



Topic
Business
& Economics

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Economics

The Economics of Uncertainty

Course Guidebook

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Duke University



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Professor Fullenkamp's areas of interest include financial market development and regulation, economic policy, and immigrant remittances. His work has appeared in a number of prestigious academic journals, including the *Review of Economic Dynamics*, *The Cato Journal*, and the *Journal of Banking and Finance*. Along with Sunil Sharma, Professor Fullenkamp won the third annual essay contest on financial regulation sponsored by the *Financial Times* and the International Centre for Financial Regulation; their paper was entitled "Good Financial Regulation: Changing the Process Is Crucial."

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Professor Fullenkamp's Great Courses also include *Understanding Investments* and *Financial Literacy: Finding Your Way in the Financial Markets*. ■

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The Economics of Uncertainty

Scope:

Our lives are full of uncertainties—from minor ones, such as the prices we’ll pay for gas and groceries tomorrow, to major ones, such as whether your job will exist five years from now. Where does all this uncertainty come from, and what can we do to protect ourselves from it? These are the two main questions that this course addresses, using tools and insights from economics and finance. This course will not only build up your understanding of the uncertainties in your life, but it will also help you use these tools to develop your own personal risk management strategies.

The course begins with several lectures that give an overview of uncertainty and our main ways of dealing with it. The first lecture defines uncertainty as a lack of information, then asks the obvious question: Can we eliminate uncertainty by getting better information? To answer this question, we need to take a deeper look at the sources of uncertainty, which include both nature and human activity. As we’ll see, both of these sources are so complex that our best strategy is to learn to live with uncertainty, rather than trying to eliminate it from our lives. The two lectures that follow flesh out the main menu of alternatives we have for living with uncertainty. These include converting uncertainty to risk, diversifying, and sharing risk, as well as other strategies.

Then, we turn to measuring the uncertainty in our lives, because this is the first step toward managing its impact. Measuring risk may sound easy, but it turns out to be very challenging. We’ll learn that there are multiple ways to think about probability, and not all are equally relevant to the uncertainties we normally face. In addition, we’ll learn that humans often have a difficult time simply thinking about probability correctly, owing to the way our brains have evolved. Nonetheless, there are a few simple tools from probability that can help us make good decisions, and they have an appealing “bang-for-the-buck” interpretation that makes them easy to remember.

Next, we turn briefly to the business side of uncertainty. We'll learn how businesses make decisions in the face of uncertainty and how one business in particular makes a living from creating uncertainty: the gambling industry. We'll also explore several techniques that businesses use to deal with uncertainty that can be adapted to our own lives.

Our interactions with other people—at home, in the markets, and at work—are full of uncertainty that originates from the fact that no two people have the same information. This allows the person with better information to take advantage of the situation. These situations are so common and so important to our lives that several lectures in this course are devoted to exploring the problems created by differences in information. We'll learn about strategic interactions, such as negotiations, and we'll discuss three problems with odd names—adverse selection, moral hazard, and principal-agent problems. As we'll see, it's essential for us to understand and learn how to cope with these problems. We'll also learn about market-based strategies for mitigating these problems, including compensation contracts and insurance, as well as a powerful non-market method: altruism.

Much of the uncertainty in our lives originates from the broader economy; thus, the next section of the course explores the big-picture sources of risk. These sources include the business cycle, inflation, the financial markets, international trade, and even the statistics that we rely on to understand what's happening in the economy. We'll also learn that the long-term trends economists and scientists identify—and sometimes use to stoke public anxiety—are much less certain than they're made out to be. In addition, we'll see how government policies and actions inadvertently create uncertainty in the economy. These lectures focus not only on how these sources of uncertainty affect us but also on how to take action to protect ourselves from their negative effects.

In the final two lectures of the course, personal risk management becomes the primary focus. In these lectures, we'll borrow items from the toolbox of professional risk managers and adapt them to our own lives. We'll learn about professional hedging tools, such as forward contracts, futures, and options, and focus on a special version of one of these tools—the so-called real option—that can be a powerful aid for individuals. In the final lecture of

the course, we'll discover how financial firms use stress testing to improve their ability to handle risk, and we'll learn how to stress test our own lives. The overall goal of the course is to help you build up the best defense against uncertainty: confidence in your own ability to understand and manage the many risks we all face. ■

Man, Nature, and Economic Uncertainty

Lecture 1

Uncertainty is a state of not knowing, a lack of information. It can be summed up in the phrase “If only I’d have known.” In this lecture series, we will explore two significant questions. The first is, simply, “Can we know?”—that is, can we push back against uncertainty, either by finding missing information or by making the sources of uncertainty more predictable? The other question is “If we cannot reduce uncertainty—if we cannot know—then how should we deal with uncertainty?”

Black Swan Events

- There are two distinct sources of uncertainty: human activity and nature. Human activity includes everything that happens in the economy and in the world of politics. Natural phenomena include weather, geologic activity, and even cosmic events, such as solar flares. The natural world also encompasses the activities of nonhuman life, such as viruses and bacteria.
- One of the most dramatic examples of uncertainty caused by human activity was the financial crisis of 2008 and 2009. Most financial economists understood that by mid-2008, a few large banks would be adversely affected by their involvement in the subprime mortgage markets. But few thought that the entire American financial system would be at the brink of disaster in September 2008.
- This crisis was a *black swan event*, a term taken from the title of a book by Nassim Taleb. A black swan event is one so improbable that we cannot believe it can happen. But once in a while, these highly improbable events do occur. They are called black swans because naturalists did not think that it was possible for black swans to exist—until they were discovered in Australia.

Complexity and Nonlinearity

- It is extremely difficult to predict the consequences of human actions on a large scale. In 2008, almost nobody had any idea that subprime mortgages—just a small fraction of the overall financial market—could cause a chain reaction that would come close to bankrupting the entire financial system.
- The reason this couldn't be predicted is that the financial system is complex and dynamic. In this case, *complexity* means that there are intricate webs of borrowing, lending, and trading that connect people and businesses all around the world. It also means that the behavior of financial players cannot be described by simple proportional relationships. Many financial transactions trigger responses that are out of proportion to the size of the initial actions.
- In other words, some causes have nonlinear effects. Economists use nonlinear equations, with exponential growth, to model or approximate the behavior of the financial market.
- A well-known feature of nonlinear systems is that it is extremely hard to predict how they will react to even the smallest shock to the system. It's no wonder that the study of how nonlinear systems react to change came to be known as *chaos theory*. Chaos theory helps us understand that a major source of economic uncertainty is simply the complexity of the economy itself.
- The economy is made up of millions of interconnected actors, whose decisions are nonlinear functions of their own economic circumstances, their beliefs about the future, and the actions of other economic actors. This is a recipe for chaotic behavior, including unpredictable and powerful swings in prices, profits, and employment that may result from minor shocks to the system.

Self-Organized Criticality

- The specific aspect of chaos theory most relevant to the economy is *self-organized criticality*. This term refers to the concept that some complex systems will naturally push themselves to the brink of large and sometimes disastrous changes. Self-organized criticality is an ideal way to think about how the complexity of the economy plays out—both in the markets for goods and services and in the financial markets.
- The concept of self-organized criticality also provides insight into black swan events. If self-organized criticality describes how markets work, then the system will tend to produce extreme events every so often. In other words, such events as market crashes and panics are part of the normal workings of our economy. But unfortunately, we cannot predict when the next one will occur.
- People’s individual attempts to protect themselves from uncertainty may actually make uncertainty worse. This general problem with uncertainty is known as *private risk management spillover*. The idea is that individual people or companies will each deal with risk and uncertainty in the way they believe is best for them. Collectively, however, these individual actions may increase the overall level of uncertainty.

The Role of Science and Technology

- Until the last century or so, nature was the main source of uncertainty for humankind. Up to that time, the economy was based on agriculture, and people were directly dependent on nature for their survival. What’s more, humans understood very little about the laws of nature and nature’s sources of uncertainty.
- Both these circumstances changed dramatically in the 20th century, however. Economies moved away from agriculture and toward manufacturing, services, and information. On top of that, the development of global trade further reduced the impact of the

natural world. Tremendous advances in science and technology during the past century have also reduced the severity of the uncertainty caused by nature.

- In some cases, technology has been able to attack the sources of uncertainty that originate in nature. For example, the so-called green revolution in agriculture that began in the 1940s resulted in crops that are more resistant to drought, disease, and pests. Similarly, through science, many diseases can now be prevented or cured.
- Despite scientific and technological advances, however, nature is still a tremendous source of uncertainty. The natural world is a complex, dynamic system, just like economic and political systems. Even more important, human activity is interacting with nature in ways that amplify uncertainty.



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Advances in science and technology during the past century have, in many cases, reduced the severity of uncertainty caused by nature.

Uncertainty and Economics

- As mentioned earlier, one of our primary questions in this course is: “Can we know?” Given what we have learned so far about the main sources of uncertainty, the answer is no. Both human activity and the natural world are so complex that we can never predict or control them well enough to eliminate uncertainty. And when we try to predict and control these sources of uncertainty, complex systems react in ways that make the overall amount of uncertainty worse.
- Our second main question is: “If we cannot reduce uncertainty—if we cannot know—then how should we deal with uncertainty?” The answer lies in economics. Economics can help us learn to live with uncertainty—after all, economics is the study of choice. What’s more, the economics of uncertainty focuses specifically on how the lack of information affects people’s choices.
- Like all branches of economics, the economics of uncertainty has both a positive side and a normative side. The positive side describes how people actually make choices under uncertainty, while the normative side tries to show what choices we should make in the presence of uncertainty.
- An early breakthrough in the economics of uncertainty came about through a correspondence between the noted mathematicians Blaise Pascal and Pierre de Fermat in the mid-1600s. Pascal and Fermat’s correspondence contained some of the first systematic ways to determine probabilities and use them to make choices under uncertainty.
- The mathematician Daniel Bernoulli was also motivated by the normative side of uncertainty. He wrote that he was searching for a simple set of rules that would help people make good decisions in risky situations. Bernoulli added a new dimension to the economics of uncertainty that no one had considered before: human preferences.
 - Bernoulli argued that the effect of uncertain events on our happiness, or *utility*, was just as important to a decision as the probabilities that determined what happened.

- In particular, he was one of the first to make the argument that people are risk averse—although, of course, he did not use that terminology. According to Bernoulli, anyone who gambled, even when the odds were fair, was acting irrationally.

Economics of Uncertainty in the 20th Century

- Economists John von Neumann and Oskar Morgenstern, working in the mid-20th century, linked probability and utility. Their model of expected utility became the standard for how people make decisions under uncertainty and was a significant contribution to the positive economics of uncertainty. These economists also explored the normative side of economics and laid out the fundamentals of game theory.
- One of the first economists to look at uncertainty from a positive perspective was Frank Knight. Knight's work emphasized the fact that people have difficulty making decisions under uncertainty because every situation is unique; therefore, the probabilities we estimate from past data are not very accurate.
- The 20th century also saw the birth of the economic forecasting industry, personified by Roger Babson and Irving Fisher. (Babson famously predicted the stock market crash of 1929.) The real success of the forecasting industry was that it gave rise to serious efforts to measure economic fluctuations, such as the business cycle, which are some of the main sources of economic uncertainty.

Recent Developments

- During the past half century, academic research into the economics of uncertainty has intensified. The study of the impact of uncertainty on decision making was formalized into its own branch of economics, called *information economics* because it emphasizes the importance of information, or lack of information, when it comes to making decisions.

- Some of the more significant recent advances in the field have centered on a type of uncertainty known as *asymmetric information*. This is a situation in which one party in an economic relationship has more information than the other person or business entity. Another recent advance in the economics of uncertainty has to do with the tools that we can use to protect ourselves from it, such as derivative instruments.
- Some of the most fascinating work being done in the economics of uncertainty in recent years is related to behavioral economics. Behavioral economics studies the intersection of psychology and economics, including human cognition. This branch of economics often shows that psychological and emotional influences have a significant impact on the choices we make.
- In this course, we will explore the specific types of uncertainty in our lives, the different ways we can manage these uncertainties, and what the economics of uncertainty can teach us about personal risk management.

Suggested Reading

Bernstein, *Against the Gods*.
Casti, *Complexification*.
Friedman, *Fortune Tellers*.
Mlodinow, *The Drunkard's Walk*.
Taleb, *The Black Swan*.
Waldrop, *Complexity*.

Questions to Consider

1. This lecture discussed black swan events, which are highly improbable, extreme events that have significant impacts on the economy and society. What black swan event do you worry about? Are there such things as positive black swan events?
2. What do complexity and self-organized criticality imply for the existence of black swans? In particular, are black swan events really as improbable as we think they are if the economy and financial markets are characterized by complexity and self-organized criticality?

Turning Uncertainty into Risk

Lecture 2

Economist Frank Knight has been called the godfather of the Chicago school of economics, which is widely known for its faith in the power of free markets. The reason that Knight was such a powerful figure at the University of Chicago was his skepticism, his willingness to question everything. In Knight's most famous work, *Risk, Uncertainty, and Profit*, he focused his skepticism on the definition of uncertainty and offered this advice: Whenever you are faced with an uncertain situation, turn it into a risky situation. In this lecture, we'll explore the value—and the limits—of converting the uncertainties we face into risks.

Transforming Uncertainty into Risk

- Most of us use the terms *uncertainty* and *risk* interchangeably; however, the economist Frank Knight made a powerful distinction between these words. For Knight, risk implies that we know or can measure the probabilities of events that could happen or could be true. Uncertainty, on the other hand, means that we cannot know or measure the probabilities of events that could happen or could be true.
- According to Knight's definitions, risk includes much more information than uncertainty does—specifically, information about probabilities. Because uncertainty is essentially a lack of information, the move from uncertainty to risk can represent a significant reduction in the amount of uncertainty surrounding a situation. We make the move from uncertainty to risk by assigning probabilities to the possible outcomes of an uncertain situation.
- Assigning probabilities to an uncertain situation also makes it more concrete and easier to manage. This step opens the door to ways of understanding and managing risk that can improve our lives. We may worry less if we have a sense of the actual probabilities

of certain events. Reducing anxiety about uncertainty is also important because of the effect that anxiety can have on our ability to make decisions.

Assigning Probabilities

- In many cases, where the amount of uncertainty is low or the stakes are low, you may convert uncertainty to risk without consciously thinking about it. For example, suppose you walk into the produce section of the grocery store and look at the price of blueberries. You are unsure whether to buy them now or wait until the price comes down. In other words, you have uncertainty about the future price of blueberries. But you have some knowledge about the behavior of the prices of blueberries, based on previous shopping trips, that helps you make a quick calculation about whether to buy now or wait and see whether they will be cheaper later.
- The decision is more difficult, however, when the stakes are higher. For example, the investment aspect of buying a home is a major source of uncertainty. In high-stakes decisions, such as home



For the vast majority of American families, the house they live in is their primary investment; thus, the decision to buy a house involves high-stakes uncertainty.

buying, it is much more likely that you will consciously convert the uncertainty to risk. You consider the likelihood that home prices will go up, and you measure the probability that the value of the house would go up during the time you own it.

- Rather than calculate a probability directly, most of us would calculate the average rate of growth of housing prices in the area and use that instead. If house prices have been rising at a good pace in the past, then they'll probably continue to do so into the future. As in the case with the blueberries, you are not trying to guess a probability number but, rather, trying to reach a sufficient level of confidence in the likelihood that house prices will go up that will enable you to make a decision.

Model Risk

- Whenever you use data to assign probabilities to an uncertain situation, remember that the data come from the past. There's no guarantee that the future will behave as the past did. Therefore, the act of assigning probabilities in order to convert uncertainty to risk actually introduces a new source of uncertainty into your decision.
- Economists have several names for the uncertainty that resides in our probability guesses. The most suggestive of these is called model risk—the danger that the model used to assign probabilities is wrong. At times, model risk can become so large that it raises the overall amount of uncertainty in a decision.
- For example, during the financial crisis of 2008, model risk became a major source of uncertainty that probably ended up increasing the overall amount of uncertainty in the markets. Much of it came from a simple probability model that is used throughout the banking system called *value at risk* (VaR). The VaR model estimates the probability that a bank will lose at least a certain amount of money, say, \$100 million, on a given day.

- During the financial crisis, the markets became incredibly volatile, and the VaR models drastically underestimated the probabilities of large financial losses at major banks. The banks lost far more on their investments than they expected, which increased the uncertainty in the financial system rather than reduced it.

Multiple Uncertainties

- A significant problem in converting uncertainty to risk is the fact that many of our most important decisions involve multiple uncertainties of different types. Think about saving for retirement, for example.
- Many financial advisors will tell you that stocks are a good investment for your retirement savings. But you have to pick which stocks to invest in, which involves uncertainty related to unknown characteristics. At any given time, any given stock can be overvalued in the market. Once you buy the stock, another factor in uncertainty kicks in—uncertainty over how the stock market will move in the future.
- The strategy of converting uncertainty to risk can become extremely complicated when you have to wade through several decisions involving different types of uncertainty. You might feel more secure if you could break down the decision into separate steps with distinct types of uncertainty at each step. But it often turns out that these different types of uncertainty are interrelated; thus, you have to work with them all at once as you convert uncertainty to risk.

Risk Aversion

- Converting uncertainty to risk helps us make decisions, but it does not protect us against risk. Economists have long understood that people dislike uncertainty or risk; the term used for this tendency is *risk aversion*.

- Economists have incorporated risk aversion into their basic model of human preferences, which is one of the most fundamental aspects of economics. This model of preferences is called the *utility function*. The utility function is a mathematical expression of what people like and do not like and how much they like or dislike different phenomena.
- The characteristic of risk aversion is implied by another basic human characteristic, which economists call *decreasing marginal utility*. Decreasing marginal utility simply means that getting more of something good makes you happy, but as you obtain more of these good things, the extra happiness you get from each additional unit falls.
- The process of declining marginal utility gives the utility function a particular shape that also demonstrates that people are risk averse. With declining marginal utility, a graph of your utility function would look like the side of a hill that starts out steep, then flattens out as you get to the top. It's this flattening of the utility graph, or the decreasing slope, that implies that people are risk averse.

Declining Marginal Utility

- Suppose that someone offers to trade you a risky opportunity for \$50. The risky opportunity is a simple one: If you flip a fair coin and it comes up heads, you get \$100. But if the coin comes up tails, you get nothing.
- Notice that on average, the risky opportunity would leave you exactly where you started—with \$50. But in reality, you'll either end up with \$100 or nothing. In terms of utility, you would not make the trade.
- Again, consider that your starting point is \$50. You could end up with \$100, which would move your utility up the hill, so to speak, by a certain amount. But you could end up with nothing, which would move your utility down the hill, all the way to zero. If the extra happiness you would get by moving from \$50 to \$100

was greater than the happiness you'd lose by moving from \$50 to nothing, then the risky opportunity would be worth it overall, and you'd be happy to take the risk.

- That's where the slope of the hill comes in. Because the slope of the hill—that is, the slope of your utility function—flattens out, this guarantees that the amount of utility you'd lose if you wind up with nothing is larger than the amount of utility you'd gain if you end up with \$100.
- Overall, you're worse off if you give up \$50 in exchange for this risky opportunity. Risk aversion, in economic terms, means that people get more utility from a sure thing than they do from a risky opportunity that gives people, on average, the same amount as the sure thing.

Dealing with Uncertainty

- Converting the uncertainties we face into risks is the first step in dealing successfully with the uncertainty in our lives. Two more steps keep us moving toward the goal of converting uncertainty into risk.
- First, we can learn more about how to measure uncertainty so that we can do a better job of translating uncertainty into risk when we're faced with complex and high-stakes decisions, such as saving for retirement.
- Second, we can learn some techniques of risk management so that once we've converted uncertainty to risk, we can actually do something to protect ourselves from that risk.

Suggested Reading

Bernstein, *Against the Gods*.

