying fundamental values, but that trading costs nevertheless prevent you from exploiting this profitably (in large scale), where would you classify yourself?

12.3 The Random Walk and the Signal-to-Noise Ratio

The low signal-to-noise ratio allows our arguments about market efficiency to continue.

Why is the debate over market efficiency so tough to settle? It is the fact that the **signal-to-noise ratio** in financial returns is low. The signal-to-noise description draws on an analogy from physics—the **signal** (the appropriate expected price change) is small compared to the **noise** (the day-to-day price **volatility** that clouds our senses).

Let me illustrate the signal-to-noise ratio with a stock's rate of return on a particular day.

Let me explain. What are typical price change magnitudes? For example, June 17, 2016, was a fairly quiet and uneventful day on the financial markets. 10-year Treasuries stood at 1.6%, up 5 basis points; 13-week T-bills traded at 0.3% (unchanged); and just about half of all stocks advanced and half declined. The S&P 500 dropped from 2078.0 to 2071.2, about 30 bp. The Dow-Jones had 12 gainers and 18 losers. On this day, the volume leaders (not the biggest price movers) were Wester Gas (down 5.8%), Greif B (+3.7%), Synchrony (–5%), Alon (+1%), and Linked in (60%). Intel Corp increased from $31.69 to $31.76, up 0.2%. What can you learn from this magnitude? Read on.

The Signal

You cannot expect a real-world trading signal to be as strong as 1% per day: It would amount to over 1,000% per year.

Let's first put your statistical and financial expertise to good use: *In a perfect market, if the shares of a company cost $50 today, what do you expect them to cost tomorrow?* What is a typical daily rate of return on a stock? Could you expect a reasonable model of market prices to predict that 1 day's stock price movement could be something on the order of ±1%? Think about it: If the expected rate of return on a stock were the same as the typical up or down movement of 1% per day, the rate of return on this stock over the 252 trading days in one year would be more than 1,000%. The $50 stock would be worth over $600 by next year. Who would want to sell such a stock? Who would not want to bid a lot more than $50 for it right now? The same argument applies to a price decline of 1% per day. An investment strategy of holding onto such stocks would transform $50 into less than $5 by next year. Who would ever want to hold onto such stocks? The same logic would also apply to a signal that tells you on some days that one particular stock is expected to go up by 1% and on other days that some other particular stock is expected to go down by 1%. Each day, you would earn 1% by either going long or short in the

relevant stock—according to your signal—and end up filthy rich. (The investors on the other side would end up poor.)

So what kind of average daily returns can you expect from the U.S. stock market? Say a reasonable range of rates of return is between 0% and 40% per year. For 252 trading days, absent complications, this gives you daily rates of return of between 0 basis points and about 15 basis points. The majority of stocks should allow you to earn expected rates of return of between 5 and 10 basis points a day. One basis point of signal per day is 3% per year. Thus, when you test for market efficiency with a reasonable model of stock pricing, about 5 to 10 basis points per day is what you would expect to find for most stocks. If your signal allows you to earn 1 bp extra per day, then your strategy will be better by about 3% per year.

Great Mathematicians and Gambling: The Origin of the Random Walk

In the 1700s, it was not beneath mathematicians to study how to gamble in order to gamble better. Jacob Bernoulli (1654–1705) and Abraham DeMoivre (1667–1754) studied the random walk of a gambler's stake in fair games.

Later reinventions and applications of the random-walk concept abound: Jan Ingenhausz (1730–1799), a physician and plant physiologist, placed charcoal powder on an alcohol film and observed that the grains moved randomly. The botanist Robert Brown (1773–1858) reported erratic dancing of small particles in fluids at rest. Albert Einstein (1879–1955) considered such fluids to be composed of discrete molecules, whose many collisions with a "Brownian particle" caused the particle to jump in random directions—a random walk. Einstein's analysis not only explained **Brownian motion**, which has itself become a building block of high-tech finance nowadays, but also bolstered the case for the existence of atoms, which was not yet universally accepted. The first recorded use of the phrase "random walk" was by Lord Raleigh (1842–1919) in 1899. (Raleigh made a connection between diffusive heat flow and random scattering and showed that a one-dimensional random walk could provide an approximate solution to a parabolic differential equation.) The name is believed to have originated with the description of a drunk who stands on a ladder. The drunk can walk up or down and does so in a random fashion—just like stocks.

Fortunately, in 1900, Louis Bachelier introduced the random-walk theory of financial market fluctuations (although Karl Pearson (1857–1936) introduced the term "random walk" only later, in 1905), finding that bond prices could diffuse in the same manner as heat. Unfortunately, this has only pointed out the obvious: It is not easy for an investor to outperform the market. The first rigorous and published investigation of the random-walk hypothesis was done by Alfred Cowles, an eclectic investor and economist at Yale in the 1930s and 1940s. *Mostly Michael F. Schlesinger, Office of Naval Research,* Scienceweek.com, *2001.*

Let's make this into a formula. If your expected rate of return is a small constant m, that is, $\mathsf{E}(r) = [\mathsf{E}(P_1) - P_0]/P_0 = m$, then your best expectation of the price tomorrow (P_1) must be roughly the price today (P_0).

Over short intervals, the stock price should follow a mostly unpredictable random walk with practically no drift.

$$\text{Expected Price Tomorrow} = \text{Price Today} + \text{Tiny Drift} \qquad (12.1)$$

$$\mathsf{E}(P_1) = P_0 + \underbrace{m \cdot P_0}_{\text{Tiny Drift}}$$

This is customarily called a **random walk** with drift. As you just learned, depending on the stock, this tiny drift m may be around 5 to 10 basis points for most stocks. You should not be able to predict better than this drift, because this is your expected rate of return in an efficient perfect market.

Note that price behavior very close to a random walk is a necessary consequence of an efficient market, but you cannot conclude that a market is (truly) efficient just because stock prices follow roughly a random walk. For example, a market would be inefficient if you could find advance knowledge based on some other external signal—say, whether the sun is shining on a particular day—that would tell you whether the stock price will go up or down the following

Don't wag the tail: Market efficiency ⇒ random walk. Random walk ⇏ market efficiency.

day. In this case, stock prices would still follow a random walk, but your signal would allow you to outperform the EMH. The random walk only states that the known lagged price can't be this signal.

A Complication—Transaction Costs

Transaction costs destroy the profitability of many high turnover strategies.

➤ Transaction costs, Sect. 11.3, Pg.250.

The important point of perfect markets (and market efficiency) is that, given today's information, no signal can be very accurate. It should not be possible to predict stock price movements accurately enough to earn, say, 1% on a given day. Of course, in the real world, financial markets are not perfect and there are financial transaction costs that would also prevent you from really exploiting misvaluations, especially short-lived ones that require a lot of trading to exploit. You would have to pay money to your broker to buy the shares, and again to sell them. (This is why financial markets are not exactly perfectly competitive, only approximately perfectly competitive.) Even small transaction costs can render trading strategies with very high turnover unprofitable. Even if the bid-ask spread is only 10 basis points, if incurred 252 trading days a year, you would only be left with $(1-0.1\%)^{252} = 0.999^{252} \approx 78\%$ of your original investment. For a *daily* trading strategy in which you have to pay the bid-ask spread every day, you need to have a signal that allows you to earn at least 23% per year before you break even—and few signals are that good.

It may be best to think of the EMH in terms of after-transaction costs.

In an imperfect market with transaction costs, you can view the efficient market hypothesis in one of two ways:

1. The EMH should hold if you work with post-transaction cost rates of return. One percent per day is still unreasonably large, because typical round-trip transaction costs should not exceed 10 to 30 basis points, depending on the stock and the size of the trade. A daily rate of return of 0.7% is still way too large.
2. The EMH should hold if reasonably many investors have very low transaction costs, perhaps because they already had specific trading desires. For example, a signal may tell some investors to buy a stock today and sell it tomorrow. They would have to pay transaction costs to take advantage of it. But investors who were considering selling the stock *anyway* may need to wait only another day to take advantage of the soon-to-be misvaluation and then sell. Such investors really incur no additional transaction costs. However, if they are *all* asleep at the switch, it may be impossible for others to take advantage of their failures.

So the EMH won't hold perfectly in an imperfect market, but it should be a fairly reasonable description of reality—at least it is one that you can use to compute back-of-the-envelope magnitudes, and it is a hypothesis that can be tested.

Q 12.9. From memory, write down the formula for a random walk.

Q 12.10. What is the typical expected rate of return on a stock on an average trading day?

Q 12.11. What kind of rates of return does a strategy of trading stocks once a day have to offer so that you can earn a positive rate of return? Assume typical real-world trading transaction costs are about 10 basis points.

The Noise

The daily noise in stock returns is much larger than the daily signal.

To put more emphasis on the noise, we can write our random walk with drift in terms of the stock prices that you will actually observe:

$$\text{Price Tomorrow} = \text{Price Today} + \text{Tiny Drift} + \text{Noise}$$

$$P_1 = P_0 + m \cdot P_0 + \epsilon \qquad E(\epsilon) = 0$$

What do we know about reasonably typical standard deviations for the price noise of U.S. stocks? There is no particular theoretical reason why the day-to-day standard deviation of a particular stock could not be 10%, 50%, or even 100%. So it is best for us simply to rely on the empirical data. Historical averages suggest the following:

- The typical day-to-day standard deviation of individual stocks in the market is around 2-3% per day—of course depending on the firm. For well-diversified portfolios, like stock market indexes, the standard deviation is usually lower—perhaps 1-2% per day.

June 17, 2016, was on the low side in terms of volatility, but the typical noise movement of 200 to 300 basis points for individual stocks was clearly much higher than the 5 to 10 basis points that you would expect them to earn.

IMPORTANT

In the financial market context, "random walk" refers to a process in which the *expected* value tomorrow is (almost) the same as the value today. Technically,

$$E(P_1) = P_0 + \underbrace{m \cdot P_0}_{\text{Tiny Drift}} \iff P_1 = P_0 + \underbrace{m \cdot P_0}_{\text{Tiny Drift}} + \underbrace{\epsilon_{0,1}}_{\text{Noise}}$$

where m is a very small positive drift. (Another version of a random walk is $E(P_1) = P_0 + m$; in practice, this version is almost indistinguishable from the one in the formula above.)

Naturally, *actual* values tomorrow will likely be different from their values today. The empirical stock price evidence is highly favorable. Stock prices indeed tend to follow roughly a random walk, at least in the short run. This means that you cannot get rich trading based on past prices.

Q 12.12. What is the typical movement of a stock on an average day?

Q 12.13. If stocks follow a random walk, can the price tomorrow be different from the price today?

Detecting an Interesting Signal in the Noise

Detecting a signal in a lot of noise is difficult.

You now know that the tiny drift is typically around 5 to 10 basis points per day, and the noise is typically about 100 to 300 basis points per day for U.S. stocks and stock portfolios. How easy is it to determine whether you are facing a stock with 5 basis points' signal versus one with, say, 7 basis points' signal? Why 7 basis points? Because it is what you should be earning extra every day if you have a signal that allows you to earn an extra 5% per year in expected performance, above and beyond what your model of risk-adjusted returns says you should be earning. (A performance of 5% per year in risk-adjusted returns would be stellar for just about any fund.) Put differently, to determine whether your signal is real or illusory, you must be able to distinguish between an appropriate 5 basis points and an excessive 7 basis points for the average daily rate of return.

You cannot conclude anything from just 1 day of return

How easy is it to detect an extra signal of 2 basis points when hidden in noise of about 200 basis points? Obviously, 1 daily return is not going to do it. If I tell you that your investment pick happened to earn 50 basis points today, you could not reliably conclude that it was your signal. In fact, if anything, you should believe it was primarily noise. Recall from your statistics course that the T-statistic is defined as the mean divided by the standard deviation, $\mathsf{E}(r)/\mathsf{Sdv}(r)$. If your strategy performs as expected, your 1-day T-statistic would be only $2\text{bp}/200\text{bp} = 0.01$. To have good statistical confidence, you would want a T-statistic of around 2. Your expected 0.01 is a long way off.

You cannot consider multiple returns from the same day as independent observations.

To draw reliable conclusions, you need a lot more independent daily observations. Unfortunately, you cannot use the returns from many stocks from the same day as independent signals. First, your signal may apply only to some particular stocks and not to all stocks. Second, all stocks tend to move together on a given day and are therefore not independent observations. (If all 100 oil stocks go up, and your signal suggested holding oil stocks, you do not have 100 independent observations confirming your signal's ability to predict.)

You can use consecutive days as independent observations. Here is how mean, standard deviation, and T-statistic accumulate over time.

Fortunately, you can regard returns from different days as independent observations. You can therefore use sequential days of investment performance to investigate the quality of your signal. How many daily returns would you need to expect to be able to reliably detect a signal of an extra 2 basis points hidden in noise of 200 basis points? Let's ignore compounding and pretend that rates of return over time are just the simple sum of daily rates of return. In this case, your expected rate of return over N days is N times the expected rate of return over 1 day. Recall from Section 8.2 that the standard deviation of your rate of return over N days is $\sqrt{N}$ times the standard deviation over 1 day. Your expected T-statistic over N days to detect your superior excess rate of return is therefore

➤ How risk and reward grow over time, Sect. 8.2, Pg.170.

$$\text{N-day T-Statistic} = \frac{\text{Excess Mean}}{\text{Standard Deviation}} = \frac{\text{N} \cdot \mathsf{E}(r)}{\sqrt{\text{N}} \cdot \mathsf{Sdv}(r)} = \sqrt{\text{N}} \cdot \text{1-day T-Statistic}$$

Only diversified strategies that perform well for many decades give us the chance to learn whether they are real.

How many trading days (N) do you need in order to expect a T-statistic of 2 if your 1-day T-statistic is 0.01? You need $200^2 = 40,000$ days to have such confidence. This is about 157 years worth of data. This is if your strategy performs as expected—if the world is not changing and your signal's forecasting ability is not deteriorating. If your signal is not about individual stocks but about large diversified portfolios, then the noise is lower than 200 basis points. If it is, say, noise of 100 basis points per day, which may be the case for highly diversified portfolios, then you "only" need about $100^2 = 10,000$ days (39 years) of data. There are many signals for such diversified trading strategies, which can therefore be examined with real-world data. (I already described some of these, principally momentum and book/market value, although it is not perfectly clear whether their high historical average returns were due to risk or market inefficiencies.) Still, with the world and the signal always changing (after all, there may be more and more investors trying to profit from historical signals), the historical evidence alone may not always be entirely convincing.

IMPORTANT

- The quality of your inference about a strategy's performance increases roughly with the square root of time.
- On an average day, the typical stock may easily move up or down by about 20 to 50 times as much as it offers in expected rate of return. Therefore, it takes at least many decades, if not centuries, of data to reliably conclude whether a signal-based strategy of picking individual stocks is real or illusory.

Q 12.14. To be a consistent superstar trader, by how many basis points should you be able to outperform the risk-adjusted financial market per typical day?

Q 12.15. Assume that the typical day-to-day noise (standard deviation) is about 100 basis points. Assume that you have the kind of stock-picking ability that earns you an extra 200 basis points per annum. Assume no transaction costs. Ignore compounding and assume that your rate of return is the sum of returns over trading days. Assume there are 252 trading days per year.

1. With only 1-day performance, how much extra do you expect to earn per day?
2. How bad is your noise over 1 day?
3. What is your expected T-statistic (the excess mean divided by the standard deviation)?

Recall from your statistics course that a T-statistic of 1.96 gives you good statistical confidence above the 95% level. In Section 8.2, you learned that the standard deviation grows with the square root of time.

4. With 252 trading days of performance, how much extra rate of return do you expect to earn per annum?
5. How bad is your noise over 252 days?
6. What is your expected T-statistic now?
7. Work out how many years you would expect to wait before you would obtain reliable statistical evidence that you have a positive ability to pick stocks.

12.4 True Arbitrage and Risk(y) Arbitrage

Measuring investment performance brushes on a closely related topic—what exactly is the financial concept of arbitrage? Intuitively, an arbitrage is a great investment opportunity, perhaps so great that you should not be able to find one. It is the desire of traders to exploit any arbitrage opportunity as soon as it appears that makes financial markets efficient. It is a matter of basic financial literacy for you to understand what arbitrage is.

Do you understand arbitrage?

The Definition of Arbitrage

First recall that the *law of one price* states that two identical items at the same time and location should have the same price. This is true in a perfect market, but even if the market is not perfect, it can be (and in fact usually is) still true. For example, even if all investors disagree about the future, even if there are taxes, even if there are transaction costs, and even if there is only one market maker, it should be, and usually still is, the case that one share of Intel Corp costs the same as another. But in a perfect market, the law of one price does not just *usually* hold; it must *always* hold. If it did not hold, you and the other infinitely many potential buyers could find arbitrage opportunities. The arbitrage concept is so important that you should understand it exactly, not just intuitively.

In a perfect market, the market will be efficient and the law of one price will hold.

➤ Law of One Price, Sect. 1.1, Pg.2.

IMPORTANT

- A **true arbitrage** is a business transaction
  - that offers positive net cash inflows in at least some scenarios,
  - and under no circumstance—either today or in the future—has a negative net cash flow. This means that it is risk-free.

An example: \$5 for free.

- A **risk(y) arbitrage** is a business transaction that may not be risk-free but that still offers an excessive expected rate of return given its (risk and other) characteristics. A good way to think of a risk(y) arbitrage is as a **great bet**. Admittedly, the term "risk(y) arbitrage" is an oxymoron. However, Wall Street uses the term "risk arbitrage" for a particular type of trading (most often in the context of M&A transactions) that is similar to the sense in which we shall be using it. Thus, we shall commit the same sin.

  An example: A chance to win \$1,000,000 with 99% probability and to lose \$1 with 1% probability.

Arbitrage is the "perpetual motion" of economics. It is defined in terms of (the possibility of) negative cash outlays.

Arbitrage is an ex-ante concept, not an ex-post concept—beforehand, not after the fact. For example, it does not mean that a lottery ticket that won was an arbitrage. Ex ante, a lottery ticket is not an arbitrage. Please also pay close attention to what the "no-negative-cash-flow" condition means in the definition of arbitrage:

➤ Ex-ante fair bet, Sect. 6.1, Pg.106.

1. Arbitrage is not the same as "earning money without risk." After all, Treasuries do just that, and they are not arbitrage. The reason is that you have to lay out cash to buy Treasuries. This is a negative net cash flow today.
2. Arbitrage is also not the same as "receiving money today without a clear obligation to repay": If you are willing to accept risk, you can often receive cash today. For example, insurance companies take money in exchange for the possibility that they may have to pay up in the future.

"Risk(y)" arbitrage ≈ great bet. Unlike a true arbitrage, a risk(y) arbitrage could possibly lose a little money.

Now contemplate the difference between the examples of the true arbitrage and the risk(y) arbitrage in the definition. You can lose \$1 with 1% probability in the risky arbitrage, so it is "just" a great bet and not a true arbitrage. One difference is conceptual: Every investor would want to take a true arbitrage opportunity, but an infinitely risk-averse investor would not take a risk(y) arbitrage. This does not mean that, given an either-or choice, a less risk-averse investor would necessarily prefer the small, true arbitrage opportunity. In our example, would you prefer the \$5 true arbitrage, if it cannot be repeated, to the risk(y) arbitrage with an expected payout of close to \$1 million? (If you could scale the true arbitrage opportunity to take it infinitely many times, the true arbitrage opportunity would dominate.) Of course, this example of risk(y) arbitrage is extreme. More realistically, bets are never this great—"very good" is rare enough. And because there is still risk, you may not want to scale up good but risk(y) arbitrage bets in the same way you would always want to scale up true arbitrage bets as much as possible. Eventually, with enough investment in the risk(y) bet, your risk aversion would kick in and stop you from taking more of it.

There should be few arbitrages in competitive financial markets. Only this fact allows us to study and describe (sane) markets.

Most of all, unless financial markets are very imperfect, you should expect not to find many arbitrage opportunities of either type. If you agree with this assessment—basically that the world is sane and that money does not grow on trees—you can draw some surprisingly strong conclusions about how financial markets work. If you disagree, why are you still in this class? If you are right, you should be among the richest people in the world and there is little that this book can teach you.

Q 12.16. Is earning money without risk an arbitrage?

Q 12.17. When and why you would prefer a risk(y) arbitrage to a true arbitrage opportunity.

More Hypothetical Arbitrage Examples

In a sense, positive-NPV projects under certainty are arbitrage.

Of course, it is difficult to find real-world examples of arbitrage. Arbitrage is principally a concept. What would a hypothetical arbitrage opportunity look like? For example, if you can buy an item for $1, borrow at an interest rate of 9% (all costs, including your time), and sell the item tomorrow for $1.10 for sure, you earn 1 cent for certain today without any possible negative net cash flows in the future. If you ever stumble upon such an opportunity, please take it—it is a positive-NPV project! More than this, it is a true arbitrage because you cannot lose money in any scenario; it is riskless. Yet it is obviously not a very important arbitrage by itself. Searching for 1-cent arbitrage opportunities in financial markets is potentially more lucrative, because they often allow transactions to be scaled up. If you could repeat this 1-cent arbitrage 1 billion times, then you could earn $10 million. Unfortunately, although you may find an arbitrage that works once for 1 cent, it is unlikely that you can find such an arbitrage opportunity that works for 1 billion items. After all, you are not the only one searching in the financial markets! True arbitrage opportunities are difficult or outright impossible to find in the real world, especially in very competitive financial markets.

Small arbitrages matter only if they are scalable.

Another hypothetical example of arbitrage would involve stock prices that are out of sync on different stock exchanges. If PEP shares are quoted for $51 on the Frankfurt Stock Exchange, and for $50 on the New York Stock Exchange, you could theoretically buy one share in New York for $50 and sell it in Frankfurt for $51. You then pocket $1 today. If you can do this with 20,000 PEP shares worth $1 million, you earn $20,000 without effort or risk.

Arbitrage could conceivably occur between different financial markets.

But before you conclude that this is an arbitrage, you still have to make sure that you have not forgotten about costs or risks. The arbitrage may be a lot more limited than it seems—or may not even be present at all. Consider the following issues:

But be skeptical. There are many complications to take into account.

1. Could the price change in between the time you buy the shares in New York and the time you sell the shares in Frankfurt (even if it is only 3 seconds)? If such execution-timing risk exists, this is not pure arbitrage because there is a chance of a negative net cash flow. The real-world evidence suggests that price discrepancies between markets often disappear within a few seconds.
2. Did you account for the direct and indirect transaction costs? How much commission do you have to pay? Is $51 the Frankfurt bid price at which you can sell shares in a market, and $50 the NYSE ask price at which you can buy shares? Can you sell the share in Frankfurt and get it quickly enough from New York to Frankfurt to make the closing? Have you accounted for the value of your own time watching the screen for opportunities?

➤ Bid and ask prices, Pg.252.

3. Could the share prices move when you want to transact a significant amount of shares? Only the first 100 shares may be available for $50 for a net profit of $100. The next 900 shares may cost $50.50—perhaps still worthwhile, but less profitable. And buying the remaining 19,000 shares may cost you $51 or more.
4. Did you account for your fixed cost of setting up your business? If it costs you a million dollars to get offices and computers in order to "arbitrage" a few thousand dollars, it is obviously not a real arbitrage. So you must account for how expensive it is to set up your operations.

It may be that small arbitrage opportunities occur from time to time, but large financial firms are constantly running automated computer trading programs that search for even tiny arbitrage opportunities in order to exploit them as soon as they appear—and thereby make them disappear.

Q 12.18. Before you dedicate your life to exploiting a seeming arbitrage between financial markets, what questions should you ask?

12.5 Investment Consequences

Is the past rate of return a good signal for the future rate of return?

How does the EMH matter to you if you are an investor? In an efficient market, there should be no obvious signals to outperform the risk-adjusted appropriate expected return to the tune of, say, 10 basis points a day above transaction costs. For sure, it should not be possible for you or anyone else to earn arbitrage returns. Let's consider two examples—technical analysis and investment fund management.

Weak-Form Efficiency and Technical Analysis

Could there be "cycles" in the market?

The main point of the traditional classification of market efficiency, specifically the "weak" version, is the claim that you should not become rich by trading a strategy that relies only on historical prices. So let me start with some trick questions. Look at the various graphs in Exhibit 12.2. Do they show what stock market patterns could look like? Perhaps. Does it make sense to think that all these patterns can predict the future? Absolutely not! Graphs (a) and (b) display a strong regular cycling pattern. If they indicated future returns, you should quickly become a wealthy technical analyst. You would buy the stock only when it has "bottomed out"—a pattern that you can reasonably detect if you see a multimonth period of losses followed by about a quarter of stable returns. It need not be the kind of regular cycles in the figure: Any good predictable patterns (such as "every time the price hits $22, it drops by $2") would allow you to get rich. Now, if you look hard enough, can you find some stocks in the real world that have historically behaved like these graphs? Yes—because with over 10,000 stocks currently trading, by pure chance, maybe one or two could show a pattern that would look remarkably similar to a cycle pattern. But, despite assurances from some stock analysts that you could have made money if you had just trusted their cycle patterns and that you should trust them henceforth, the patterns would *not* represent the future—they would just be historical coincidence.