Brown, *Red-Blooded Risk*.

Gigerenzer, *Risk Savvy*.

Skousen, "Frank Knight and the Origin of the Chicago School of Economics."

Questions to Consider

1. What are one or two major uncertainties in your life that you would like to convert to risks? What are the main difficulties you encounter when you try to do this?
2. Think of a situation in your life when you've had the opportunity to take a high-stakes risk and you chose to take a sure thing instead. Does this situation give an accurate picture of your own level of risk aversion?

Five Ways to Face the Unknown

Lecture 3

To deal with all the uncertainty we face, it is crucial to use multiple strategies or approaches. Both individuals and multinational companies need to understand what these strategies are in order to make the best choices about how to deal with the specific risks they face. In this lecture, we'll learn five key strategies to deal with uncertainty: information production, diversification, risk sharing, risk avoidance, and absorption of risk.

Information Production

- Because uncertainty is defined as lack of information, one way to deal with uncertainty is to obtain more information—either by collecting it or by drawing inferences from other information we already possess. Every piece of information we produce reduces uncertainty.
- One of the main ways to produce information is by measuring. What's more, when we compare numbers—or data in any form, such as pictures—we notice patterns. These patterns help us make inferences about what we do not know and probably cannot ever know directly. We can make better guesses about what will happen in the future by looking at patterns in the data.
- When we have more information, we can make better choices, which in turn, can increase production and profits and reduce losses and waste. It's no wonder, then, that we devote significant resources to producing information. The federal government invests billions of dollars a year in collecting data. The private sector also gathers vast amounts of data. Companies routinely do test marketing, hold focus groups, and conduct surveys before they commit to new products. Many companies thrive simply on the business of collecting and selling data.

- These days, the biggest data collectors are on the Internet. Companies not only collect information about what you buy online but also compile lists of the websites you visit. What's more, the mobile web, combined with satellite positioning and other technology, enables companies to gather information about where you are and where you are going.

Using Models

- People are very good at noticing patterns in data and at figuring out how to use this information to reduce risks. What's more, it's not much of an intellectual leap to go from noticing patterns in data to creating models to help make educated guesses about information. When we use models, we are using mathematics to describe the patterns more concretely, enabling us to make more precise guesses more quickly and easily.
- For example, suppose you are a lending officer in a bank. Your business revolves around distinguishing good borrowers from bad ones and lending only to the good ones. If you come up with a successful model to determine which loan applicants are responsible borrowers, you'll earn more profits because your loans will experience fewer delinquencies and defaults. You might make even more money by selling the model to other banks.
- In another example, airlines use supercomputers to design their route systems and to determine ticket prices. The airlines are trying to guess how much the different types of travelers are willing to pay and charge as close to that amount as possible, while still keeping the planes full enough to cover their operating costs.

Elasticity of Demand

- Often, companies change their prices just to see how consumers will react. That is, a company will temporarily raise or lower its prices and measure what happens to sales. One of the most important pieces of information that a company needs to know about the demand for its products is how sensitive consumers are to changes in price.
- The sensitivity of demand to changes in price is called the *elasticity of demand*, and the more elastic the demand for a product is, the more sensitive consumers are to changes in its price. If demand is very elastic, then consumers will react strongly to changes in the price of the product. This means that a small drop in the price of the product will attract many more sales.
- But if demand is not very elastic, then companies can raise prices without losing too many sales. Information about elasticity, or price sensitivity of demand, can help companies set their prices at levels that maximize profits.

Diversification

- Another way to use information to deal with uncertainty is through diversification. Diversification uses patterns in data to reduce uncertainty—but the pattern used here is randomness. In diversification, we intentionally take advantage of randomness to reduce uncertainty.
- For example, if you buy only one stock, your return is completely dependent on the fortunes of that one company. Buying two different stocks instead of just one, however, presents the chance that bad luck for one stock will be canceled out by good luck for the other stock. And the more stocks you add to your portfolio from different companies, the more these random bits of good and bad luck will tend to cancel each other out.

- When we add multiple sources of randomness together, we can get an overall reduction in randomness because of this cancellation effect. In order for this to happen, however, the multiple sources of randomness need to act at least somewhat independently of each other. That is, diversification will not reduce uncertainty if all the stocks always have the same amount of good luck or bad luck at the same time.

Risk Sharing

- The main idea behind diversification—putting multiple sources of randomness together so that the randomness cancels itself out—can be used in other situations, as well, such as risk sharing.
- Consider this example involving farming. Suppose that a large group of corn farmers from different parts of the country got together at the start of the growing season and agreed that each farmer whose corn crop was larger than usual would promise to transfer part of the excess production to farmers whose corn crops were below average.
- It's important that the farmers make this agreement at the start of the growing season to ensure that they don't know who will have good weather and who will have bad weather. If the farmers are risk averse, this sounds like a good deal. They give up some of the benefit of good weather if they get it, but in return, they get protection from the effects of bad weather, if they're unlucky this year. This is a real risk-sharing arrangement. It sounds like insurance, but actually it works a little bit differently from insurance. Instead, it's closer to what we would call *hedging*.
- The risk-sharing arrangement works by pooling resources and agreeing to share them according to how you are affected by some source of uncertainty. This arrangement relies on the principle of diversification to be successful.



With car ownership, having insurance is the best way to share risks because it allows you to enjoy the benefits of driving while protecting you against the risk of having an expensive accident.

- Insurance companies sell a financial product called an insurance policy, but what they are really doing is coordinating a risk-sharing arrangement among all the policyholders. There are differences between insurance and hedging, however. In an insurance arrangement, you pay a fee up front for protection. In a hedging arrangement, you do not usually pay any money up front. Instead, you promise to give up all or part of the gains that you might earn later in exchange for protection against a possible loss.

Risk Avoidance

- Besides insuring risks or hedging them, there is another way to share risks with other people simply by transferring the risk to someone else. The idea of transferring risks to other people might make us think we can completely avoid risks and uncertainty. But avoiding risk and uncertainty is more concerned with picking your battles wisely than it is with completely avoiding risk.

- An excellent example of this is bank lending. Risk avoidance—that is, not lending to people who are bad borrowers—is one of the main strategies of risk management in lending money. But the bank wants to take on the risk of lending to good borrowers. In other words, the bank uses risk avoidance to pick its battles, not to avoid risk completely.
- Overall, we simply cannot get rid of all the risk and uncertainty in our lives. And we shouldn't want to. Every company and every person has to take on some kind of risk in order to create wealth and prosperity. The way to improve your life is to take risks—which is true both at the individual level and in the overall economy. The growth and development of the economy rest to a great extent on innovation, which is a fundamentally risky activity.

Absorption of Risk

- In order to be able to absorb financial risks without going bankrupt, we must save. Economists use the term *precautionary saving* to describe the practice of setting aside money to absorb risks.
- Another term for absorbing risks is *self-insurance*. This term is appropriate because it implies that we all have to pick a level of coverage. The other connection to insurance is the cost; it is expensive to set aside savings to cover risks, especially when we all have other demands on our savings, such as retirement and our children's education. But this kind of precautionary saving is important, and we'll return to the subject in a future lecture.
- An effective exercise is to think about how to address your main economic uncertainties. Sit down and make a list of the risks that you face and how you can deal with them. Think of negative risks, such as an accident that totals your car or the possibility that your parents will need full-time care as they get older. Don't forget the more positive risks, as well, such as what you would do if you had the chance to be transferred overseas or to start your own business.

- Taking the time to really think about the major risks in your life and your strategies for managing them can help you become better prepared to deal with these risks. By understanding the five main strategies to deal with uncertainties, you may discover that you have more options to address risks in your life than you thought.

Suggested Reading

McDonald, *Fundamentals of Derivatives Markets*.

Mlodinow, *The Drunkard's Walk*.

Taleb, *Fooled by Randomness*.

Questions to Consider

1. One of the strategies for dealing with uncertainty that was discussed in this lecture was to pass risks onto someone else. What are the possible drawbacks of this strategy? To make this issue more concrete, you may want to think about the subprime mortgage crisis, in which banks passed risks onto other lenders by selling mortgages. A brief version of this story can be found in an article in the *Federal Reserve Bank of San Francisco Economic Letter*, "Mortgage-Backed Securities: How Important Is 'Skin in the Game'?" (<http://www.frbsf.org/economic-research/publications/economic-letter/2010/december/mortgage-backed-securities/>).
2. The lecture discussed diversification as a way of dealing with uncertainty. Is there such a thing as being too diversified? In other words, are there costs to diversification that may outweigh the benefits at some point? Think about the ways that you use diversification in your life to deal with uncertainty and whether your strategies have costs.

Probability: Frequency or Belief?

Lecture 4

Probability is one of the basic tools we use to deal with uncertainty in our lives. We use probability to measure the uncertainties we face and to make decisions. In this lecture, we will examine two views of probability—the frequency-based, or *frequentist*, view and subjective probability. We will explore how these two approaches differ and evaluate whether one is more reliable than the other for making decisions. We'll conclude the lecture by exploring a deeper and more significant issue—the ultimate reliability of any probability we encounter.

Frequentist View of Probability

- According to the frequency-based interpretation, probability simply represents the relative frequency that an event will occur. When we express a probability as a percent, we mean that if we repeat an experiment or a situation 100 times, the probability tells us the number of times we should get a particular result or occurrence. For example, if we toss a fair coin, the probability of the coin's coming up heads is 50%. If we toss the coin 100 times, heads should come up 50 times.
- However, we must consider these two conditions:
 - First, the frequentist view of probability relies on being able to repeat an identical experiment or re-create an identical situation, enabling us to count the number of times that each possible outcome occurs.
 - Second, we can estimate the probability that a particular event will occur by counting up the number of times it occurred in the past and dividing by the total number of times it could have occurred. In other words, we use the relative frequency that an event actually occurred in the past in order to estimate the probability that it will occur again in the future.



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Manufacturers measure quality in terms of the probability that a given product coming off the production line will be defective.

- For example, we might count up the number of months during the past 50 years in which the stock market went up in value (600 months). Looking at that data, the stock market went up during 352 of the 600 months. We then divide the 352 months with positive returns by the 600 total months and say that the probability that the stock market will go up in any given month is $352/600$, or 58.7%.
- Another feature of the frequency-based view of probability is that in some situations, it enables us to calculate probabilities without actually having to perform experiments or collect data.
 - If we can define all the events that could result from an experiment or situation, and we know something about the frequency with which each event occurs, we can then calculate probabilities by using what are called *counting rules*. To use a counting rule, we simply divide the number of times a particular event could happen by the total number of possible outcomes.

- For example, we use counting rules to determine the probability of winning big lotteries. Clearly, it's not realistic to have someone make millions of draws and calculate the probability that each different combination of numbers will come up. Instead, we count the total number of different numerical combinations that could be drawn. Because each combination is unique, the probability of each combination is simply 1 divided by the total number of possible combinations of numbers.

Accuracy-Relevance Tradeoff

- Although we often treat them as if they are objective and true, frequency-based probabilities are not as dependable as they seem. One of the main reasons for this is that in the frequency-based approach to probability, we rely on history for our estimates of probabilities and probability distributions. We assume that an outcome will occur with the same frequency in the future as it has in the past.
- Because the economy changes and evolves over time, the future can look very different from the past, especially as new discoveries, new products, and new ways of doing business are introduced. That is not to say that the past gives us no clue about what might happen in the future, however. Starting with historical frequencies is far better than nothing.
- In order to be perceived as credible and accurate, a frequency-based probability should be estimated from many repeated experiments. A handful of cases will not suffice. But the need for many repeated experiments implies that for many probabilities, we have to go far back in history to accumulate enough examples to form accurate probability estimates based on frequencies. And the farther back in time we go, the less relevant the events are likely to be to our current situation.

- The risk management expert Riccardo Rebonato refers to this problem as the *accuracy-relevance tradeoff*. This means that for frequency-based probabilities (and any statistic calculated from historical data), we can have either accuracy or relevance—but not both.

Degree of Belief

- Another problem associated with the frequency-based approach to probabilities is that there are many questions about the future that we simply cannot answer using frequency-based probabilities.
- For example, consider the probability that a company's newly hired CEO will be able to return the firm to healthy profitability. The answer depends on conditions that are unique to this particular situation. Yet there are many who will invest in the company based on their estimate of the probability that the CEO will turn things around. These investors are not using a frequency-based probability. They are using another way to look at probability that interprets probability as a degree of belief.
- Probability as a degree of belief is internally determined, rather than externally discovered. The internal process that generates our degree of belief certainly uses experience and knowledge of history, but the resulting belief is not necessarily dictated by these conditions alone. We can also use our intuition, instincts, and other evidence to form these probabilities.

Subjective Probability

- Probabilities viewed as a degree of belief are often called *subjective probabilities*. Subjective probabilities may sound vague and arbitrary and can reflect wishful thinking. In most situations, we do not assign numbers to our subjective probabilities. But we should take degree-of-belief probabilities seriously as long as they are based on some kind of evidence.

- In fact, the main difference between frequency-based probabilities and subjective probabilities comes down to the types of evidence we use to form them. In the case of frequency-based probabilities, only one type of evidence is used to construct them: the frequency of occurrence. The frequency can be theoretical or historical, but it must involve some counting of events.
- We form subjective probabilities precisely in those cases where we don't think we can rely on frequency itself to give us a reliable probability estimate. A positive aspect of subjective probabilities is how easily they can incorporate new evidence. Because people base important economic decisions on their own subjective probabilities, they have an incentive to get these probabilities right. And one of the main ways that people try to get their subjective probabilities right is by changing and updating them as they learn new information about an uncertain situation.
- Frequency-based probabilities do not change very quickly with the arrival of new information. This is partly because it takes dozens or hundreds of repeated experiments to establish a credible frequency-based probability; thus, one or two additional experiments won't make a big difference at the margin.
- In addition, the frequency-based approach to probability assumes that the information contained in each experiment is equally important. This means that any new information should not change the view of the probability significantly. Subjective probabilities, in contrast, allow different types of evidence to take on different levels of importance, depending on their relevance.

Comparing Frequentist and Subjective Probabilities

- Subjective probability is not perfect, nor is it more reliable than frequency-based probability. In order for subjective probabilities to be credible and effective, they must be used with some discipline and skepticism. In short, they are more difficult to use well than frequency-based probabilities.

- Frequency-based probabilities are more clear-cut, and because we know them before we make a decision, they make the decision process easier. On the other hand, when we have to rely on subjective probabilities, sorting out our degrees of belief is part of the decision-making process.
- Most of the important decisions we make in life are ones that rely on subjective probabilities. Should you major in accounting or finance? Should you try to retire early or work until you're 65? Should you buy a vacation home in Miami? Such decisions would be much easier if we knew more about related probabilities up front, based on actual experience. But because we really cannot know these probabilities, we must form our own subjective probabilities and use those to make decisions.

Questioning Probabilities

- It's important to question the probabilities that people use, especially when they try to convince you to do something. For example, a financial advisor may tell you to sell off your stocks because the probability of a market correction in the next year is high. Or a professor may tell your child that his or her chance of getting into Harvard Law School is only 50/50.
- Whenever someone tries to use probability to convince you to take some action, you should ascertain how that person arrived at the probability. If it's a frequency-based probability, determine how much historical data went into the estimation. If it's a subjective probability, determine what evidence and thought went into it.
- The key step is to think about the evidence behind a particular probability for yourself. This is especially important when you are using your own subjective probabilities. Before you make a final decision in an uncertain situation, try to explain in words what evidence you are using to form a probability and how you are using that evidence to arrive at that probability.

Suggested Reading

Bernstein, *Against the Gods*.

Mlodinow, *The Drunkard's Walk*.

Rebonato, *Plight of the Fortune Tellers*.

Wheelan, *Naked Statistics*.

Questions to Consider

1. Some statisticians claim that subjective probabilities are the general type of probability and frequentist probabilities are just a special case of degree-of-belief probabilities. Do you agree with this claim?
2. One of the advantages of subjective probabilities discussed in the lecture was that they can be easily and quickly revised and updated when we receive new information. Statisticians believe that the proper way to do this is by using a formula known as Bayes's rule. An intuitive discussion of how Bayes's rule applies to revising your subjective probabilities can be found on the website *Better Explained* (<http://betterexplained.com/articles/understanding-bayes-theorem-with-ratios/>). Can you think of a situation in which new information caused you to significantly revise your subjective probability of some event? If so, do you think you followed Bayes's rule, more or less?

How We Misjudge Likelihood and Risk

Lecture 5

Scientists believe that humans are hardwired to think about uncertainty in ways that lead us into poor decision making. To find out how the human mind works with probability, we go to the intersection of psychology and economics, where researchers are studying how humans process information and make choices. In this lecture, we'll explore how humans make decisions by examining the two ways that the brain approaches decision making, which psychologists have labeled System 1 and System 2. These systems coexist in our minds, but they do not share the decision-making responsibilities equally.

Systems of Decision Making

- During the past few decades, researchers have determined that the human brain approaches decision making using two systems. System 1 acts quickly, automatically, and almost involuntarily; it excels at making snap decisions. When we use System 1 to make decisions, it does not seem as if we are expending much effort; the answers seem to pop up instantly and naturally, without prompting. System 1 is usually first on the scene whenever we are confronted with a new situation or decision.
- System 1 reacts quickly because it is tied closely to our senses and our strongest emotions. In addition, System 1 is extremely effective at creating stories that make sense of the information we have.
- System 2 is analytical and methodical, and it works much more slowly than System 1. It does the heavy-duty thinking, such as inventing models that explain how the world works and using those models to figure out what to do in the future. When we consider the rational and calculating side of human behavior, that's System 2.

- In fact, whenever we have to stop and calculate something, we're using System 2. You can usually tell when you're using System 2 because you can feel yourself expending the mental effort to organize your thoughts, remember data, perform calculations, or arrive at decisions.

Interactions between System 1 and System 2

- Although System 1 and System 2 are clearly very different, they communicate with each other constantly and often work together. Psychologists believe that System 1 often proposes decisions to System 2, which can accept, reject, or modify them. System 2 assigns chores to System 1, such as searching for a memory.
- Another significant way that System 1 and System 2 interact is by developing areas of expertise. These are sets of knowledge and skills that must first be learned by System 2, a process that involves expending a great deal of mental effort. Examples include learning how to drive a car or acquiring skills in a complicated game, such as chess.
- As we acquire these areas of expertise and gradually improve our skills, we have to think less about doing the tasks associated with them. That is, playing a particular game or driving a car seems to become almost automatic after a while.
- What is happening is that as tasks become increasingly familiar and routine, System 1 starts to handle them instead of System 2. We become better at making quick judgments and even develop intuition based on our areas of expertise. This is a very powerful ability of the human mind because it enables us to master complicated tasks and perform them repeatedly without expending much mental effort.

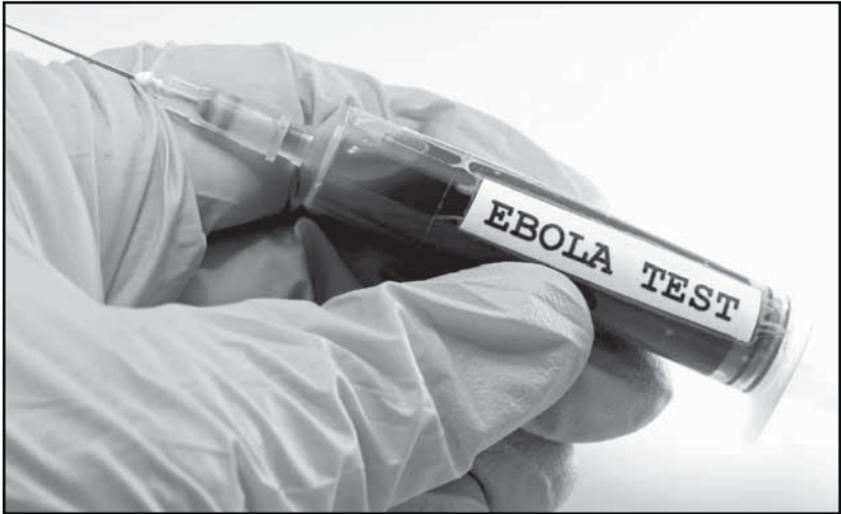
Estimating Probabilities

- System 1 and System 2 work together to notice associations between events and build up expertise in the probabilities of events that occur repeatedly over a period of time.