Cycles are not reasonably likely—although there are ups and downs in the market, too.

On the other hand, graphs (c) and (d) could actually be representative. On average, each price in the next month is just a little higher than the previous (i.e., the expected rate of return on stocks is positive), but the important aspect of (c) and (d) is that there is a lot of *noise*, up or down. Noise is by definition unpredictable, and stock prices must largely be unpredictable, or you could outsmart the stock market. Incidentally, one of these graphs is a real stock price that I picked at random, while the other is a simulated random walk. Can you detect which one? I cannot! The real-world price series looks just like a simulation of patternless day-to-day random-walk changes. In fact, if you ever look at graphical representations of stock prices, most will look like graphs (c) and (d) and not like graphs (a) and (b). (Solution: Graph (d) was an actual stock price series of Intel.)

The Empirical Evidence on Trends

Predicting with past rates of return mostly appears to fail.

Traders have been trying all sorts of strategies in their efforts to become rich. So how well does technical analysis—which tries to find patterns in historical stock prices—typically do? For example, according to one version, stocks that rise one day are more likely to fall back the next day. Exhibit 12.3 shows tomorrow's rate of return on the tech-heavy Nasdaq market index and on Intel Corp as a function of today's rate of return (from 2000 to 2016). The graphs show no pattern that would allow you to get rich quickly. There is definitely not much juice in trying to predict how a stock will perform tomorrow, given how it performed today. (Although difficult to spot here, there is a small day-to-day reversal in this data—a tiny negative slope. This is caused by the **bid-ask bounce**: If a stock's closing price is a [higher] ask price, on average it will fall back the next day when it will close with either a bid or an ask price with roughly equal probability. If the stock's closing price is a [lower] bid price, on average it will gain the next day. This is a data illusion and not exploitable.) Similar conclusions apply if you extend your use of historical price information beyond yesterday. You can even try out your own technical analysis at

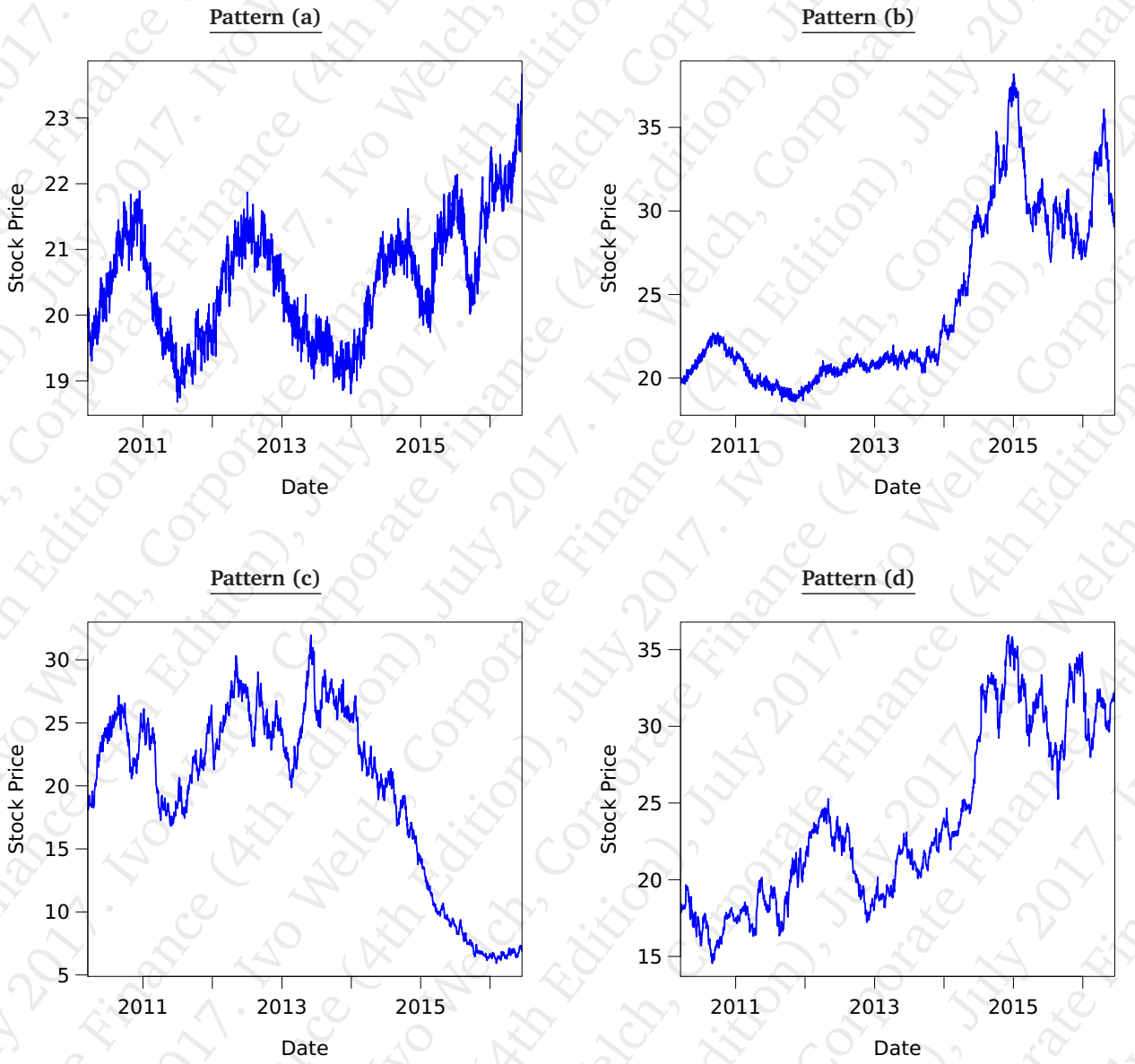

Exhibit 12.2: *Potential Stock Price Patterns.* If these patterns were systematic, some of them should make you rich. Which ones? And which is the real series?

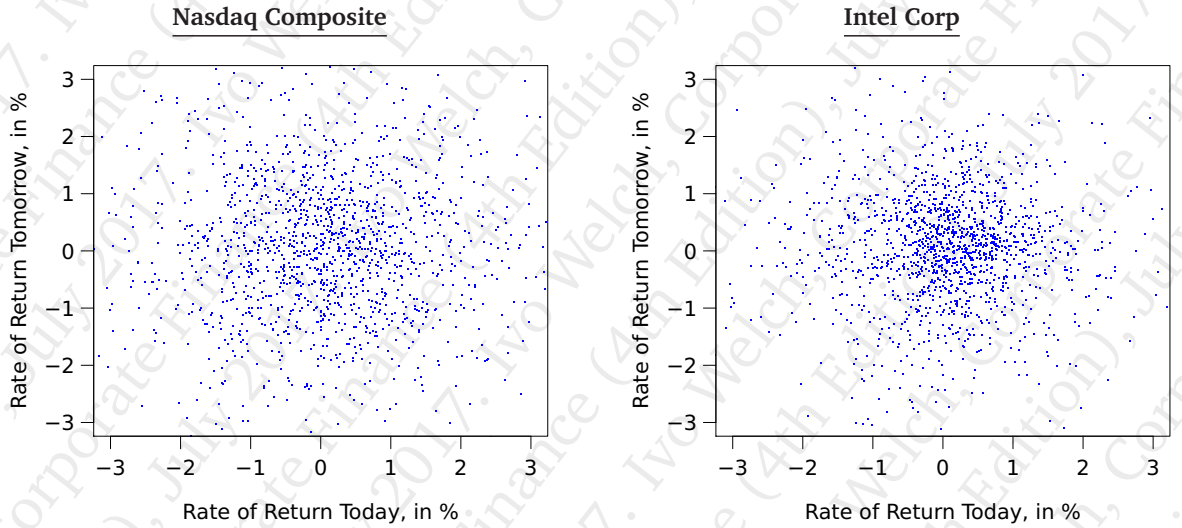

Exhibit 12.3: *The Relation between Lagged and Current Rates of Return.* The left panel is the tech-heavy Nasdaq Composite Market Index (IXIC). The right panel is Intel Corp. Both plots graph the rate of return against itself one day earlier from 2010 to 2016. Obviously, there is no obvious pattern.

Momentum: Firms that did well over the last year (with 1-month lag) continue to do well.

a number of financial websites, such as YAHOO! FINANCE—look up any stock and choose "Charts," then "Technical Analysis"; it is fun, but unfortunately fairly useless.

However, over annual horizons, it appears as if stocks tend to continue their pattern just a little bit. This is the "momentum" effect mentioned earlier. It should be covered in more detail in an investments course. (Of course, as you already know from Section 12.1, it is very difficult to determine whether an extra few percent is an appropriate rate of return to compensate investors for some risk, or whether it is a market inefficiency.)

Are Women Better Investors Than Men?

Analyzing 35,000 households from 1991 to 1997, Terry Odean and Brad Barber found that men trade 45% more than women. Apparently, men are overconfident in their trading prowess. (Men also have a higher propensity to suffer from compulsive gambling and other mental disorders.) On average, the men's investment rates of return were lower than women's by a little less than 1% per year. Much, but not all, of women's better returns could be attributed to the higher transaction costs that men incurred for transactions that did not gain them higher returns.

Despite strong evidence to the contrary, many investors still believe that stock prices do not follow random walks, as evidenced by the plethora of financial talk shows and investment newsletters. It would perhaps be better for the general public to watch more sports and cooking shows and fewer investment shows—especially for males like myself!

Odean and Barber, 2001

Investment Manager Performance Evaluation

What about celebrity investors?

What about all the televised stock analysts who explain which stocks are undervalued and which stocks are overvalued? And what about the aforementioned technical analysis, the art of seeing patterns (shoulders, price barriers, faces, etc.) in historical prices and using them to forecast future prices? And what about famous investors such as Warren Buffett, George Soros, and many others? Should you trust them?

What could you conclude from their stellar past performances? There are three possibilities.

First, recall that the low signal-to-noise ratio means it is difficult to determine why a particular trading strategy has earned high returns:

- Was it because it had a lucky outcome, which will not repeat (random luck)?
- Was it because it took on some risk that your appropriate return model forgot (your fault in measuring performance)?
- Or was it because the market was inefficient (you have a good signal, skill, and trading ability)?

This is not just a problem for academics. In fact, we finance professors are lucky: We can continue to write papers that argue one side or the other. The real conundrum is faced by every investor in the real world every day: How do you distinguish between a good and a bad signal—between skill and luck—when it comes to investing or to selecting a fund manager?

Here are possible objections to believing in their magical investment abilities (and in inefficient markets).

But the signal-to-noise ratio problem is not even the only problem that you need to consider when you pick an investment manager. If you believe that the market is inefficient so that your fund manager can make you money, consider the following:

Evidence? Of course, maybe there are some investors who *can* pick stocks. Unfortunately, they would not want anyone to learn how they do it. In fact, they may want to do so secretly and privately, never eager to appear on anyone's radar screen. This can make it difficult to find investors with superior ability and thus impossible to confirm their abilities.

Why would they tell anyone?

Enough data? Recall our earlier conclusion that a strategy with great performance requires many decades before you can realistically conclude that it has worked. (This is assuming that the world is not changing.) Few strategies have such long track records.

➤ Ascertaining superior performance, Pg.290.

Remarkably, the most common industry standard for evaluating funds is their most recent three years of investment performance. There is no disagreement that most of the 3-year performance of funds is noise. This means that many investors (and especially investors in hedge funds) shift their holdings often based on noise. Why? Either they do not understand how long it takes to determine reliably whether a strategy works (possible), or they do not care too much about reliability (more likely). If they believe that there are many other strategies that also have a close to 50-50 probability of success, then eliminating one strategy that had 3 bad years and therefore only a 49-51 probability of success may not be a costly choice.

The industry standard of three years' performance is not driven by the need to get solid statistical inference.

What is Risk? Here is another lesson for the wise (and unwise). Until 2008, I would have sworn that investing in momentum stocks was a strategy that was reasonably well-diversified and yet outperformed the overall stock market. On average, it had delivered abnormal returns to the tune of about 5-10% per year. Stocks that have gone up over the last year and which are therefore momentum purchase candidates did not seem to be particularly risky. More importantly, momentum stock portfolios appeared well-diversified—a fact that should have moderated their ups and downs. Yet, after many decades of superior performance, in 2009, this momentum strategy suddenly lost 83 percent of its investment! (One plausible reason is that too many hedge funds were trying to chase momentum returns, and they all had to unload at the same time.) Which other seemingly great investment strategies are exposed to some risk factors that have just not shown themselves yet?

Is Momentum Risk?

➤ "Peso" risk., Pg.201.

Pure chance means that some investors succeed many years in a row.

➤ Mutual funds, Sect. 7.2, Pg.157.

Monkeys on keyboards? There are about 10,000 mutual funds today that invest money on their investors' behalf. How many of them are likely to outperform the overall stock market next year (at least before they collect fees) if none of them has any superior investing ability? About 5,000. How many of these outperform the year thereafter? About 2,500. Even if there is absolutely no ability, pure randomness means that about 10 funds outperform the market every year for 10 years in a row. With enough candidates, some funds will inevitably produce consistently positive long-run track records.

Good past performers grow.

Who is still alive? What happens to the funds that have underperformed several years in a row? They disappear quietly. (In fact, they don't even need to appear. The SEC even allows a fund family to "incubate" funds privately for the purpose of obtaining track records. Start 1,024 of these funds, and after 10 years, you should expect to be able to go public with at least 1 of them that has outperformed 10 years in a row!) What happens to the funds that have outperformed several years in a row? They proudly announce their performances, advertise, boast, and collect more investments from outside investors. Their managers are supported by larger "research teams," appear better dressed and more "professional," and fly in executive jets. They are the ones that are most visible. Indeed, if you made money 10 years in a row in the stock market, would you not yourself believe that you have the ability to pick stocks?

Why funds' average historical performance looks good to you as an investor today.

Now put yourself in the shoes of an investor looking at the universe of mutual funds offered today. First, you won't notice funds that have performed poorly. They have already disappeared. Second, you will notice that the larger funds seem to have done better. On average, it will seem that currently available funds indeed can make you money—even if in the real world there is absolutely no ability. This phenomenon is called **survivorship bias**, because it means that you cannot consider the historical performance of existing funds to be a fair projection of their future performance.

If there was superior fund performance, the fund manager—not the investor—would profit the most.

Who gets the rents from trading ability? Even if the financial markets were inefficient and even if some fund managers could in fact systematically outperform the market, in a reasonable market, these fund managers would charge appropriately high fees to capture all the advantages that they provide to investors. After all, it is the fund manager who would have the scarce skill (picking stocks) and not the typical investor. Investors with money would compete to place money with such managers and accept higher and higher fund fees. In the end, it would be highly unlikely that uninformed investors could earn excess returns by investing in some manager's actively trading fund.

In sum, if you are looking for future performance, past performance may be your best guide. But always remember that recent past performance is still a very poor guide.

Many hedge funds are compensated on the upside. This does not solve investors' problem, but the alternative is no better.

Obviously, picking the right investment manager is not an easy task. Many mutual funds earn fees regardless of whether they make you money or not. Would it be better to have them participate in the upside (as is the case for hedge funds)? Maybe, but consider this: I give you stock tips, and I ask for money only if you make money. In fact, I only want 10% of your winnings. "You have nothing to lose." I only get something if I help you make money. Sounds like a deal? Now, if I pick a stock randomly, I have a 50-50 chance of making money. If you gain, I get something. If you lose, I pay nothing. In effect, I am arbitraging you! Remember, next time someone gives you a great stock tip, regard it with some skepticism: It probably has a 50-50 chance of being right. (Maybe I should give you the advice to buy a stock, and your neighbor the advice to sell it. This way, I will surely make money from one of you.) My only mistake is that I have told you my plan.

Dilbert on Management Books: 2013-06-30

The Three Top Investment Books of 1996

The three best-selling investment books of spring 1996 were David and Tom Gardner's *Motley Fool Investment Guide*, based on a popular investment website; Matt Seto's *The Whiz Kid of Wall Street's Investment Guide* (Matt Seto was 17 years of age at the time); and the *Beardstown Ladies' Common-Sense Investment Guide*, authored by septuagenarians whose first book mixed cooking recipes with investment advice. All touted "common-sense methods" to beat the market, earning 30% per year or more. Not a week went by without dozens of prominent radio and TV shows featuring their advice. Why does anyone need a Ph.D in finance? It is difficult to argue with performance!

Naturally, best-selling books are a great business. However, the stock performance of these three experts was not.

1. From 1996 to 2002, the *Motley Fool* recommended a number of hypothetical portfolios (now discontinued!). In 1997, they launched a real-money portfolio, called DRIP. From July 28, 1997, to July 31, 2002, it lost about 10%, while the S&P 500 lost 2.5% and NASDAQ lost 15%. One should not judge a fund by just 5 years of performance (and certainly not without risk adjustment), but it does appear that the *Motley Fool* has not exactly found the Holy Grail of investment opportunities.
2. Matt Seto stopped publishing his stock-picking performance and decided to pursue a career as a student.
3. The Beardstown Ladies, five books richer, were found to have miscalculated their returns: Their returns were not 30%, but 9%—significantly lower than the 15% turned in by the S&P 500 stock market index during their investment period.

How disappointing: On average, about one of them should have continued beating the market, one should have done about the same as the market, and one should have underperformed it. *Time Magazine, March 1998.*

The Empirical Evidence

You must realize that even top investors seem to have at most mild predictive abilities.

So what is the empirical evidence? In general, it suggests that fund managers' luck is far more important than their ability. Whenever academics (or the *Wall Street Journal*) have searched for better performance among analysts or professional fund managers who have outperformed in the past, they have found little or no exceptional forward-looking performance. Exhibit 12.4 shows a typical result in the literature: There were more funds that performed miserably than what we would have expected by pure chance. Fewer than half of the funds could beat the zero benchmark. And many fewer funds than expected by random chance did great.

Are there some persistently good performers at least?

But what about persistence? Maybe there are some funds that are better than others? True. But the empirical evidence is again disappointing. Only about 54% of mutual funds that have outperformed their benchmarks over the last 1-3 years tend to outperform their benchmarks over the following 1-3 years. This is better than 50%, but not by much. And if you subtract fund fees, the average performance drops significantly below 50%. As fund prospectuses so aptly note—and as the evidence suggests—*past performance is no predictor of future performance*.

Dilbert on past performance + hedge funds: 2013-04-17

Do Fund Managers Know?

There is a whole industry full of fund managers whose job it is to allocate assets to the actual investing funds. Chances are that your corporate pension fund will be managed by some. (So is mine. So is the UCLA endowment.) They of course all swear that they are immune to this, because they *know* which funds are better than others. Beside the occasional Madoff misstep, could they really tell? Goyal and Gupta (JF, 2008) look at 3,400 retirement plan sponsors from 1994 to 2003 and find that they were not particularly prophetic:

Nerdnote: There are some high-tech statistical techniques to take into account that researchers have searched, individually and collectively, for anomalies. This is beyond our scope.

what to expect →	Miserable (T < (–1)) Should be <16%		Average or Better (T > 0) Should be >50%		Great (T > 1) Should be >16%	
AUM	Before Fees	After Fees	Before Fees	After Fees	Before Fees	After Fees
< $5 million	22.4%	37.8%	48.2%	32.1%	**21.2%**	10.2%
–$250 million	25.0%	41.0%	44.8%	28.3%	17.4%	8.5%
> $1 billion	29.8%	45.0%	41.5%	28.3%	15.6%	7.9%

Exhibit 12.4: *U.S. Equity Mutual Fund Performance, 1984–2006.* This table looks at the historical performance of about 1,308 mutual funds, with an average of $650 million assets under management (AUM). You don't need to be too concerned about the details, but the T mentioned in the first row is similar to the T-statistic of the alpha that was mentioned in Chapter 10. A negative alpha and a negative T means underperformance. For example, the second line tells you that if monkeys had done the investing, you would have expected about 16% of the mutual funds to have a T as lousy as –1. In real life, 22.4% of mutual funds with less than $5 million AUM managed to perform as lousy before fees, 37.8% after fees. As a group, only the best small funds with AUM outperformed the random benchmark (21.2% had good performance, instead of the expected 16%), but fees negated this group advantage. Source: Fama-French, JF 2010.

	Years Relative to Hiring	
	–2 to 0	0 to +2
Fired Funds	–1.6%	+3.1%
Hired Funds	7.6%	+2.3%

They fire funds after they have performed poorly, not before they perform poorly. And they hire funds after they have performed well, not before they perform well. So why do these managers pretend that they can do a good job managing your money? Well, how much would you pay for a plan sponsor who admitted that it could not pick funds better than either you or a monkey?

For the most part, it seems that old-fashioned work and insurance (or liquidity) provision work better in earning returns than stock picking.

There are, of course, other ways to make money: Warren Buffett's fund, *Berkshire Hathaway*, for example, runs many businesses (e.g., insurance and aircraft), too. These businesses make money. But it is money earned the old-fashioned way—through hard work, liquidity provision, and risk-taking. Writing insurance is risky business, and it deserves extra return. Warren Buffett himself would of course not attribute his own performance to luck, but to his ability. Still, even he acknowledges that the efficient markets hypothesis is the most natural benchmark. He is on record as stating that "the professors who taught efficient market theory said that someone throwing darts at the stock tables could select stock portfolios having prospects just as good as ones selected by the brightest, most hard-working securities analyst. Observing correctly that the market was frequently efficient, they went on to conclude incorrectly that it was always efficient." Even Buffett is still a mild believer!

➤ Business of liquidity provision, Sect. 11.3, Pg.253.

Where should the burden of proof be?

In sum, most finance professors nowadays would agree that when one particular investor earns an unusual amount of money, even over a few years, it is usually more likely due to luck than to ability. The burden of proof is with the side that is claiming superior signals and investing ability—and a number of former finance professors have taken up the challenge and started their own funds. On the client side, if I were you, I would be very cautious investing my money with anyone who charges high fees.

IMPORTANT

Even in an efficient market, in which no one can pick stocks better than anybody else, with a very large number of investors, many will beat the market. A small number of investors will beat the market again and again.

In the real world, there is little evidence that investors who did well picking stocks in the past are better at picking stocks in the future when compared to investors who did poorly.

Q 12.19. If you want to determine whether fund managers have an ability to outperform the stock market, given that many of them are likely to beat the market, does it make sense to look for these high-ability managers among the better historical performers?

Q 12.20. If a firm employs 10,000 analysts, how many of them are likely to issue forecasts that beat the market 10 years in a row *if* none of them has any special ability and there are no transaction costs?

Q 12.21. Explain what survivorship bias is and how it manifests itself in the mutual fund context.

12.6 A Cynical Perspective

Buy Low, Sell High.

When fund managers earn great returns, they often become famous. To attract new investors, they then talk more about their performance. The first targets are easiest to find at cocktail parties and hedge fund conferences. Thereafter, it is usually admiring students in universities. A few lucky investors even go on to write books. Please read some of them. They all seem so sensible. All you need to do is to buy low and to sell high. Having sat through many presentations and having read many books, I can confidentally state that about half emphasize the "buy low" while the other half emphasize the "sell high." When I am in a good mood, I can fake admiration for their brillant investment insights. When I am in a bad or cynical mood, I offer ambiguous praise that amuses only myself. (These are our university donors, after all.)

Rat Selection

Unfortunately, even though genetic algorithms and artificial intelligence are rather sexy high-tech sophisticated ways to pick investment assets, true genetics and intelligence seem to have been somewhat neglected. Fortunately, Michael Marcovici has remedied this with his "I Trained Rats to Trade, and Win, on Wall Street" true laboratory experiments. Sure enough, a number of them outperformed. Unfortunately, their ability to present their superior ability to potential investors (and thus generate higher fees) is limited by their lacking eloquence.

Grandiose Claims and Dumb Excuses.

Most funds write monthly communiques to their investors. They are largely collection ex-post rationalizations and platitudes. Read some with an open mind. There are some patterns. Funds on the up often write about the credit they deserve for their brillant insights. They describe competitive advantages, signals, edges, exciting and smart strategies, sentiment reading abilities, contrarian acumen, etc. Funds on the down often write that nobody could have known; that Buffett did it, too; unprecedented market turmoil; irrational herd sentiments; unpredictability; temporary profit-taking; dollar averaging; the market failing to understand fundamentals; deteriorating data and decision making of others; fat-tail risk; dislocations; short-sellers; the Chinese, Russians, Saudis, Jews, or Arabs; the Fed doing too little or not enough, and so on. Yet, the simple fact is that neither is on target. Not the ups and not the downs. Most performance in financial markets is luck. In 2016, about a thousand hedge funds closed shop, usually because of poor performance. There are a lot of one-hit wonders among them (and, of course, about half as many two-hit wonders, and about a quarter as many four-hit wonders).

Academics are not so different.