- Human beings seem to have an innate ability to estimate some types of probabilities. If the probabilities are fairly high—between about 10% and 90%—and they can be inferred from past events that have occurred sufficiently often in the past, then our minds are able to come up with subjective probabilities that are fairly accurate in the sense that they lead to correct conclusions or good decisions.
- But this ability leaves out two large categories of probabilities. The first category includes probabilities that are less than 10% or greater than 90%. Statistically speaking, these are the probabilities that are found in the tails of a distribution. The second type of probability left out includes the whole set of probabilities that are more like degrees of belief than measures of relative frequency.
- When it comes to extreme probabilities and degree-of-belief probabilities, we run into problems. System 1 and System 2 have several significant quirks that make them prone to mistakes whenever they have to estimate these kinds of probabilities.

Availability Heuristic

- System 1 is always looking for a story that connects information together, and it is effective at making up such stories. The downside here is that System 1 tends to jump to conclusions. It does not occur to System 1 to look for more information or alternative explanations; System 1 uses the information it has at hand and creates the best story it can. Therefore, when System 1 tries to estimate a probability, it will look only at the immediate evidence and make a guess based on that.
- The problems go deeper than that, however. Because the story is so important to System 1, researchers have found that System 1 bases its guesses of probability on the quality of the story. For System 1, plausibility is often equal to probability; thus, the more plausible the story, the higher the probability. In fact, psychologists have found that System 1 will ignore the quality and quantity of evidence at hand and will instead focus on the story that it can tell based on the evidence.



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An intense emotional reaction to an event, such as the outbreak of a dangerous disease, will cause System 1 to overestimate the probability of that event.

- The quality of the story that System 1 puts together is strongly affected by the ease with which it can find evidence or examples that back up the story. Psychologists call this the *availability heuristic* at work—if examples are readily available, probability increases.
- The availability heuristic is so strong in people that psychologists now talk about a bias called the *law of small numbers*—the tendency to rely on small samples of evidence to draw conclusions about the world. People form biased estimates of probabilities and make bad decisions as a result.

Substitution

- Another quirk of System 1 is that it is adept at substituting an easy question for a difficult one. When it comes to estimating probabilities, which is difficult, System 1 often substitutes an easier-to-answer question that does not really tell us much about the probability. That can be dangerous, especially if you are basing important decisions on this information.

- For example, suppose you had an excellent sandwich for lunch at a new restaurant in town. When you return home, you immediately buy 100 shares of the company, thinking that if the sandwich was great, the company's stock must be going up. Although having a good product is an important aspect of a successful company, it is only a small part of a complicated set of factors that determine whether the stock price will go up or down over time.
- In this case, System 1 substituted an easy-to-answer question (How good was the company's product?) for a much harder question (What is the probability that the company's stock price will go up?).

Rare Events

- When it comes to estimating extreme probabilities, especially the likelihood of rare events, the quirks in System 1 can create problems. Psychologists have found that most humans estimate the probability of a rare event in one of two ways.
- One way is that we set the probability of these events equal to zero and ignore them altogether. This characteristic helps explain the existence of black swans, which are low-probability events that we tend to ignore.
- The second way that people estimate the probability of a rare event is to vastly overestimate its probability. A good example of this is the public panic surrounding exotic diseases, such as SARS and Ebola, which is driven in part by an overestimation of the probability that the disease will become an epidemic. System 1 associates the ease of visualizing an event and the intensity of our reaction to the event with a higher probability.

Quirks of System 2

- System 2 has the capability to think more objectively and abstractly about probabilities, and human beings have been able to build some impressive probability models because of System 2. But like System 1, System 2 has its own set of quirks.

- First of all, System 2 is lazy. Because it takes a great deal of mental effort to use System 2, it has a tendency to slack off. For example, when System 1 suggests something to System 2, System 2 can choose whether to look more carefully at the suggestion or just accept it. In many cases, when System 1 proposes some kind of probability estimate, System 2 accepts it without objection.
- And even when System 2 does look more carefully into System 1's suggestions, we run into the second quirk. Psychologists call it *confirmation bias*—the tendency that System 2 has to look only for evidence that backs up its position. In many cases, when System 2 finds some supporting evidence, it ceases to search for possible contradictory evidence.

Estimating Probabilities—A Primer

- In estimating probabilities, you should guard against the mistakes that System 1 and System 2 can make. For example, when your intuition tells you something is likely or unlikely, ask yourself how you know that to be true.
- Humans are adept at estimating probabilities in some circumstances—when the probabilities are based on events that have occurred fairly often in the past and the probabilities themselves are fairly high. If the probability you are estimating fits this description, then you can put more trust in your intuition.
- However, if you are trying to estimate the likelihood of a rare event or estimate the degree of belief that something will occur, be careful. Don't accept System 1's snap judgments at face value. For example, ask yourself whether you are substituting plausibility for probability or whether you are being influenced by only a small number of events.
- When you use System 2 to check up on System 1's stories, watch out for confirmation bias. Be skeptical about the evidence you use to back up probability estimates and go out of your way to look for evidence that could either support or cast doubt on your idea.

- Finally, push System 2 to think more systematically about probabilities. That means finding data and even learning to use some simple statistical concepts and models. These tools can help clear up your thinking, especially in the areas where it is most likely to fall victim to the quirks of System 1 and System 2.

Suggested Reading

Gigerenzer, *Rationality for Mortals*.

Kahneman, *Thinking, Fast and Slow*.

Rebonato, *Plight of the Fortune Tellers*.

Taleb, *Fooled by Randomness*.

Questions to Consider

1. The lecture discusses several quirks in System 1 that can lead us to misjudge probabilities of events by a large amount. Can you think of an example in which you've made a mistake in estimating a probability because System 1 made up a convincing but inaccurate story? Have you ever used the law of small numbers to make a decision? What would be an effective way to prevent yourself from falling victim to System 1's quirks?
2. The lecture also discusses how humans either ignore or vastly overstate small probabilities. When have you overstated a small probability, and what was the consequence for you? Similarly, when have you ignored a small probability?

The Reward in Risk

Lecture 6

In the second lecture of the course, we learned about converting uncertainty to risk by assigning probabilities to the uncertainties we face. In this lecture, we'll understand how to use probabilities to measure rewards and risks, so that we can make better decisions in uncertain situations.

Expected Value

- Economists believe that we make decisions by comparing costs and benefits. In the case of uncertainty, risks and rewards are really the costs and benefits. Because human beings are risk averse, risk is a cost to us. The benefit is the reward we get from bearing the risk.
- When the outcome is uncertain, the best way to make a decision is to find the expected value of the reward. An expected value is a weighted average, where the weights are given by the probabilities. To determine an expected value, we multiply the probability that each possible outcome in an uncertain situation will occur and add up all the products.
- Let's apply this to find the expected value of a venture capital fund seven years from now. Assume that the fund invests \$5 million each into 10 start-up companies. For each investment, let's assume that there is a 20% probability that the investment will be worth \$35 million in seven years, a 20% probability that the investment will be worth \$15 million; a 30% probability that the investment will be worth \$5 million, and a 30% probability that the investment will be worth nothing in seven years.
- This means that the expected value of a \$5 million dollar investment in one company, seven years from now, is given by: $0.2(35) + 0.2(15) + 0.3(5) + 0.3(0) = \11.5 million. Assuming that each investment in a particular company is independent of the

investments in the other companies, then we can find the expected value of the entire fund by multiplying the expected value of a single investment in a single company by 10: \$115 million.

- Because the original investment was \$50 million, the expected profit is \$65 million. When we divide \$65 million by \$50 million, we get an expected return of 130%. If we find the compound average annual rate of return over those seven years (which is a better number to use for the expected return), we arrive at 12.6%.

Variance and Standard Deviation

- The most common gauge of risk that people use in making economic decisions is the variance—and its twin, the standard deviation.
- The idea of the variance builds off the concept of the expected value. The expected value represents what we think the value of profits or returns or some other uncertain economic outcome will turn out to be once the uncertainty is resolved. In this context, risk is the chance that the actual value of the economic variable will be far away from its expected value, which in turn, will cause some loss for us.
- The challenge is how to measure this aspect of the uncertainty. A good way to measure risk is to find the average amount by which the actual value tends to be below the expected value—or above the expected value, if that's what would cause the loss.
- As in the case of expected value, the variance is a weighted average, where the weights are probabilities. To determine the variance, we take each possible value of a random variable, subtract from it the expected value, and square that difference. Then, we multiply each difference by the probability of realizing that particular value for the random variable and add all the products.
- One of the drawbacks of using the variance as a measure of risk is that the answer is in squared units. Therefore, it cannot be compared directly to the expected value, which is measured in

non-squared units. Because of this problem, most people do not use the variance directly; instead, they use the variance's twin: the standard deviation.

- The standard deviation is the square root of the variance. When we take the square root of the variance, the resulting number is measured in the same units as the expected value. In the case of our venture capital fund, the standard deviation of the value of the fund is the square root of 1652.5, which is \$40.65 million. Both the expected value and the standard deviation are measured in dollars, giving us a measure of risk that we can actually compare to our expected value in a straightforward way.
- In order to make that comparison, we need to understand an important technical issue about the variance and standard deviation. These statistics are what are known as *symmetric measures of risk*, so called because when we calculate the variance, positive differences between the actual value and the expected value of the variable count just as much toward the measure of risk as negative differences.

Measuring Risk

- Often, economists use the expected value and the standard deviation to find two other numbers. The first is the expected value plus the standard deviation, and the second is the expected value minus the standard deviation. In the case of our venture capital fund example, the high number is \$155.65 million, and the low number is \$74.35 million. This range of values represents the *average dispersion*, or the average range of values that this venture capital fund will reach after seven years.
- In situations where we do not know the probability distribution, we can still use variance and standard deviation as a measure of risk. Actually, we use estimates of these statistics, called the *sample variance* and *sample standard deviation*. The sample variance is the simple average of the squared distance from the sample

mean, rather than the weighted-average squared distance from the expected value. The sample standard deviation is the square root of the sample variance.

- There is a clever way to combine expected value and standard deviation into a single number that can help us make good choices. Suppose we divide the expected value for some variable, such as returns, by the standard deviation of the variable. Statisticians call this the *coefficient of variation*. If we do this, then we have a measure of the amount of expected return we get per unit of risk that we have to take on in order to earn the return. In other words, we get a measure of this project's “bang for the buck” in terms of risk.
- The noted financial economist William Sharpe came up with a small tweak on the coefficient of variation, called the *Sharpe ratio*, that is a standard part of the investing toolbox.
 - To calculate the Sharpe ratio, we first take the expected return on an investment and subtract the rate of return on government bonds to arrive at the *expected excess return*. Then, we determine the Sharpe ratio by dividing this expected excess return by the standard deviation of the asset's return.
 - The Sharpe ratio is the amount of excess return we earn per unit of risk that we bear. It is another measure of “bang for the buck” in terms of risk. Assets with higher Sharpe ratios are more attractive investments because they should give you a bigger return in the long run as a reward for bearing the short-term ups and downs.

Covariance

- Another measure of risk essential to managing uncertainty in business and finance is *covariance*. As its name suggests, it is a deviation-based measure of risk, like the variance and standard deviation. But the *co* in *covariance* implies that it is a joint or shared risk, which is the source of its usefulness. Shared risks are risks that affect multiple variables in the same way.

- The way we measure shared risk, or covariance, is analogous to the way we measure variance. But unlike the variance, the covariance can be negative or positive. A positive covariance indicates shared risk that affects both returns in the same direction, while a negative covariance indicates that a particular shared risk tends to move each company's stock return in the opposite direction.
- One similarity between the variance and the covariance, though, is that the units of the covariance are difficult to interpret and compare to such measures as the expected value. As in the case of the variance, the units of the covariance are squared units. Generally, when we encounter covariances, they must be divided by other variables to help put the covariance's information about shared risk into a more usable form.

Beta Coefficient

- One of the most discussed variables in stock investing is a stock's *beta coefficient* (β). Every investor wants to know this value, and just about every investing website will report a stock's beta as part of the basic information about the stock.
- A stock's beta is a number that measures the amount of shared risk between an individual stock and the entire stock market. Because it's a shared risk, a covariance is included. And indeed, the beta for a stock is a fraction, in which the numerator is the covariance between the individual stock's return and the overall stock market's return. This covariance is then divided by the variance of the return to the overall stock market.
- The reason we want to measure this shared risk relates to the capital asset pricing model theory, which says that the return on any stock should be proportional to the amount of market return risk that is in the stock. The fraction known as beta measures this amount of risk; thus, it is key to telling an investor what the return on the stock should be.

Correlation Coefficient

- A stock's beta is similar to another use of the covariance, which is the *correlation coefficient*, or *correlation*. To find a correlation coefficient, we divide the covariance between two variables by the product of each variable's standard deviation.
- When we do this, we'll always get an answer that has no units and is between -1 and $+1$. The higher the correlation between two variables, the more the variables tend to move in proportion to each other, as if there were a linear relationship between the two variables. A negative correlation indicates an inverse linear relationship between the two variables.
- The correlation is one of the most powerful tools we have to deal with uncertainty because correlations suggest connections between different variables that we can use to peel back uncertainties and make better decisions.

Suggested Reading

Rebonato, *Plight of the Fortune Tellers*.

Wheelan, *Naked Statistics*.

Questions to Consider

1. In this lecture, the Sharpe ratio is discussed as a tool to help make decisions that are affected by uncertainty. A concept that is related to the Sharpe ratio is Roy's safety-first criterion. A brief discussion of this can be found at *Investopedia.com* (<http://www.investopedia.com/terms/r/roys-safety-first-criterion.asp>). How is the safety-first criterion different from the Sharpe ratio? Are there risky situations where you think you would rather use this criterion than the Sharpe ratio to choose what to do?

2. So-called fat-tailed distributions have gained much attention in the past few years as a way of visualizing risk. You can find information about fat-tailed distributions by searching on the Internet. (A good example can be found in the first three minutes of a *YouTube* video called “Paul Wilmott on Quantitative Finance, Chapter 16, Fat Tails” at https://www.youtube.com/watch?v=jF-v_MAIF18). How does this fat-tail view of risk differ from using variance or standard deviation to measure risk? What does it tell us that standard deviation doesn’t?

Decision Science Tools

Lecture 7

When we are faced with complicated uncertainties, it is almost impossible to come to a good decision just by thinking it through in our heads. We need some way to organize our thinking about the decision, so that we can keep the issues straight and have a productive deliberation about the pros and cons. Fortunately, the field of decision science has produced a set of concepts and tools that can help us think more clearly about the decisions we face in business. In this lecture, we'll examine the use of these concepts and tools, including scenario analysis; decision rules, such as maximin, maximax, average payoff strategy, and expected payoff strategy; and decision trees.

Scenario Analysis

- Scenario analysis is used to simplify all the possible effects that a source of uncertainty can have on a decision. Most sources of uncertainty that affect businesses can take on a wide range of values. For example, suppose that you are an investor trying to choose the right asset; your choice of investments includes a money market fund, a corporate bond, and a stock index fund that tracks the S&P 500.
- No matter which of these assets you choose, a major source of uncertainty that will affect your total return on this investment is the direction of future interest rates. Simplify the problem by choosing a few different interest rate scenarios rather than all possible values. In particular, three scenarios—interest rates increase, stay the same, or decrease—cover everything that could possibly happen to interest rates over the next few years.
- With the three scenarios, the next step is to consider the consequences or payoffs for each action you can take. The payoff from each action here is the return that you expect to earn from making the investment. There are three possible payoffs for each of

the three actions you can take. The easiest way to keep track of the actions, scenarios, and outcomes is to make a table, as shown in the example below.

| Investment Choice | Expected Yearly Return | | |
|-------------------|------------------------|--------------|--------------|
| | Falling Rates | Stable Rates | Rising Rates |
| Money market fund | 1% | 3% | 6% |
| Corporate bond | 5% | 5% | 5% |
| Stock index | 7% | 4% | 2% |

- In some cases, you could come up with a statistical model that could help predict what should happen. In other cases, you have to rely on your experience and judgment. With the scenarios laid out, determine whether there is one choice that does better, no matter what happens to interest rates. A quick glance at this table, however, indicates that none of the three choices is the best.

Maximin and Maximax

- We need to bring in an additional tool from decision theory, a *decision rule*. A decision rule offers a concrete way to judge between the different outcomes. This sounds like an ideal solution—except that there are many possible decision rules that can be used, and different decision rules will lead us to make different choices.
- The first two decision rules we'll consider depend only on the payoffs in the table. In other words, they do not take probabilities into consideration. This may seem strange because we use probabilities to measure risk, but these decision rules are not ignoring risk; they are simply looking at risk in a different way than we would if we incorporated probabilities.
- A conservative strategy would focus on the worst payoffs and would literally choose the best of the worst. Because we are choosing the best of the worst, this strategy is called the *maximin strategy*. The

maxi part means that we are choosing the best alternative, and the *min* means that we are considering only the worst outcomes. Notice, however, that the maximin rule ignores potential upside gains.

- An alternative decision rule would be to choose the best of the best, which is the aggressive strategy called *maximax*. But like the maximin strategy, the maximax ignores important information—the downside risk.

Average Payoff and Expected Payoff

- Maximin and maximax strategies can be useful when we are simply framing a decision or in situations where we are hesitant to make guesses about probabilities. But using probabilities as part of a decision rule can usually help, even when we are not particularly confident about the probabilities we assign.
- One simple decision rule that uses probability is called the *Laplace rule*, or *average payoff strategy*. The name comes from Laplace's advice that one should assume that all possible scenarios are equally likely until there is good evidence that they are not. If we assume that all scenarios are equally likely, finding the expected payoff for each decision is equivalent to finding the average payoff.
- In many, if not most, cases, we'll actually have some idea of the relative probabilities of each of the scenarios. In the case of future interest rates, for example, we can use information about recent trends in economic growth and the statements of the central bank to get an idea of the likelihood of each of the three scenarios. We can use these estimated or subjective probabilities to follow the expected payoff rule, which advises us to choose the decision with the highest expected payoff.

Assigning Probabilities

- Suppose we believe the economy is coming out of a recession, and economic growth is picking up. Interest rates usually rise during economic recoveries, especially if the recession was deep and the recovery is strong. We are so convinced that interest rates are going

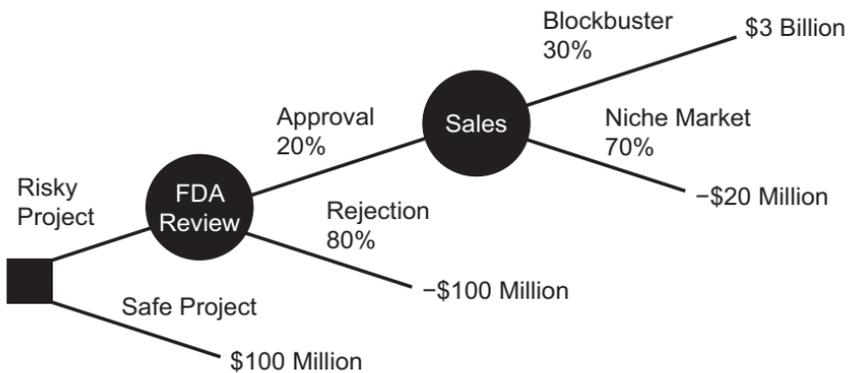
up that we assign an 80% probability to an increase in interest rates, and a 10% probability to each of the other two scenarios. We need to determine what investment has the highest payoff under that set of subjective probabilities.

- In our example, the expected payoff of the money market fund is $0.1\% + 0.3\% + 4.8\%$, for an expected return of 5.2%. The expected return on the corporate bond is 5% exactly. The expected payoff of the stock index fund is $0.7\% + 0.4\% + 1.6\%$, for a total of 2.7%. If we place a high enough probability on an increase in interest rates, then the best decision is to go with the money market fund.
- Different sets of probabilities will lead to different expected values and different choices. For example, if we think there is a high probability that interest rates will fall rather than rise, then the stock index fund will have the highest expected payoff.
- When using the expected payoff rule, however, it is advisable to change some of the probabilities to see how big a change in probabilities it takes to change a decision. For example, if we think that it is only 70% likely that interest rates will rise, 20% likely that they will stay the same, and 10% likely that they will fall, then the corporate bond once again has the highest expected payoff.

Decision Trees

- So far, we have been looking at fairly simple, one-time decisions. For more complex decisions with multiple sources of uncertainty, we use a tool called the *decision tree*—a simple but powerful way to organize our thinking about complex decisions.
- A decision tree is a diagram that represents a decision to be made. The diagram consists of lines, squares, and circles. Lines denote the different possible decision paths we can take, and every path in the diagram ends in some kind of payoff. The lines originate from squares, which denote a place where we have to choose an action. Multiple lines branch out from each square in the diagram, giving the diagram its tree shape.

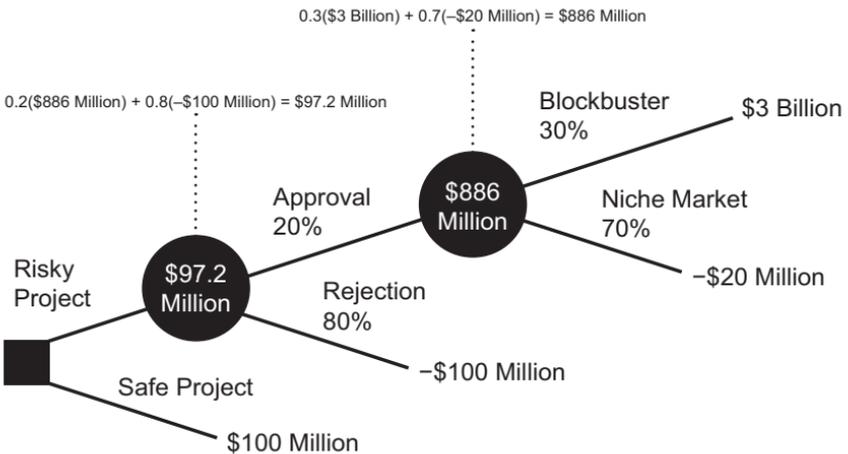
- Lines can also connect to circles, which denote uncertain events that influence outcomes. Because uncertain events can have multiple outcomes, circles create further branching within the decision-tree diagram. If there are multiple places where the decision maker must take action and multiple sources of uncertainty, the tree can end up having many branches.
- The tree diagram is organized in chronological order running from left to right. Generally, the decision tree starts with a square denoting the main decision. Then, the branches take us through the uncertain events and subsequent decisions that need to be made in the order they occur, until we get to the ultimate payoffs on the right-hand side of the diagram.



- The decision tree shown here illustrates possible paths in a decision faced by a medical device company. The company can upgrade an already successful product that it is confident will earn profits of \$100 million, or it can develop a new product that carries some risks: It may or may not get FDA approval, and it may find a large market or only a small one.

Decision Rules

- The ultimate goal of a decision-tree model is to use it to help actually make a decision. To do that, we need to add in a decision rule, just as we did in the case of scenario analysis. If the payoffs are measured in profits, then the most common rule used is the expected payoff rule, which tells us to choose the option that maximizes the expected payoff. That sounds easy enough to implement, until we look back at the tree and realize that there are multiple payoffs and sources of uncertainty.



- In order to apply the expected payoff rule in decision trees, we use the same approach that we use to solve many economic models, particularly ones that involve a time element. To find out what the best decision is at the start of the model, we go to the end of the model and work backward until we get to the beginning.
- In our example, we start with the payoffs for the Blockbuster and the Niche Market. We find the expected payoff by multiplying each of these payoffs by their respective probabilities and adding them: $0.3(\$3 \text{ billion}) + 0.7(-\$20 \text{ million}) = \$886 \text{ million}$.

- We then replace the Sales circle with its expected value and keep tracing backwards. In other words, we assume that \$886 million is the actual payoff from the Approval line coming from the FDA Review circle. This payoff is associated with a 20% probability. The payoff from the Rejection line is $-\$100$ million, and this has an 80% probability. Thus, the expected payoff from the FDA Review circle is $0.2(\$886 \text{ million}) + 0.8(-\$100 \text{ million}) = \$97.2 \text{ million}$. We then replace the FDA Review circle with its expected payoff of \$97.2 million.
- Once we do this, the decision is simple. We have our original square with only two branches. We can choose the safe project and earn an expected profit of \$100 million or take the risky project and earn an expected profit of \$97.2 million. It's close, but in this case, the safe project is slightly better than the risky project, and it's the one the company will choose.

Suggested Reading

Clemen and Reilly, *Making Hard Decisions*.

Evans, *Statistics, Data Analysis, and Decision Modeling*.

Questions to Consider

1. Scenario analysis works best if the source of uncertainty can be characterized by two or three simple alternatives, where each alternative has a clear and different implication for some outcome that matters to you. What would be a useful way to designate scenarios if the source of uncertainty is the next presidential election? What if it is the price of oil? The sales of your startup business?
2. Suppose you go through the effort of setting up a decision tree and when you're done, your gut feeling contradicts the recommendation of the decision-tree model? What should you do in this situation?

Gambling Economics

Lecture 8

We can learn a great deal about how to manage risk in business and everyday life by watching people play games of skill and chance. Interestingly, many of the pioneers in probability theory and modern risk management were also accomplished gamblers. Gambling is not just a game of skill or chance that people enjoy for entertainment, however. Many decisions that we make—even the most important ones—are closer to gambles than we might want to admit. Analyzing gambling gives us the opportunity to think about why some decisions are better than others.

A \$400 Billion Pastime

- Professional gamblers seem almost detached from the action and excitement. The reason is that they have learned to block out or turn down their emotional involvement in the game in order to focus as much as possible on managing the risks. That is a valuable skill when it comes to dealing with uncertainty.
- Gambling is tremendously popular; annual gambling revenues total more than \$100 billion in U.S. casinos and lotteries alone. According to Global Betting and Gaming Consultants, worldwide legal gambling revenues total more than \$400 billion and are forecast to rise to more than \$500 billion.
- These figures include only legal gambling. Gambling is also a large part of the underground economy. What's more, there is also informal gambling among small groups of people, such as the weekly neighborhood poker game. Informal and underground gambling is estimated to take in at least as much as government-sanctioned legal gambling.



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No matter whether you like to gamble yourself, you can learn about how to deal with risk in business and everyday life by studying games of skill and chance.

Popularity of Gambling

- There are several reasons for the popularity of gambling. First, many forms of gambling are enjoyed as social activities. Second, some forms of gambling may actually enhance our enjoyment of other pastimes. In the language of economics, gambling may be a complement to other goods and services. For example, betting on a sporting event, such as a football game, may be a way to enhance our enjoyment of it.
- A third reason for the popularity of gambling has to do with our complex relationship with risk and uncertainty. Although people are generally risk averse, at the same time, they crave variety and excitement. Economists have worked this aspect of human preferences into their models.

- The risk of gambling provides a thrill because of the variety of the outcomes and the possibility of being surprised by winning prizes. In most gambling games, the possibility of winning some sort of prize is actually fairly high. Most people who gamble do not lose every bet; they lose money because their total winnings are less than the total amount they bet.
- Yet another reason that gambling is popular is that some people—mainly entrepreneurs—have turned to gambling as a source of seed capital. Many entrepreneurs have few realistic alternatives when it comes to raising money. Banks are often too conservative to lend money to entrepreneurs. What’s more, entrepreneurs tend to be risk takers in the first place.
 - Financial economist Aaron Brown argues that this situation describes the western frontier of the United States during much of the 19th century. Entrepreneurs were drawn west by the opportunities and arrived in the new territories well before the bankers. They had some money or other resources, but they were not wealthy. When groups of them got together in the trading post or mining camp, they would inevitably start gambling.
 - Although the rules that govern the transfer of money among people in a gambling game are very different from the ones used in traditional borrowing and lending, gambling games placed large amounts of money in the hands of people who were often willing to invest that money in new business ventures. Gambling was not just a pastime in the Wild West. It was also a form of frontier venture capital—adventure capital, so to speak.

“Put Your Money Where Your Mouth Is”

- Gambling can be a lens that helps us to look at other economic activities in a different way. In particular, let’s consider the gambling expression “Put your money where your mouth is”—and use it to reexamine how we deal with risk and uncertainty.

- “Put your money where your mouth is” means to make a bet, using money or some other valuable as the stake. The simple act of making a bet, because it is explicit and transparent, changes us in significant ways. First, it focuses our minds on the bet and makes us take the consequences seriously. If we lose the bet, we lose the resources that we placed at risk.
- Putting real resources at stake makes people think harder about probabilities. Economists have used this insight to resolve one of the major problems in probability. We cannot estimate many important probabilities because the events that are involved do not occur often enough for us to use their frequency of occurrence. We have to come up with our own subjective, degree-of-belief probabilities instead.
- This is a difficult process. In fact, it is so hard that most of us give up instead of making any kind of precise guess. We might guess that something is very likely or very unlikely, but that is as far as we get. If we are forced to make a bet on the event, however, we’ll put more effort into our guess of the probability.
- In fact, risk management expert Riccardo Rebonato suggests the following procedure to turn an imprecise subjective probability into a more precise and dependable probability: Imagine that you are forced to place a bet on an event whose probability is subjective. You must give odds on each side of the bet, but you do not get to choose which side of the bet to take.

Odds

- There are many ways to present betting odds, and they vary across different forms of gambling. One of the simplest ways to express betting odds, however, is to base them on the probability ratio. The probability ratio is simply the ratio of the probability that the event happens divided by $1 - \text{probability}$. The answer gives you the amount, in dollars, that someone needs to bet in order to win a payoff of \$1.

- For example, suppose you want to bet that there will be a recession next year, and the quote you get from a casino is 3 to 1 against the recession. That means that if you bet \$1, you'll receive a profit of \$3 if the recession occurs.
- According to the probability ratio method of calculating odds, the 3-to-1 odds against a recession means that if we divide the probability that there won't be a recession by the probability that there will be a recession, the result will be 3. To translate this to probabilities, first add up the numbers in the odds expression; here, the result would be $3 + 1$ because the odds are 3 to 1.
- Then, divide the numerator and the denominator by this number to get the implied probabilities of the two events. Odds of 3 to 1 against a recession occurring means that the probability that there won't be a recession is $3/4$, or 75%. The probability that there will be a recession is $1/4$, or 25%. Notice that the ratio of the two probabilities is $75/25$, which is indeed 3.

Setting Odds First

- Riccardo Rebonato argued that having to set odds first, without knowing which side of the bet you will take, clears out any biases you have and leads to your best estimate because you want to avoid losing money. And the best you can do in this situation, in expected terms, is to break even.
- In our example, if someone wants to bet with you that a recession will happen next year, then that person will win \$3 if the recession occurs. If your probabilities are correct, then you will win \$1 with probability 75% and lose \$3 with probability 25%. On net, you expect to earn zero.
- Similarly, if someone bets \$1 with you that the recession won't happen, then with probability 75%, you'll lose and have to pay one-third of a dollar. With 25% probability, though, you'll win \$1. Again, the total or expected profit is zero.

- Although Rebonato's argument is basically correct, it still can't overcome the fact that coming up with these subjective probabilities is very difficult. However, making a betting market can be a way to find a reliable estimate of a subjective probability.

Prediction Markets

- The idea of using gambling-like markets to find probabilities of future events seems fairly promising. In fact, such markets have been used not only on the question of who will win a big football game but also to predict who will win a presidential election or what future GDP growth will be.
- Gambling-like markets called *prediction markets* have been created in many countries around the world, effectively allowing people to bet that specific future events will occur. In the United States, there is one prediction market. Operated by the University of Iowa's Henry B. Tippie College of Business, it is called the Iowa Electronic Markets (IEM). The IEM has been operating since the 1988 presidential election, and it features a political prediction market that is open to public participation.
- The IEM is allowed to operate in the United States, despite a general ban on prediction markets, because it maintains a relatively small scale, and its primary purpose is education and research. These markets have proven that they can be accurate predictors of future events and solid estimators of probabilities.
- The success of the IEM shows that trading on prediction markets could benefit society. Prediction markets can create reliable estimates of the subjective probabilities of events that affect the economy and financial markets.
- In sum, we should not be hesitant to think about the decisions we need to make in terms of gambles. If we consider decisions in these terms, then we are forced to think about how much we are betting, what the probabilities are, and what we will gain or lose. Being

confronted with the terms of these gambles can help clarify our decisions. Approaching decisions with a gambler's eye may help us do a better job of separating the good bets from the bad ones.

Suggested Reading

Brenner, Brenner, and Brown, *A World of Chance*.

Brown, *The Poker Face of Wall Street*.

Questions to Consider

1. People sometimes say, "You make your own luck." What does this expression mean, and how can it help us become more successful in choosing the risks that we actually want to take?
2. In *Plight of the Fortune Tellers*, chapter 4, Riccardo Rebonato claims that all financial trades (even bank lending) can be characterized as one of three types of gambles: selling lottery tickets, buying insurance, and rolling dice. How does each of these trades work, and what are real-world examples of these trades?

Game Theory: Reveal or Conceal?

Lecture 9

In this lecture, we will examine the strategic interactions that are part of economic life—transactions in which we compete against others. Bargaining is an example of a strategic interaction that has a great deal of uncertainty to it. The formal branch of economics devoted to strategic interaction is called *game theory*. Game theory has played a significant role in foreign policy, especially as part of formulating defense strategy. What's more, game theory has produced insights for those who have to interact strategically in the markets on a daily basis. In this lecture, we will explore significant insights from game theory that will help us deal with the uncertainty that is embedded in all our strategic economic interactions.

Credible Threats

- One economic interaction with which many people are familiar is the negotiation of a home sale. At some point in such a negotiation, one of the bargainers may say, “Take it or leave it.” This is a threat, an indication that the person who makes the threat is willing to walk away from the negotiation without a deal at all if the other side doesn't agree. In order for this action to be effective, the threat must be credible.
- Credible threats are an important part of strategic interactions, including in the markets. But they are difficult to follow through with, especially when we get emotionally tied up in the negotiations and start to rethink our bargaining positions. We can use game theory to explore credible threats, understand their function, and deal with them more effectively.
- The act of making a threat—if it's credible—reveals information to the other side in a negotiation. A threat indicates that one party is at the edge of what he or she considers an acceptable outcome.

Coordination

- If the proposed terms of a deal become too favorable to one side or the other, then the negotiations will break down and no deal will be made. That's an unsatisfactory outcome that's usually worse for both sides than coming up with a deal that's acceptable to both sides—even if the deal favors one side over the other.
- In the language of game theory, this is a coordination problem. If the negotiating gets out of hand, then no deal at all will be made, which is much worse than making a deal that is at least minimally acceptable to both sides. The two sides need to coordinate the bargaining somehow to signal that they may be in danger of losing the deal completely.
- There are many ways to coordinate bargaining, but they all involve revealing information. Of course, revealing information and making threats can simply be ploys to trick the other side into acting in a way favorable for you. In other words, saying “Take it or leave it” could just be a bluff. Both sides to a negotiation need to stand ready to call each other's bluffs, especially when it's the first or only time they'll interact.
- Some people see bluffing as a low-cost way to start a negotiation. From the bluffer's standpoint, your acceptance of the bluff could be a big win, and if you call the bluff, a good deal may still be reached—as long as you're still willing to negotiate after calling the bluff. If the person you're interacting with follows this strategy, you won't get fair treatment until after you've started to walk out.
- In many strategic interactions, there's an extra layer of uncertainty you have to cut through just to get to the negotiations. First, you have to deal with the uncertainty over whether the person you're competing with is telling the truth or trying to trick you. If you decide that the person is telling the truth or has finished trying to trick you, then you can move on and deal with the uncertainty you wanted to resolve in the first place, such as coming to an agreement on a price or other terms of a contract.

Reputation

- When there's a possibility of multiple interactions between two people, or when the strategic interaction plays out over a long period of time, bluffing becomes a much less attractive strategy. The reason for this is that in repeated interactions or interactions that take place over long periods of time, a special kind of information is created that helps coordinate the interactions: reputation. Reputation is information about you that others think is true, regardless of whether it is actually true.



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Reputation is especially valuable in winning one of the most important strategic games we all play—competing for raises and promotions at work.

- People create reputational information through their words and actions. Sometimes, reputation takes a long time to build, especially when the nature of the information implies something positive about you. But negative reputation seems to take less time to establish.
- The advantage of reputation is that it achieves the coordinating function that is essential to success, and it reduces the time and effort spent negotiating. Reputation is an extremely powerful informational tool that we use to resolve potential problems in strategic interactions, particularly ones that involve personal interaction and negotiation.
- It's usually costly to build up a reputation, especially a good one. It can take a significant amount of time to establish a reputation, and in many cases, it also involves some expense. You have to make sure that the reward you get for winning the game is worth what you have to spend to build up your reputation.

Game Theory

- In some types of strategic interactions, the best move is to increase uncertainty, not reduce it. To explain these situations, we'll consider the very beginnings of game theory. In 1926, Hungarian-born American mathematician John von Neumann presented a paper at the University of Göttingen in Germany that addressed how to play the child's game of matching pennies.
- The game is played as follows: Two players each hold one penny behind their backs and decide which face of the coin they're going to reveal—heads or tails. They count to three, then show each other the pennies at the same time. If the pennies match—either both heads or both tails—then one of the players wins both coins. If the pennies don't match, then the other player wins both coins.
- Von Neumann was interested in this game mainly because of its simplicity. If you can find the best move to make in this game, chances are that you can figure out how to solve more complicated games. But at the time, neither von Neumann nor anyone else had a systematic way to analyze games or strategic interactions. Nonetheless, von Neumann came up with an intuitive argument that helps us understand what is different about this game and why it's necessary to add uncertainty in this situation.
- Von Neumann's insight was that in a simple game, such as matching pennies, if your opponent can predict what you're going to do, he or she will take advantage of that information. Therefore, your best strategy is to be unpredictable and randomize what you play. You should play heads 50% of the time but not in any predictable pattern. It's a paradoxical strategy, because you win by trying not to lose.
- You should expect to win only about 50% of the time. The person you're playing against should also be following the same strategy of playing randomly. Thus, your coins should match half the time and not match the other half of the time. You may end up winning more often, but if you do, you're just having a run of good luck.

Increasing Uncertainty

- Twenty years after Von Neumann's original paper, the American mathematician John Nash came up with a formalized way to solve games, called the *Nash equilibrium*. When you solve for the Nash equilibrium in matching pennies, you find that von Neumann's recommendation is indeed correct. In the terminology of game theory, the Nash equilibrium to the game of matching pennies is for each player to follow a mixed strategy of playing heads with 50% probability and tails with 50% probability.
- The term *mixed strategy* means that a player randomly chooses one move from a set of two or more different moves. The mixed strategy—that is, random strategy—is commonly found to be the Nash equilibrium of many games, especially simple ones. For example, in tennis, players can aim their serves to the left or right side of the court, seeming to randomize this choice.
- In the matching pennies game, there's no coordination problem. In every interaction, one of the players wins and the other loses, and that's all that can happen. What's more, the fewer actions a player can take, the more likely it is that mixing it up will be a winning strategy for that player.