We academics are not so different. John Oliver's May 2016 show on Scientific Studies explains it better than I can. I will try it anyway. If you read academic journals, you will find hundreds of papers showing how to beat the market. Just like fund managers, academics do not get rewarded for writing papers that opine "the markets are fairly priced." They get rewarded for writing papers that find that factor X had amazing returns. It's even better when the factor can be claimed to be behavioral—hedge funds and investors (our consulting clients) love irrational behavior stories. The problem is that even if each individual economist is (or were) scrupulously honest, as a collective, with thousands of us mining the data, we will find many factors that seem statistically significant, yet are entirely spurious. Most of the time, hedge funds try to replicate and further test the academic factors right after the first public posting. When they hold up, many academically oriented hedge funds start trying to exploit past patterns. They all slowly pile up into the factor as they backtest the factor, itself contributing to some further good performance. Virtually every academic equity fund is playing "value" and "momentum" in some strategy or another. And then, one day, they realize that they may have overreached and then all seem to want to withdraw roughly at the same time. This seems to have happened to so-called momentum strategies in 2009.

Intellectual Humility, please.

What about me? Am I not brillant? I placed large short bets on oil in 2013 when it traded above $100/bl. I believed long-term supply and demand could not sustain such a high price. In 2014, the oil price dropped below $50/bl, and made my oil bets my best bets ever. I had talked about this in 2013 to my colleagues, who are now admiring my foresight. It is easy to rationalize how smart and prescient I was. But it's really all non-sense. I don't like to bet on horses, I like to bet on financials. I placed a bet, pure and simple. Ex-ante, someone on the other side believed the opposite. I happened to win. In financial markets, it is easy to place bets and someone ends up winning. In this case, it was me. Does this make me a brillant investor? Or just a lucky one?

Asymmetric-Pattern Strategies

Not Understanding Profit Sources

But funds can wittingly or unwittingly seem even better than random gamblers. It is not difficult to show good historic performance. You can even do it on a roulette table. Just double up. Choose red, and when black comes up, try again and double up. When you have won, go home and record today's investment performance as a gain. With a lot of money, it is likely that you will have years of good performance without losses. Many funds unwittingly follow strategies with such payoffs. They make a little money most of the time until they have dramatically large losses. The 2008 Great Recession showed exactly this pattern for many strategies. Many investors (banks in particular) who had made small amounts of money for a long time suddenly lost it all. Writing options or making markets are other strategies that follow this pattern: modest returns most of the time, followed by a sudden large disaster. I don't think they even knew this and tried to deceive their investors. They just stumbled onto the "has made nice little money for a long time" investment strategy and followed it. My advice: be very skeptical about claims that someone expects to beat liquid financial markets.

It is difficult to be a contrarian.

The opposite of the usual pattern of hedge funds are strategies that lose money most of the time but then gain a lot in a crisis. These are strategies that are very difficult to maintain. Which investor wants to earn negative rates of return for years on end, while their peers are doing well? The bears on real estate in the first half of 2000 went out of business long before the Great Recession of 2007-8. Only a few very lucky investors managed to maintain their shorts—and, just as there are books by and about successful investors, there are movies about these lucky unicorns, too (in this case, The Big Short). Yes, in theory, you can offer a fund with a negative market-beta strategy with negative expected rates of return, because it provides great insurance. In practice, your investors will drift away when the market goes up, and withdraw their gains when the market goes down to cover their losses elsewhere. It's tough to bet against the market.

12.7 Corporate Consequences

How does the EMH matter to you if you are a manager? Does it matter whether financial markets are perfect, efficient, or neither? Because a perfect market implies an efficient market, you need to think about three different cases:

When creating value for your firm, there are three different market scenarios to consider.

1. The market is efficient and perfect.
2. The market is efficient but not perfect.
3. The market is neither efficient nor perfect.

These cases help you organize your thinking about what it takes to create value—which is *the* most important question if you are the CFO. Can you add value by changing your capital structure? Can you create value by splitting your shares, so that every share becomes two shares? Can you create value by paying out dividends next year rather than this year? Can you create value by changing how you present your earnings to investors? Can you create value by taking over other companies when they are priced too low if you do not have any unique knowledge or anything unique to add?

If the Financial Market is (Close to) Perfect

If the financial market is perfect, the answers to these questions are simple—they are always no. It does not matter how the firm communicates its earnings to investors, what its capital structure is, how many shares it has, how it pays out its dividends, and so on. In fact, you already know that the firm is worth the value of its underlying projects' present values. Everything else is irrelevant.

In perfect markets, all that counts are the firm's underlying projects.

Earnings reporting: For example, if you have previously reported your foreign division's earnings separately and now you consolidate them into your main earnings, you will indeed increase the firm's reported earnings. However, it will not create anything intrinsically valuable. Such a change should not add or subtract firm value. Your firm owned the subsidiaries' cash flows before and after its reporting change. Your investors can add or subtract the subsidiaries' numbers themselves, whether you include or exclude them in your overall report.

You cannot fool your investors by how you report your earnings.

➤ Do reported earnings matter?, Sect. 14.1, Pg.355.

Capital structure: For example, say your firm is currently financed with equity only and worth \$100, but if you had a 50-50 debt-equity ratio it would be worth \$102. In this case, an arbitrageur could buy your firm, issue \$51 in debt and \$51 in equity, and pocket \$2. With legions of entrepreneurs competing to do this, your firm value would instantly adjust to \$102. Thus, a \$100 price for your firm would be absurd.

There must be no value to changing capital structure.

➤ Capital structure arbitrage, Sect. 17.2, Pg.451.

Stock splits: In a stock split, each old share becomes multiple new shares. For example, if each share trading at \$80 were to become two shares, the new shares should trade for \$40 each in a perfect market. Nothing fundamental about your underlying projects would have changed. Splitting by itself cannot add value. If this were not the case—for example, if shares would be worth \$41 each after the split—arbitrageurs would buy the old shares for \$80, and sell them an instant later for the equivalent of $2 \cdot \$41 = \$82$, pocketing \$2.

Stock splits must be irrelevant, too.

➤ Stock splits, Sect. 20.2, Pg.558.

Dividends: The same argument applies to dividends. In a perfect market, a \$100 firm that pays \$10 in dividends should be worth \$90 thereafter—no value is magically created or destroyed. Keeping the money for another year in the marginal zero-NPV investment (e.g., Treasuries) is as good as paying it out. Investors in a perfect market can borrow against this extra future money and use it today.

Still trying to fool investors, this time with dividends? Fugeddaboutit.

➤ Stock dividends, Sect. 20.2, Pg.558.

The lesson is simple: As a manager, you should forget about the smoke and mirrors and instead focus exclusively on finding and executing projects with positive net present values.

If the Financial Market is Not Perfect but At Least Efficient

An efficient market means "the price is right." Thus, you can learn from your own market price.

If markets are not perfect but efficient, the implications are not as profound. However, it means that you can still obtain valuable market intelligence. Your market price is the aggregate assessment of many investors who have put their money where their mouths are. The market price aggregates a whole lot of information that you as a corporate manager may not learn as easily yourself. For instance, if your stock price seems very high relative to current fundamentals, it probably means that the market sees great opportunities ahead for your firm and expects that you will take them. Thus, you should consider growing the business. Naturally, a high firm value allows you to raise more funds from the financial markets at favorable rates. On the other hand, if the stock price is very low, it probably means that the financial market anticipates your business to go down or expects you to waste the remaining money. In this case, you should think carefully about whether you should reinvest investors' money into the business or into repurchasing the (relatively cheap) stock.

You can also learn from other market prices.

In addition to learning from your own company's market price, you can also learn from all sorts of other market prices. You can find out how good your competitors' opportunities are, and whether you should get into the fray. Commodity price information can also be very helpful. If the price of oil in the forward market is \$100/barrel, it probably does not make sense for you to plan ahead based on an oil price of \$70/ barrel. The financial market price for oil forwards is very large and efficient. It makes no sense for you to plan your business around much lower or higher oil prices in 6 months, simply because if you really knew this better, you could get rich easily without needing any of your current businesses—just start trading oil futures. This may sound obvious, but it is sometimes easy to overlook the obvious in the heat of battle. For instance, a large conglomerate oil company in the 1990s planned to explore for more oil, based on a working assumption of doubling oil prices within two years. This company could just have purchased oil in the market instead of drilling. Why explore for oil if you can buy oil cheaper in the market? If you are a farmer planting, the futures exchanges provide you with forward prices for corn and wheat, and you can use this free price information to help you decide which crop to plant.

Personal opinion alone (without synergies) is not a good argument for taking over other companies.

Let's consider a specific example of how you can learn from market prices in an efficient market. Put yourselves in the shoes of a smart and successful manager of an aircraft manufacturer. Every morning, you read the newspaper, and every morning you think that company X should really be worth a lot more. It makes no sense to you that X has annual earnings of \$10/share but its shares are trading at only \$50/share. X just seems undervalued. Should you go out and buy it? If the market is perfect, the answer is no. You would have no competitive advantage in owning X. The hordes of arbitrageurs could have accomplished it in an instant, and less expensively than you ever could. On the other hand, owning X would not do any harm, either. But let's take away the perfect market assumption and leave only the efficient market one. This means that both your aircraft company's price and the price of X are correct. Buying X because you think that X is undervalued is likely to be wrong. After all, our working assumption is that the financial markets have used all available information to find the best possible price.

However, in an imperfect market, it is possible for an acquisition to add value...

However, in the absence of perfect markets, the efficient market does not mean that you should never be able to create value by buying other companies. You can indeed sometimes create value. The trick is that you must be able to do something that investors cannot do for themselves, because the market is imperfect. Most likely, this would be related to your business's real operations. For example, if X is a supersonic aircraft parts supplier, you may have better information about the supplier's product. You may know that you will reward it with a huge contract soon. Or, by owning the patents of this supplier, you may make it more difficult for other aircraft companies to compete with you. Or you may find cost savings by cutting out the middleman in purchasing these parts, or improving X's products through your own intellectual capital, or by increasing the scale of operations. All of these can add value to the firm—value that

outside arbitrageurs cannot accomplish without you. (This violates the infinitely many potential buyers assumption of a perfect market.)

But be careful: Market efficiency means that you cannot create value for your shareholders simply by your personal view that X is undervalued. Yes, you may be smart, but the financial markets are just as smart and presumably could recognize just as well whether X is undervalued—in fact, chances are that the target was rightly valued to begin with and it was you who got the target value wrong. For example, if X manufactures diapers, it is highly unlikely that you would create value for your shareholders, even if the firm is trading for only 5 times earnings and this makes no sense to you.

...as long as you have more than just an opinion that the market got prices wrong.

The same argument applies to all sorts of other corporate actions. You may be able to create value by reducing perfect market barriers. For example, you may be able to create value by reducing the costs with which investors can trade your shares (e.g., by listing on an exchange). Or you may be able to reduce the mistrust that your investors have in your creditworthiness by hiring a good auditor or by reporting your earnings in a transparent fashion. Indeed, there is evidence that many corporate activities can create value by reducing the perfect market frictions, even in very efficient financial markets. For example, when firms split their shares 2-to-1, it is not necessarily the case that the two post-split shares are worth exactly half of the pre-split share of, say, $80. Instead, they tend to be worth a little more, say, around $40.20. The likely reason is that managers signal their confidence in the future by splitting shares today. This brings more information to the market.

In an imperfect market, you can also create value with financial transactions that reduce market imperfections.

➤ Splits as signals, Sect. 20.4, Pg.570.

If the Financial Market is Not Even Efficient

Loosely speaking, financial markets tend to be reasonably, but not always perfectly, efficient. Perfect market efficiency is almost surely *not* a good description of reality. Even in a perfectly rational market, as an executive, you may know the firm value better than the market—for example, you may know that your company is about to sign a large contract, but this information cannot yet be disclosed. What should you do if you know that the stock price is not equal to the appropriate market value? The right way to conceptualize your problem is to consider what you would do if you were the sole owner of the firm. You would really care about firm value. (As its executive, you should want to maximize this value on behalf of the owners.)

What should you do if markets are not efficient?

➤ Strong market efficiency, Sect. 12.2, Pg.284.

If your shares are undervalued, you should recognize that your cost of capital is effectively too high, given the true characteristics of your project. The reason is that you cannot raise risky capital at fair prices—especially equity capital. The CAPM clearly is no longer the right model for the cost of capital.

If you are undervalued, sometimes it is better to pass up positive-NPV projects...

For example, assume you know that your current projects will return $500 tomorrow. Also assume that you have no cash and that you can only raise financing through equity. Now assume you come across a new project that costs $100 and will return a terrific $200 tomorrow. The problem is that your investors do not believe that the firm will return $700, falsely believing that the combined firm will only be worth, say, $200. Thus, to raise $100, you would have to sell 50% of your firm, and keep only 50% of the true $700 return, for a true $350 share of it. You would therefore be better off passing up this new project and just taking the $500 from the old project. Put differently, the opportunity cost of new capital to fund this project is way too high for you.

➤ Separation of financing and investing, Sect. 11.1, Pg.245.

...and use your cash to repurchase your own shares.

You would definitely not want to raise cash at these "high" prices. Instead, you would want to do the opposite. The best use of corporate cash may now be to repurchase your own cheap, underpriced shares—for example, from other investors. However, there is an intrinsic paradox here: As an executive, you are supposed to act on behalf of your shareholders. Therefore, repurchasing underpriced shares from them at bargain prices would not be what would make the selling shareholders better off. (It would, however, make your remaining shareholders better off.)

➤ Share repurchases, Sect. 20.2, Pg.558.

If you are overvalued, sometimes it is better just to issue more shares.

If your shares are overvalued, your cost of capital would be very low. You should be tempted to take more projects. This is easiest to see if you again consider what you would do if you were the primary owner of this overpriced firm. You would want to sell more equity shares at higher prices and pay the money out in dividends to existing shareholders. (Alternatively, you can just invest in Treasury securities.) Here the paradox is, of course, that just one instant later, as CEO, you are now the representative of these new shareholders to whom you have just sold overpriced shares. They will not be happy campers. (Many researchers believe that this is exactly what happened when AOL purchased Time-Warner at the height of the Internet craze in the late 1990s. AOL used its overpriced shares to buy Time-Warner's real assets.)

These are robust insights for CEOs who are not conflicted and wish to act on behalf of their existing shareholders.

IMPORTANT

When managers have superior information:

- If the firm is undervalued, CEOs should assume a relatively high cost of capital and consider repurchasing the firm's own shares.
- If the firm is overvalued, CEOs should assume a relatively low cost of capital and consider issuing more of the firm's own shares.

A good decision rule for managers is to take projects up to the point where the marginal costs and benefits of projects are the same as what they could obtain from repurchasing or issuing the firm's own shares.

➤ Overconfidence, Sect. 13.7, Pg.339.

(It can become a bit more complex if you see yourself as a representative of both new and old shareholders, though.) But be careful: Most executives are notorious for *always believing* that the financial markets do not fully reflect the value of their companies even if they have no inside information—as an executive, you should be wary of your own perceptions and biases!

Q 12.22. For convenience, assume a zero discount rate. You have no cash on hand and can only raise financing for new projects by issuing more equity. You know that your existing project will truly return $500 next year. Everyone knows that your second, newer project costs $200, but only you know that it will return only $180 next year. This newer project is the only one that investors think is in line with your current expertise—you cannot raise funds and deposit them elsewhere (or any new investors would smell a rat).

1. Does your second, newer project have a positive or negative NPV?
2. If your investors know both true projects' costs, but they also (incorrectly) believe that you have the magic touch and any of your expertise projects will earn a rate of return of 100%, what fraction of the firm would you have to sell to raise $200 to start the new project?
3. If you act on behalf of your existing investors, should you take this new project?

Comparison and Summary

Here is a summary of the two conceptual classifications of how markets work:

A summary of the two market concepts and their consequences.

Efficient versus inefficient markets: If the market is efficient, you can learn from financial market prices, because they accurately incorporate the information of financial market participants. This means that you cannot create value by buying other companies just because you think that these companies are worth more than they are trading for.

If the market is inefficient, you may be able to identify underpriced firms that you can take over, or even create value by working on how information about your own company comes to the market.

Perfect versus imperfect markets: If the market is perfect, you can focus exclusively on your projects' net present values. You can forget about most financial choices, such as what your capital structure should be, how you should report earnings, and so on.

If the market is imperfect, you can create value, often by reducing the market imperfections themselves. For example, you could signal what you know about your company's prospects by reporting earnings sooner. On occasion, this can even become a dilemma: For example, what should you do if you know that a project has a positive NPV but the financial market does not believe you? If you take it, your stock price may go down. Now you have to think about the lesser of two evils—passing up on the project, or passing up on a higher stock price.

Don't be too dogmatic: Nothing is perfectly perfect, or perfectly imperfect.

In the real world, financial markets are definitely not 100% perfect. For large firms, they are very close to efficient, but this is not necessarily so for small firms. Still, the economic magnitudes of deviations should be fairly modest. As a real-world manager of a publicly traded corporation, it is generally better for you to focus on underlying value creation than on actions that investors can accomplish for themselves without you. It makes sense for you to believe that market prices are almost always informative, but not to believe too slavishly that they are also always fully efficient—you may have better information than the market. Use it wisely when you have it.

12.8 Event Studies

Market reactions should be immediate and reflect all value changes.

The immediacy of price reactions in any efficient market offers a surprisingly useful real-world application: In some cases, market price reactions can allow you to estimate value consequences more easily than traditional NPV techniques, using a technique called an event study. An **event study** is an empirical analysis of the effect of a set of events on the price of assets. The idea of an event study is that if the public market is valuing projects appropriately, and if the value of an unexpected event or action is $1 million, then the stock price should increase by $1 million at the instant the event becomes publicly known. You can therefore (often) back out cash flow value changes from stock price changes. The details of how to conduct such a study are in the appendix.

Capital-Structure-Related and Other Event Study Results

Event studies have been used on many different events. In finance, they often tell us whether corporate actions are good news.

Researchers have run event studies on all sorts of interesting events, ranging from new legislation, to corporate name changes, to analysts' opinions, to corporate earnings, to stock splits, to corporate dividends, to corporate debt and equity issuance and retirement, to deaths of the founder, and so on. Here are some of the more important findings. (You will see some more evidence obtained from event studies again in later chapters, especially in the chapters on capital structure and payout policies.) On the day of the announcement, firm values *increase* on average:

- When firms announce increases in dividends, share repurchases, or stock splits (by about 0.1-1%; if you are interested, there is a longer explanation in Chapter 20).

- When firms are taken over by other firms (by about 10-30%).
- When firms announce earnings that significantly beat analysts' expectations.
- When drug firms announce that the FDA has approved one of their drugs.
- When the founding CEO dies (by about 3-4%).

Bad news...

Conversely, firm values *decrease* on average:

- When firms announce new stock sales (by about 1-3%).
- When firms overpay for other firms in acquisitions.
- When firms announce lower-than-expected earnings.
- When firms fend off an acquirer who has made a bid.
- When drug firms announce that the FDA has rejected one of their drugs.

Unfortunately, because we do not know the markets' probability assessments prior to these announcements (some of the effects would have already been anticipated and thus already incorporated in the stock price), these value estimates are conservative lower bounds.

Government Regulation—who benefits? who does not?

Event studies have also informed us whether certain government regulations had a positive or negative impact on firms. For example, we know which firms were helped and which were hurt when the telecommunications, trucking, and airline markets were deregulated—or how the Treasury's rescue program of 2008 ("TARP") helped some banks, but not others.

The Effects of Sanctions on South Africa

South Africa's apartheid regime (1948–1994) rightly deserved to be overthrown. To accelerate its demise, the U.S. Congress imposed banking and tax-related sanctions on firms doing business with South Africa's apartheid regime.

We may all wish we could report success—that sanctions on South Africa's racist regime had been effective. Unfortunately, the event study evidence clearly shows that sanctions played no economic role. Upon the announcement of new sanctions or corporate divestments, neither prices of targeted U.S. companies nor of South African financial securities moved. One explanation is that there were too many loopholes and non-U.S. firms that were willing and able to evade the embargo.

Although we can conclude that, despite all its publicity, the embargo was largely ineffective economically, sanctions may still be appropriate on moral grounds regardless of their economic effectiveness. Whether to boycott socially objectionable behavior is a decision that policymakers should make, not economists. The role of the financial economist is only to inform policymakers of the ultimate effectiveness of their actions. Even this one failed on the economic effectiveness benchmark.

Teoh, Welch, and Wazzan, Journal of Business, *1999.*

Q 12.23. In a perfect market, what kind of response ("unusual" stock price change and "unusual" rate of return) would you expect when your company announces that it has struck oil and plans to pay a special dividend next month? What reaction do you expect over this month? What reaction do you expect on the day that it pays the dividends?

Q 12.24. What kind of corporate events are greeted as good news by the financial markets? What events are greeted as bad news?

Summary

This chapter covered the following major points:

- Market efficiency means that the market uses all available information in setting prices to offer "appropriate rates of return."
- In the short run, the appropriate expected rate of return on stocks must be small. Therefore, market efficiency prescribes that stocks roughly follow random walks.
- In the long run, it is rarely clear what this "appropriate rate of return" should be. Because noise makes it difficult to measure the average rate of return accurately, it is also difficult to test either models like the CAPM or long-run market efficiency.
- Beliefs in efficient markets come in different forms.
  - The standard efficient markets classification emphasizes what information it would take to beat the market: weak form (past stock price patterns are not enough to beat the market), semistrong form (other historical firm information is not enough to beat the market), and strong form (inside information is not enough to beat the market).
  - A more current efficient markets classification emphasizes the rationality of the stock market: true believer (stock prices always reflect underlying project NPVs), firm believer (small deviations between price and value, but difficult to take advantage of), mild believer (small deviations between price and value, and somewhat possible to take advantage of), or nonbeliever (arbitrage opportunities abound).
- The overall evidence suggests that it is not easy to become rich—a belief shared by most finance professors. The relative strength of their beliefs in market efficiency—the extent to which professors believe that market prices always reflect underlying value—separates finance professors into "rationalists" (or "classical" economists) and "behavioralists."
- In a perfect and efficient market, investors should not find arbitrage opportunities:
  - True arbitrage is a riskless bet with no negative net cash flows under any circumstances. Everyone would like to take all true arbitrage opportunities. When and if they appear, they are likely to be very small.
  - Risk(y) arbitrage is more like a great bet. An infinitely risk-averse investor would not want to take it, because there is a chance that risk(y) arbitrage will lose money.
  - Both true and risk(y) arbitrage opportunities should be very rare in the real world. An investor who is not too risk-averse may or may not prefer taking one large, great bet to taking one tiny, true arbitrage.
- Given the millions of investors, many will beat the stock market by chance, and some investors will beat the stock market many years in a row. Market efficiency does not mean that there are not some investors who will beat the stock market 10 years in a row *ex post*; rather, it means that any one particular investor is unlikely to beat the stock market *ex ante* 10 years in a row.
- Managers can learn valuable information from market prices, both from their own share prices and from other prices. To improve corporate firm value, managers must create fundamental value—they must undertake positive-NPV projects. Simple activities such as purchasing a random firm to lower risk or splitting shares will not add value.
- Event studies allow you to ascertain the corporate value impact of sharp events, such as election results, legislative action (FDA rulings), or corporate events (dividend increases).

Preview of the Chapter Appendix in the Companion

An online appendix illustrates a specific event study—the value relevance of the elections of 2006 for the overall market, health care stocks, and oil stocks. It explains the limitations of event studies—specifically, how it is important to take out the *expected* events and focus only on the unexpected, i.e., the real news.

Keywords

Behavioral finance, 283. Bid-ask bounce, 294. Brownian motion, 287. Classical finance, 283. Due diligence, 282. EMH, 283. Efficient market hypothesis, 283. Efficient, 277. Event study, 307. Fundamental trading, 284. Futures contract, 282. Great bet, 292. Market efficiency, 277. Noise trader, 284. Noise, 286. Random walk, 287. Rational economics, 283. Risk(y) arbitrage, 292. Semistrong market efficiency, 284. Signal, 286. Signal-to-noise ratio, 286. Spurious, 284. Strong market efficiency, 284. Survivorship bias, 298. Technical analysis, 284. True arbitrage, 291. Volatility, 286. Weak market efficiency, 284.

Answers

Q 12.1 The "efficient market" phrase is shorthand for "the market uses all available information in the setting of its price." There are further nuances about what "available" means, which creates different classifications of market efficiency.

Q 12.2 As a believer in market efficiency, you would point out that the heretics are wrong in how they measure the risk-reward trade-off (the model for what expected rates of return should be). Your second line of defense would be to ask the provocative question of why the heretics are not yet rich. (Of course, you would have to claim it was by pure chance if the heretic that you are talking to *is* rich.)

Q 12.3 Market efficiency is a much more powerful concept over short horizons, because the expected rate of return over a short horizon (say, a day) is very small (a few basis points) in virtually all reasonable models of market pricing.

Q 12.4 An efficient market is one in which the market uses all available information. In a perfect market, market pressures by arbitrageurs will make market efficiency come true, so a perfect market should be efficient. However, an efficient market need not be perfect. For example, stocks could be priced fairly even when there are taxes.

Q 12.5 Markets are more likely to be efficient when transaction costs are low, because this makes it easier for smart investors to compete away any unusual opportunities.

Q 12.6 The foreign currency market may well be the biggest market in the world, with the dollar and the euro being the world's two main currencies. With so many smart investors trading on the exact same instrument, and with incredibly low transaction costs, we would expect arbitrageurs to take advantage of even the smallest inefficiency. Thus, it would seem likely that the foreign exchange market is much more efficient—and much closer to perfection than, say, U.S. stock markets.

Q 12.7 Momentum strategies seem to violate even weak-form market efficiency—unless you believe that their returns are just normal because they reflect some sort of normal compensation for risk.

Q 12.8 If you believe that market values do not always perfectly reflect underlying fundamental values, but that trading costs nevertheless prevent you from exploiting this profitably (in large scale), then you should classify yourself as a firm believer in market efficiency.

Q 12.9 The random-walk formula is on Page 287. It states that the expected price tomorrow is the price today plus a drift. The drift can be a small constant or a very small fraction of the price today.

Q 12.10 There are about 250 trading days per year. More accurately, it is 252 on average. If a stock has an expected rate of return of 20% per year—which is definitely on the high side for most firms—the daily rate of return would be $1.2^{1/252} - 1 \approx 7.24$ basis points. If you computed the non-compounding $0.20/252 \approx 7.84$ basis points, or even used 365 calendar days instead of 252 trading days, you would still get a reasonably similar answer—the average daily rate of return is very small.

Q 12.11 A *daily* trading strategy would have to offer above 20% per annum in order to overcome typical transaction costs. The calculation in the text came to about 23% per annum.

Q 12.12 The typical movement (variation) of a stock is around plus or minus 2% to 3% a day. The average rate of return on a day is much lower. Thus, the signal-to-noise ratio is very low.

Q 12.13 Even if the stock price follows a random walk, its actual price can definitely—and most likely will be—different from today's. Only the *expected* price is the same as the price today.

Q 12.14 If you want to be a superstar trader who outperforms by, say, about 4% per year, you would have to earn an extra $\sqrt[252]{1.04}-1 \approx 1.6$basis points per day.

Q 12.15 With 100 basis points per day of noise and 200 basis points per year of excess performance:

1. With 1 day's performance, you would expect $200/252 \approx 0.794$ basis points per day.
2. The noise was given as 100 basis points per day.
3. The expected T-statistic is about $0.794/100 \approx 0.00794$.
4. Over 252 days, the performance was given as 200 basis points.
5. The noise would be $100 \cdot \sqrt{252} \approx 1,587$ basis points.
6. The expected T would be about $200/1,587 \approx 0.126$.
7. You need to solve $(0.79 \cdot N)/(100 \cdot \sqrt{N}) \geq 1.96$, or $0.0079 \cdot \sqrt{N} \geq 1.96$. The critical N is approximately 250 years.

Q 12.16 No! Treasuries earn money without risk, but they are not an arbitrage, because investing in them requires a negative net cash flow upfront.

Q 12.17 If the true arbitrage opportunity can only be done once and gains \$10, it is probably worse than a risk(y) arbitrage that loses 1 cent with 1% probability, and gains \$1,000,000 with 99% probability.

Q 12.18 Good topics to consider when thinking about how plausible an arbitrage is include: time and execution risk, direct and indirect transaction costs, price impact of trades, and fixed costs.

Q 12.19 Yes, it makes sense to look for high-ability managers among historical high performers. However, many high-ability managers will have underperformed historically, and many low-ability managers will have outperformed historically.

Q 12.20 If each of the 10,000 analysts has a 50-50 chance to beat the market in any given year, then the answer is that $10,000/2^{10} \approx 10$ analysts beat the market 10 years in a row.

Q 12.21 Survivorship bias means that you, as an investor, will only see the funds that were ex post successful. Most unsuccessful funds do not show up in the historical statistics of funds in existence today. Existing funds will therefore have had positive performances in the past.

Q 12.22

1. This project has a negative NPV, $-\$200 + \$180 = -\$20$, at the zero interest rate. (A positive interest rate would make it even more negative.)
2. If you do take this second newer project, all your investors would believe that your firm would be worth $(\$500 + \$200) \cdot (1 + 100\%) = \$1,400$. To raise \$200 in funding, you would therefore have to sell $\$200/\$1,400 \approx 14.286\%$ of your firm.
3. The true value of your firm will be $(\$500 + \$180) = \$680$, and the 14.3% stake is worth only \$97.14. Put differently, your old investors have just sold a \$180 project for \$97.14, giving them a net profit of \$82.86. You can also compute this directly: Your old investors will therefore own $(1 - 14.286\%) \cdot \$680 \approx \$582.86$. This is \$82.86 more than the \$500 that they would own if you did not take the new project. You should take it if you are acting on behalf of the existing investors.

Q 12.23 The immediate share price response to the news that you have struck oil would be positive. Over the following month, you would not expect any unusual upward or downward drift: It should be about zero. Finally, when your firm pays out the special dividend, the rate of return should be zero on average, too, because the market would have known that the dividend would be paid. Of course, its share price will have to drop by the amount of the dividend paid to keep the return around zero. Chapter 20 explains how this may not be the case in the presence of market imperfections, especially personal income taxes on dividend payouts.

Q 12.24 Good news: becoming an acquisition target; the announcement of new dividends, share repurchases, and stock splits; earnings significantly higher than analysts' projections; FDA approvals; and CEO deaths. Bad news: Acquiring other firms at too high a price; the issuance of new equity stock; earnings significantly lower than analysts' projections; declining an acquirer's bid; and FDA rejections.

End of Chapter Problems

Q 12.25. What kind of evidence would heretics against market efficiency ideally want to muster? If they fail to find this kind of evidence, does it mean that you should conclude that markets are efficient?

Q 12.26. Define "efficient market" and explain how it differs from a perfect market.

Q 12.27. Peter Lynch, a famous former fund manager for Fidelity, suggested that it is wise to invest in stocks based on "local knowledge"—you invest in the stock of your local supermarket if you notice that it does better than expected. In an efficient stock market, is this a wise recommendation?

Q 12.28. Evaluate the following statement: It does not matter what portfolio you are holding in a perfect and efficient stock market.

Q 12.29. A paper by Frieder and Zittrain looked at a large sample of spam email touting a particular stock. Such distributions increased the trading volume and resulted in a 4–5% gain over the 2 days following the spam release. Is this evidence against market efficiency?

Q 12.30. What are the three main categories in the traditional market efficiency classification? Give an example of what each excludes.

Q 12.31. Comment on the following statement: "An efficient market seems like an impossible concept. In an efficient market, no one can earn excess returns. Therefore, no one collects information. Therefore, prices do not contain information, and collecting information should earn excess returns."

Q 12.32. Describe the fundamentals-based classification of the strength of belief in market efficiency. Explain how one individual can be at one level but not in the level above or below.

Q 12.33. Does a random walk imply that the expected rate of return on a stock is zero?

Q 12.34. Define arbitrage. How is it different from a great bet? Is one always better than the other?

Q 12.35. Would it make sense for a model of the financial world to assume that there is no arbitrage? Would it make sense for a model of the financial world to assume that there are no great bets?

Q 12.36. Assume that the typical day-to-day noise (standard deviation) is about 100 basis points. Assume that you have the kind of stock-picking ability that earns you an extra 400 basis points per annum. Assume no transaction costs. Ignore compounding and assume that your rate of return is the sum of returns over trading days. Assume there are 252 trading days per year.

1. With only 1 day of performance, how much extra do you expect to earn per day?
2. How bad is your noise over 1 day?
3. What is your expected T-statistic (the excess mean divided by the standard deviation)?
4. With 252 trading days of performance, how much extra do you expect to earn per annum?
5. How bad is your noise over 252 days?
6. What is your expected T-statistic now?
7. Work out how many years you would expect to wait before you would obtain statistically significant evidence to prove that you have a positive ability to pick stocks.

Q 12.37. What kind of costs should you consider when evaluating whether an opportunity is an arbitrage?

Q 12.38. The typical hedge fund investor evaluates its fund based on the most recent three years of performance. What do you think of this practice?

Q 12.39. Why does the average mutual fund in the market today appear to have been a great performer? Does this evidence suggest that these funds will be good performers in the future, at least on average?

Q 12.40. Do you expect fund managers with high ability to prefer compensation that is more performance based? How good an "insurance" is this for fund investors?

Q 12.41. If a corporation acquires another firm, it can lower the firm's uncertainty. This should lower its cost of capital. This should create value. Is this correct?

Q 12.42. Give an example of how the cost of capital for taking a project can be too high if the market has undervalued your firm.

Q 12.43. For convenience, assume a zero discount rate. You know that your current projects cost $400 today and will truly return $500 next year—but your investors believe they will return only $400. In addition, you have no cash on hand and can only raise financing for new projects by issuing more equity. A new project costs $200 and will return $220 next year. Your investors mistakenly believe that your firm will earn an internal rate of return of 0%, either with or without this new project. Acting on behalf of your existing investors, should you take this project? Does it have a positive NPV?

13

Capital Budgeting Applications and Pitfalls

Tips and Tricks

Applying the concepts of NPV and IRR in the real world can be very difficult. This chapter explains many of the nuances and pitfalls in their application. It will help you avoid many common mistakes that many companies commit almost every day—mistakes that cost them value.

13.1 So Many Returns: The Internal Rate of Return, the Cost of Capital, the Expected Rate of Return, and the Hurdle Rate

Before we begin, let us just recap the four commonly used rates of return in finance: the *internal rate of return*, the *cost of capital*, the *expected rate of return*, and the *hurdle rate*.

In the real world, these four terms are often used casually and interchangeably.

Internal rate of return: The internal rate of return is a characteristic of project cash flows (hence "internal") and usually has nothing to do with capital markets (unless the project itself is a capital markets-related project). This is its big advantage—you can calculate it before you ever look at the capital markets. It is only later that you will compare the IRR to the prevailing rate of return in the economy. Because the IRR is really a descriptive statistic for the project with an internal focus, it is the most different of these four rates. Be careful, though: You should not use promised cash flows to compute it. IRR requires *expected* cash flows, which are much harder to come by.

➤ IRR, Sect. 4.2, Pg.59.

Cost of capital: Always think of it as the *opportunity* cost of capital. It is the rate of return your investors could expect to receive by investing in similar projects elsewhere. It is determined by the prevailing required rates of return for projects of your type. Therefore, it is driven by the demand and supply for capital in the economy—the expected rate of return that investors demand when they give money willingly. In perfect capital markets, with many lenders and borrowers, loans usually have zero net present values. (Otherwise, the borrower or lender is giving away free money.) The cost of capital is sometimes called the "required expected rate of return." (The CAPM is one perfect-market model that can provide an estimate of the cost of capital.) Finally, realize that the cost of capital is itself an expected value concept—you do not need to write the "expected cost of capital."

➤ Cost of capital, Sect. 2.5, Pg.22.

Expected rate of return: The expected rate of return is a generic term. It could mean your project's expected rate of return, or the cost of capital (the lender's expected rate of return). In most cases, if your project's actual expected rate of return is above its required expected rate of return (the cost of capital), then it is a positive-NPV project. If management makes smart decisions, projects' expected rates of return are above their costs of capital. The very

➤ Expected rate of return, Sect. 8.1, Pg.167.

last marginal project often has an expected rate of return just about the same as the cost of capital.

Hurdle rate: The appropriate project hurdle rate is the expected rate of return above which management decides to accept and go forward with the project. It is set neither by the financial markets nor by the project, but by management. Bad management could choose any arbitrary, or even outright idiotic, hurdle rate. Good management should accept all projects that have positive net present values.

Usually, this means that good managers should set a project's hurdle rate to be equal to its cost of capital. They should determine whether the project's IRR exceeds this hurdle rate. If management makes smart decisions, taking all positive-NPV projects, the "hurdle rate," "cost of capital," and "required expected rate of return" are all the same.

➤ Hurdle rate, Sect. 4.2, Pg.64.

Warning: The IRR should be an expected return concept, but it is often misapplied to promised returns.

You already know that expected project returns are difficult to come by. Managers often incorrectly use promised rates of return. Because corporations are aware that claims based on expected project returns are regularly inflated, many of them have established hurdle rates high above a reasonable cost of capital for such projects. It is common to find corporations requiring projects to have hurdle rates of 15% or more, even when the cost of capital for such projects would seem to be on the order of only 10%. Venture capitalists regularly employ project hurdle rates as high as 30%, knowing full well that this is far above the rate of return that their projects are *truly expected* to earn.

➤ Agency problems, Sect. 13.8, Pg.340.

The differences are sometimes subtle, and the terms are often used interchangeably—which is okay in many, but not all, situations.

Q 13.1. Can you compare a project's internal rate of return to its hurdle rate?

Q 13.2. Can you compare a project's cost of capital to its hurdle rate in a perfect market?

13.2 Promised, Expected, Typical, or Most Likely?

The simplest error—confusing promised and expected returns—is perhaps the worst.

By now, you know that you must always distinguish between promised and expected numbers. In particular, models like the CAPM are about expected rates of return and simply do not tell you anything about credit risk. When you want to apply the present value formula, you must use the *expected* cash flows in the numerator (adjusted for credit risk), not the *promised* cash flows. When it comes to your risk judgment, it goes into the PV numerator first. Never, ever discount promised cash flows with (CAPM) costs of capital!

Promised and Expected Returns

Here is how users get it wrong most of the time.

Let's recap this difference. Say the world is really as perfect as the CAPM suggests and you have a B-rated corporate zero-bond that promises \$1,000 next year and has a beta of 0.2. Assuming you believe the risk-free rate is 5% and the equity premium is 3%, you can still not compute the bond price as

$$\text{PV} \neq \frac{\$1{,}000}{1+5\%+3\%\cdot 0.2} \approx \$946.97$$

$$\text{PV} \neq \frac{\text{Promised Cash Flow}_i}{1+r_F+[E(r_M)-r_F]\cdot\beta_i}$$

Yes, in a perfect CAPM world, the expected rate of return on this bond should be $5\%+3\%\cdot 0.2 = 5.6\%$. (In an imperfect world, you would have to add the liquidity and tax premiums.) Yet, to determine the price, it is not enough for you to know the *promised* bond cash flow. You need the *expected* cash flow, a number that is always less than \$1,000. The same problem arises, of course, not only in the context of bonds but also in the context of corporate projects. You cannot simply discount the "good-scenario" cash flows. You must discount the project's expected cash flows!

➤ Imperfect market premiums, Sect. 11.6, Pg.264.

The same mistake appears sometimes in another form when managers use the IRR capital budgeting rule. This rule says "accept the project if its IRR is above the hurdle rate." The common mistake here is that the cash flows from which the IRR must be computed are not the promised cash flows, but the expected cash flows. Of course, you can also compute a number from the promised cash flows, but you should probably call it the "promised IRR" to distinguish it clearly from the "expected IRR"—and you should never compare the promised IRR to a hurdle rate based on the expected rates of return of other projects in the economy when you want to determine whether you should accept the project or not. In fact, the promised IRR should not be used for capital budgeting purposes.

For capital budgeting (comparison to the cost of capital), an IRR must be computed from the project's expected (and not promised) cash flows.

Q 13.3. An Amazon.com bond quotes an internal rate of return of 8% per annum. Assuming the market is perfect, is this its cost of capital?

Expected, Typical, and Most Likely Scenarios

Managers often commit a related (but milder) error in applying NPV. They tend to confuse expected values with "typical" or "most likely." (Statistically speaking, this means that they confuse the mean with the median or the mode of a distribution.) If you do this, you will fail to consider low-probability events appropriately: a plane crash, a legal suit, an especially severe recession, or a terrific new client.

The NPV formula requires expected cash flows, not typical cash flows. (Do not ignore low-probability events.)

For example, your business may have the following payoffs:

An example: The statistical distribution has a left tail.

Event	Probability	Value
Good Business	46%	$1,200,000
Normal Business	44%	$1,000,000
Lawyers Sue for Punitive Damages	10%	–$10,000,000

The most likely payoff is $1,200,000. The median payoff is $1,000,000. The expected payoff, however, is only

$$\begin{aligned} \mathsf{E}(\text{Payoff}) &= 46\% \cdot \$1{,}200{,}000 + 44\% \cdot \$1{,}000{,}000 + 10\% \cdot (-\$10{,}000{,}000) \\ &= -\$8{,}000 \end{aligned}$$

An NPV analysis requires *this* expected payoff. If you run this business 100 times, you would receive $1.2 million 46 times, $1 million 44 times, and lose $10 million 10 times. Fortunately, if the statistical distribution is symmetric—as it is in the case of the normal bell-shaped distribution—then the center of the distribution is all three: mean, median, and mode. Unfortunately, few businesses are immune to low-probability shocks, often negative, so you need to think about whether the distinction between mean, median, and mode is applicable to your business.

Q 13.4. A zero-bond promises $100,000 and has a beta of 0.3. If the risk-free rate is 5%, and the equity premium is 3%, and the CAPM holds, then what is the bond's price?

Q 13.5. A machine that costs \$910 is likely to break irreparably with 10% probability at the end of each year (assuming it has worked the previous year). (Many electric devices without moving parts have such breakdown characteristics.) However, the regulatory agency has phased out this machine, and so will neither allow you to replace it nor use it for more than five years. The machine can produce \$300 in profit every year, beginning next year. The discount rate is 12% per annum. (Hints: This means that the machine will produce some value between \$300/1.12 ≈ \$268 [if it breaks down immediately] and \$1,081 [if it lasts for all years] in present value.

1. What is the most likely number of years that the machine will last? If this number were instead guaranteed to be the certain life of the machine in number of years (instead of just the most likely number of years), what would be the machine's value?
2. What is the expected number of years that the machine will last? If this number were instead guaranteed to be the certain life of the machine in number of years (instead of just the expected number of years), what would be the machine's value?
3. What is the correct present value of this machine?

Hint: First, work this out case by case for a two-year machine, then for a three-year machine. Think "DDDD," "WDDD," "WWDD," "WWWD," and "WWWWD," where W means working and D means dead.)

13.3 Badly Blended Costs of Capital

Independent projects should be considered based on their own costs of capital.

One of your first lessons about NPVs was that you can add them if projects are independent. Yet, believe it or not, although most managers know that it is impossible to add value by merely combining independent projects, in practice they often make exactly this mistake. This error arises most commonly in contexts in which costs of capital need to be blended across multiple projects, and especially when projects are financed with different levels of debt and equity. As always, the concept is straightforward, but the devil is in the details. It is easy to overlook the forest in the trees. Let's make sure you do not commit this mistake.

Does Risk Reduction Create Value?

Synergies determine M&A value for shareholders; lower risk (diversification) does not. Managers, however, are conflicted: They like lower risk.

Recall the insight from Section 10.2 that companies cannot create value by reducing risk via diversification into multiple businesses. However, some mergers can add value due to synergies, which will be discussed in the next section. But these synergies are not a result of the plain diversification effect. Many researchers believe that the most common but unspoken rationale for mergers are not synergies but the fact that managers like to take over other firms. They prefer the reduced idiosyncratic firm uncertainty and higher salaries guaranteed by larger firms to the higher risk and lower salaries in sharply focused, smaller firms. To justify a merger, managers will want to argue for a lower cost of capital for the target any way they can—including incorrectly using the acquirer's cost of capital. (This is an example of an agency conflict, which will be explained later in this chapter.) There is also good evidence that in the real world, diversified firms often do not operate as efficiently as stand-alone firms (e.g., due to limited attention span of management or more bureaucratization). Many mergers actually *destroy* firm value.

Risk and Conglomeration

In the 1970s, a lot of firms diversified to become conglomerates. Management argued that conglomerates tended to have lower risk, which created value for shareholders. This argument was, of course, total nonsense: Investors could diversify for themselves. It was the managers who liked lower risk, with less chance of losing their jobs and higher compensation packages that came from running a bigger company. Worse, because conglomerates often operated less efficiently than individual stand-alone, focused companies, diversification actually often destroyed firm value. In the 1980s, there were many "bust-up buyouts," which created value by purchasing conglomerates to sell off the pieces.

A good example of such a conglomerate was Gulf and Western. It was simultaneously involved in oil, movies (Paramount), recording (Stax), rocket engines, stereo components, finance, publishing (Simon and Schuster), auto parts, cigars, and on and on. It promptly crashed and split up in the 1980s. A more current example is Tyco, which has over 260,000 employees in 50 separate business lines, including electronics, undersea fiber optic cables, health care, adhesives, plastics, and alarm systems. (Its former executive, Dennis Kozlowski, became famous for his extravagant looting of Tyco's assets. With so many business lines, no wonder no one noticed for years!) The most interesting conglomerate, however, may be General Electric. It has hundreds of business lines, but unlike most other conglomerates, GE appears to have been running most of its divisions quite well.

Oligopoly Watch *and other sources*

Does Corporate Risk Management Create Value?

Hedging is a form of risk management.

Although risk management is discussed in more detail in the companion chapter on options, let me give you a brief preview. Firms can reduce their own overall risk by **hedging**. A hedge is an arrangement that reduces the firm's volatility. For example, a refinery could purchase crude oil today in order not to suffer if the future oil price were to increase. (This is further discussed in the companion chapter on risk management and hedging.)

Hedging against stock market risk can lower the market exposure and/or risk of the firm. Hedging against jet fuel price increases can reduce risk exposure.

Remarkably, a firm with a high cost of capital and risk could even transform itself into a firm with a low cost of capital! (Hedge funds often do this.) The firm can hedge away market risk by selling the stock market itself. S&P 500 futures contracts make shorting the stock market exceptionally easy. Whenever the stock market goes up, the futures contract goes up in value. The futures contract sold by the hedging firm goes down in value. Put differently, the firm's hedge contract has a negative market exposure. The hedged firm is now a bundle, consisting of the unhedged firm plus this contract. Therefore, the market exposure of the hedged firm would be lower than the market exposure of the unhedged one. If it wished, the firm could even make its own market exposure zero or negative. Usually, being hedged against market risk would also reduce the overall idiosyncratic risk of the firm. Some firms may hedge against other risks. For example, Southwest Airlines has often purchased jet fuel far in advance (through futures contracts), though it is not altogether clear whether Southwest's intent was to hedge or to speculate.

➤ Shorting stocks, Sect. 7.2, Pg.155.

Does hedging create value? Only in an imperfect market.

But would this hedging contract create firm value in a perfect market? No. The firm has not given its investors a new positive-NPV project. If investors had wanted less exposure to the overall stock market, *they could have shorted the stock market themselves*. Alternatively, investors can simply undo a firm's hedging—they can buy the financial markets contracts that the firm has sold. This undoes any corporate hedge from the investors' perspectives. So, in itself, in a perfect market, trading fairly priced hedging contracts neither adds nor subtracts value. It is only if the market is imperfect that a hedge may allow a firm to operate more efficiently. For example, the extra cash from a hedge contract could help the firm to avoid running into a liquidity crunch in situations in which more funding would be difficult to raise. Or the firm may have inside information concerning what the future will hold and thus whether the hedged good is underpriced. In this case, risk management could add value.

IMPORTANT

In a perfect market, the following holds:

- If two firms are independent, then combining them into a conglomerate usually reduces the overall firm risk, but does not create value for investors. Investors can easily diversify risk themselves.
- Adding independent projects to the firm cannot create value if these projects are not positive-NPV in themselves.

In an imperfect market, the value effects of hedging are complex. Hedges could indeed add (or subtract) value.

Q 13.6. When two unrelated firms with uncorrelated rates of return merge, is the resulting conglomerate riskier or safer? Does this add value?

How to Misuse Costs of Capital

A common misuse of CC is to use a uniform cost of capital for all projects.

This brings us to a common simple NPV mistake: forgetting that the NPVs of independent projects are additive. Sounds obvious, but here is how it gets lost in the details: In a perfect market, NPVs are only additive if you use each individual project's own costs of capital. You cannot use the firm's overall cost of capital for its individual projects.

When Acquiring Another Company

Assume the firm uses the same overall cost of capital for all projects. old should not take new.

Your old firm, cleverly named *old*, is worth \$100 and has a cost of capital of 5% (maybe because its business is mostly holding debt). At a fair price, it expects to pay off \$105 next year. A potential acquisition target (or just a new project), cleverly named *new*, costs \$10 this year, expects to pay out \$11 next year, and has a cost of capital of 15% (maybe because its business is mostly holding a stock market portfolio). The simplest method to compute the value of acquiring project *new* relies on the fact that the NPVs of independent projects are additive. You can value the new project using its own expected cash flows and its own cost of capital. *Who* owns *new* should matter little: The project is worth what it is worth. Therefore, the true NPV of project *new* is

$$\text{NPV}_{\text{new}} = -\$10 + \frac{\$11}{1+15\%} \approx -\$0.43$$

Therefore, if *old* adopts *new*, the original owners of *old* become 43 cents poorer than they would have been otherwise (i.e., \$100 versus \$99.57). (If you want to practice the CAPM, think of a beta of 0.5 for the old project, a beta of 3.0 for the new project, a risk-free rate of 3%, and an equity premium of 4%.)

Bad company policy: Using its own cost of capital on this project, the firm would mistakenly take it.