Using a Mixed Strategy

- We all know that a significant amount of shopping has moved online and that the businesses that are trying to sell to us are tracking every move we make on the Internet.
- When we shop online, we lose any chance to negotiate prices—and our actions are limited to “buy” or “don't buy.” What's more, any information we reveal about ourselves will be used to adjust the price that the business quotes to us, to make sure that we pay the highest prices possible. In short, online shopping has many of the characteristics of matching pennies.

- Therefore, the best advice in online shopping is mix it up a bit. Introduce some randomness into your buying habits. Don't always take the first price you're offered. Put some items in your shopping cart once in a while, then log off the site without buying them.
- The concern is that if you act too consistently, you give away too much information that companies will use to extract higher prices from you on future visits. Given what we know about game theory and about the Internet, we can all stand to be more strategic.

Suggested Reading

Binmore, *Game Theory*.

Dixit and Nalebuff, *Thinking Strategically*.

Questions to Consider

1. How do companies build up reputations for quality or good service? What costs do they have to incur to build up these reputations? What do they get in return for doing this?
2. This lecture discusses situations in which you should reveal information to the markets and others in which it's best to add uncertainty to your actions in the markets. Suppose you are participating in an auction in which many items are being sold, one at a time, to a roomful of bidders. Do you think it would be better to try to build up some kind of reputation as a bidder or to add uncertainty to your actions?

Adverse Selection: Hiding in Plain Sight

Lecture 10

In this lecture, we'll study the adverse selection problem, one of three classic information problems that profoundly affect how humans interact with one another. All three of these problems are caused by a particular form of uncertainty called *asymmetric information*. Someone in a situation has more information, and that extra information is important to everyone, but it remains hidden. There are three main types of asymmetric information problems, and they differ by the kind of information that is known to some but hidden from others. In the case of the adverse selection problem, the information that is hidden is an important characteristic. The adverse selection problem is often called the *problem of hidden type*.

Asymmetric Information

- Consider the many decisions we make without knowing an important characteristic or type. Suppose, for example, you want to hire a highly skilled plumber. But you cannot tell whether plumbers are skilled just by looking at them or by reading their advertisements. Information about their skills is hidden from you.
- Hidden characteristics, such as the skill level of a plumber, are not problems in themselves. The real problem with them is that they affect people's incentives. Whenever we have a product or person with a hidden characteristic, the people who have information about this characteristic have an incentive to misrepresent it to others. They do this in order to gain some kind of economic benefit.
- A significant part of the adverse selection problem comes from using information selectively, not by lying. People try to present themselves or products they want to sell in the best possible light. They tell the truth but not necessarily the whole truth. And when they do this, they take advantage of asymmetric information.



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In the famous used-car example, it's not possible to have one market for dependable cars and one for lemons because the owners of lemons will always try to sell their cars in the wrong market.

Adverse Selection Problem

- Let's consider this example of the problem of hidden type, or adverse selection problem. This example was made famous by the economist George Akerlof in a seminal paper entitled "The Market for Lemons: Quality Uncertainty and the Market Mechanism." (*Lemon* here refers to a used car.)
- If you've bought used cars in your life, then you know that it's difficult to tell just by looking at a car or even from a test drive whether the car is a dependable one or a lemon. The previous owner of the car knows whether it's a lemon, however, and that's the source of the asymmetric information. This leads to an adverse selection problem.
- Assume that the price of a dependable used car is \$20,000, and the price of a lemon is \$10,000. Assume that buyers know that half the cars available for sale are dependable and half are lemons. That

means that any car will have a 50% probability of being a lemon and 50% probability of being dependable. That translates to a 50% chance that the car will be worth only \$10,000 and a 50% chance that the car will be worth \$20,000. The most that buyers would be willing to pay for a car under these circumstances is \$15,000.

- If the car buyers are risk averse, however, they'll only pay a price that's lower than the expected value of the car—perhaps \$13,000. When the owners of dependable used cars hear that buyers are willing to pay only \$13,000, they won't sell. But when the owners of lemons hear that buyers are willing to pay \$13,000, they are delighted to sell, because their cars are worth only \$10,000. Thus, the only used cars for sale in this market will be lemons.
- We can see that with adverse selection, products that have less desirable characteristics are actually the ones that are selected for, which means that they dominate the market. Adverse selection is a perverse outcome in that the market will become dominated by products with the least desirable characteristics.

A Market Killer

- In actuality, markets that are plagued by adverse selection problems fail. In the used car example, buyers won't buy at all, and the market will flop. The adverse selection problem is a problem because it's a market killer.
- Adverse selection is a particularly serious problem in financial markets. In any financial market, there are good borrowers who take their obligations seriously and bad borrowers who are irresponsible. However, lenders cannot be sure whether a borrower is a good borrower or a bad one.
- A bad borrower should have to pay a higher rate of interest on a loan than a good borrower because the bad borrowers are much more risky. But if lenders cannot tell the difference between good and bad borrowers, they'll want to charge at least an average interest rate that reflects the relative proportions of good and bad

borrowers. But this rate will be too high for the good borrowers, and they won't want these loans. Only the bad borrowers will want loans at this rate.

- Even in developed financial markets, banks and other lenders know that they cannot push interest rates up too high because doing so will drive the good borrowers out of the market and leave the market to the bad borrowers.

Fraud

- Another major problem associated with adverse selection is fraud. Identity theft is an example of adverse selection because of the role of hidden type. In other words, the true identity of the person is hidden from the bank, and that opens up the possibility for fraud.
- Sometimes, criminals try to steal your money by pretending to be a legitimate business. Internet phishing is a two-stage adverse selection problem. In the first stage, criminals pretend to be businesses in order to engage in identity theft. Then in the second stage, the criminals pretend to be those individuals whose identities they've stolen.

Third-Party Experts

- One obvious way to address asymmetric information or a lack of information is to invest in information gathering about the hidden characteristic. For example, a bank that wants to stay in business must devote significant resources to gathering information about each potential borrower, then interpret what this information implies about the borrower's creditworthiness. This process is called *credit analysis*.
- But gathering information about someone's hidden type or learning how to estimate someone's hidden characteristic can be time consuming and expensive. In certain situations, people who lack information pay others to discover it. For example, many used-car buyers will pay to have a car inspected by a mechanic before they buy. That is, they take the car to an unbiased third-party expert who can measure or discover the hidden characteristic.

- Third-party experts are used in many markets, especially where the products are very expensive. For example, the bond market depends on the rating agencies, whose job it is to judge the creditworthiness of borrowers—a characteristic that is difficult for most bond investors to discover on their own.
- The Internet has made yet another type of information gathering possible. One of the best ways to learn about hidden characteristics is to find out from someone who has firsthand experience with a product or person that has a hidden type. Entire Web-based services have sprung up that collect and distribute word-of-mouth recommendations based on people's experiences.

Signaling

- Many market mechanisms and practices try to incentivize people who possess hidden information to reveal it truthfully—and *truthfully* is the key word here. Remember that talk is cheap, especially when someone has an information advantage. Therefore, these mechanisms and practices are mostly ways to show that what a person says about the hidden characteristic is actually true.
- If a seller of a used car wants to convince a potential buyer that the car is dependable, the seller can offer a warranty or other guarantee on the car's performance. These days, it's quite common for products to come with money-back guarantees as a way for the seller to signal that the product being offered is a high-quality one and not a lemon.
- *Signaling*, as the economists call it, is a common tactic that people who possess information about hidden characteristics try to use to prove that their claims about the hidden characteristics are true.
- One particular guarantee that is essential to financial markets is collateral. Collateral is an item of value that a borrower promises to surrender to a lender if the borrower fails to repay a loan. Collateral is an effective signaling tool because bad borrowers won't want to post any collateral. But for good borrowers who intend to repay the loan in full and on time, pledging collateral is not of major concern.

- Another signaling tool that is extremely important in dealing with adverse selection is reputation. A reputation is a public perception or opinion about a person or a product; reputations are built up over time by patterns of repeated behavior.
 - Certain companies have incredibly strong brands that are recognized for their quality. The brand is a reputation that the company has built up by always producing a quality product, despite the trouble and expense of doing so. The brand signals to the market that the quality of the product is dependable, and this reputation both attracts new customers and retains existing ones.
 - As the example of name brands shows, reputation is a powerful tool that people and companies use to overcome the adverse selection problem. Like other signals, reputations are costly—it takes a great deal of time, effort, and money to build a good one. But once you have a good reputation, people will believe you when you make a statement about a hidden characteristic.

Counterfeiting

- It's important to note, however, that signals are imperfect solutions to the adverse selection problem. A signal may not be strong enough to be convincing. What's more, if the signal is too good, it can invite another problem: counterfeiting.
- These days, most of us are aware of the thriving business in so-called knockoff products—products that look nearly identical to brand-name products but are sold at only a fraction of the price.
- The counterfeiting of famous brands is fascinating because it's a case in which the solution to the adverse selection problem backfires. These famous brands, which were created to solve an adverse selection problem, actually create the same problem for themselves.

Suggested Reading

Akerlof, “The Market for Lemons.”

Milgrom and Roberts, *Economics, Organization, and Management*.

Szuchman and Anderson, *Spousonomics*.

Questions to Consider

1. To contain costs, many health insurers require people to use generic drugs instead of name-brand drugs when they have prescriptions to fill. Is there an adverse selection problem with generic drugs? For more information, see the FDA’s “Facts about Generic Drugs” at <http://www.fda.gov/Drugs/ResourcesForYou/Consumers/BuyingUsingMedicineSafely/UnderstandingGenericDrugs/ucm167991.htm>.
2. The lecture discusses warranties as one possible way to mitigate the adverse selection problem. But are there adverse selection problems in warranties also? For example, compare how easy it is to use the warranty on a new car against how easy it is to use the warranty on a television or other electronic device. In other words, what do you have to do with these products when they break?

Moral Hazard: Whom Do You Trust?

Lecture 11

Uncertainty, in the form of asymmetric information, exerts a powerful influence over human behavior. In this lecture, we'll learn about an asymmetric information problem called the *moral hazard problem*. Although the adverse selection problem starts with a hidden characteristic that is known to one person but not to others, the moral hazard problem starts with hidden action. That is, one person takes an action that is important to the outcome of an economic transaction, but the others in the transaction cannot see that action—until it is too late.

2007–2008 Financial Crisis

- In the aftermath of the 2007–2008 financial crisis, the Financial Crisis Inquiry Commission found evidence that during the heyday of the mortgage boom, some large mortgage lenders were making mortgage loans that they knew the borrowers couldn't afford. Then, these loans were packaged into mortgage-backed securities and sold to investors around the world. No one outside the banks knew how the loans were being made or how they were being packaged into securities. All this was hidden from the investors who bought the securities.
- The banks had incentive to make and then sell off as many of risky mortgage loans as they could because doing so generated large fees. The result was that buyers of the mortgage-backed securities took on far more risk than they originally thought, then suffered significant losses when the loans went bad. Of course, the problem was so massive that it nearly triggered the collapse of the entire financial system.

- As this example demonstrates, if our actions are hidden from the people they affect, then we have an incentive to take actions that benefit us but are costly to others. The more beneficial the actions are to us, the greater the incentive is to take them. What's more, the greater the chance we can avoid punishment, the greater the incentive to take the actions.

Moral Hazard Problem

- In many cases of moral hazard, the person who has the ability to take hidden actions has promised to behave in a way that protects the interests of the person affected by these hidden actions. Therefore, when people take these hidden actions, they have done something immoral by going back on their word or, perhaps, by lying about their intentions in the first place.
- Even when people make an explicit promise not to use their hidden actions to take advantage of others, the behavior covered by the promise can be difficult to measure or control. Therefore, people taking the hidden actions have trouble ensuring that their actions live up to what they've promised.
- For example, consider car insurance. When you take out this insurance, you promise the insurance company that you'll be just as careful behind the wheel once you're insured. At the same time, there's a powerful incentive not to be as careful. Being careful takes a great deal of effort, and if you have insurance, you won't bear the full cost of any accident. The incentive to economize on effort leads people to be less careful once they're insured.
- The insurance company relies on your moral character to keep driving as carefully after you're insured as you did before. In fact, the term *moral hazard* originated in the insurance business: There is a hazard to the insurance company that people's morals won't be strong enough to keep them from giving into the incentive to act less carefully.

Asset Substitution Problem

- The moral hazard problem does not just apply to situations that involve insurance. Many types of transactions, business deals, and relationships that have nothing to do with insurance are affected by hidden action.
- Financial transactions, especially loans, are full of hidden action that leads to moral hazard problems. For example, consider a business taking out a loan. The business will have a good chance of getting a loan if it tells the bank that it plans to use the money to expand a project that has already proven to be successful.
- For example, suppose you own a successful landscaping business and you apply for a loan to buy more equipment. After you get the loan, though, you have a desire to take the money and use it on a project you've dreamed about—developing a mobile phone app for a landscaping video game.
- In this case, once the loan is made, borrowers have an incentive to take on riskier projects than the ones they reported to the lenders. This particular moral hazard problem is called the *asset substitution problem* because the borrower substitutes a riskier project for a safer one after the loan is made. The asset substitution problem is just one of many moral hazard problems in finance.

The Social Contract

- A certain type of moral hazard problem plays a significant role in our economy and society as a whole. One of the most crucial underpinnings of our modern society is the social contract—the agreement between the citizens and the government regarding how the society will be governed. Much of the social contract is formalized in written documents, such as the U.S. Constitution and the country's laws. However, the social contract also comprises a set of expectations about people's behavior that is more implicit than explicit.

- Most important, the social contract is a real contract that calls on each of us to behave in certain ways. For example, our social contract requires us to respect other people's rights and property. It also requires us to participate in government by being informed and voting in elections. And it requires us to follow the laws that our elected officials create.



Not voting violates the social contract and presents a moral hazard issue; if the government doesn't fully represent all of its citizens, then society as a whole can be harmed.

- Crime can be considered a moral hazard problem. Generally speaking, people commit crimes only when they think their actions are hidden from the rest of us. Voting is another moral hazard issue. People have the right to vote, and it's considered a key civic obligation. If you pay attention to voter turnout numbers, however, you know that many people avoid the inconvenience of voting.

Remediating Information Asymmetry

- As in the case of all asymmetric information problems, there are two broad approaches to mitigating moral hazard. One approach is to remediate the information asymmetry, generally by investing in information gathering. The other approach is to create better incentives, which correct or balance out the bad incentives that gave rise to the problem.
- In information gathering, the obvious solution is to monitor the behavior of the person whose actions would otherwise be hidden. Monitoring, however, can be expensive and time consuming.

- In many instances, it is possible to require people to produce proof that they did what they said they were going to do. For example, consider the case of the bank loan. One way to combat the asset substitution problem is for the lender to require the borrower to bring in proof of purchase. Businesses may have to provide financial reports that detail how they spent the loans they received from the bank or other lender.

Using Technology

- One solution to the expense and practical difficulties of monitoring is technology. Technology has improved dramatically in the past two decades, and much of it has applications to monitoring. These days, thanks to computerization, global positioning system (GPS) devices, wireless communications, and the Internet, we leave incredibly detailed electronic trails of our activities that can be used to verify or infer our actions. Actions can also be tracked by credit card and debit card records, which can be quickly collected and analyzed.
- Similarly, advances in technology have made it possible to put cameras everywhere. Public places, such as parks and subway systems, as well as private businesses and even homes are safer now because of the presence of cameras.
- The threat to privacy from all this monitoring is serious, however, because the monitoring itself can be stealthy and hidden. That leads to another set of moral hazard problems. If people can observe all our actions without our knowledge, then they can use this information to make themselves better off at our expense in a number of ways—both legal and illegal.

Creating Better Incentives

- The moral hazard problem comes about in part because people can take hidden actions that make themselves better off but impose costs on others. We can try to offset this incentive by making sure that the people who take hidden actions also face these costs.

- For example, in many situations that give rise to moral hazard, we require the person who can take the hidden action to provide a security deposit. Whenever someone signs a lease on an apartment, for example, a security deposit of at least a month's rent is usually required by the landlord. The tenant forfeits the security deposit at the end of the lease if the apartment is damaged, which provides an incentive to take care of the property.
- Similarly, in loan agreements, the lender often requires the borrower to pledge something of value that the borrower stands to lose if the loan is not paid back. In other words, collateral helps to mitigate the moral hazard problem.
- When the moral hazard involves an insurance arrangement, companies try to mitigate moral hazard by using deductibles and copayments. A deductible is a set amount that the insured person must pay before the insurance pays any benefits. Having a deductible or copayment helps to overcome the incentive to be less careful because the insured person still faces a significant financial cost even though the insurance company pays for most of the damages.
- The price of most insurance is highly sensitive to the size of the deductible. If the deductible is small, the insurance company is concerned that it's not large enough to compensate for the moral hazard; thus, the company asks the insured person to pay higher premiums to make up for the higher chance of accidents. In fact, the price of the insurance goes up very quickly as the deductible falls. There's usually a nonlinear, inverse relationship between the size of the deductible and the size of the insurance premium.

Suggested Reading

Milgrom and Roberts, *Economics, Organization, and Management*.

Szuchman and Anderson, *Spousonomics*.

Questions to Consider

1. Is moral hazard responsible for environmental problems, especially pollution? If it is, will the usual economic remedy for pollution—taxing the polluters—actually work?
2. The U.S. government recently revealed that it uses license plates to track millions of vehicles on a daily basis to combat drug trafficking. How much public monitoring, such as this type of tracking or the use of surveillance cameras, should people be willing to tolerate in order to reduce moral hazard problems?

The Principal-Agent Problem: When Mice Play

Lecture 12

Many of the people who produce goods and services in today's modern economy have expertise and skills that require years of study to master. What's more, the more complex and specialized our lives and our economy become, the more we have to rely on specialists and experts in their fields. Relying on others exposes us to a special case of the moral hazard problem called the *principal-agent problem*. As we'll learn in this lecture, principal-agent problems can be extremely costly and, in some situations, downright dangerous.

Principal-Agent Problem

- The principal-agent problem always involves two persons or entities: a principal and an agent.
- A principal is a person who has a specific task or goal to achieve but does not have the time or expertise to accomplish that task. For example, with most new cars, when a problem comes up, it's nearly impossible for you to diagnose it, let alone fix it yourself. When your car won't run, you become a principal who is trying to get your car fixed.
- To do that, you hire an agent. An agent is anyone a principal hires to carry out a task or reach a goal. Using the example of the car, you would take your car to the dealer's service department or find an independent mechanic and hire that person to find the problem and repair it. Once you hire the mechanic, he or she becomes your agent.
- Any time a principal hires an agent, economists say that the two people involved have an *agency relationship*, and any resulting problems are called *agency problems*. It is possible to have many principals and many agents involved in one agency relationship, especially in companies and governments.

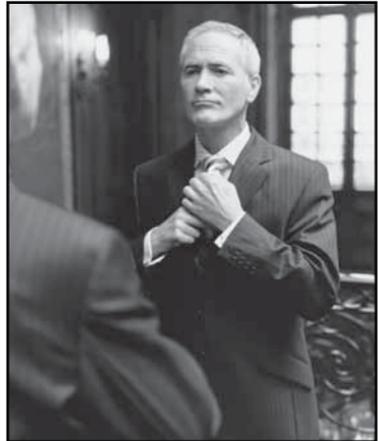
Agency Costs

- Although agency relationships do not automatically lead to agency problems, they often become problems in the presence of asymmetric information. The agency problem is a special case of the moral hazard problem because moral hazard is the problem of hidden action.
- The agent's actions can be hidden in two ways. First, the agent's actions usually take place out of the principal's sight. Second, because the principal lacks the agent's expertise, crucial aspects of the agent's actions—such as the quality of the work or the amount of effort expended—are effectively hidden from the principal.
- When the agent's actions are hidden from the principal, the agent has a major incentive to take advantage of the situation. Agents may take actions that enrich themselves but end up being costly to the principal. Or the agent may avoid doing what the principal wants in order to save effort and expense. Either way, the actions taken by the agent impose costs on the principal. Economists call these *agency costs*.