Unfortunately, in many firms, it is standard policy to evaluate *all* projects by the firm's overall cost of capital. Would such an *old* firm take the *new* project now? Evaluated incorrectly at a cost of capital of 5%, the *new* project looks a lot better, $-\$10 + \$11/(1+5\%) \approx \$0.48$.

The loss if the firm takes this project is exactly the negative NPV of the project.

If the *old* firm did take project *new*, how would its value change? The true present value of the combined firm would be

$$\text{PV}_{\text{combined}} = \frac{\$105}{1+5\%} + \frac{\$11}{1+15\%} \approx \$109.57$$

$$\text{PV}_{\text{combined}} = \text{PV}_{\text{old}} + \text{PV}_{\text{new}}$$

This is 43 cents less than the original value of \$100 plus the \$10 acquisition cost of the new project. Taking *new* makes the *old* owners \$0.43 poorer.

Of course, not all acquisitions are driven by such mistakes. Don't make the mistake of reflexively thinking everything is a perfect market. Thus, it is not always true in the real world that mergers *never* add value on the cost-of-capital side. If capital markets are not as efficient for small target firms as they are for large acquiring firms, it would be possible for a large acquirer to create some value also on the cost of capital side. For example, if a target previously had no access to a perfect capital market, then the cost of capital to the target can change when it is acquired. The correct cost of capital for valuing the acquisition (the target), however, is still *neither* the cost of capital of the acquirer *nor* the blended post-acquisition cost of capital of the firm. Instead, the correct cost of capital is the lower rate that is appropriate for the target's projects, given the improved access to capital markets. For example, if an entrepreneur inventor of holographic displays previously had faced a cost of capital of, say, 303%, primarily due to access only to personal credit card and credit-shark financing, and if this inventor's business is bought by Intel with its cost of capital of 6.5%, the proper cost of capital is neither Intel's cost of capital nor a blended average between 303% and 6.5%. Instead, once part of Intel, the holographic project division should be evaluated at a cost of capital that is appropriate for projects of the risk class "holographic display projects." This can add value relative to the 303% earlier cost of capital. (Of course, there are also many examples of large corporations that have destroyed all innovativeness and thereby all value in small companies that they had taken over.)

Real-world exception: If the capital market for the target is inefficient, the act of acquisition can create value.

➤ Entrepreneurial finance, Sect. 11.5, Pg.263.

When Acquiring Another Project

It is not only firms to be acquired, but also smaller or sub projects themselves that can have components with different costs of capital. For example, when firms keep cash on hand in short-term U.S. Treasuries, such investments have a lower expected rate of return. These bonds should not need to earn the same expected rate of return as investments in the firm's risky long-term projects. (The presence of this cash in the firm lowers the average cost of capital for the firm by the just-appropriate amount.)

Projects must be discounted by their own costs of capital.

Here is another application, which shows how you can decompose projects into categories with different costs of capital: Assume that you consider buying a rocket to launch a telecom satellite next year. It would take you 1 year to build the rocket, at which point you would have to pay \$80 million. Then you launch it. If the rocket fails (50% chance), then your investment will be lost. If the rocket succeeds, the satellite will produce a revenue stream with cost of capital of, say, 13%, beginning immediately. (Telecom revenues may have a high covariance with the market.) The telecom's expected cash flows will be \$20 million *forever*.

A project can have components that require one cost of capital, and other components (even contingent ones) that require another cost of capital.

The correct approach is to think of the rocket as one project and of the telecom revenues as another. The rocket project has only idiosyncratic risk. Presumably, its risk can be diversified away by many investors, its beta is close to zero, and it may have a discount factor that is close to the risk-free rate of return—say, 3%. The rocket value (in millions of dollars today) is

The solution to this multi-cost-of-capital problem.

$$\text{PV}_{\text{rocket}} = \frac{\mathsf{E}\big(\text{Rocket Price}\big)}{\mathsf{E}\big(\text{r}_{\text{rocket discount rate}}\big)} = \frac{-\$80}{1+3\%} \approx -\$77.7$$

You can think of this as the cost of storing the \$80 million in Treasuries until you are ready to proceed to your second project. The telecom revenues, however, are a risky perpetuity. With telecom-like costs of capital of 13% and cash flows that appear only if the rocket succeeds (a 50-50 probability), its value is

$$\text{PV}_{\text{telecom}} = \frac{\mathsf{E}\big(\text{Telecom Cash Flows}\big)}{\mathsf{E}\big(\text{r}_{\text{telecom discount rate}}\big)} = \frac{50\% \cdot \$20 \;+\; 50\% \cdot \$0}{13\%} \approx \$76.9$$

Consequently, the combined project has an NPV of about –\$1 million. If you had mistakenly discounted the rocket's \$80 million cost by the same 13%, you would have mistakenly valued it at $-\$80/1.13 + \$76.9 \approx +\$6.1$ million.

Q 13.7. Some companies believe they can use the blended post-acquisition cost of capital as the appropriate discount rate. However, this also leads to incorrect decisions. Let's explore this in a CAPM context. (It could work without it, too.) The risk-free rate is 3%, the equity premium is 4%, and the old firm is worth \$100 and has a market beta of 0.5. The new project costs \$10, is expected to pay off \$11 next year, and has a beta of 3.

1. What is the value of the new project, discounted at its true cost of capital, 15%?
2. What is the weight of the new project in the firm? (Assume that the combined firm value is around \$109.48.)
3. What is the beta of the overall (combined) firm?
4. Use this beta to compute the combined cost of capital.
5. Will the firm take this project? (Use an IRR analysis.)
6. If the firm takes the project, what will the firm's value be?

Differential Costs of Capital—Theory and (Agent) Practice

In practice, a good number of firms do not use project-specific costs of capital.

➤ 2001 CFO survey, Sect. 4.5, Pg.69.

It is clearly correct that projects must be discounted by their project-specific costs of capital. Yet Graham and Harvey found in their 2001 survey that just about half of surveyed CFOs *always*—and often *incorrectly*—used the firm's overall cost of capital rather than the project-specific cost of capital! And even fewer CFOs correctly discounted cash flows of different riskiness within projects. (They sometimes do and sometimes do not take into account that cash flows farther in the future typically require higher expected rates of return—they should!) The easy conclusion is that CFOs are ignorant—and many CFOs may indeed incorrectly use a uniform cost of capital simply because they are ignorant. CFOs should at least use debt capacity and duration adjustments for differential project cost of capital.

A possible reason: Finding project costs of capital may just be too difficult. Intuitive methods may work better than formal methods.

➤ Imperfect markets premiums, Sect. 11.6, Pg.264.

However, even some intelligent CFOs use the same discount rate quite deliberately on many different types of projects. Why? You already know that it can be difficult to estimate the appropriate cost of capital correctly. In theory, markets are perfect and we know the cost of capital. In practice, this may or may not be a good approximation. Do you really know the correct expected rate of return for projects of this specific type? (Do you really even know the correct expected cash flows? Remember—this is not physics where we understand all the driving processes from the mechanics of the spinning wheel.) In addition, you have not even yet considered such issues as the influence of liquidity and tax premiums on your cost of capital. Quite simply, you must be aware of the painful reality that our present value methods are usually just not as robust as we would like them to be.

Flexible costs of capital can cause endless debate and worsen agency conflicts.

Together, your uncertainties distort not only your overall corporate cost-of-capital estimates, but also your relative cost of capital estimates across different projects. Consequently, the problem with assigning different costs of capital to different projects may now become one of disagreement. Division managers can argue endlessly about why their projects should be assigned a lower cost of capital. Is this how you want your division managers to spend their time? And do you want your managers to play revenue games? Managers could even shift revenues from weeks in which the stock market performed well into weeks in which the stock market performed poorly in order to conjure up a seemingly lower market beta. The cost-of-capital estimate itself then becomes a pawn in the game of agency conflict and response—all managers would like to convince themselves and others that a low cost of capital for their own divisions is best. What the overall corporation would like to have in order to suppress such "gaming of the system" would be immutable good estimates of the cost of capital *for each division and potential project* that no one can argue about. In the reality of corporate politics, however, it may be easier

to commit to one-and-the-same immutable cost of capital *for all projects* than it would be to have different costs of capital for each division and project. This is not to argue that this one cost of capital is necessarily a good system, but just that there are cases in which having *one* systemwide cost of capital may be a lesser evil.

In sum, a good rule of thumb in real life is not to worry too much about differential costs of capital across projects of similar horizon and financing class, unless your projects are vastly different. (A good rule of thumb in job interviews is to understand what you must do in a perfect world, though—you will be asked. Make sure to answer that each project needs its own cost of capital.)

Errors: Do Projects Really Need Their Own Costs of Capital?

You will never get the cost of capital perfectly right. Get it right where it matters!

But let's not get carried away. Does every project *really* need its own cost of capital? Don't miss the forest from the trees. Yes, in theory, each component must be discounted at its own discount rate if you want to get the value (and incentives) right. However, in practice, if you want to value each paper clip by its own cost of capital, you will never come up with a reasonable firm value—you will lose the forest among the trees. You need to keep your perspective as to what reasonable and unreasonable errors are. The question is one of magnitude: If you are acquiring a totally different company or project, with a vastly different cost of capital, and this project will be a significant fraction of the firm, then the choice of cost of capital matters and you should differentiate. However, if you are valuing a project that is uncertain and long-term, and the project is relatively small, and its cost of capital is reasonably similar to your overall cost of capital, you can probably live with the estimation error. It all depends—your mileage may vary!

IMPORTANT

- Theoretically, all projects must be discounted by their own costs of capital, and not by the firm's overall cost of capital.
- Practically, the effort involved, the uncertainty in your estimates, the distraction from getting your expected cash flows in the PV numerator right, and the "gaming" by division managers may prevent you from discounting every project—every paper clip—by its own cost of capital.
- Depending on the situation, you may be better off assigning the same cost of capital to all cash flows of similar maturity, perhaps with only a modest holistic risk adjustment.

It is up to you to determine when it is important to work with different costs of capital and when it is better to use just one cost of capital.

13.4 The Economics of Project Interactions

An example of projects whose cash flows are not independent. In fact, they "interact."

If projects are independent, you have the luxury to consider them in isolation. You can compute separately the costs and benefits necessary to make a decision whether to accept or reject each project. However, in the real world, projects are not always independent.

Let's assume that you are the only person who can service a market and that you assess your potential profits in different states to be \$120,000 in NY, \$60,000 in CA and \$40,000 in RI *if* you enter only one of them. However, it may cost an extra \$70,000 to develop states on different coasts simultaneously, but the cost of developing two nearby markets may be sharable among neighboring states. For example, say that the potential profit is not \$160,000 but \$200,000 if you develop NY and RI. So, how do you select the best set of projects? (You could think about negative consequences, too. For example, if your best reseller in CT threatens to withdraw

business if you develop either NY or RI [and even more if you develop both], you would have to figure this revenue loss into developing these two states.)

IMPORTANT

The ultimate project selection rule: Consider all possible project combinations and select the combination of projects that gives the highest overall NPV.

There are too many possible action choices in the real world to evaluate (to compute NPV for). You need rules and heuristics!

Optimal project selection is easier said than done. It is easy for the basic example with these three states (take NY and RI, skip CA), but this is rarely the case. For two projects at a time, there are usually only 2^2 options to consider: take neither, take one, take the other, or take both. But the complexity quickly explodes when there are more projects. For three projects, there are $2^3 = 8$ options. For four projects, there are 16 options. For 10 projects, there are about a thousand options. For 20 projects, there are over a million options. For 50 states, there are quadrillions. And even the simplest corporate projects can easily involve hundreds of decisions that have to be made. Mathematically, it is an impossible task to find the perfect combination.

The "greedy" heuristic: Always take the next most profitable project.

To help you determine which projects to take, you need to find some rules that help you make a decision. Such rules of thumb are called **heuristics**–that is, rules that simplify your decisions even if they are not always correct. One common heuristic algorithm is to consider project combinations, one at a time. Start with the project combination that would give you the highest NPV if you were only allowed to take two projects (one pair from a set of many different projects). For example, start with the state that has the highest profit. There are only 50 of them. Now consider adding each state. There are only 49 possible choices. Then take this pair as fixed, that is, treat it as a single project. Now see which of the remaining 48 states adds the most value to your existing pair. Continue until adding the best remaining project no longer increases value. Computer scientists call this the greedy algorithm. It is a good heuristic, because it drastically cuts down the possible project combinations to consider and usually gives a pretty good set of projects. There are many possible enhancements to this algorithm, such as forward and backward iterations, in which one considers replacing one project at a time with every other option. Full-fledged algorithms and combinatorial enhancements that guarantee optimal choice are really the domain of computer science and operations research, not of finance. Yet many of these algorithms have been shown to require more time than the duration of the universe, unless you make simplifications that distort the business problem so much that the results are likely no longer trustworthy. Fortunately, finance is in the domain of economics, and economics can help simplify the project selection problem.

Project Pairs

Project combinations can be classified into positive, zero, and negative interaction combinations.

Considering projects in pairs is not only common practice, but also clarifies many economic issues. With two projects, you can decompose the total net present value into three terms:

$$\text{Overall NPV} = \text{NPV Project 1} + \text{NPV Project 2} + \text{NPV Interactions}$$

For example, the original two state project (NY+RI) project choice yielded

$$\underset{\text{NY+RI}}{\$200{,}000} = \underset{\text{NY}}{\$120{,}000} + \underset{\text{RI}}{\$40{,}000} + \underset{\text{NY RI Interaction}}{(\$40{,}000)}$$

The final term reflects the interaction of the two projects. It suggests that you can classify project combinations into one of three different categories:

1. Projects with zero interactions
2. Projects with positive interactions

3. Projects with negative interactions

An **interaction** is also sometimes called an **externality** in economics, because one project has an external influence on another project—sometimes imposing external costs, and sometimes providing external benefits. Let's consider these three cases separately.

Zero Project Interactions

Most projects in this world are **independent**—they have no mutual interactions. For example, for Walmart, opening a mall in Japan probably has no effect on opening a warehouse in Canada. Independent project payoffs permit the separate evaluation of each project. This makes decision making much easier:

Project independence is the most common case. It allows the simplest decision making.

- Taking any positive-NPV project increases firm value.
- Taking a zero-NPV project leaves firm value unchanged.
- Taking any negative-NPV project decreases firm value.

If projects are independent, then the project interaction term is zero, and project NPVs are additive. Project independence makes decisions a lot easier: For 20 projects, only 20 independent decisions (accept or reject) have to be made, not a million.

IMPORTANT

You can simply add the project NPVs of independent projects.

Positive Project Interactions

Positive interactions mean that the sum of the parts is worth more than the parts individually. If one project has a positive influence on the NPV of another project, you cannot value it without taking into account this positive influence. For example, think of a new product as one project and of an advertising campaign as another. The advertising campaign project is of lesser use without the product, and the product is of lesser use without the advertising campaign. You must consider creating a product and an advertising campaign together. Such positive externalities are even more plentiful in smaller decisions. For example, a computer keyboard is less useful without a computer, and a computer is less useful without a keyboard. Many projects or products make sense only if bought together. In this case, producers may bundle them for their consumers.

In many cases, what makes a project a project in the firm's mind is often the indivisibility of its components.

In the corporate context, investment in *infrastructure* is another classic example of positive project interactions. For example, building a road, hiring a security firm, or laying a fast Internet connection could enhance the values of many divisions simultaneously. The firm should factor in the increase in value to *all* divisions when deciding on how much infrastructure to add.

Infrastructure can benefit many different projects.

Don't take positive externalities too lightly: On a philosophical basis, positive project interactions are the reason why firms exist in the first place. If there were no cost savings to having all resources combined in the firm, all of us could work as individuals and dispense with firms altogether.

Positive externalities are why firms exist to begin with.

IMPORTANT

When deciding whether to take a project, you must credit all positive interactions to the project. The overall NPV is higher than the individual project NPVs alone.

Internal conflict and cost allocation procedures (discussed further as "agency conflicts" in Section 13.8) often hinder corporations from taking advantage of many positive externalities. For example, in real life, your division managers might argue that they should not be charged for

Agency problems often prevent properly crediting projects with all their contributions.

the Internet connection, because they did not request it and therefore do not really need it (even if it were to increase their divisions' values). After all, division managers would prefer getting the Internet for free from the company instead of paying for it out of their own divisional budgets.

Another name for positive externalities: synergies.

Nowadays, managers who want to acquire other companies usually claim the presence of large positive externalities. **Synergies** are the managerial term for positive externalities between an acquirer and a potential acquisition target. It has become an important managerial buzzword. For example, in the 2001 acquisition of Compaq by Hewlett-Packard, HP touted synergies of $2.5 billion—most from cutting employees. Of course, whether enough synergies are ever realized to outweigh the acquisition costs is yet another question. (Like many other acquirers, HP performed quite poorly after the acquisition and may have never realized any of these synergies.)

Negative Project Interactions

Negative interactions exist when taking one project decreases the value of another project.

Negative interactions mean that the sum of the parts is worth less than the parts individually. In this case, projects have negative influences on one another and thereby decrease one another's value. Economists sometimes call such negative externalities **diseconomies of scale**. Here are a few examples.

Pollution and congestion: Think of an airline company with two divisions, but only one maintenance facility. One division handles cargo; the other handles passengers. If the cargo division wants to expand, it will use more of the maintenance capacity. This will leave the passenger division with longer service waiting times. In the extreme, the extra delays may cost the passenger division more than the extra profits that the expanded cargo operation adds.

Dilbert on Cannibalization and Agency I: 2013-04-02

Dilbert on Cannibalization and Agency II: 2012-10-20

Cannibalization: If a new Apple computer can produce $100,000 in NPV compared to an older Windows machine that produces only $70,000 in NPV, how should you credit the Apple machine? The answer is that the Apple would eliminate the positive cash flows produced by the existing Windows machine, so the cash flow of the project "replace Windows with Apple" is only $30,000: the $100,000 minus the $70,000 that the now-unused Windows machine would have produced. Be careful what you consider cannibalization, though. For example, in the 1970s, IBM did not produce personal computers, fearful of cannibalizing its mainframe computer business. IBM's mistake was that it did not realize that other computer manufacturers were able to step in and eat much of IBM's mainframe business for themselves. Put differently, IBM had not realized that the present value of its mainframe business's future cash flows had already changed with the advent of new technology in the competitive market that it was in.

Dilbert on inertia: 2012-09-26

Complexity: As more and more projects are adopted, management will find it increasingly difficult to make good decisions, and do so in reasonable time frames. As you just learned, projects can often impact other projects, and no manager knows every project and cares about them in the right mix.

In trying to deal efficiently with more scale and complexity, larger organizations typically adopt more detailed processes and bureaucracy. The cost is that such **Process** itself consumes resources and can reduce cash flows for all divisions. A good example of bureaucratic destruction of projects can be found on Moishe Lettvin's blog. (To find the url, remember that Google is your friend). A programmer who worked for Microsoft for 7 years, Lettwin describes how it took between 24 and 43 people, separated by six layers of management, over one year just to talk about the Windows boot menu—and no one really knew who had the power to make the final decision. However, bureaucracy and slow change are not always all bad—and this is why "process" exists to begin with. (I could have put Process as an example of "positive externalities," where larger firms have advantages.) For example, bureaucracy is required when clients (and government regulation) want to reduce the probability that individuals can steal money or make really

Dilbert on Flexibility and Persistence: 2012-11-20

bad spur-of-the-moment judgment calls. If anything, the financial world is headed towards more bureaucracy and control after the Bernie Madoff scandal. (It will become harder for smaller funds to compete.) The Catholic Church survived for thousands of years perhaps *because* it was so inflexible. It is the canonical example for what a **status quo** bias can do. The trick is to have the right amount of Process. Too much inertia, and the firm will forego many good new projects. Too little inertia, and the firm will be too fickle, and adopt bad projects and abandon good projects too early. In sum, the greater complexity that arises with more and larger projects can be a negative externality that every new project contributes to the firm.

Dilbert on Inertia and Status Quo: 2013-06-09

Dilbert on Bureaucracy: 2012-12-04

Resource exhaustion: Perhaps the most common source of negative externalities—and one that is often underestimated—is **limited attention span**. Management can pay only so much attention to so many different issues. An extra project distracts from the attention previously received by existing projects. There are many anecdotal examples of overstretched attention spans. A spectacular example of failed attention may be the Great Recession, which left many investment bank shareholders with huge losses, and which ultimately cost the CEOs of Merrill Lynch, Citigroup, and others their jobs (but not their wealth). Most of these supposedly highly competent (and highly compensated) CEOs did not even know what their firms' holdings and exposures were. They had to correct their own estimates multiple times, as they themselves learned only after the fact what their firms had actually invested in.

Although costs always include opportunity costs, in the case of negative project externalities these opportunity costs are more obvious. If your project cannibalizes another project or requires more attention, it's clearly an opportunity cost.

IMPORTANT

When deciding whether to take a project, charge all negative interactions to the project. Because of these negative interactions, the overall NPV will be lower than the individual project NPVs alone.

Again, as in the case of positive externalities, agency problems and cost allocation systems often prevent proper accounting for negative externalities in the real world. Whatever division created the negative externality will argue that it is not its problem and that the complaining division overstates the problem. Clearly, companies that are better at overcoming these issues will end up being more profitable.

Again, agency problems often prevent properly crediting projects for all their detractions.

Q 13.8. Why is it so convenient to value projects that have zero externalities with one another?

Q 13.9. A company must decide if it should move division A to a new location. If division A moves, it will be housed in a new building that reduces its operating costs by $10,000 per year forever. The new building costs $120,000. Moving division A allows division B to expand within the old factory. This enables B to increase its profitability by $3,000 per year forever. If the discount rate is 10%, should division A move?

Q 13.10. A firm can buy a new punch press for $10,000. The new press will allow the firm to enter the widget industry, thereby earning $2,000 per year in profits forever. However, the punch press will displace several screw machines that produce $1,500 per year in profits. If the interest rate is 10%, should the new punch press be purchased?

13.5 Evaluating Projects Incrementally

Capital budgeting rule for a scenario in which you can either take or not take one extra project. The rest stays in place.

Usually, managers do not make the decision for all interacting projects simultaneously. Instead, many projects are already in place. Although existing projects should also constantly be evaluated in an ideal world, the manager often has to make a decision about adding or not adding a single new project (or project complex) in the real world. For practical purposes, the old projects are often present, given, and unalterable. The new project may have positive or negative externalities on other existing projects, and the question is how best to decide whether to take it or not. This simplifies the decision even further: The question is now only whether the new project adds or subtracts value from the total. In this case, economists use the concept of decision **on the margin**—holding the existing project structure as is, what is the *additional* contribution of the new project?

You can come to the right decision by using the marginal method, too.

➤ State Example, Sect. 13.4, Pg.324.

Return to the U.S. state example. Let's work it via the method of contributions on the margin. Naturally, we should arrive at the same conclusion:

- If you have already committed to RI, you would earn only \$40,000. Adding NY would get you to \$200,000. Thus, entering NY would bring marginal benefits of \$160,000 (and not \$120,000).
- If you have already committed to NY, you would earn only \$120,000. Adding RI would get you to \$200,000. Thus, entering RI would bring marginal benefits of \$80,000 (and not \$40,000).

Note that having one of the states committed increases the marginal value of the other state that you should use in your calculations.

IMPORTANT

- The decision on whether to take one additional project should be made based on the following rule:

$$\text{Accept New Project If: } \begin{array}{c}\text{Total Firm NPV with}\\ \text{New Project}\end{array} > \begin{array}{c}\text{Total Firm NPV without}\\ \text{New Project}\end{array}$$

- This means that the single new project should be credited with any value increase or value decrease that it confers on other projects.
- When considering a project on the margin (i.e., extra), credit/charge to this project all externalities that this project conveys onto the existing firm.
- Everything else equal, projects with positive externalities on the rest of the firm have higher marginal benefits than do projects with negative externalities.

The big advantage of the marginal method is its solvability when there are many, many choices—possibly infinitely many.

Although the marginal perspective on costs and benefits has also worked for our discrete "yes or no" projects, it becomes a lot more useful when you consider projects of which you can take a little more or a little less. (In fact, enumerating all possible combinations is no longer feasible.) Marginal thinking also helps you to understand economies of scale, sunk costs, overhead allocation, and space capacity. The marginal perspective on costs and benefits is particularly useful when it comes to projects that are not just "yes or no" but are projects of which you can take a varying amount—more or less of the project. With rare exceptions, the incremental way of thinking is the only way to make sense out of real-world complexity.

Q 13.11. A notebook computer costs $2,500; a desktop computer costs $1,500. If you buy either the notebook or the desktop, you can increase your productivity to $9,000. If you buy both, you can increase your productivity to $11,000. (There is no time-value dimension to your choice.) Assume there is no computer resale market or alternative use for a computer.

1. If you do not own either, should you buy the notebook, the desktop, both, or neither?
2. If you own the notebook, should you buy the desktop? What are the marginal costs and benefits?
3. If you own the desktop, should you buy the notebook? What are the marginal costs and benefits?

Economies of Scale

Consider an example in which there are **economies of scale**—the more airplanes you build, the lower your average per-airplane production cost will be (in millions):

An example in which your production function is continuous and exhibits economies of scale.

$$\text{Average Cost per Airplane} = \$4 + \frac{\$10}{\text{Number of Airplanes} + 1}$$

This states that it costs $\$4 + \$10/(1+1) = \$9$ million to produce 1 airplane. Producing 100 airplanes costs you $\$4 + \$10/(100+1) \approx \$4.10$ million per airplane. Again, let's assume that the interest rate is zero, so you do not need to discount.

Now say that you are currently selling 4 airplanes domestically, each for a price of $8 million. Your firm's net value is

Should you expand production?

$$\begin{matrix}\text{Total Net Value}\\ \text{with 4 Airplanes}\end{matrix} = 4 \cdot \$8 - 4 \cdot \left[\$4 + \frac{\$10}{4+1}\right] = \$32 - \$24 = \$8 \qquad (13.1)$$

Your big decision now is whether you should expand internationally. It would cost you $16 million to open a foreign sales office, but doing so would sell another 5 airplanes at the same $8 million per-airplane price. Should you expand?

With 9 airplanes in production, your average cost would fall to $\$4 + \$10/10 = \$5$ million per airplane. This means that 5 airplanes would cost only $25 million to build now, and bring in $5 \cdot \$8 = \$40$ million. The value of your foreign office would therefore be

An average cost calculation tells you not to expand.

$$\begin{matrix}\text{Value of Foreign Office} & = & 5 \cdot \$8 & - & 5 \cdot \$5 & - & \$16 & = & \text{-}\$1\\ \text{Value} & = & \text{Gross Sales} & - & \text{Average Cost} & - & \text{Start-Up Cost} & & \end{matrix}$$

This calculation suggests that you should not expand internationally.

Unfortunately, this calculation is wrong. To see this, compute your *total* net value if you open the foreign office. Your 9 airplanes generate sales of $72 million. Subtract your production costs of $9 \cdot \$5 = \$45$ million and your opening costs of $16 million. This means that your firm would be worth

Wrong! The reason is that the foreign sales office also lowers the cost of domestic production!

$$\text{Total Net Value with 9 Airplanes} = 9 \cdot \$8 - 9 \cdot \$5 - \$16 = \$11 \qquad (13.2)$$

This is more than the $8 million that you earned without the foreign office. This is the correct calculation. It tells you that you should expand internationally, because this expansion will increase your net value by $3 million.

The difference between the right and the wrong calculation is that your foreign office has one additional marginal benefit that the first calculation overlooked: Foreign sales also reduce the average production cost of your domestic production. This cost reduction is a positive externality that you must credit to your foreign office. If you do not, you are throwing away $3 million.

You must credit the foreign office with any domestic cost reductions.

Thinking in terms of marginal costs exposes the economies of scale.

It is often more intuitive to think of projects such as airplanes in terms of marginal costs and benefits. The extra marginal cost of each airplane changes airplane by airplane—it is the difference in total costs of all airplanes:

Planes	Average	Total	Marginal	Planes	Average	Total	Marginal
1	\$9.00	\$9.00	\$9.000	6	\$5.43	\$32.57	\$4.238
2	\$7.33	\$14.67	\$5.667	7	\$5.25	\$36.75	\$4.179
3	\$6.50	\$19.50	\$4.833	8	\$5.11	\$40.89	\$4.139
4	\$6.00	\$24.00	\$4.500	9	\$5.00	\$45.00	\$4.111
5	\$5.67	\$28.33	\$4.333	10	\$4.91	\$49.09	\$4.091

If you go from 4 to 9 airplanes, your production creates extra marginal costs of $\$4.333 + \$4.238 + \$4.179 + \$4.139 + \$4.111 = \$21$ (million). There is an additional marginal cost of \$16 million to open the foreign office. The total marginal cost is therefore \$37 million. The marginal benefit of 5 extra airplanes is \$40 million. Therefore, your foreign sales office creates marginal value of $\$40 - \$37 = \$3$ million. This is exactly the difference between \$8 million from Formula 13.1 and \$11 million from Formula 13.2. Thinking in terms of marginal costs and benefits is just a different and sometimes more convenient way to compare overall project values.

Economies of scale are often responsible for the big corporate success stories of our time.

Economies of scale (decreasing marginal costs) are often responsible for the biggest corporate success stories. For example, Amazon, Wal-Mart, and Dell have managed not only to use their scales to negotiate considerable supplier discounts, but they have also created inventory and distribution systems that allow them to spread their fixed costs very efficiently over the large quantities of goods they sell. They have the lowest costs and highest industry inventory turnover rates—two factors that allow them to benefit tremendously from their economies of scale. Similarly, Microsoft enjoys economies of scale—with a large fixed cost and almost zero variable cost, Microsoft can swamp the planet with copies of Windows. No commercial alternative can compete—Microsoft can always drop its price low enough to drive its competitor out of business. The socially optimal number of operating-systems software companies is very small and may even be just one—it is what economists call a **natural monopoly**. If you think of the economy as one big firm, you would not want to incur the same huge fixed software-development cost twice. The same applies to utilities: You would not want two types of cable strung to everyone's house, two types of telephone lines, and two types of power lines. But companies with monopolies can also hurt the economy: They will want to charge higher prices to exploit their monopoly powers. Society has therefore often found it advantageous to regulate monopolists. Unfortunately, the regulatory agencies are themselves often "captured" by the companies that they are supposed to regulate—a fact that can sometimes hurt the economy even more than the monopolies themselves. There are no easy and obvious solutions.

Negative economies of scale work alike.

Of course, there are also plenty of examples in which marginal costs are not decreasing, but increasing, with the number of items produced. In such cases, you must charge the diseconomies of scale to the new division you are adding. If you do not, you will be inclined to overexpand and thereby reduce your firm's overall value.

Q 13.12. The average production cost per good is estimated at $\$5 + \$15/(x+1)$. The firm can currently sell 10 units at \$20 per unit.

1. What is the current total profit of the firm?
2. How much should the firm value the opportunity to sell one extra good (i.e., #11) to a new vendor? In other words, what is the marginal cost of selling one extra good?

3. A new vendor offers to pay \$19 for one unit. However, your other existing vendors would find out and demand the same price. What is the marginal cost and benefit of signing up this new vendor now? Should you sign up this new vendor?

Q 13.13. A firm faces diseconomies of scale in both production and sales. It can produce goods for an average per-unit cost of $\$5 + (Q \cdot \$1 + \$20)/100$, where Q is the number of units. For example, to produce 10 goods would cost $10 \cdot (\$5 + \$30/100) = \$53$. The market price per good is $\$7 - Q \cdot \$1/100$. So, sales of 10 goods would generate $10 \cdot (\$7 - \$10/100) = \$69$ in gross revenues. Use a spreadsheet to answer the following questions.

1. How many items should the firm produce?
2. What are the average per-unit gross sales at this point?
3. What is the average per-unit production cost at this point?
4. What are the average per-unit net sales (gross minus cost) at this point?
5. What are the marginal per-unit sales at this point?
6. What is the marginal per-unit cost at this point?
7. What is the marginal per-unit net change at this point?
8. If your average per unit net change at this point is positive, should you expand production? Why or why not?

Sunk Costs

Sunk costs are, in a sense, the opposite of marginal costs. A **sunk cost** is an incurred cost that cannot be altered or reversed. It is a done deal and therefore should not enter into your decisions today. It is what it is.

Sunk costs cannot be altered or reversed and thus should not enter into your current decisions.

For example, consider circuit board production—a very competitive industry. If you have just completed a circuit board factory for \$1 billion, it is a sunk cost. What matters now is *not* that you spent \$1 billion, but how much the production of each circuit board costs. Having invested \$1 billion is irrelevant. What remains relevant is that the presence of the factory makes the marginal cost of production of circuit boards very cheap. It is only this marginal cost that matters when you decide whether or not to produce circuit boards. If the marginal board production cost is \$100 each, but you can only sell them for \$90 each, then you should not build boards, regardless of how much you spent on the factory. Though tempting (and often adopted), the logic of "we have spent \$1 billion, so we may as well put it to use" is just plain wrong. Now, assume that the market price for boards is \$180, so you go ahead and manufacture 1 million boards at a cost of \$100 each. Alas, your production run has just finished, and the price of boards—contrary to everyone's best expectations—has dropped from \$180 each to \$10 each. At this point, the board production cost is sunk, too. Whether the boards cost you \$100 to manufacture or \$1 to manufacture is irrelevant. The cost of the production run is sunk. If boards now sell at \$10 each, assuming you cannot store them, you should sell them for \$10 each. Virtually all supply costs eventually become sunk costs, and all that matters when you want to sell a completed product is the demand for the product.

An example of how first the capital investment becomes sunk, and then how the produced goods themselves become sunk.

Sunk costs are everywhere. With the passage of time, virtually all decisions at some point become irrevocable and thus sunk. The examples are so abundant that you can even find whole books about them. Allan Teger's book *Too Much Invested to Quit* describes investments such as the continuing Concorde airplane development even after it had already become clear that it would never become profitable.

Sunk costs are everywhere!

Time is a good proxy for what is sunk, but it may not be the deciding factor.

One more note—time itself often, but not always, decides on what is sunk or not. Contracts may allow you to undo things that happened in the past (thereby converting a sunk cost into a cost about which you still can make decisions), or they may bind you irrevocably to things that will happen in the future.

IMPORTANT

A sunk cost has no cost contribution on the margin. It should therefore be ignored.

Exasperation—letting sunk costs frustrate you and cause you to misinterpret your marginal costs and benefits.

The flip side of not ignoring sunk costs and refusing to throw in the towel is "exasperation"—though it can come about through compartmentalization (explained in Section 13.7). It can occur when you think that you have already put too much money into the project, and rather than spend any more, you throw in the towel. You just consider your budget to be exhausted and you abandon the project, rather than doing the right thing (which would be to finish it).

Overhead Allocation

Allocating already existing overhead budget to a project (i.e., adding it to the new project's cost) is a common real-world example of bad project valuation and decision making.

A closely related mistake is to forget that "overhead" is often a sunk cost. By definition, overhead is not a marginal cost but something that has been incurred already and is allocated to departments. For example, assume your firm has spent $500,000 on a computer that is currently idle half the time. It serves only one division. Assume that another division can take an additional project that produces $60,000 in net present value but will consume 20% of the computer's time. Should your firm take this project? If 20% of the cost of the computer is allocated to this new project (i.e., $20\% \cdot \$500{,}000 = \$100{,}000$), the net present value of the new project would appear to be –$40,000. But the correct decision process is not to allocate the existing overhead as a cost to divisions. The $500,000 on overhead has already been spent. The computer is a sunk cost—assuming that it really would sit idle otherwise and find no better purpose. It may seem unfair to have charged only the original division for the computer and exempt the other opportunistic divisions. Yet taking this additional project will produce $60,000 in profits without any additional cost—clearly, a good thing. Everyone who has worked in a corporation can recite plenty of examples in which overhead allocation has killed otherwise profitable projects.

Real-World Dilemmas in Allocating Spare Capacity

If capacity is otherwise unusable, it should have a zero price.

Limited capacity is a subject that is closely related to overhead allocation. For example, consider building or buying corporate car garages that can park 300 cars for $1.5 million per garage. As CEO, you have to make choices about how many garages you want to have and how you should charge your corporate divisions for parking spots. Of course, having a garage makes owning corporate cars more profitable, because they will not deteriorate as much. A new garage offers a positive externality on the project "corporate cars."

Average cost allocation—an empty parking spot problem.

Here is a bad solution to your problem: Charge users the average cost of building the garage. For example, you may calculate that about 150 cars from your corporate divisions would volunteer to use it, then divide the cost of $1.5 million by 150, and allow these divisions to buy spots at $10,000 each (which may be equivalent to, say, $60 rent per month). First, you may run into the standard overhead allocation problem. You may find that 75 of the 150 cars may not even take you up on the offer, and you may have to increase the rate to $120 per month. At this rate, more may jump ship, and you may end up with no cars wanting to go in. Second, even if you get all 150 cars to sign up, you still end up with another 150 empty spots—spots that could be used to park other, older corporate cars. You would never have built a garage just for them, but it would make sense to put them into the existing garage if it is otherwise empty. The marginal cost of adding one more old car would be zero. Is this how you should price parking spots?

If you charge zero to the division for older cars, how would your other divisions with newer cars, who are still paying for their parking spots, feel? Should these divisions be charged then? After all, the marginal cost of their new cars, given that the garage is already built, is also zero. These are internal cost allocation issues that inevitably bring out the worst in discussions among corporate division managers. Everyone will claim that it should be the other party that should pay more of the cost.

Should you charge your new division? Should you charge anyone?

One reason why this is so difficult is that you can only add capacity in discrete chunks. And there is a time dimension, too. Should you really charge zero for parking corporate cars if you suspect that the unused capacity will not remain unused forever? What if another division comes along that wants to rent the 150 currently unused garage spaces in the future? Do you then kick out all the older cars that you gave spots to for free (or a very low price)? How should you charge this new division if it wants to rent 160 spaces? Should you give it the 150 remaining unused parking spots for free and build a new garage for the extra 10 cars? Presuming that garages can only be built in increments of 300 parking spots each, should you build another 300-car garage? Should this new division pay for the new garage, or should the divisions that held the original 150 spots pay a part of this or relinquish some of their original spots? If you ask the new division to pay, should it get a refund if some of the 290 spots are eventually rented out? Should you charge parking fees for these 290 spots? Tough questions.

Often you do not have easy, smooth margins. And you face more questions—these are difficult real-world dilemmas.

Usually, you should think in terms of the relevant marginal benefits and costs. But this does not work well if capacity can only be added in large discrete chunks. In that case, the extra cost of just one more parking spot is either zero or $1.5 million. If you charge marginal cost, demand also may not be marginal. At an internal price of zero, you will likely have a large number of users—more than the garage can accommodate. At a price of $1.5 million, no user will want to pay for the garage. You can think of less extreme schemes, but the basic problem is intrinsically the discreteness of capacity.

Here is how to think about the parking allocation in terms of margins.

Remarkably, there are clear answers as to how you should solve your two dilemmas:

1. **Pricing of existing capacity:** You should use the magic of the market-price system to allocate your existing capacity. You should set the internal price of each parking spot so that those users who would value the garage the most will want to reserve exactly the 300 spots that are available. Do not set the parking spot price so that the garage generates maximum profits. (If you do, you may find yourself with parking rates that are too high, and cars that are parked on the street while the garage has some unfilled spots.) If there are more existing spots than cars that could benefit from a spot, then you should even set the parking spot price to zero. From an overall corporate perspective, it does not matter how or who you charge—just as long as you get the optimal capacity utilization. To the extent that cost allocation distorts optimal marginal decision making (i.e., that cars that should be in the garage end up not using the garage), it should be avoided.
2. **Building more capacity:** You should build more capacity when the marginal cost of adding the garage of $1.5 million is less than the marginal benefit of parking cars indoors. In principle, this is easy. In practice, this is difficult, because you need to forecast future parking needs.

Advice: Use a market-pricing system if you can, to push the decision down to the divisions themselves. But do not try to maximize garage profits.

Note that neither of these two decision rules requires the garage to generate profits by itself. In fact, your goal is to maximize the overall profit of the firm, which is achieved through optimal capacity allocation. It is irrelevant whether this increase comes about through a profitable garage or through more profitable divisions.

Managerial Gaming

Unfortunately, real life is not always so simple. Return to the earlier example of an Internet connection that has a positive influence on all divisions. You know that divisional managers will not want to pay for it if they can enjoy it for free—you cannot rely on them telling you

It becomes much harder if you do not know the right outcome, so you have to "play games" with your subordinate managers.

correctly how much they will benefit. Would it solve your problem to charge only divisions that are voluntarily signing up for the Internet connection, and to forcibly exclude those that do not? If you do this, then you could solve the problem of everyone claiming that they do not need the Internet connection. However, you are then stuck with the problem that you may have a lot of unused network capacity that sits around, has zero marginal cost, and could be handed to the nonrequesters at zero cost. This would create more profit for the firm. Of course, if you do this, or even if it is suspected that you will do this, then no division would claim that it needs the Internet to begin with, so that they will ultimately get it for free. For some projects, it is not clear whether financial incentives can solve even the most basic problems—if one of your top scientists has focused decades of her life on exploring Resveratrol as a potential longevity drug, do you really believe this scientist will now tell you if some of her preliminary findings now point towards a non-finding?

➤ Internet connection example, Pg.325.

HQ often flies blind.

In sum, what makes these problems so difficult in the real world is that as the boss, you often do not know the true marginal benefits and marginal costs, and you end up having to "play games" with your divisional managers to try to make the right decision. Such is real life! And in real life, more often than not, headquarters just mandates Internet usage and charges divisions for it, whether they like it or not. Hopefully, this is also the correct choice from a firmwide value-maximization perspective.

Q 13.14. A company rents 40,000 square feet of space and is using 30,000 square feet for its present operations. It wishes to add a new division that will use the remaining 10,000 square feet. If it adds the division, equipment will cost \$210,000 once, and the operations will generate \$50,000 in profits every year. Presently, the office staff costs \$160,000 per year. However, the expansion requires a larger staff, bringing costs up to \$180,000 per year. If the cost of capital $r = 10\%$, should the firm expand?

13.6 Real Options

A real option is the value of the flexibility to change course in the future.

There is another valuation issue that you have to consider. It can be even more important than externalities—and more difficult to work out. It is the fact that your ability to change course in the future, depending on the prevailing economic environment in the future, can itself create value. Such flexibility is called a **real option** (or sometimes a **strategic option**). In principle, the valuation of a real option is just a complex variant of the NPV problem. You have to assess all expected cash flows and their costs of capital correctly. In practice, the resulting complications can be so difficult that entire books have been written on this subject. Let me give you a taste of what real options are and how to value them.

A Specific Real Options Example

An example of a factory.

A factory costs \$3 million to build. It can transform \$2 million worth of inputs into 1 million gadgets. If demand is strong, gadgets will sell for \$9 each. If demand is weak, gadgets will sell for \$1 each. The discount rate is 10%. Presumably, the expected value of the factory is therefore (in millions)

$$\text{NPV} = -\$3 + \frac{50\% \cdot (\$1 - \$2) + 50\% \cdot (\$9 - \$2)}{1.1} \approx -\$0.273$$

$$\text{NPV} = \text{Factory Cost} + \text{Present Value of Net Sales}$$

You should not undertake this project. Or should you?

Prob	Component	Ignore Real Option Always Run Factory (Dumb NPV)	Recognize Real Option Shut Down if Optimal (Smart NPV)
50% Demand is Weak	Factory, Time 0	–$3 million	–$3 million
	Inputs, Time 1	–$2 million	$0 million
	Sales, Time 1	+$1 million	$0 million
	Net, Time 1	= –$1 million	= $0 million
	⇒ NPV at 10%, Time 0	**–$3.909** million	**–$3** million
50% Demand is Strong	Factory, Time 0	–$3 million	–$3 million
	Inputs, Time 1	–$2 million	–$2 million
	Sales, Time 1	+$9 million	+$9 million
	Net, Time 1	= $7 million	= $7 million
	⇒ NPV at 10%, Time 0	**+$3.364** million	**+$3.364** million
	Total Net Present Value	**–$0.273** million	**+$0.182** million

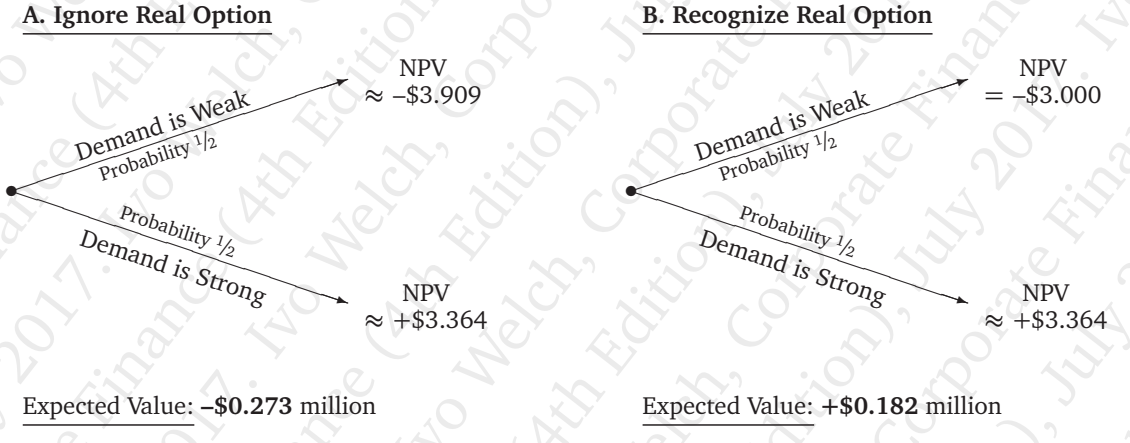

Exhibit 13.1: *A State-Contingent Payoff Table for the Factory.*

Without the real option, you could have calculated the NPV using just the most likely (expected) pricing path.

Take a look at Exhibit 13.1. Without considering real options, there are two possible outcomes:

1. **Weak demand:** The running factory will yield –$1 million in net sales, which turns into –$3.909 million in total net present value.
2. **Strong demand:** The running factory will yield $7 million in net sales, which turns into +$3.364 million in total net present value.

Because both outcomes are equally likely, your loss is the $0.273 million already calculated.

With the real option, you can shut down the factory if there is no demand.

However, if you can shut down the factory when demand is weak, then your factory is worth more. You still get the upside (a full $3.364 million in present value), but you no longer suffer the full –$3.909 million downside. That is, you would still be out the upfront $3 million cost of the factory, but you would avoid the extra future running loss of $1 million. *With* the real option to shut down when demand is weak, your factory is worth about $50\% \cdot (-\$3) + 50\% \cdot (\$3.364) = +\$0.182$ million. (If you are really clever, you may detect that I am falsely assuming that your cost of capital is still 10%. This may no longer be the case. However, the contribution of your cost-of-capital uncertainty to your valuation is usually much more modest than the contribution of your cash flow uncertainty.)

Uncertainty usually makes real options more valuable!

Remarkably, real options are an instance in finance where you actually like uncertainty in the underlying economic environment. For example, how would you value the project if you could change the sales from the +$1 and +$9 million to $0 and +$10 million? In the bad state, it would not make a difference to you. You would still just shut down the factory and lose $3 million. However, in the good state, you would now earn $8 million next year, not $7 million. Your NPV would therefore go from $0.182 million to $50\% \cdot (-\$3) + 50\% \cdot (\$4.273) \approx +\$0.637$ million.

Family resemblance: This particular real option is like limited liability.

With its real option, this firm is a little similar to a contingent equity claim: *As owner, you can still get the upside, but you do not suffer the full downside*. However, it is not the limited liability that has created this payoff pattern. Instead, it is your managerial flexibility that increases the factory's expected cash flow. Your flexibility means that this factory is well worth building.

➤ Limited liability, Sect. 6.4, Pg.123.

Q 13.15. Your factory can either stamp 150,000 CDs at a cost of $5 per CD, or 500,000 CDs at a cost of $8 per CD. If your CD has a hit song, you can sell it to retailers for $10 per CD. Otherwise, you can only charge $6 per CD. There is a 1-in-10 chance that your CD will be a hit. You will not find out whether you have a hit until next year, but fortunately this will be before you have to stamp CDs. Your cost of capital is 10% per year. You only have the lease of the factory for next year. There is no production this year.

1. What is the expected selling price per CD?
2. How many CDs should you produce at the expected selling price—that is, if you had to gear the factory for a particular production quantity today?
3. What is the value of your factory if you can decide next year?
4. What is the value of flexibility in this example?

Importance and Valuation Difficulty

The reason why real options are so difficult to value is that you get the wrong answer if you are working out the value at the expected (or most likely) inputs. In our example, the expected gross sales were $(50\% \cdot \$9 + 50\% \cdot \$1) = \$5$ million. This was more than the \$2 million cost of inputs. Thus, you could conclude that you should operate, which would give you \$3 million in expected net sales *next year*. But then you realize that this is not enough to cover the \$3 million in upfront factory costs *today*. You would therefore most likely conclude that you should not undertake the factory—a mistake because you failed your real-option analysis. In effect, in our example, working with the expected inputs is the same as assuming that you would always act the same way in the future, regardless of demand. Instead, the correct way to value a real option is first to consider all possible future demand scenarios, then to determine your own optimal behavior and the resulting cash flows in each scenario, and only finally to compute expectations over all possible scenarios. This is almost always easiest to do in a decision tree, like the one at the bottom of Exhibit 13.1. In management-speak, it is called **scenario analysis**.

You cannot work out the project value based on the expected input and output costs. You must work out a scenario analysis in a decision tree.

IMPORTANT

- The expected value of a project is not the value of the project at its expected value or its expected inputs.
- This means that you cannot value a real option by computing project value in the expected (or most likely) scenario.
- Instead, you must first determine all possible scenarios, then figure out your own behavior and the cash flow this earns in each scenario, and only finally compute the expected net present values over all scenarios.

➤ Sensitivity analysis, Pg.57.

Here is what real-world managers tell us they do.