Agency Problems in the Workplace

- The workplace is full of agency problems. For example, the managers of a company hire employees to produce goods and services. But managers don't have the time to watch over what each and every employee does, and they often lack the expertise that the employees possess. This gives employees the opportunity to act in ways that benefit themselves but impose costs on the managers. If the workers don't produce, this lowers productivity and causes expenses to rise, which may result in penalties for the managers.
- A related agency problem has to do with quality control. Employees may not put enough effort into maintaining the quality of a product because doing so is demanding and time consuming. But poor product quality can cause sales to fall and, depending on the product, can even be dangerous. For example, many food products can become contaminated during the manufacturing process if employees aren't careful enough about maintaining sanitary conditions.

- The agency problem in the workplace that has received a great deal of attention is the one between the shareholders of a corporation and the managers. In a corporation, the shareholders are the owners and have the right to operate the business. But the shareholders don't have the time or expertise to run the company. They are just looking for a good investment; thus, they hire a professional management team.
- The shareholders are principals, and the managers are their agents, who take on the day-to-day operations of the company. But because shareholders can't observe what the managers do and lack expertise, the managers have incentives to take actions that benefit themselves at the expense of the shareholders.



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Agency Problems in Government

- Agency problems also arise in government. If we think of taxpayers and voters as the principals, elected representatives are our agents. We ask these agents to achieve an enormous number of goals, such as providing for the country's defense and ensuring fairness in the workplace. We hire these agents because most of us don't have the time or expertise to pursue these goals ourselves. Because we aren't able to observe all the actions our elected representatives take, however, agency problems may arise between taxpayers and elected officials.
- For example, a representative in Congress may insert a small provision into the annual budget to give a tax break to pumpkin farmers because pumpkin farmers make large campaign donations

Empire building refers to the practice of taking on large and expensive projects that mainly benefit the CEO's ego and have little if any benefit for shareholders.

that help the representative stay in office. But giving a tax break to pumpkin farmers costs the government money that it otherwise could have used to benefit all taxpayers.

- The representative's action is hidden to most of us because it amounts to just one or two sentences added to a budget that's hundreds of pages long. But the representative gets a benefit from doing his or her actions in the form of increased campaign donations, and the rest of the taxpayers pay the cost of giving the tax break.
- You may point out that the cost of this tax break is very small. But every one of the 535 elected representatives in Congress has the incentive to do a similar favor. When you add them all up, the total cost can easily run into the billions of dollars.

Monitoring

- The two main strategies for dealing with agency problems are the same as those used to deal with the other problems that result from asymmetric information: We can get better information, and we can use incentives.
- In many cases, it is not practical for the principal to monitor the agent directly; it is either too costly or the principal is simply incapable of monitoring. Hiring someone else to do the monitoring can be a partial solution—but one that actually substitutes one principal-agent problem for another.
- In situations where there are many agents and few principals, however, hiring professional monitors can significantly mitigate the total agency costs. Each monitor can watch over a manageable number of agents, and the principal monitors a manageable number of monitors. This is the system of management in most large organizations, which have hierarchical structures and multiple layers of management.

- Interestingly, one of the management trends of the past couple of decades is to create so-called flatter organizations, in which there are fewer layers of management with more people in each layer. This can have benefits for companies, but one of the costs of flattening the organization is an increase in agency costs due to the decreased ability to monitor people.

Incentive Compensation

- Instead of investing in monitoring, companies can use incentive mechanisms to mitigate the agency problem. A major cause of agency problems is differing incentives between the principal and agent: The principal wants to accomplish one thing, but the agent wants to do something else. If the source of the problem is differing incentives, a solution would be to make the incentives the same.
- Although we can't make the incentives exactly the same, we can try to align them better. The principal can give the agent some kind of incentive to pursue the principal's goal. In other words, the principal tries to turn the agent into another principal—to some degree, at least.
- The principal can tie the agent's rewards to how well the agent complies with the principal's wishes. This is called *incentive compensation*. In many cases, the incentive compensation that principals offer the agents is the same reward that the principal hopes to achieve. For example, many companies offer profit-sharing plans to their employees. This helps align incentives between the employees and the shareholders of the company. The harder the employees work, the more profit the shareholders earn, and the more income the employees also earn.
- It's important to note that the principal must pay some cost to align incentives. The benefit to the principal in terms of reduced agency costs must be greater than the compensation the principal must offer to the agent.

- In corporations, another way for principals to share compensation with agents is to align the managers' incentives by turning the managers into shareholders. That is, part of the managers' compensation can be paid in shares of the corporation rather than money.

Guarantees

- Although having the principal share some of the rewards or compensation with the agent can help mitigate the principal-agent problem, it works only in some cases, not all. For example, it doesn't work in cases where the agent's actions don't produce a profit or produce a profit that can't be shared. This might be case in hiring a contractor to repair your roof.
- In such situations, it's still possible to align incentives. But here, it's the agent who must give up something. In particular, the agent can give the principal a guarantee on the quality of the work.
- With guarantees, agents potentially give up part of their compensation to align their incentives better with the principal's incentives. Because this is costly to the agent, we may not necessarily see service providers offering guarantees in all markets. But in highly competitive markets that have many agents offering their services for hire, providing a guarantee becomes a way for agents to distinguish themselves from the competition and win more business.

Suggested Reading

Jensen and Meckling, "Theory of the Firm."

Milgrom and Roberts, *Economics, Organization, and Management*.

Questions to Consider

1. Many observers claim that one significant reason for the financial crisis of 2008 was that some banks became “too big to fail.” Did the principal-agent problem of empire building play any role in creating banks that were (and may still be) too big to fail? The cases of Bank of America and Citigroup may be interesting to consider.
2. A possible way to mitigate the principal-agent problem that is discussed in the lecture is for the principal to hire an expert to supervise or monitor the agent. Who do shareholders hire to do this for them in a corporation? How well does this arrangement work, and why? For more information, conduct an Internet search on the phrase “corporate governance problems.”

Compensation Traps

Lecture 13

A significant source of uncertainty that businesses face is how their employees will perform—from the lowest-paid hourly worker all the way up to the CEO. In this lecture, we'll study the many forms of compensation contracts that businesses use to create incentives for employees. Most compensation contracts include at least one mechanism that either encourages positive behaviors or discourages negative behaviors. In fact, many compensation arrangements are shaped more by the need to prevent adverse selection and moral hazard than they are by the other economic force that affects them: productivity. Compensation contracts are fascinating in part because they can create as much uncertainty as they resolve.

Marginal Revenue Product and Efficiency Wage

- Economic theory predicts that every worker will get paid an amount called the *marginal revenue product*. This is the cash value of the extra output that an extra unit of an employee's work would produce if the employee were to work that extra unit.
- For example, suppose you work in an assembly line putting plastic screen protectors on smartphones. This job adds \$2 in value to each phone. Further suppose that by working an extra hour, you'd be able to attach 10 more screen protectors on 10 more phones. That means that your marginal revenue product is \$20. According to economic theory, therefore, your pay in equilibrium would be \$20 an hour.
- But in reality, your wage is likely to be higher than that. The company will build an incentive into your compensation contract that encourages workers to produce more. Instead of paying you the marginal revenue product of \$20, the company will pay you \$25 or \$30 an hour. Economists call this an *efficiency wage*.

Piecework

- Another approach to incentivizing employees is to tie compensation to output. A compensation scheme like this works best in a manufacturing context, where it's clear whether a worker has produced a product or not. This compensation scheme is often called *piecework* because the workers are paid for each piece they complete.
- Compensating for piecework can still lead to asymmetric information problems. For example, pieceworkers have an incentive to sacrifice quality for quantity. To deal with this issue, quality control workers are used to check whether the pieces are good enough, and the manufacturing workers are paid only for the pieces that pass the quality check.



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- Piecework also exists in the context of services. For example, the Medicare system in the United States largely compensates doctors and hospitals on a piecework basis. In the case of medical care and other services, it's relatively easy to overstate the number of procedures performed under a piecework system. Unfortunately, the Medicare system has had problems with hospitals and doctors charging for procedures they didn't perform or for performing a low-cost procedure, then billing Medicare for a higher-cost one.
- Although piecework compensation has largely died out in the modern economy, its spirit still lives on in specific situations. For example, if you hire a contractor to renovate your kitchen, you make a large initial payment to the contractor to pay for supplies and hire subcontractors. However, you would likely hold back a

Holding back a part of their payment gives contractors incentive to complete jobs on time and to meet acceptable quality standards.

significant portion of the contractor's fee—perhaps 10%—until final completion of the project. There are two reasons to structure the contract in this way: to ensure that your project gets finished on time and to ensure the quality of the work.

Milestone Payments and Commissions

- Building significant incentives into payments is standard practice when companies or governments hire contractors to take on large projects. For example, many large-scale road and infrastructure projects these days have significant bonuses built into the contractors' pay if they finish early or on time and significant penalties if the contractor takes too long to finish.
- Massive projects have incentives built into the contracts that correspond to the completion of important steps in the process, called *milestones*. These payments are known as *milestone payments*. Milestone payments are also frequently used when two or more companies cooperate on a joint venture or a licensing agreement. Milestone payments give both sides the incentive to keep working to make the project successful.
- Yet another way to tie work incentives to output is to use commissions. A commission is a fraction of the selling price of a product that's paid to the person who sells it. Most people who work on commission these days also collect part of their pay in terms of a salary. Working only for commission can be a risky way to earn a living because sales of most products tend to swing up and down, sometimes quite wildly.
- Finding the right mix of salary and commission is tricky, however. If commission rates or salary are too high, then salespeople will only work hard enough to get a few sales. If commission rates are too low or if commissions are too high a fraction of total compensation, we see the opposite effect: Salespeople become too aggressive and may even resort to questionable or illegal practices.

Salaries and Promotions

- A salary is a fixed amount that an employee earns each pay period. We often see salary contracts offered in jobs with an output or product that's difficult to measure and in highly trained and specialized professions. Given what we've learned in this course, a salary contract seems like an open invitation for agency problems. The challenge to companies is to avoid having hundreds of salaried employees sitting in their cubicles all day, doing nothing.
- One way to address agency problems is to pay salaries predominantly to employees who have higher levels of training or expertise. In this case, the thinking is that these employees will have a strong sense of professional pride and will resist the temptation to shirk.
- A key incentive compensation mechanism for salaried employees is promotion. Promotion is the salaried employee's reward for putting in a high level of effort and doing a good job. The possibility of promotion is intended to keep good employees motivated and focused on their tasks. In theory, the opportunity for promotion should be an effective incentive.
- But it's difficult to get a promotion system right in practice. For one thing, the criteria for promotion are subjective. Another problem with promotion systems is that they may encourage employees to put a great deal of effort into actions that don't actually help the company succeed.

Bonuses

- CEO compensation has long been a controversial issue—mainly because it often includes mechanisms that try to overcome principal-agent problems, and it's not clear that these mechanisms actually work. In addition, these mechanisms are at least partially responsible for the incredibly high compensation some top managers receive.

- In the past, compensation for top managers had two main parts: regular salary and a year-end bonus. The bonus is an incentive mechanism, a performance-based form of compensation that increases as the company does better.
- The first challenge in determining bonuses is how to measure the performance of the company—by sales or market share. A CEO can pump up sales by cutting the selling price of the company’s products, which is actually bad for profits—and profits are what shareholders care about. Also, a CEO might work hard and make all the right moves but just have a bad year, when profits fall.
- Therefore, companies come up with complicated formulas based on profits, sales, market share, and other measures of company performance, or they base the CEO’s bonus on a nonstandard measure of profits that ignores certain categories of expenses and makes the company look more profitable than it actually is.

Stock Options

- Despite their problems, CEO bonuses are still quite common. In fact, they’ve been joined by another type of incentive-based compensation that is potentially much larger than either a salary or a bonus: stock-based compensation. One of the most popular forms of stock-based compensation is stock options, also known as employee incentive options.
- Stock options seem to be an ideal solution to the agency problem that exists between shareholders and CEOs. CEOs are motivated to work hard for the company because doing so will increase profits and raise the price of the company’s stock; this, in turn, will increase the payoff on the incentive options that the CEO is holding. In fact, a significant portion of CEO compensation often comes from exercising stock options, not from salary or bonuses.

- However, some people believe that stock options give CEOs an incentive to take actions that raise the price of the company's stock in the short run but may hurt the company in the long run. In fact, a recent poll of CEOs demonstrated that most CEOs would forego promising long-term investments in favor of actions that help their companies' stock prices in the short run, such as stock buybacks. In addition, because dividends are known to reduce the value of incentive options, CEOs holding incentive options are likely to pay out fewer dividends to their shareholders.

Restricted Shares

- Because options-based compensation has proved to have negative impacts on CEO behavior, many companies have moved away from stock options to awarding shares of stock, in the form of *restricted shares*. These are shares in the company that are awarded to employees as part of their compensation; however, the shares become the employee's property only after a period of a few years. This is similar to the case of options, which cannot be exercised for a minimum number of years.
- Restricted shares do a much better job of tying the CEO's incentives to those of the other shareholders in the company, but they are still not perfect. For example, CEOs compensated with restricted shares may end up holding most of their personal wealth in the company's stock, which will actually make them too conservative when it comes to taking risks. What's more, CEOs who hold a great deal of company stock may be tempted to engage in insider trading.

Suggested Reading

Jensen and Meckling, "Theory of the Firm."

Milgrom and Roberts, *Economics, Organization, and Management*.

Questions to Consider

1. In the lecture, we learned how above-market efficiency wages represent an attempt to overcome moral hazard problems on the job, especially the temptation to shirk. Where do we usually see efficiency wages paid? What are the potentially harmful effects of efficiency wages on the economy and society?
2. The lecture discusses the effect on CEO behavior of different types of compensation, including options. Researchers have shown that when CEOs are paid with numerous incentive options, they take on more risky projects, but when they receive many restricted shares, they take on much less risk. What is the essential difference between incentive options and restricted shares that can account for this difference in effects on risk taking?

Caring, Sharing, and Risk Bearing

Lecture 14

In economics, the situation of caring about another person's happiness or well-being is called *altruism*. A sense of altruism can be a powerful motivating force in people's lives, prompting us to share resources with other people. Altruism is not selflessness, however; instead, it's the world's oldest—and quite possibly the most effective—risk-sharing system. In this lecture, we'll explore the connection between altruism and risk sharing and understand how altruism can help overcome some of the information problems discussed in the past few lectures.

The Utility Function

- Economists use the idea of a utility function to describe people's preferences. The utility function is simply a mathematical way to express the relationship between all the things that a person consumes or experiences and the happiness he or she gets from consuming or experiencing those things. The inputs into the utility function are the amounts of the things we consume and experience, and the output is some measure of happiness.
- The utility function is nonlinear; in particular, as you consume more of something, you get less additional happiness for each additional unit you consume. Economists represent the utility function as a hill that is steep at the bottom but flattens out as we approach the top.
- The utility function is written as $u(c)$, where u stands for utility, and c is the total amount of things a person consumes directly.
- Using this basic utility function, economists model altruism in a simple but effective way. The expression $u_1(c)$ models the happiness you get from the things you consume and experience yourself. Note that this is a selfish utility function because it counts only the things you consume yourself.

- In order to add in altruism to the equation, we take the selfish utility function and add the amount of weight placed on another person's happiness. This weighting of another person's happiness is represented as $\beta[u_2(c)]$, where β is a number between 0 and 1.
- The entire utility function, in the presence of altruism, is given by this equation: $u_1(c) + \beta[u_2(c)]$. What this utility function says is that your happiness comes from two main sources: what you consume directly and the happiness of a person you care about. The β multiplier on the other person's utility expresses how much you care about this person. If β is close to 0, you don't care all that much. But if β is close to 1, then you care about this person almost as much as you care about yourself.
- Think about what happens if $\beta = 0$; in that situation, the other person's utility disappears from your utility function. This is a way to model complete selfishness. If β is above 1, that would imply that you actually care more about the other person's happiness than you care about your own.

A Risk-Sharing System

- In order to demonstrate how altruism leads to risk sharing, consider a situation where your son is laid off from his job. After your son is laid off, his consumption will be low and, thus, his utility will be low. If you don't do anything, then your utility will fall as well, because your happiness depends on β multiplied by your son's happiness.
- If you reduce some of your own consumption and transfer that freed-up money to your son, that would lower the utility you get from the things you consume directly; thus, the value of the first term in your overall utility function will fall. But your son will take the money and increase his consumption, which will raise his happiness; that will raise your happiness, too.

- We can use the shape of the utility function to answer whether the increase in your utility resulting from the increase in your child's happiness outweighs the fall in your utility that comes from consuming less yourself.
 - Suppose that at the time your child gets laid off, you're consuming \$2,000 a month, which gives you a utility of 200 utils. *Utils* are invented units for utility that economists use to measure happiness.
 - After your son gets laid off, suppose his consumption is only \$500 per month and his utility is 50 utils. If the weight you place on your child's happiness is 80%, or 0.8, then your total utility after the layoff is $200 + 50 \times 0.8 = 240$.
 - Now suppose that you give your son \$500 per month to help replace some of his lost income. Your consumption falls to \$1,500 per month, which will cause your utility to fall. But because you were consuming a great deal, the fall in utility is only 25 utils. At high levels of consumption, your utility curve is relatively flat.
 - When you give that \$500 to your son, his consumption goes up from \$500 to \$1,000. His utility goes up significantly because his consumption was starting from a low level. At low levels of consumption, the utility function is very steep; thus, small increases in consumption produce large increases in utility. In this case, your son may realize a gain of 60 utils, for a total of 110.
 - That gain of 60 utils for your son increases your own overall utility by 0.8×60 , or 48 utils. In other words, you're giving up 25 utils to get 48 back. The choice, then, becomes obvious; you should give the money to your son because doing so makes both of you happier.

Moral Hazards with Altruism

- Altruistic risk sharing seems to closely resemble insurance. The altruistic person functions like an insurance company that makes a transfer to a policyholder when the policyholder experiences some kind of loss.
- Because altruistic risk sharing really is insurance, it's subject to the same basic problem that affects all insurance: the moral hazard problem. As we've seen, the moral hazard problem means that once people know they are covered by insurance, they become less careful about avoiding risks.
- Consider the example of your son losing his job. He knows that you care about his welfare, and you'll step in to transfer money if he loses his job. Knowing that his parents will bail him out if he runs out of money may prompt him to quit his job before he has another position lined up.

Samaritan's Dilemma

- Moral hazard problems similar to this one above play out in millions of families around the world, every single day. The temptation is for parents to refuse to help out. But, in the language of strategic interaction, an altruist can threaten not to help, but the threat isn't credible.
- The people you care about, such as your children, know that you feel altruistic toward them and that if something bad does happen, it will be very difficult, if not impossible, for you to refuse to help. Thus, your children don't take your threat not to help very seriously and still engage in risky behavior.
- This particular problem of altruism has been termed the *Samaritan's dilemma*. If you feel altruistic toward others, they know that you'll insure them against risks, which means that they will take on more risks than they should. And that's bad for all parties.

Reciprocal Altruism

- There is a possible way out of the moral hazard problem in altruism. So far, we've assumed that altruism goes in only one direction, from parents to children or from one friend to another. But for most of us, altruism is a two-way street, and altruism is usually reciprocated. This fact can help us realize the benefits of altruism while avoiding moral hazard problems.
- Research on reciprocal altruism has shown that when two people feel altruistic toward each other, they each place a high weight on the other person's happiness in their own utility functions. In other words, β is relatively high for both.
- Trust is defined as mutual, reciprocal altruism that is high and balanced. This is the reason that moral hazard problems in families tend to be limited in scale. Children care too much about their parents and feel bad if they take advantage of them too much.
- Trust can significantly reduce other moral hazard problems, as well, such as the agency problem. For example, suppose you're working together with another person on a project at the office. If you know



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To foster altruism in the workplace, companies must value the bonds between employees and emphasize trust as a key value.

that the person you work with feels altruistic toward you, you have an incentive to slack off, because it's virtually guaranteed that your coworker will insure you by working harder.