Sensitivity analysis is a close relative of scenario analysis. It means trying out different assumptions to see how sensitive the NPV is, and it is usually done in a valuation spreadsheet. If it considers different managerial responses, it becomes, in effect, a form of scenario analysis. **Simulation analysis** (also called **Monte Carlo simulation**) can be an automated form of sensitivity or scenario analysis. It, too, is sometimes used to value real options. These methods can be simple or complex, and are generally beyond the scope of this book. (More real option valuation techniques are explained in a web chapter, which—you should be warned—is a difficult chapter.) Valuing real options is so complex that it is not used as often as simpler NPV techniques, but it is also not obscure. In the same survey described in Section 4.5, 27% of surveyed CFOs explicitly value real options. About 52% perform sensitivity analyses and 14% perform simulation analyses.

➤ CFO valuation method survey, Sect. 4.5, Pg.69.

Real options are tough to value. If the optimal decision depends on the past history (and not just the current environment), then this problem becomes even harder.

The ubiquity and economic importance of real options are unfortunately often matched by the difficulties that arise in estimating their values. They become both economically more important (and more difficult to value) when projects last longer and when there are many possible economic scenarios. You have to figure out what you would do in every possible *future* scenario. Sometimes, this is feasible. If there is only one variable that determines your optimal action, such as one prevailing product price, then the problem can often be broken down in a way that simplifies it. Sometimes, this is not feasible. If your decisions cannot be made based on just one variable, but instead depend in turn on the future or the past, then the complexities become vexing. For example, if it costs money to close and reopen your plant, then your decision to close the plant must also depend on your assessment of how quickly the product price can recover. If there is a good chance of recovery soon and if closing/reopening a factory is expensive, you may take your chances and continue operating your factory even if you incur a small loss. In turn, this means that you may find yourself with an operating or nonoperating plant, depending on the history of past demand, and this can influence what you decide to do in this period, too.

With history dependence, even your optimal decision rule itself can be very difficult to work out. In any case, the current product price is no longer the only decision variable that you have to take into consideration, and this makes it a complex problem.

There are also cost-of-capital implications, but we have mostly ignored them.

A final complication is that the presence of a real option can have an influence not only on the expected cash flows but also on the cost of capital. For example, if this real option helps you to avoid losses when the stock market goes down, then your market beta and/or your cost of capital could be lower, too. You already know that the cost of capital can have a strong value influence, especially for long-lived projects. However, compared to your headache of estimating the uncertainty about your cash flows and of assessing your own future flexibility, your headache about the right cost of capital is usually only a secondary malaise.

➤ Cost-of-capital errors, Sect. 4.1, Pg.57.

Embedded Real Options

Here are some other examples of real options.

Most corporate projects teem with embedded real options that arise with your ability in the future to change course. For example:

Expansion or contractions: If the future turns out better (or worse) than expected, firms can expand (or contract). In the extreme, firms may outright abandon a project.

Acceleration and delay: If the future turns out better (or worse) than expected, firms can speed up (or slow down) projects. This can often be done by hiring (or firing) additional consultants and contractors.

Switching: Different technologies may be best in different future scenarios—and some projects may be more amenable to multiple technology alternatives.

Spinoffs: If a technology makes a serendipitous discovery, firms can start entirely new businesses.

The companion chapter on real options values some examples of these options.

Many projects are nothing except real options.

In fact, many projects are nothing but real options: For example, the value of unused land around cities is essentially the option that the city might expand enough to make building on the land economically worthwhile. Research and development often have no immediate usefulness, or even usefulness in the most likely scenario—but there is a chance that they might yield a highly profitable discovery. You have to consider this real option value in your expected cash flow computation, or you will underestimate your project's value.

Different projects contain different types of real options.

Real options become even more tantalizing when you consider not just the real options for one particular project but the fact that different projects come with different types of real options. For example, replacing workers with expensive, high-fixed-cost robots may be cheaper in the most likely scenario, but it effectively gives up on the real option to lay off workers if the future turns out worse than expected. Have you properly valued the project that has more real options?

It is most important to recognize the real options that you have.

Obviously, it would be best if you knew perfectly the types and exact values of all your real options. In practice, this is usually impossible. You should therefore focus on the most important real options. Strange as it may sound, the most common mistake that many managers commit when it comes to real options is that they just do not recognize that the real options are there. Once you recognize real options, even if you cannot fully value them, at least you can try to find an "intuitive" value adjustment. Fortunately, you have one further bit of knowledge that may help you here: The presence of a real option can only increase project value, because it is the value of *your* flexibility.

Deeper: This chapter's appendix escalates the depth of explanations for real options. The *Real Options* web chapter escalates it even further.

13.7 Behavioral Biases

Model inputs are usually not what they should be.

So far, we have neglected the fact that you need accurate inputs and that you need to use them rationally if you want to make good decisions. But most cash flow and cost-of-capital estimates rely on human judgment, which is prone to all sorts of errors. We know that our brains tend to commit systematic decision errors. Managers who fail to recognize these biases will make poor decisions.

Innate human decision biases cause predictable valuation mistakes.

There are literally dozens of well-known behavioral errors, but limited space allows us to highlight just three: **overconfidence**, **relativism**, and **compartmentalization**.

1. **Overconfidence** is the tendency of people to believe that their own assessments are more accurate than they really are. In lab experiments, ordinary people are found to be dramatically overconfident. When asked to provide a 90% confidence interval—which is just a range within which they are confident that their true value will lie in 9 out of 10 times—most people end up being correct only 5 out of 10 times.

   It is difficult to document overconfidence empirically—after all, if it were easy, managers would recognize it themselves and avoid it. However, there is empirical evidence that many managers who are already heavily invested in their own company tend to throw caution overboard and voluntarily invest much of their own money into the corporation—even in companies in rather shaky financial shape. There is also good empirical evidence that those of us who are most optimistic in overestimating our own life expectancy disproportionately will become entrepreneurs. Even if optimism is a disease, it seems to be a necessary one for entrepreneurs!

Dilbert on managerial overconfidence: 2013-01-18

Small Business Failures

In New York City, two out of every five new restaurants close within one year. Nationwide, the best estimates suggest that about 90% of all restaurants close within two years. If successful, the average restaurant earns a return of about 10% per year. Owners seem to lose money on average. So, why open yet another restaurant? I mentioned earlier that restauranteurs may just enjoy owning restaurants. But a more likely explanation is that restauranteurs are overly optimistic and just do not realize how tough it is to run a restaurant profitably.

More generally, a Small Business Administration study of small business failures from 1989 to 1992 found that 33% of businesses failed within 2 years, 50% within 4 years, and 66% within 6 years. Yet in a survey of about 3,000 entrepreneurs, 81% of entrepreneurs believed that their chances of success were at least 70%, and 33% believed that they had zero chance of failure!

San Diego Online (Jan 2002), Business Week (Apr 2001), WSJ (Oct 2002), and other sources

2. **Relativism** is the tendency of people to consider issues of relative scale when they should not. For example, most people are willing to drive 15 minutes to a store farther away to save $40 on the purchase of $80 worth of groceries, but they would not be willing to drive the 15 minutes to a car dealer farther away to save $100 on the purchase of a new $20,000 car. The savings appear to be less important in the context of the car purchase (0.5%) than in the context of a grocery purchase (50%). But this is flawed logic, similar to comparing IRRs while ignoring project scale. The marginal cost is driving 15 minutes extra, and the marginal benefit is a higher $100 in the context of the car than the $40 in the context of the groceries. Put differently, the problem is that humans tend to think in terms of percentages. The smaller the amount of money at stake, the more severe this problem often becomes. When a gas station advertises a price of $2 per gallon rather than

Sidenote: To understand overconfidence better, you can go to the class notes accompanying this chapter and take the quiz (questionnaire). Taking this quiz will make you understand overconfidence better than reading long paragraphs of prose here. (Incidentally, the only population segments who are known not to be systematically overconfident are weather forecasters and clinically depressed patients.)

$2.10, some customers drive for miles and wait in long lines—all to fill a 20-gallon gas tank at a total savings that amounts to a mere $2.

3. **Compartmentalization** is the tendency of people to categorize decisions. Most people are more inclined to spend more when the same category has produced an unexpected windfall earlier. For example, winning a lottery prize while attending a baseball game often makes winners more likely to buy more baseball tickets, even though the project "baseball game" has not changed in profitability. Similarly, an unexpected loss may stop people from an otherwise profitable investment that they should make. For example, say an individual likes to attend a particular baseball game. If she loses her baseball game ticket, she is less likely to buy a replacement, even though the cost and benefit of buying the ticket are the same as they were when the original ticket was purchased. Compartmentalization can sometimes be the opposite of the sunk cost mistake. For example, Federal Express went through three venture capital funding rounds in the 1970s, the first two leading to rather disappointing operating profits. The investors who then compartmentalized—refusing to throw "good money after bad money"—lost everything. Only investors in the final venture capital round got rich.

Know thyself to avoid these errors!

Q 13.16. Is relativism a bigger problem when evaluating small or large projects?

Q 13.17. Describe how common mental decision biases can bias NPV calculations.

13.8 Incentive Issues

Incentive problems arise when the information provider has incentives that are different from those of the project owner.

Mental biases are not the only source of bad choices. Another kind of bias arises when one individual has to act on behalf of others. This is called an **agency** problem or **moral hazard**. For example, it occurs in situations in which the owner of a project has to rely on information from someone else, who has divergent interests.

The essence of the problem.

A cynical synopsis of agency biases would be that "all people act and lie in their own self-interests." Now, although everyone does have incentives to lie—or at least to color the truth—to make themselves better off, not everyone does so equally. Of course, not many people sit down and contemplate how to intentionally lie and cheat. Instead, they convince themselves that what is in their best interest is indeed the best route to take. Thus, mental biases often reinforce incentive problems: "Wishful thinking" is a disease from which we all suffer.

Try to hire ethical employees...and please behave ethically, too.

My strong personal advice is to hire only employees that you judge to be intrinsically honest and ethical (and even then, not to tempt them too much). Ultimately, unethical employees will always find a way to cheat you, no matter how good your controls are. But figuring out who is intrinsically honest is also very difficult: sociopaths seem notoriously honest. It's what makes them so dangerous. Sadly, economics and finance training can often reinforce unethical tendencies. Such training points out what you can do to enrich yourself and almost makes it seem normal and acceptable. Some version of the rationalization "it's their own fault—it's what they should have expected" comes into play. I hope you won't fall into this trap. Instead, *please* follow the golden rule: treat others as you would like to be treated.

Dilbert on Ethics and Self-Interest: 2012-10-06

In the end, this section's message is simple: you should keep in mind that despite their best attempts to control cheating, organizations remain rife with agency problems. It's a pragmatic realization.

Some Examples of Moral Hazard

Conflict-of-interest dilemmas are pervasive and important in organizations.

Agency problems exist up and down the corporate ladder. Top management has to rely on division managers who have to rely on department managers who have to rely on their subordinates for information about what they should do and how profitable potential projects really are. You can take the fact that we have already had to mention agency problems repeatedly to indicate how important and pervasive they are. But again, lack of space forces us to highlight just a few issues with some examples:

1. **Competition for capital:** Managers often compete for scarce resources. For example, division managers may want to obtain capital for their projects. A less optimistic but more accurate estimate of the project cash flows may induce headquarters to allocate capital to another division instead. Thus, division managers often end up in a race to make their potential projects appear in the most favorable and profitable lights.

2. **Employment concerns:** Managers and employees do not want to lose their jobs. For example, scientists may tend to highlight the potential and downplay the drawbacks of their areas of research. After all, not doing so may cut the project and thereby cost them both their funding and then their jobs. Think about it—how can you evaluate new drug development, when the only person who understands it is the scientist herself?? Once hired, employees like to be indispensable. This leads them not to want to communicate about their work to potential successors. It is well-known that many IT departments live on not *despite* but *because* of poorly designed software. CEOs rarely like to groom potential successors.

   Dilbert on Mentoring and Succession: 2013-07-17

   Dilbert on Indispensable Wally: 2013-03-10

3. **Perks:** Managers do not like to give up perks. For example, division managers may like to have their own secretaries or even request private airplanes. Thus, they are likely to overstate the usefulness of the project "administrative assistance" or "private plane transportation."

4. **Power:** Managers typically love to build their own little "empires." For example, they may want to grow and control their departments because bigger departments convey more prestige and because they are a stepping stone to further promotion, either internally or externally. For the same reason, managers often prefer not to maximize profits, but instead focus on maximizing sales.

5. **Hidden slack:** Managers like to be able to cover up problems that may arise in the future. For example, division managers may want to hide the profitability of their divisions, fearing that headquarters may siphon off "their" profits into other divisions. They may prefer to hide the generated value (through legal accounting maneuvers discussed in the next chapter), believing that the cash they produced in good times "belongs" to them and that they are entitled to use it as "plaster" in bad times.

6. **Reluctance to take risk:** Managers may hesitate to take on risk. For example, they may not want to take a positive-NPV project because they may get fired if it fails—and may not be rewarded enough if it succeeds. A popular saying once was that "no one was ever fired for buying IBM." Then, Microsoft took over from IBM. Then, Oracle. Then, ...

7. **Direct theft:** Managers and employees have even been known to steal outright from the company. For example, a night club manager may not ring sales into the cash register. Or a sales agent may "forget" to charge her cousins. In some cases, this can be a fine line. Is taking a pad of paper from your company or answering a personal email on company computers really theft? In other cases, the theft is blatant. In September 2002, Dennis Kozlowski, former CEO of Tyco, was charged with looting $600 million. His primary defense was that he did so in broad daylight—with approval from the corporate board that he had helped put in place. (It was a little too brazen—Dennis spent 10 years at Club Fed.)

Contributing Factors

Agency problems are worse in certain (known) situations.

We do know where agency problems play bigger and lesser roles:

1. **Scale and owner engagement:** In a small company with one owner and one employee, agency conflicts are less important than they are in big corporations with their many layers of management and disengaged owners.

   Do you believe that professionally run companies really make the best decisions on behalf of their public shareholders? Remember that agency issues do not just arise between shareholders and management—they start with the lowest-level employee and bubble all the way up to the top-level CEO. Decision making is often based on a chain of miscommunications or even deceptions. It is a testament to the importance of sharing risks among many investors that large, publicly traded companies still manage to net-in-net create shareholder value!

2. **Project duration:** If the project is short term and/or comes with good interim progress points, it is easier to reward managers appropriately for success and punish them for failure than it is for longer-term projects. For example, think how you would judge and reward a manager who is (supposedly) working on an R&D project that is not likely to have visible results for decades. This is a difficult task. Agency problems for large and very-long-term projects may be so intrinsically high that they cannot be undertaken.

3. **External noise:** If good luck is an integral and important part of the project, it becomes more difficult to judge managerial performance, which in turn aggravates agency problems. For example, it is relatively easy to measure the productivity of a line worker in a factory; you know whether he works or slacks off. Therefore, agency problems matter less. In contrast, it is more difficult to determine if your sales agent worked hard but the customer just did not bite, or if your sales agent was to blame. Similarly, your night-watch security guard may or may not be working hard, and it could take years before you could learn (probably the hard way) whether she regularly stayed awake or just dozed off.

4. **Opaqueness:** If information is very difficult for outsiders to come by, agency problems will be worse. For example, if only your manager sees what projects are available, he can present only those that he would like to undertake. He can also not mention those that have higher NPVs but require skills he may not have or that require work he finds unpleasant.

Dilbert on Wally's Choice: 2012-12-02

Control Mechanisms

There are mechanisms that can help control agency problems.

Fortunately, the principals (i.e., the owners) are not helpless. There are a number of mechanisms that can help alleviate agency problems.

1. **"Voluntary" Disclosure:** If it is possible for employees to volunteer their information credibly (e.g., that they can be sued after the fact if they have lied), then firms can insist on employees disclosing this information. For example, think of a situation in which every division claims that it has better projects than others. If it was possible for divisions to reveal everything they know, even if they did not want to (because the information is bad), there would be no agency problem. Headquarters would simply not fund any division that did not disclose everything.

Dilbert on Compensation Specificity: 2012-11-28

2. **Contract Specificity:** It may be possible to write contracts that are detailed and specify everything that your employee or contractor might or might not do. Of course, if you want to write too detailed a contract, then the other side will begin to wonder what your own true intentions are—or even take it as a license to commit bad-faith behavior that your contract forgot to specify.

Dilbert on Contract Specificity: 2013-07-07

3. **Audits:** If the company runs independent assessments or **audits**, managers can make decisions based on better information, even if their employees are unwilling to provide it. However,

many consultants suffer from the same disease as employees: They know that they are most likely to be rehired if they tell the manager what she wants to hear.

4. **Truth-telling incentives:** If managers can be rewarded for telling the truth, agency conflicts will become less important. For example, if your company has a research scientist who has expertise in alpha-proteins and works on an alpha-protein project, your goal as manager should be to allow this scientist to say, without suffering any negative consequences, "Do not waste your money putting any more research dollars into alpha-proteins." This means that the scientist's salary and promotion chances must remain the same regardless of the research outcome—even if this means that she no longer has a good alternative use for her time and effort. You might even offer a reward for any scientists who voluntarily cancel their projects due to lack of viability.

   Would you really be willing to carry through on such a promise? Would your research scientists believe that you will?

   Some companies also undertake **post-audits**, which are designed to evaluate not only the quality of the financial numbers (like a usual audit) but also the quality of managers' upfront forecasts. Knowing that there will be such post-audits will strengthen managers' incentives to give accurate forecasts to begin with.

5. **Contingent compensation:** If managers are rewarded more for a successful project (or if they are more likely to be retained), agency conflicts can become less important. This is the carrot-and-stick approach. For example, if you pay your managers bonuses only when their projects succeed (or fire them when their projects fail), then your managers may work harder and choose projects that they believe are more likely to succeed. The press calls this **pay-for-performance**—and there is much argument about whether U.S. CEOs are paid so much because they need to be motivated and because they work so hard, or because the corporate board members are their friends.

   Of course, like any other mechanism to control agency problems, the pay-for-performance control strategy has its costs, too:

   - Competent managers may not want to work for you if they get paid only if the firm succeeds. You may end up driving the best risk-averse managers to work for your competition instead.
   - Risk-averse managers may not take positive-NPV risky projects.
   - Contingent compensation creates incentives to inflate performance—not to tell the truth.
   - Less risk-averse managers may take *huge* negative-NPV risks in order to gamble for a *huge* bonus. This is a *huge* problem in the financial services industry. Pay-for-performance is a good idea when employees can only improve the average outcome if they work harder. It was invented in the context of factory piece work. Pay-for-performance is a bad idea when employees can also increase the variance of outcomes. In this case, traders and CEOs may want to ramp up risk, especially when their performance is not properly benchmarked for risk (which is very difficult to do). Would you prefer 10% of a $1 million gamble or a $1 billion gamble? Pay-for-performance then becomes a recipe for disaster.

   You will sometimes read that humans are more complex than these examples. Here is my own take: It is true that aspects other than pay can help motivate your employees. But with exceptions, your employees first and foremost work for compensation. (In the military, soldiers will risk their lives for comrades and sometimes for medals and rank.

Nerdnote: PS: The next financial crisis is already pre-programmed: the incentives in the financial industry are still all wrong today. (And don't think the government is the salvation. It's like asking the fox to guard the hen house.)

Dilbert on Cash vs. Recognition Comp: 2013-05-19

In charities, many employees may be truly altruistic.) The violations are interesting, not because they are so common, but because they are so rare.

6. **Reputation:** If managers can build a reputation for truth-telling and capable management, they are less likely to undertake bad projects. For example, agency concerns are likely to be a worse problem when it comes to secret one-shot projects, where your managers cannot build a track record that will help them with future projects. On the other hand, sometimes reputational considerations can themselves become the problem. Witness the many beautifully artistic office buildings that are great monuments to some famous architectural firms—yet completely dysfunctional for their poor inhabitants.
7. **Capital rationing:** If nothing helps to restrain your managers from wasting money when they get it, just don't give it to them. Or give them only enough money to satisfy their most urgent needs, hoping that these needs will then more likely be positive-NPV projects.
8. **Selecting managers:** There are people out there who are more inclined to be honest and others who are not. If you can hire managers of high integrity, they may not abuse the firm (or do it less), even when it is in their own self-interest to do so. Again, dealing with honest individuals may well be the most important (partial) remedy to the agency problem.

Some losses due to conflict of interest are unavoidable. The best "solution" is ample skepticism and common sense.

Even if there are exceptions, your first baseline assumption should be that your employees are self-interested. Most of us are. Are you really any different? And everyone will try to convince themselves that what they are doing in their own self-interest is appropriate and ethical, even if it is not. Some more so than others. There are no obvious and cheap solutions to moral hazard problems. You would not want to spend a million dollars in audit fees and complex control mechanisms to save a hundred dollars in theft. You would not want to hire a manager of the highest integrity who is utterly incompetent over another manager who may steal a small amount but will otherwise generate enormous value for shareholders. In the real world, you have to realize that all firms suffer conflicts of interest. All you can do is to try to limit the problem intelligently. As a manager or principal, remain skeptical of your employees' estimates and judgments and take the biases and incentives of each information provider into account. My last word is a reminder: Do not let the fact that I just spent only a few pages on agency problems fool you. They are everywhere and they are important.

Corporate Governance

Corporate governance is how shareholders and creditors control the firm.

A very important aspect of managing moral hazard in firms is how firm owners (shareholders and creditors) deal with their firms—what rights they have. This is called **corporate governance**. If the top managers are not incentivized to do the right thing, they will not incentivize their subordinates to do the right thing, either. (The medieval proverb "the fish stinks from the head downward" very much applies.) How do shareholders and creditors get "their" managers to act in shareholders' interest—and not to buy themselves lavish airplanes, or take excessive gambles with investors' money? It's a tough problem.

Good management is not good governance.

Do not confuse good management with good corporate governance. Governance matters only if management is bad. Apple's Steve Jobs was not only the world's best-performing CEO, but he also did not cost Apple an undue amount of money. In contrast, corporate governance at Apple was poor. Jobs was almost in complete control of a board that was officially supposed to supervise him. This bad governance did not matter in his case. Yet if Jobs had decided to go rogue, it could have. Arguing that good managers do not need good governance is like leaving your wallet lying around because most people will not steal it. Do not tempt fate. Eventually, someone will.

Fiduciary Responsibility, or the Fox Guarding the Henhouse

On Wednesday, December 29, 2004, the *Wall Street Journal* reported on page 1:

> In the biggest U.S. merger this year, JP Morgan Chase & Co. announced last January it would acquire Bank One Corp. To assure investors it was paying fair price, JP Morgan told them in a proxy filing that it had obtained an opinion from one of "the top five financial advisors in the world."
> — *Itself.*
> The in-house bankers at JP Morgan endorsed the $56.9 billion price—negotiated by their boss—as "fair."

Next to the main article was a sidebar called "Passing Muster," which explained:

> A 'fairness' opinion tells a company's board that a deal's terms are fair to shareholders.
> **Purpose:** Legal protection from an investor claim that a deal was done without due care.
> **Cost:** A few hundred thousand dollars to a few million.
> **Potential Conflicts**
> - Bankers may have incentives to call a deal fair because most of their advisory fee is paid only if the deal closes.
> - Bankers' fee is tied to the deal price.
> - Bankers may support a deal where executives will personally profit, in hopes of securing future work.
> - Bankers use financial data supplied by a client who wants the deal to go through.
> - When the deal maker is a bank, its own bankers often write the fairness opinion.

Remember that everyone—in-house bankers, management, and corporate boards—are employed by the shareholders, to whom they owe fiduciary responsibility and whose interests they are supposed to represent. It is a clear agency conflict for an employee to provide a fairness opinion. But it would also be difficult for management to have these in-house bankers fired for doing them a personal favor—another agency conflict.

And there is also the original agency conflict: the incentive of acquiring managers to pay too high a price or of target managers to accept too low a price. Here is how the WSJ story continues:

> But during the negotiations, Bank One Chief Jamie Dimon had suggested selling his bank for billions of dollars less if, among other conditions, he immediately became chief of the merged firm, according to a person familiar with the talks. That suggestion wasn't accepted by JP Morgan.

Obviously, Jamie Dimon did not offer to pay his own personal billions for the privilege of becoming CEO early, but Bank One's shareholders' billions. Obviously, the JP Morgan management did not decline these billions on behalf of their own pockets, but on behalf of JP Morgan shareholders' pockets.

Still, there are of course the corporate boards that could have fired either the in-house bankers or their management teams. Neither happened. Instead, Jamie Dimon took over as head of JP Morgan, as scheduled, on December 31, 2005. On May 16, 2013, as more companies split the CEO and chairman position, news companies reported how Dimon had handpicked his board members for many years. Unlike many of his fellow bank executives, Dimon knew how to survive the Great Recession of 2008! In fact, as of 2017, he still rules!