- If the two team members trust each other, they internalize the cost they would impose on the other person if they were to slack off. Thus, each team member will resist the temptation to shirk, and instead, each will make an honest effort to contribute to the project's success. In fact, research has demonstrated that fostering trust in the workplace is a way to increase efficiency and productivity.

Balanced Altruism

- The key ingredient in trust is the idea of balance between the degree of altruism on each person's part. Even when people are altruistic toward one another, this may not be enough to prevent moral hazard problems. If the altruism isn't balanced—that is, it isn't equal between the two people—then the person with the lower value of β will end up taking advantage of the person with the higher value for β .
- The problem with unbalanced altruism also explains why it's so hard to get large groups of people to work together well. In order for a group to experience the efficiency-improving benefits of trust, each member of the group must feel altruistic toward every other member of the group to exactly the same degree. Otherwise, the ones with the lowest β will start to slack off at the expense of those with higher β .

Unselfish versus Selfless

- Economist Oded Stark has published extensively on the economics of altruism. In one paper, Stark applies economic analysis to the Judeo-Christian scriptures, focusing on Jesus's charge in Mark 12:31: "Love your neighbor as yourself." Stark argues that this command demonstrates that the writers of these scriptures deeply understood the importance of balanced altruism for healthy personal relationships and a productive society.

- In the language of economics and its definition of altruism, Stark showed that this command implies that we should be altruistic toward everyone we meet, with a $\beta = 1$.
- Interestingly, the message from Jesus is to be unselfish—but not selfless. In other words, the writers of these scriptures realized that caring about other people more than you care about yourself can be harmful, just as not caring about other people can be harmful. Altruism is a positive force, but balanced, mutual altruism is the ideal.

Suggested Reading

Chami, “King Lear’s Dilemma.”

Chami and Fullenkamp, “Trust and Efficiency.”

Stark, “Altruism and the Quality of Life.”

Questions to Consider

1. An interesting debate in economics is over the role that bequests play in the family. Why do people leave behind substantial amounts of wealth for their surviving family members? Some economists believe that the older generation “purchases” attention or other desired behavior from the younger generation by holding out the possibility of a bequest as a reward. Others believe that bequests are an expression of altruism on the part of the older generation toward the younger generation. Have you experienced examples of either motivation? Which do you believe is the stronger motivation for bequests?
2. Some researchers in economics have explored the question of how large groups can get before such mechanisms as trust break down. What is the largest group you have worked with in which you think the members truly trusted each other? What difficulties do you think prevent large groups from developing this altruism-based trust?

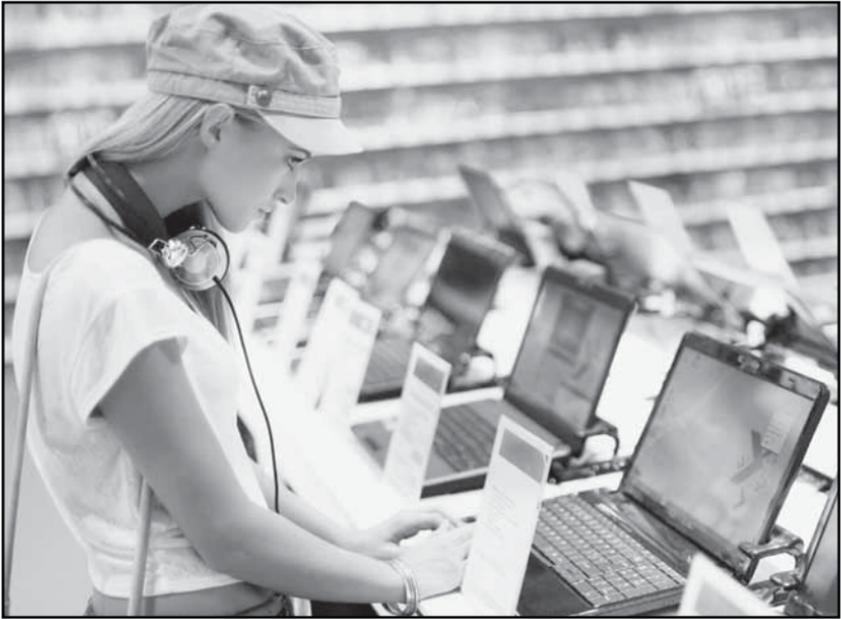
Mayhem! Insurance Protection

Lecture 15

Insurance is one of the main ways that individuals can protect themselves against some of life's biggest uncertainties, such as the premature death of the family breadwinner or a grave illness that runs up large hospital bills. The prospect of experiencing a personal financial disaster drives us to purchase insurance. However, insurance is one of those financial products, like a home mortgage, that almost everyone buys without really understanding it very well. This lecture explains the different types of insurance, how much insurance is sufficient, and what kinds of risks are worth insuring.

Types of Insurance

- The insurance industry distinguishes between two main lines of business: life and health, and property and casualty. Life and health includes life insurance, health insurance, long-term disability insurance, long-term care insurance, and annuities.
- Property and casualty insurance insures against damage done to you and your property, as well as damage that you may do to other people and their property. In other words, property and casualty is liability insurance, which includes automobile and other vehicle insurance, homeowners and renters insurance, and flood insurance.
- In addition to these main two lines, many other specialized insurance products are also available, such as travel insurance, special event insurance, title insurance, private mortgage insurance, identity theft insurance, and extended warranties.



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These days, it's possible to purchase extended warranties on most electronic devices, as well as insurance against accidental loss or damage.

An Investment Balancing Act

- All types of insurance work in the same basic way. The insurance company collects premiums from the people who buy the insurance, and the companies manage the money. Most of the money is paid to the policyholders who experience financial loss or to the people harmed in a way that is covered by the policyholder's liability policy. These payouts are unpredictable, however; thus, the insurance company may have to pay out significant amounts one day, then have very low payouts in the following weeks or months.

- Between the time that the money comes into the insurance company as a premium and the time that it's paid out, the insurance company will invest in a variety of assets. A major part of the insurance company's job is simply to manage a portfolio of investments; insurance companies are money managers. In fact, insurance companies are often put into the same investor category—institutional investors—as mutual funds and pension funds.
- Although insurance companies invest money in order to provide a good return, they also have to invest in ways that allow them to have enough cash on hand to pay out claims. It's an interesting balancing act.

Premium Calculations

- A significant challenge for insurance companies is to determine what to charge customers for insurance policies. This activity requires specially trained professionals called actuaries who are experts in statistics, economics, and finance.
- Let's use the example of a fire insurance policy on your house. Assume that there is only one event covered by the policy—a simple house fire—and that it can only happen once per year. In this case, the actuary comes up with this formula: Probability of a house fire \times Average monetary damage of a house fire = Expected value of a claim filed against a fire insurance policy.
- Economists say that if the insurance company charges you exactly the expected value of the claim that you may make against the policy, then the premium is *actuarially fair*. However, real-life insurance premiums are generally higher than what actuarially fair premiums would be to cover the operating expenses of the insurance companies.

- If you did not have access to commercial insurance, you would have to self-insure by setting money aside in a savings account to use in case you had a house fire. In the meantime, however, there's a good chance that the fire would occur well before you had enough money saved up to repair your home or buy a new one.
- But if millions of homeowners pool some money, they can collectively save enough to pay for the relatively few fires that actually occur each year. By sharing risk across individuals during a short period of time, insurance companies provide a product that's superior to trying to self-insure over long periods of time.

Problems of Adverse Selection and Moral Hazard

- Insurance companies charge different premiums to different people, depending on their personal characteristics and the characteristics of their property. What's more, if you have to make a claim on your insurance, chances are that your premiums will go up significantly.
- The adjustments in premiums represent the insurance company's attempt to deal with the adverse selection problem. Insurance companies gather information about you, which they use to guess your true customer type. Your premium reflects the insurance company's best guess of your type, and if the company gets new information about your true type, this information will be reflected in your premium.
- Just about every type of insurance plan has some kind of deductible whose size dramatically affects the amount of the premium. The purpose of a deductible is to mitigate the moral hazard problem. The idea is that if you have to pay your own money before the insurance company pays, then you'll be more careful. If you didn't have to pay a deductible, then you'd be tempted to be much less careful, which is the classic moral hazard problem.

Life Insurance

- A fundamental source of confusion about life insurance is that many life insurance policies combine two products. In other words, many life insurance policies are actually life insurance plus an investment plan.
- Term life insurance is intended to cover you for a period of time. This type of insurance will pay out a death benefit if the insured person dies, but it will pay out nothing otherwise.
- With whole life insurance, you continue paying into the policy for the rest of your life. The insurance company invests part of the premiums you pay now, then uses the future value of these investments to offset much of the future premiums. In a whole life policy, the policyholder can either continue to pay the insurance premiums and be covered or can terminate the insurance policy by trading it in for its current cash value.
- In variable life and universal life insurance policies, the value of the investment account can be used not only to offset premiums but also to increase the death benefit or the cash value of the policy. Another noteworthy aspect of variable and universal life policies is that they represent tax-advantaged ways for people to save. Gains on the investment part of the insurance are not taxed until they are cashed out by the policyholder. In addition, policyholders can borrow against the cash value of many of these policies, and the loan is not taxed.

Annuities, Long-Term Care, and Health Insurance

- Most of us think that the purpose of life insurance is to cover against the risk of a family member's dying too young. The annuity is a life insurance product that protects against the risk of living too long—or, rather, the risk that a person will outlive his or her retirement savings. There are many different types of annuities, but the most common one provides a guaranteed monthly income. The insurance company usually charges a large lump-sum amount at the start of the annuity.

- Long-term care insurance pays a benefit that helps cover the cost of nursing home or assisted-living care. Long-term care insurance is a relatively new life insurance product, and the features of the policies are changing rapidly as the insurance companies accumulate more data on the time people spend in long-term care, as well as on the costs of this care. Generally speaking, a long-term care policy will have a cap on the benefits it pays and on the length of time that the policy will cover.
- Like permanent life insurance, health insurance policies actually combine two financial products in one: One is a maintenance contract that covers routine checkups; the other is actual insurance protection against large, unexpected health expenses.

Property and Casualty Insurance

- Property and casualty policies pay a cash benefit intended to reimburse you for losses that you sustain or that you caused and are liable for. When you file a claim on this kind of insurance, you're required to submit proof of the loss; the insurance company will then investigate the loss on its own. Insurance adjusters gather evidence and estimate the value of the damages, and the policyholder is paid based on this estimate.
- In some types of property insurance, the insurance company will not only cover the cost of the damage but also the cost of replacing the property. As you might expect, the premiums for this type of coverage can be significantly higher than those for simply covering the value of the damage.

Financial Risk Management

- A crucial challenge in buying insurance is to determine what kind of insurance you need and what kinds of risks are worth insuring. The best way to decide is to use the principles of financial risk management.

- Most risk managers assume that risks cause two types of losses: expected losses and unexpected losses. The key is to buy insurance that will cover unexpected losses that are large enough to disrupt our lives. And although it can be difficult, we need to estimate how much an unexpected loss would actually be. For example, if you buy life insurance, you need to think about what major financial needs of your family would go unmet if one of its members dies unexpectedly.
- This kind of logic can also help us determine whether or not to buy extended-warranty products. Suppose that your son or daughter has the latest smartphone, and if you had to replace it suddenly, this would seriously disrupt your monthly budget. In this case, paying a few dollars a month to insure your child's phone might be a good deal. If such a loss would be small enough to merely cause an annoyance, however, you might consider covering it yourself.

Suggested Reading

Insurance Information Institute, *Insurance Handbook*.

Rejda and McNamara, *Principles of Risk Management and Insurance*.

Questions to Consider

1. One popular product related to the annuity is the variable annuity. You can read up on variable annuities at MarketWatch, “Variable Annuity Pros and Cons” (<http://www.marketwatch.com/story/variable-annuity-pros-and-cons-2014-12-30?page=1>). How are variable annuities similar to, and different from, regular annuities and whole-life insurance policies?
2. A trend in health insurance is to offer policies with very high deductibles—often in the thousands of dollars. To whom are these policies attractive? Would health insurance policies with high deductibles help hold down the costs of health care?

Uncertainty in the Numbers

Lecture 16

Numbers that we use on a daily basis to comprehend the world and to make decisions are not nearly as reliable as we make them out to be. In fact, estimates are some of the most important sources of economic uncertainty we face. The reliability of any given fact, figure, or statistic is limited, regardless of the source. In this lecture, we'll examine where the uncertainty is hiding in numbers, and we'll explore what steps we can take to deal with this uncertainty.

Estimates

- Statistics measure and summarize important aspects of reality that are difficult to understand simply from observation. The vast majority of the statistics we use are estimates. Estimates are systematic attempts to get at the truth, using tools that have been developed from both theory and practical tests.
- Consider the example of the unemployment rate. Assume that we want to know the unemployment rate—that is, the fraction of the people in the labor force who are unemployed—because this number will help summarize the state of the labor market. Say that u^* = true rate of unemployment.
- We cannot observe u^* directly because to do so would be simply too expensive and time consuming. It would be impossible to count up all the people who are unemployed and divide that by the total number of people in the labor force.
- Therefore, we have to form an estimate of u^* . To do this properly, according to statistical science, we must proceed in a certain way. The first step, and probably the most critical one, is to select a sample from the overall population. A sample, as the word suggests, is a small subset of the overall group used to represent the entire group.

- If we get the sample right, then we can be fairly confident that this small group accurately represents the much larger group. For now, let's suppose that the sample accurately represents the overall labor force. Then, we determine the unemployment rate in the sample, and use that rate as an estimate of the unemployment rate in the overall population.

Sampling

- A crucial element in making an estimate is to get the sampling right. Ideally, the sample must be truly random, but obtaining a truly random sample is extremely difficult. To obtain a truly random sample for the unemployment rate, we would need to know contact information for everyone in the United States from the U.S. Census Bureau—and to make that task more difficult, even the U.S. census is an estimate.
- When the Bureau of Labor Statistics chooses a sample of households to survey on unemployment, it knows from the outset that some households have no chance of being selected. But if the sample is not random, then the estimates derived from that sample will not represent the true characteristics of what you are trying to measure. This problem is called *sample selection bias*.
- In the case of the Bureau of Labor Statistics household survey, the true unemployment rate will most likely be understated. The reason for this is that the households left out are those that haven't been reached by the census, and these tend to be low-income households whose members have a greater chance of being unemployed.

Law of Large Numbers

- No estimate is exactly equal to reality; in fact, nearly every estimate of some phenomenon is bound to be incorrect. Assume that \hat{u} = estimated rate of unemployment. However, \hat{u} is almost never equal to u^* , because \hat{u} is based on a sample of the population rather than the whole population.

- The difference between the estimated value and the true value of a phenomenon is called the *sampling error*. The sampling error is almost never 0. However, suppose we use multiple samples and estimate the unemployment rate in order to see if the average $\hat{u} = u^*$.
- A noted law in statistics—the law of large numbers—says that it is possible for average $\hat{u} = u^*$. Basically, the law of large numbers says that if the size of the sample is large enough, then the estimated value you get from a sample will be equal to the true value of the characteristic—on average. The law of large numbers drives all estimates that are based on surveys. It notes that if your survey is truly random and includes enough people, then the estimate you get from the survey will be a dependable one.

Confidence Intervals

- A dependable estimate means that the average estimate over many samples should be equal to the true value of the characteristic. Another condition that makes an estimate dependable is that the actual sampling errors tend not to be excessively large.
- Given that virtually every estimate is going to be wrong, it's important to know how far from the truth an estimate will be, on average. In dealing with estimates, researchers note the *confidence interval*. This is a range of values—that is, an interval—around the specific estimate created from the sample. It's called a confidence interval because although we don't know for sure whether the true value of the characteristic lies somewhere within the confidence interval, we have a high confidence that it does.
- We express this confidence in the same language as we use for probabilities. Confidence intervals are stated in terms of a plus-or-minus factor, rather than the actual boundaries of the confidence interval. To form the actual confidence interval, we take the estimated change in unemployment and subtract the plus-or-minus factor to get the bottom of the range. Then, we add the factor to the estimate to get the top of the range.

- Confidence intervals demonstrate the uncertainty associated with an estimate. The wider the confidence interval is relative to the value of the estimate, the greater the level of uncertainty in the estimate. Large sampling errors lead to large confidence intervals, which weaken the reliability of the estimates created from these samples.

Gross Domestic Product

- Gross domestic product (GDP) is the total value of all the finished products produced in a country during a year. That's a vast amount of products, manufactured by hundreds of thousands of businesses. Because we cannot possibly get an accurate count of them, we must estimate this number.
- In the United States, the Bureau of Economic Analysis is the agency charged with making this estimate. This agency, in turn, relies on estimates produced by other government agencies, such as the U.S. Census Bureau, and some private groups, as well. In general, these estimates are based on surveys, which means that they're subject to the same issues of sampling error.
- The case of estimating GDP provides an excellent illustration of other issues that introduce uncertainty into economic statistics. One of these is the time constraint on producing statistical estimates. To meet the demand for numbers, agencies often release preliminary statistics as soon as they can, with the full intention of revising them over time as more data come in and earlier data are rechecked for accuracy. In the case of GDP, this statistic is estimated quarterly, but each quarterly GDP estimate is released three times, so that it's revised twice.
- Occasionally, there are major revisions to data caused by changes in measurement techniques. GDP sounds as if it would be a straightforward measurement, but it turns out that many of the services produced in the economy aren't sold on the market and, therefore, don't have a value that's easy to measure.

- There are many hard-to-measure products that should be counted in GDP, and economists are constantly updating and changing the ways in which they measure these things. For example, in 1985, there was a major revision in GDP because of advances in the way that economists estimate the size of the so-called informal or underground economy. This includes people who work for cash and don't pay taxes on their earnings, as well as the markets for illegal substances. Even as recently as 2013, there was a significant revision in GDP to reflect the value of intellectual property.

Misleading Statistics

- Some statistics are so important that governments can't resist the temptation to meddle with them—not necessarily to make them better but, rather, to manipulate their message. For example, the consumer price index (CPI) has several different versions, each of which varies according to what kinds of goods and services are included.
- The government can make inflation seem lower by publicizing a version of the CPI that isn't going up as fast as other versions. For example, the government will often report the CPI without including the costs of food and energy if the costs of these items are rising quickly. That makes inflation look lower than it really is.
- Similarly, the government can choose to include or exclude certain groups from the unemployment numbers. For instance, the unemployment rate calculations ordinarily exclude people in the military. But when unemployment gets very high, as it did in the 1980s, the unemployment numbers that were reported often included people in the military, just to make the overall unemployment rate look lower by several tenths of a percent.
- Selective reporting is also a favorite tactic of public companies that report their earnings. Because a company's earnings per share (EPS) is a key number, there's a temptation on the part of companies to report what are called pro forma ("as if") earnings. When

companies calculate pro forma earnings, they ignore certain types of expenses that they claim are extraordinary, one-time charges that distort the true picture.

- Despite the problematic issues with numbers discussed in this lecture, many statistics are both useful and informative. In addition, you can take two important steps to protect yourself from the uncertainty in statistics.
 - First, make decisions based on confidence intervals rather than single numbers because single numbers may embody a great deal of uncertainty.
 - Second, always make sure that a statistic is measuring what you think it does.
- Statistics are essential tools for helping us deal with uncertainty—but don't let them make your decisions for you.