The Wall Street Journal

In many large Fortune-100 companies with diffuse shareholders, management is actually pretty good. However, corporate governance is usually pretty bad. If self-interested, a CEO intent on gaining control of the board that supposedly supervises him or her will usually take only a few years to stack the board with his friends. The best example of a complete absence of corporate governance is the financial industry collapse in the Great Recession. Almost all financial firms

Corporate governance in the U.S. is badly broken for many firms. It works well for smaller firms.

had very few real incentives and did very little to control risk before the crisis. Risk control was no more than lip service. Heads, the bonus payments would make the executives rich and shareholders better off. Tails, the shareholders and the government would lose. Thus, almost all financial executives, who had gambled and ultimately lost *all* their shareholders' money, still walked away super-rich. Most are worth more than $100 million each today. (Of course, they would have ended up even richer if heads had come up more often. They did not *want* the financial crisis to happen.) PS: Don't think that anything fundamental has changed. No board has ever clawed back paid-out bonuses. The incentives to gamble remain overwhelming. Hired lobbyists are convincing legislators and regulators to roll back even the limited Dodd-Frank reforms. (And please don't think our government is less conflicted.) This is why the next financial crisis is already pre-programmed.

⟼ Center for Public Integrity: The Price of Failure: Ex-Wall Street CEOs still living large

Fortunately, corporate governance works pretty well for small and growing firms—and especially in **private equity** firms, whose business it is to run their own portfolio firms under tight supervision. In fact, private-equity firms often pay their corporate managers more than publicly traded firms pay theirs—but they also fire them more often.

Corporate governance works well when there are concentrated owners.

The companion book contains a full chapter about corporate governance. It's my favorite. You should read it.

Read all about it...

Q 13.18. Describe common agency problems and explain how they are likely to bias corporate NPV calculations.

13.9 An NPV Checklist

After reading this chapter, you probably understand now why professors think "theory is easy." The complications of real life make theory look like a child's game. Yes, the principles of capital budgeting theory are easy—only their application is hard. It is usually very difficult to estimate future cash flows (and even their appropriate interest rates), especially for far-in-the-future returns. It is usually more important and more difficult to avoid errors for the expected cash flow (the NPV numerator) than it is for the cost of capital (the NPV denominator). The NPV formula is less robust to cash flow errors than it is to cost-of-capital errors, and it is "easier" to commit dramatic errors in the cash-flow estimation than in the cost-of-capital estimation.

If you think academics like to make easy things difficult, you have it totally wrong. It is academics who try to avoid the difficult problems.

Here is an abbreviated checklist of items to consider when working out NPV estimates.

Here is an abbreviated list of issues to worry about when using NPV.

- **Appropriate (after-tax) dollars** (Pages 82, 85):
  - Have you quoted all relevant inputs and outputs in relevant-to-you after-tax dollars? This applies to both expected cash flows and to appropriate discount rates. (Corporate income taxes will be covered in more detail in Chapter 18.)
  - Have you properly included inflation? Preferably, have you performed all computations using nominal expected future cash flows and nominal costs of capital, with inflation used only to gross up nominal cash flows appropriately?
- **Interactions** (Pages 320, 323):
  - Have you credited all projects with their contributions, positive or negative, to the values of other projects (externalities)?
  - Have you judged all projects "on the margin," that is, without charging them for unalterable or previously made choices, such as sunk costs, overhead, and so on?
  - Have you used the cost of capital applicable to each project component, respectively, and not the (incorrect) overall average cost of capital? (Note: Some errors and simplifications here are unavoidable in the real world, because it is impossible to put different costs of capital on each paper clip.)

- **Real options and flexibility** (further discussed in the companion chapters on options and real options):
  - Have you considered all possible future options (using scenario analyses) in order to find the correct *expected* cash flows, such as,
    1. your ability to extend a product into different markets,
    2. your ability to find product spinoffs,
    3. your ability to learn about future products,
    4. your ability to stop the project if conditions are bad,
    5. your ability to delay the project if conditions are bad,
    6. your ability to mothball the project if conditions are bad and to restart the project if conditions improve,
    7. your ability to accelerate the project if conditions are good,
    8. your ability to expand the project if conditions are good,

    and so on?
- **Accuracy** (Pages 57, 224, 339, 340):
  - How accurate are your estimated project cash flows?
  - If project success and project cash flows were estimated by someone else, what are the assessor's motives? How tainted can these estimates be? Does the estimator want the project accepted or rejected?
  - Is it possible to get another independent evaluation/audit of the project estimates?
  - Can your cash flow estimates be improved by doing more research?
  - Given unavoidable simplifications, assumptions, and errors, how sensitive/ robust are your NPV calculations to changes therein?
- **Correct inputs** (Page 317):
  - Are your cash flows *expected* rather than *promised*? Are your interest rates *expected* rather than *promised*? (Recall: Expected interest rates are below promised interest rates due to default premiums, not just due to risk premiums.)
  - Are your expected cash flows the "average outcome" (correct), and not the "most likely outcome" (incorrect)?
  - Do your expected cash flow estimates include the correct weighted probabilities of low-probability events, especially for negative outcomes?
  - If you need to borrow money to execute the project, have you used the expected (not the promised) borrowing rate as your cost of capital? If capital is already available, are you using your expected lending (investments) rate as the appropriate cost of capital?
- **Corporate income taxes** (To be covered on Page 477f):
  - For use of WACC and APV, is the numerator in your NPV calculation the expected cash flow "as if all equity-financed"? (This means that the company bears the full brunt of its corporate income tax load.)
  - In the weighted cost of capital, is your debt cost of capital the *expected* (not the promised) interest rate on debt? Is your numerator the *expected* cash flow, not the *promised* cash flow?

➤ WACC and APV, Sect. 18.2, Pg.477.

A final warning: Although many of these issues seem obvious in isolation, they are much harder to spot and take care of in complex real-world situations than in our highlighted expositions. Watch out! Another warning against the most common error is worth its own box:

Easy here. Tough in the jungle.

IMPORTANT

The most common NPV method is to estimate cash flows for the numerator, and to use an expected rate of return (cost of capital) from a model like the CAPM (see Chapter 10).

- The default risk is handled only in the numerator, that is, in the computation of expected cash flows.
- The time premium and risk premium are handled only in the denominator. The CAPM formula provides an expected rate of return, which contains only these two components.
- Do not try to adjust the cash-flow numerator for the time or risk premium. Do not try to add a default premium to the rate of return in the denominator. (This would yield a promised, not an expected, rate of return on capital.) Do not believe that you have taken default risk into consideration merely by using the CAPM expected rate of return in the denominator.

Q 13.19. The CEO projects earnings of $100 million next year. List three reasons why this might not be a good input into an NPV valuation.

Summary

This chapter covered the following major points:

- You should never confuse promised and expected cash flows in the numerator, or promised and expected rates of return in the denominator. The *expected* cash flows are often not the *most likely* cash flows, either.
- Corporations can reduce their risk by diversification—but if investors can do so themselves as easily, diversification per se does not create value. As a manager, you can create value only by increasing cash flows or decreasing the cost of capital. Diversification for the sake of diversification does not add value.
- You should not use the cost of capital applicable to the entire firm, but rather the cost of capital applicable to each new project. However, because the effort involved can be enormous, it is reasonable to use individual, project-specific costs of capital only when it really makes a difference.
- When selecting projects, consider all possible project combinations and choose the combination that gives you the highest overall NPV.
- You should attribute to each project's NPV its influence on other projects, either positive or negative. If a project is independent from other projects, you can consider its NPV in isolation, and add it to the total.
- You should think about how you can take advantage of, or create, positive externalities among projects. If you cannot, there is no reason for the firm to exist in the first place.
- You should think "on the margin"—take all projects that contribute more marginal benefits than they create marginal costs.
- You should consider economies of scale, which can reduce average production costs and thus add to project value.
- You should ignore sunk costs.
- You should take real options into account. These are the value of your ability to change course depending on future conditions. They include your flexibility to delay or accelerate projects, and to expand or shut down projects.
- You should be aware of your own biases, such as overconfidence, relativism, compartmentalization, and others.
- You should realize that real-world implementation problems—which range from differences in short-

term and long-term marginal costs, to political reasons and agency considerations inside corporations—often make taking the best set of projects difficult.

- You should design your operations to reduce agency conflicts when it is marginally profitable to do so.
- To make your task a little easier, refer to the NPV checklist in Section 13.9.

No doubt about it: Good capital budgeting is a difficult problem. Each subsection covered in this chapter can easily be expanded into a full chapter, or even a full book. There are pitfalls everywhere. In the end, capital budgeting is as much an art as it is a science. You have to rely as much on common sense and intuition as on the mechanics of valuation. The best analysis combines both.

Preview of the Chapter Appendix in the Companion

The appendix to this chapter shows how to value some specific real option scenarios with decision trees.

Keywords

Agency, 340. Audit, 342. Compartmentalization, 339. Corporate governance, 344. Diseconomies of scale, 326. Economies of scale, 329. Externality, 325. Hedging, 319. Heuristic, 324. Independent, 325. Interaction, 325. Limited attention span, 327. Limited capacity, 332. Monte Carlo simulation, 337. Moral hazard, 340. Natural monopoly, 330. Negative interaction, 326. On the margin, 328. Overconfidence, 339. Pay-for-performance, 343. Positive interaction, 325. Post-audit, 343. Private equity, 346. Process, 326. Real option, 334. Relativism, 339. Scenario analysis, 337. Simulation analysis, 337. Status quo, 327. Strategic option, 334. Sunk cost, 331. Synergies, 326.

Answers

Q 13.1 Yes, it makes sense to compare the project's IRR to a hurdle rate. Indeed, if the hurdle rate is the cost of capital, the IRR rule tells you what you should do.

Q 13.2 Comparing a project's cost of capital to its hurdle rate would be silly, because your hurdle rate is just another name for your cost of capital in a perfect market.

Q 13.3 The Amazon.com bond's stated 8% is a promised rate of return. It is not the expected rate of return. Therefore, it is not the cost of capital.

Q 13.4 You cannot determine this, because you do not know the expected bond payoff.

Q 13.5 The probabilities of different outcomes are as follows:

Scenario	Probability	Y	PV
DDDD	$90\%^0 \cdot 10\% = 0.1000$	1	\$268
WDDD	$90\%^1 \cdot 10\% = 0.0900$	2	\$507
WWDD	$90\%^2 \cdot 10\% = 0.0810$	3	\$721
WWWD	$90\%^3 \cdot 10\% = 0.0729$	4	\$911
WWWW	$1 - \text{above} = 0.6561$	5	\$1,081

1. The single most likely outcome (with 65.6% probability) is that the machine will operate for all 5 years (because there is only a 10% breakage probability each year). If this machine were guaranteed to work for exactly 5 years, then the present value would be $\text{PV} = (\$300/0.12) \cdot (1 - 1/1.12^5) \approx \$1{,}081$. The NPV would be \$171.
2. The expected number of years the machine will operate is $0.1 \cdot 1 + 0.09 \cdot 2 + 0.081 \cdot 3 + 0.0728 \cdot 4 + 0.6561 \cdot 5 \approx 4.1$. If this machine were guaranteed to work for exactly 4.1 years, then the present value would be $\text{PV} = (\$300/0.12) \cdot (1 - 1/1.12^{4.1}) \approx \$929$. The NPV would be \$19.

3. The true expected value is $0.1 \cdot \$268 + 0.09 \cdot \$507 + 0.081 \cdot \$721 + 0.0728 \cdot \$911 + 0.6561 \cdot \$1{,}081 \approx \$906$. The NPV would be –$4. This number is lower than the $19, because the NPV at the expected outcome is not the same as the expected NPV. (The math name for this is Jensen's inequality.)

(As usual, because of rounding, your answers may be slightly off from those I report here.)

Q 13.6 The merged firm has a lower standard deviation (it is safer), but this adds no value.

Q 13.7 1. The new project's value is $\$11/1.15 \approx \$9.57$. At a cost of $10, the net present value is –$0.43.

2. The value today of the new project is $\$11/1.15 \approx \$9.57$. Therefore, the weight of the new project is $w_{new} = PV_{new}/PV_{combined} \approx \$9.57/\$109.48 \approx 8.74\%$.
3. The beta of the combined firm is $\beta_{combined} = w_{old} \cdot \beta_{old} + w_{new} \cdot \beta_{new} \approx 91.26\% \cdot 0.5 + 8.74\% \cdot 3 \approx 0.719$.
4. The combined cost of capital according to the CAPM is $E(r_{combined}) \approx 3\% + 4\% \cdot 0.719 = 5.876\%$.
5. Yes! The IRR of *new* is 10%. (For IRR, see Chapter 5, Page 75.) 10% is above the blended cost of capital of 5.876%.
6. The firm value would be

$$PV = \frac{E(C_{new}) + E(C_{old})}{1 + E(r_{combined})} \approx \frac{\$105 + \$11}{1 + 5.876\%} \approx \$109.57$$

Again, you conclude that the firm has destroyed $0.43.

Q 13.8 Zero externalities are convenient for valuation, because they allow you to add up NPVs. If there are nonzero externalities, the total NPV is larger or smaller than the sum of its part.

Q 13.9 Without taking the externality into account, the NPV of division A's move would be negative. The $120,000 of costs would be higher than the benefit of $10{,}000/10\% = \$100{,}000$. However, the correct answer is "Yes, division A should move." Moving saves $10{,}000/10\% = \$100{,}000$ in division A costs and $3{,}000/10\% = \$30{,}000$ in division B costs. The total savings is therefore $130,000, which is $10,000 greater than the cost of the building.

Q 13.10 The firm should not buy the press, because it earns $2{,}000/10\% = \$20{,}000$. But the press costs $10,000 to purchase and eliminates $1{,}500/10\% = \$15{,}000$ of profits from the screw machines. The total cost of the press, including the $15,000 in opportunity costs, is $25,000. The project's net present value is $\$20{,}000 - \$25{,}000 = -\$5{,}000$.

Q 13.11 1. Either buying the desktop or the notebook would be a positive-NPV project. However, you should buy the desktop, because it is cheaper (more bang for the buck).

2. You should still buy the desktop. The marginal cost is $1,500. The marginal benefit is $11{,}000 - \$9{,}000 = \$2{,}000$.
3. You should not buy the notebook. The marginal cost is $2,500. The marginal benefit is $2,000.

Q 13.12 1. The profit of the firm is $\text{Profit}(x = 10) = 10 \cdot [\$20 - \$5 - \$15/(10+1)] \approx \$136.36$.

2. With 11 goods, the cost to produce is $\$5 + \$15/(11+1) = \$6.25$. With 10 goods, it was $\$5 + \$15/(10+1) \approx \$6.3636$. The marginal production cost is $\$6.25 \cdot 11 - \$6.3636 \cdot 10 \approx \$5.11$.
3. The marginal cost would now be an additional $1 times 10 in rebates. It would therefore cost the firm $5.11 plus $10, or $15.11, assuming that the other clients also get the $1 discount ($19 price). Thus, because the marginal revenue of $19 exceeds the marginal cost of $15.11, the firm should still sign up everyone.

Q 13.13 Total sales and costs are

Units	Sales Price	Production Cost	Net
Q	$Q \cdot (7 - Q/100)$	$Q \cdot [5 + (Q+20)/100]$	
1	$6.99	$5.21	$1.78
2	$13.96	$10.44	$3.52
⋮			
43	$282.51	$242.09	$40.42
44	$288.64	$248.16	$40.48
45	$294.75	$254.25	$40.50
46	$300.84	$260.36	$40.48
47	$306.91	$266.49	$40.42
⋮			

1. The table shows that the optimal production is 45 units.
2. The average per-unit gross sales at $Q = 45$ is $\$294.75/45 = \$6.55$.
3. The average per-unit production cost at $Q = 45$ is $\$254.25/45 = \$5.65$.
4. The net sales at $Q = 45$ are $\$40.50/45 = \$0.90$.
5. From 44 to 45, the marginal per-unit sales is $294.75 – $288.64 = $6.11. From 45 to 46, it is $6.09.
6. From 44 to 45, the marginal per-unit cost is $254.25 – $248.16 = $6.09. From 45 to 46, it is $6.11.
7. It is just about $0. (If you move from 44 to 45 units, or from 46 to 45 units, you gain 2 cents.) This is what it means to be at the optimal production level.
8. Your average per-unit net change at $Q = 45$ is still positive, but you should *not* expand production. If you do, you are ignoring the negative effects that unit number 46 would have on all your earlier units. This means that you would earn less money in total, not more.

Q 13.14 Yes, the firm should expand. The PV of the division's profits will be $50{,}000/10\% = \$500{,}000$. The division costs are $210,000 for new equipment and $20,000 per year in increased overhead. The PV of the increased overhead is $20{,}000/10\% = \$200{,}000$. The total PV cost of the new division is $\$210{,}000 + \$200{,}000 = \$410{,}000$, and the PV of the benefits is $500,000. Thus, bringing in the new division represents a project with an NPV of +$90,000.

Q 13.15 1. The expected per-CD selling price is $\$6 \cdot 90\% + \$10 \cdot 10\% = \$6.40$.
2. If \$6.40 was the price, you would gear your factory to produce 150,000 CDs. Without flexibility, your factory would be worth $90\% \cdot [150,000 \cdot (\$6 - \$5)] + 10\% \cdot [150,000 \cdot (\$10 - \$5)] = 150,000 \cdot (\$6.40 - \$5) = \$210,000$.
3. With flexibility, you would expect to earn $90\% \cdot (150,000 \cdot [\$6 - \$5]) + 10\% \cdot (500,000 \cdot [\$10 - \$8]) = \$135,000 + \$100,000 = \$235,000$.
4. The value of flexibility is $\$235,000 - \$210,000 = \$25,000$.

Q 13.16 Relativism may induce you to make mistakes on both types of projects (and it is not clear which one is worse): For small projects, you may chase a large percentage increase too vigorously. For large projects, you may not realize that even a small rate of return can be a lot of money.

Q 13.17 Mental decision biases are the subject of Section 13.7. The text discussed overconfidence, relativism, and compartmentalization.

Q 13.18 Agency problems are the subject of Section 13.8. The text discussed eagerness for capital, employment concerns, direct theft, and desire for perks, power, and laziness. The effects can be manifold, often resulting in misvaluation of projects.

Q 13.19 First, the CEO's projected figures probably represent the most likely outcome, not the expected outcome. It is probably more likely that the firm will go bankrupt due to totally unforeseen circumstances than that it will have a windfall. Second, the CEO has an incentive to distort the truth and report optimistic projections. This is an agency problem. Third, the CEO is probably subject to mental biases, too.

End of Chapter Problems

Q 13.20. Can you compare a project's internal rate of return to its expected rate of return?

Q 13.21. Does it make sense to distinguish between a promised and an expected internal rate of return? What do issuers provide? What do you usually need?

Q 13.22. A zero-bond has a stated rate of return of 8%. Its price today is \$92,593. What is its expected payoff?

Q 13.23. A machine that costs \$2,000 is likely to break irreparably with 20% probability at the end of each year (assuming it worked the previous year). You can neither replace it nor use it for more than 5 years. (Many electric devices without moving parts have such breakdown characteristics.) The machine can produce \$1,000 in profit every year. The discount rate is 12% per annum.

1. What is the most likely operating time? If this comes true, what is the value?
2. What is the expected operating time? If this comes true, what is the value?
3. What is the true net present value of this machine? (Hint: First work this out case by case for a two-year machine, then for a three-year machine. Think "D," "WD," "WWD," "WWWD," and "WWWWD," where W means working and D means dead.)

Q 13.24. Practice the CAPM. A \$300 million firm has a beta of 2. The risk-free rate is 4%; the equity premium is 3%. Assume that the firm can easily tap a perfect capital market to obtain another \$95 million. The firm can also easily tap the financial markets. So far, it has had a policy of only accepting projects with an IRR above the hurdle rate of 10%. Suddenly, one of its main suppliers (perhaps one facing credit constraints) has approached the firm for a 1-year loan. Assume that the loan is risk-free for you—you hold more than enough sway over your supplier to ensure repayment. The supplier wants to borrow \$100 million and pay back \$106 million next year.

1. Without the new loan, what is the firm expected to earn per year?
2. What is the NPV of the loan?
3. If the firm changes its policy and extends the loan, how would its value change?
4. If the firm changes its policy and extends the loan, approximately how would its beta change?
5. If the firm changes its policy and extends the loan, approximately how would its cost of capital change?
6. If the firm changes its policy and extends the loan, can you compute the combined firm's NPV by dividing its expected cash flows (assets) by its combined cost of capital?
7. Should the firm change its policy?

Q 13.25. Assume that the risk-free rate is 5% and the equity premium is 2%. A $1 billion firm with a beta of 2 has just sold one of its divisions for a fair price of $200 million. The CEO is concerned that investors expect the firm to earn 9%, and so believes keeping the money in short-term Treasuries that only pay 5% would be a bad idea. Is it really a bad idea?

Q 13.26. What are the arguments for and against discounting every project by its own cost of capital?

Q 13.27. As the CEO of an expanding airlines cargo division, would you acknowledge that an increase in your operations would be harmful to the passenger division? Should you be charged for the increased use of shared maintenance facilities?

Q 13.28. What are the main sources of positive externalities? What are the main sources of negative externalities?

Q 13.29. As a manufacturer, you have to decide how many regional distributors to sign up. Serving a distributor costs more the farther away it is from the factory, and different distributors have different demand. By region, gross revenues and costs are (in millions of dollars) as follows:

Distributor	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Gross Revenue	$5	$4	$4	$3	$2	$7	$1
Cost	$2	$2	$3	$4	$4	$5	$6

There is no "time value of money" dimension in this problem.

1. Is it feasible to work out all possible combinations of distributors you can service? Is it sensible?
2. Which regions should you deliver to?
3. What is the total profit for serving them?
4. What is the marginal benefit and cost of serving the least profitable of your serviced distributors?
5. What would be the marginal benefit and cost of serving one more distributor?
6. Now assume that to get into this business, you would also have to set up the factory. This would cost you a one-time upfront expense of $5 million. You can think of this as spreading the cost across distributors. How would this change your decision?

Q 13.30. A firm can produce goods for an average per-unit cost of $\$5 + \$10/(Q \cdot \$1 + 2)$. For example, to produce 10 goods would cost $10 \cdot (\$5 + \$10/12) \approx \$58.33$. The market price per good is $\$7 - Q \cdot \$1/10$. So, you can fetch $10 \cdot (\$7 - \$10/10) = \$60$ for selling 10 goods. Use a spreadsheet to answer the following questions.

1. What is the break-even point where total gross revenues are equal to total cost?
2. What is the gross profit (revenues minus costs) at the break-even point?
3. What is the marginal gross profit at the break-even point?
4. How many items should the firm produce?
5. What is the average per-unit gross profit at this point?
6. What is the marginal gross profit at this point?

Q 13.31. Comment on, "It is best to allocate costs only to divisions that request a resource."

Q 13.32. Comment on, "It is best to allocate costs to divisions that benefit from a resource."

Q 13.33. A perpetual firm's headquarters consumes $1 million per year. It has six divisions of equal size, but not equal profitability. The annual profitabilities (in thousands of dollars) are as follows:

Project	**A**	**B**	**C**	**D**	**E**	**F**
Profitability	$180	$450	$900	$80	$130	$300

The cost of capital is $r = 10\%$.

1. What is the firm's NPV?
2. If the firm adopts a rule whereby each division has to carry its fair (size-based) share of the headquarter overhead. What is the firm's NPV? (Assume that the total amount of overhead does not decrease unless the whole firm is closed, in which case the overhead is 0.)

Q 13.34. Your factory can either stamp 150,000 CDs at a cost of $5 per CD, or 500,000 CDs at a cost of $8 per CD. If your CD has a hit song, you can sell it to retailers for $10 per CD. If it is a moderate success, you can only charge $6 per CD. If it is a complete bomb, you cannot sell it at all. There is a 1-in-10 chance that your CD will be a hit, and a 3-in-10 chance that it will be a bomb. You will not find out whether you have a hit until next year, but fortunately this will be before you have to stamp CDs. Your cost of capital is 10% per year. You only have the lease of the factory for next year. There is no production this year.

1. What is the expected selling price per CD?
2. How many CDs should you produce at the expected selling price—that is, if you had to gear the factory for a particular production quantity today?
3. What is the value of your factory if you can decide next year?
4. What is the value of flexibility in this example?

Q 13.35. What are the types of real options that firms need to take into account in their project valuations?

Q 13.36. You have to purchase $600 worth of staples. You have just found out that the stationery store across from you charges $300 more than the warehouse outlet 20 miles away. Would you spend the 40 minutes to drive to the warehouse? Now, assume you are buying a Porsche that costs $100,000. You have just found out that the Porsche dealer also 40 minutes away offers the Porsche for $300 less. Assuming you can receive after-market service in both locations, would you drive 40 minutes to pay $99,700? What should you do from an economic perspective? Is this what you would be tempted to do?

Q 13.37. Explain how you can exploit human biases in attracting signups for your new health club.

Q 13.38. Describe a manifestation of an agency problem, where it is worse, and what can be done to remedy it.

Q 13.39. Are agency problems worse in startup or established firms? Discuss.

Q 13.40. Should you suppress all agency conflicts? Discuss.

Q 13.41. Contrast Google and Wal-Mart. Which agency conflicts are likely to inflict Google worse than Wal-Mart, and vice-versa? Discuss.

Q 13.42. Recall as many items from the NPV checklist as you can remember. Which are you most likely to forget?