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The statistics reported by the government and in the media can be useful and informative, but it's important to keep in mind that they're neither as precise nor as infallible as we often assume them to be.

Suggested Reading

Baumohl, *The Secrets of Economic Indicators*.

Constable and Wright, *The Wall Street Journal Guide to the 50 Economic Indicators That Really Matter*.

Questions to Consider

1. In this lecture, we learned about the law of large numbers. In Lecture 5, we learned about the law of small numbers. What is the law of small numbers, and why is it a problem, given what we learned in this lecture?
2. Suppose an exit poll at an election is accurate to $\pm 4\%$. In a two-way race between Candidate A and Candidate B, what fraction of voters would have to support A in order for you to be confident that Candidate A would really be the winner?

The Business Cycle's Wheel of Fortune

Lecture 17

Since at least the time of the Industrial Revolution, economists have observed that general economic activity goes through distinct periods of expansion and contraction, or recession. These expansions and recessions are part of the economic phenomenon called the business cycle. The business cycle remains one of the biggest unsolved puzzles in economics. In this lecture, we'll examine a number of theories of the business cycle and explore whether there are driving forces common to all business cycles.

The Business Cycle

- A business cycle is a fluctuation in the overall economy that is recurrent but not periodic and consists of a complete economic expansion, followed by a complete contraction. Three parts of this definition are crucial.
- First, the fluctuation must be generalized to the overall economy—it cannot simply be a boom or a slump in a handful of industries.
- Second, the business cycle consists of a complete expansion, followed by a complete contraction. Economists who study business cycles note that an expansion goes from a trough to a peak and a contraction goes from a peak to the next trough.
- Third, a business cycle is recurrent but not periodic. Business cycles happen repeatedly but not on any particular schedule. That lack of predictability is a major part of the uncertainty associated with business cycles.

Tracking the Business Cycle

- The beginnings and ends of business cycles are not predictable. Generally speaking, most expansions and contractions last at least six months, but ultimately it is impossible to predict how long a given expansion or recession will go on. For example, in 1980, there

was a so-called mini-recession that lasted only about seven months. By contrast, the United States spent almost an entire decade in an economic expansion during the 1990s, from 1992 to 2001.

- Looking at the length of the business cycle over time, two aspects stand out. First, the business cycle seems to have gotten longer over the past 150 years. According to the National Bureau of Economic Research, the average length of the business cycle is about 56 months, or just over 4.5 years.
- This average number, however, conceals an interesting fact. Although the average business cycle from 1850 until World War I was almost exactly four years long, the average business cycle from 1919 through 1945 was five months longer. And if we look only at postwar business cycles, the average length rises to about 69 months.
- Another interesting change in the business cycle has taken place over the past 150 years. It seems that the amount of time spent in recessions has fallen and the amount of time spent in expansions has risen. The average length of a recession fell from 21 months during the period up to World War I down to just over 11 months during the postwar period.

Intensity of the Business Cycle

- A significant aspect of the business cycle is its intensity—or, in the language of cycles, its amplitude. When there's a recession, gross domestic product (GDP) tends to fall, perhaps by a percent or two in a tough recession. The problem is that in a normal economy, economic activity should be growing all the time.



Because it's difficult to estimate where GDP is relative to where it ought to be, the intensity of a recession is often measured by the highest level of unemployment reached during the recession.

- The business cycle actually describes how our economy fluctuates around the long-term trend of GDP growth rate. Imagine a simple graph that looks like a road going uphill. Rather than a smooth rise, there are bumps and potholes in it. If this graph is a picture of GDP over time, then these bumps and potholes are the business cycle, and the underlying hill is the trend.
- Another way of measuring the intensity of business cycles is to calculate the variance in the growth rate of GDP. The idea is that if a business cycle is more intense, then the positive growth rate will be higher during the expansion phase and the rate of decline will also be steeper during the recession phase. That means that the variance of the growth rate will be larger, because the variance is the average squared distance between the actual and the expected growth rate.
- Economists noticed that the variance of GDP growth during the 1990s was much lower than it had been in the 1970s and 1980s. This implied that the business cycle was less intense than before; thus, economists call this period the Great Moderation. Some thought that we had finally learned to tame the business cycle. Unfortunately, the Great Recession of 2007–2009 shattered that illusion. In fact, the business cycle seems just as wild and unpredictable as ever.

Jevons's Early Business Cycle Theory

- William Stanley Jevons was one of the fathers of modern economics, who introduced mathematical methods into economics and was an early proponent of using preferences to understand how people made choices.
- Jevons's business cycle theory was actually based on the natural world—in particular, sunspots, which are dark regions on the surface of the sun that emit powerful magnetic fields. Sunspots go through an 11-year cycle of increasing and decreasing frequency. Jevons reasoned that the increased appearance of sunspots would affect the production of crops on earth. As the sunspots made crops more or less plentiful, this would drive a cycle of spending and investing.

- In the modern economy, where agriculture plays a smaller role, Jevons's theory becomes completely unconvincing. We certainly experience effects of disturbances to agricultural production but mostly through changes in the prices of food. These days, it's nearly impossible to imagine that the agricultural sector could drive the business cycle of an industrialized country.

Capital Investment Theory

- Jevons's theory is distinctive because it has an external, or exogenous, source of business cycle fluctuations: the sun. Many theories of the business cycle that have been developed over the years explain how an economy can generate business cycles internally, or endogenously. That is, endogenous theories try to explain how business cycles are a natural consequence of the ways people spend money and operate businesses.
- According to one theory, the business cycle is driven by the amount and timing of capital investments. This story is based on the actions of entrepreneurs and companies that expand their businesses.
- When companies see their sales go up, they are more likely to expand their businesses. They build factories, buy equipment, and hire people.
- The increased investment in real capital raises income and employment, further increasing sales. Thus, for a while, there is a virtuous circle. More investment leads to more demand for the company's products, which in turn, leads to still more investment.
- But there's a limit to how far this can go. People eventually get their fill of the company's products, profits decline and may even turn into losses, and the company cuts back. That marks the change from expansion to recession. The process changes from a virtuous circle to a vicious cycle, as layoffs lead shoppers to cut back their spending, leaving more goods unsold and leading to more job losses. Prices fall, and ultimately, wages follow suit.

- Eventually, though, prices and wages fall so much that some companies simply can't pass up the opportunity to try a new project or build a new factory while resources are relatively cheap. They try something new, on a limited scale, and if the project is successful, the uphill climb begins again.

Financial Market Theory

- Another theory of the business cycle focuses on the financial market. In the 19th century, people believed that banks and other lenders played a key role in the business cycle.
- For example, during a financial panic, one or more banks or other lenders collapse. That causes a scramble for cash among the remaining banks. Banks call in loans, but many borrowers cannot repay and either default or are forced to sell off their assets cheaply. The scramble for cash bankrupts businesses and causes the value of such assets as factories, land, and buildings to fall. In this way, financial panics touch off what we now call recessions.
- But just as in the case of business investment, eventually, the prices of buildings, land, and factories fall so low that they represent a good opportunity for profit. Then, banks are much more willing to lend to people who will buy these cheap assets and put them to work.

Monetary Policy Theory

- The monetary policy theory of business cycles applies only in the postwar period. This theory is based on a belief in the ability of monetary policy to affect the demand for goods and services by changing both the amount of money and, more importantly, the level of interest rates and the amount of credit in the economy.
- The story here is that the Federal Reserve intentionally pursues contractionary monetary policy—that is, it cuts the growth rate of money and raises interest rates—whenever it believes that inflation is too high or that the overall economy is overheating. Of course, monetary policy is not a precise tool, which means that sometimes the Fed cuts back too much and there is an actual recession.

- The Fed may actually let the recession go on for a bit, though, if it thinks that this will help reduce people's expectations of future inflation. But eventually, the Fed acknowledges that it has cut back too much on the money supply and starts to stimulate the economy again by increasing the money supply and cutting interest rates. And the cycle starts over.

Real Business Cycle Theory

- The three business cycle theories discussed above are all demand-based theories, where changes in aggregate demand are the driving force behind the cycle. Demand, however, is just one side of the economy.
- The real business cycle theory is a modern supply-based theory. In this theory, the business cycle originates in sudden changes to people's preferences and to our level of technology. Business cycle theorists call such changes shocks. Technology shocks affect production costs. A positive technology shock means that production gets cheaper, and a negative technology shock means that production becomes more expensive.
- According to the real business cycle theory, the business cycle is simply a name for the adjustment to a new equilibrium that follows after a shock to preferences or technology. The adjustment takes some time to work its way through the economy because of imperfections that don't allow production or prices to adjust quickly. Sometimes, the imperfections lead to overshooting the new equilibrium, so that economic activity has to reverse course.

Suggested Reading

Friedman, *Fortune Tellers*.

Greider, *Secrets of the Temple*.

Knoop, *Recessions and Depressions*.

Simpson, *Money, Banking, and the Business Cycle*, vol. 1.

Questions to Consider

1. The lecture discusses the idea of the Great Moderation and the mistaken belief that economists and policymakers had learned to tame the business cycle. What forces do you think are responsible for the Great Moderation (which took place from the 1990s through about 2007)? In other words, what large trends at work in the economy help explain this phenomenon? Were we able to foresee any of these trends?
2. Many economists seem to think that government policy can start recessions but can't end them. Do you agree with this? If this idea is true, how does it contribute to the uncertainty of the business cycle?

The Danger of Inflation

Lecture 18

A significant source of economic uncertainty is the danger of inflation. Inflation is an increase in the price level, where the price level is a number that describes the average price in the economy. When inflation gets out of control, it can destroy an entire economy. Inflation attacks our savings by reducing the purchasing power of money—that is, by reducing the amount of goods and services that each dollar can buy. Although this is the most direct way that inflation poses a danger, there are many other ways that its negative effects can ripple through the economy, as we will learn in this lecture.

Inflation Rates

- Looking over the past 100 years of price-level data for the United States, the annual inflation rate has ranged from as high as nearly 18% to as low as -10.5% per year. A negative inflation rate, which is also called *deflation*, means that prices are generally falling instead of rising.
- Even within our own lifetimes, inflation has had a very wide range. For example, the U.S. economy experienced annual inflation of 13.5% in 1980, while prices fell by a little over one-third of 1% in 2009. The average inflation rate since 1960 has been almost exactly 4% per year, with a standard deviation of about 2.8%. This means that two-thirds of the time, our inflation rate falls between 1.2% and 6.8%.
- When we are in the middle of a period of relatively high or relatively low inflation, it's hard to believe that the future will be very different. That's why inflation is so uncertain and can be so dangerous. We get lulled into thinking that life will always be this way. Then, when the situation changes, we're not prepared for the new reality.



When inflation is low, you may go to only one store per week for all your groceries, but when inflation starts to climb, it becomes worth your while to devote more time to comparison shopping, and you may visit more stores each week.

- When inflation starts to rise higher—say, to 5% or more per year—people start to pay more attention to it, and it begins to affect their behavior. People begin to put more effort into managing the effects of inflation on their lives and less effort into doing productive work. Businesses also incur more costs when inflation starts to go up.
- In the case of hyperinflation, people devote an absurd amount of resources just to distribute and spend money. High inflation makes economies less productive because it leads people to burn up more and more resources simply in the act of spending the money that is worth less and less.

Fisher Effect

- Another way that high inflation hurts the economy is by driving up interest rates. This phenomenon is known as the *Fisher effect*, in honor of the economist Irving Fisher. Fisher realized that high inflation can potentially benefit borrowers and hurt lenders because

high inflation reduces the value of money. Over time, borrowers pay back their loans with money that is less and less valuable in terms of the goods and services it will buy.

- Fisher theorized that lenders try to protect themselves against the falling value of the money that borrowers use to pay them. Lenders do this by building into the interest rate the average inflation rate they expect over the life of the loan.
- This means that the interest rates we pay consist of two parts: first, compensation to the lender for the act of making the loan (the real interest rate), and second, compensation for the expected decrease in the value of money over the life of the loan. The interest rates quoted by banks and other lenders (nominal interest rates) are the sum of the real interest rate and expected inflation.

Deflation

- A very narrow range of inflation is actually good for the economy. Inflation can have harmful effects when it's too low, as in negative inflation, or deflation. In fact, most economic policymakers are more worried about the negative consequences of deflation than about high inflation or even hyperinflation.
- The reason for this concern is that falling prices can have deleterious effects on business. For businesses, there's usually a large gap between the time they pay their costs of production and the time they sell their goods or services. This time lag becomes a business's worst enemy when prices fall.
- The longer this time lag is and the faster prices fall, the more likely it is that the ultimate selling price of the goods or services won't provide much profit. It's also possible that eventually, the selling price won't even cover production costs.
- In the face of deflation, the best policy is to produce less—or maybe not even produce at all. In fact, depending on how fast the rate of deflation is, a business could earn a higher rate of return simply by

holding onto cash. After all, deflation means that the value of cash is rising—that is, each dollar bill buys more goods and services because prices are falling.

- During deflationary times, businesses don't produce, leading to layoffs and higher unemployment. The people who have cash, meanwhile, don't spend it. They prefer to wait as long as they can to spend money because the longer they wait, the more they can afford to buy.

Measuring Inflation

- A problem with inflation is that we cannot measure it accurately. The main gauge we use for inflation, the consumer price index (CPI), is based on a survey. As we saw earlier, all data derived from surveys are affected by sampling error, and this sampling error can be significant.
- In our modern understanding, economists believe that the primary cause of inflation is an increase in the money supply. Many people define inflation as “too much money chasing too few goods.” The celebrated economist Milton Friedman famously claimed, “Inflation is always and everywhere a monetary phenomenon”—again emphasizing the connection between inflation and the money supply.
- In fact, inflation has two main sources. The overall price level is set by the forces of supply and demand. This means that inflation can be caused by changes in either of these factors. In particular, an increase in aggregate demand will make prices rise, but so will a fall in aggregate supply.

Inflation throughout History

- When we consider the different episodes of inflation throughout history, we can see both supply and demand forces at work. For example, economic historians point out that since the Middle Ages, four major waves of inflation have affected the Western world. According to this theory, we're currently in the middle of the fourth wave.

- During the first three waves, which took place in the 14th, 16th, and 18th centuries, population growth seems to have been the main factor that drove inflation. During each of these periods, rapid population growth led to an increased demand for food, shelter, and fuel.
- Interestingly, the second wave of inflation was observed during the conquest of the New World, which led to huge inflows of gold and silver into Europe from the Americas. Because gold and silver coins were the main type of money used at the time, this inflow of precious metals contributed to the second wave of inflation, but according to economic historians, this inflationary wave started well before the gold and silver started arriving. Again, it was concentrated in food, land, and fuel prices.
- The current wave of inflation, which began in the late 19th century, seems to have been primarily caused by increases in the money supply. During this time, most of the world gradually abandoned the use of gold and silver for money and adopted *fiat currencies* instead. Fiat currencies have value only because the government says they do—there is nothing backing them up other than the government’s promise to protect the value of the money.

Monetary and Fiscal Policies

- Most governments today adjust the money supply indirectly, through the interaction of the central bank with the commercial banking system. This process actually increases the unpredictability of inflation because it can take from six months to two years for a change in monetary policy to achieve its full effect on the economy.
- Monetary policy affects inflation through increasing or decreasing the amount of demand in the economy, especially by increasing or decreasing the amount of lending that takes place. The government can also affect inflation through its own spending and taxing (fiscal policy) because this also has a significant impact on the level of aggregate demand.

- A major influence on inflation comes from the supply side of the economy. If the efficiency of production falls or the cost of production rises significantly, then the supply curve will contract, pushing prices up and leading to inflation.
- Over the past several decades, changes in supply have actually tended to reduce the rate of inflation in our economy. Thanks to the tremendous increases in technology that we've seen in the past several decades, production of just about everything in the economy has become much more efficient. Production costs have fallen, and this increase in aggregate supply has helped to offset the effects of increases in demand that would have led to higher inflation.
- Despite the increasing efficiency of our economy, inflation will continue to remain a major source of economic uncertainty for all of us. Not only is inflation simply hard to predict or control, but it also seems as if government policy has a bias toward promoting inflation. Governments want to promote higher economic growth, and the best way to accomplish this quickly is to put more money into the economy.

Suggested Reading

Fergusson, *When Money Dies*.

Fischer, *The Great Wave*.

Greider, *Secrets of the Temple*.

Simpson, *Money, Banking, and the Business Cycle*, vol. 1.

Questions to Consider

1. In this lecture, we learned that the government often changes the version of the inflation it reports in its press releases. For more information about why it does this, read “If You Want to Know the Real Rate of Inflation, Don’t Bother with the CPI” (<http://www.forbes.com/sites/perianneboring/2014/02/03/if-you-want-to-know-the-real-rate-of-inflation-dont-bother-with-the-cpi/>). Look at the most recent press release of the CPI to find out what number is reported in the press. Why do you think the government is reporting this version of the CPI now?
2. Look at the most recent forecasts for short- and long-run inflation in the Philadelphia Fed’s survey of professional inflation forecasts (<http://www.philadelphiafed.org/research-and-data/real-time-center/survey-of-professional-forecasters/historical-data/inflation-forecasts.cfm>). Do you agree with these forecasts? If you do, what actions should you take with your personal finances to deal with this level of inflation?

Extreme Markets

Lecture 19

At any given moment, some financial market somewhere is making headlines because it's either hitting record highs or crashing. And because nearly all of us invest a significant share of our savings in financial products, such as bank deposits, government bonds, and mutual funds, when the financial markets act like a roller coaster, it's a wild ride for us. This lecture emphasizes the fact that unpredictable behavior and large swings in prices are normal in the financial markets and offers strategies on dealing with these uncertainties.

Volatility in the Marketplace

- The S&P 500 index, which measures the price of 500 large U.S. stocks, is a customary way to represent the overall value of the U.S. stock market. Examining the data on returns for the S&P 500 index since 1950, it turns out that the market has gone up by as much as 11% in one day and fallen by as much as 20% in one day. Looking at the returns for each calendar year since 1950, we find an even wider range. The stock market rose by over 40% in 1954 and over 30% in 2009, but it fell by over 40% in 2008 and by over 24% in 2002.
- The large swings in stock returns from day to day and year to year tell us that a simple average of returns is unlikely to give us an accurate picture of the level of uncertainty in the stock market. The reason for this is that the large number of positive and negative returns tend to cancel each other out. In fact, the average daily return from 1950 to 2013 is only 0.0003%.



Extreme behavior in the financial markets affects all of us who are saving to meet financial goals, such as sending children to college or affording a comfortable retirement.

- However, the standard deviation of daily returns, which measures the dispersion or variability of these returns, is almost 1%. In other words, a so-called normal day in the stock market might see a relatively big jump in prices—either up or down by 1% and maybe more. The average return doesn't tell us the reality of the up-and-down swings in the market.
- Other financial markets may not be quite as wild as the stock market, but they still exhibit a great deal of uncertainty. For example, from 1950 to the present, bond returns went from 2.5% to more than 15%, then back down to 2.5% and kept falling. In fact, in the United States, bond returns reached a low of just over 1.5% at the end of 2012.
- There has been a great deal of uncertainty for borrowers, as well. Mortgage interest rates went from 7% at the beginning of the 1970s to over 18% in the early 1980s, then back to 7% by the late 1990s. Then, mortgage rates kept falling for more than a decade, until they bottomed out at 3.33% in late 2012.
- Finally, consider the price of gold, which went from under \$100 an ounce in the early 1970s to \$900 an ounce within a decade. It fell to under \$300 an ounce by the late 1990s, then climbed to over \$1,600 an ounce by 2013.

Connection between Financial Assets and Real Assets

- The level of uncertainty in the financial market is actually a bit of a mystery to economists. To understand why, consider the connection between financial assets and real assets.
- A financial asset is a contract that people use to exchange valuable items with each other. For example, a loan is a contract between a lender and a borrower in which the lender trades a single large amount of cash today for a set of future cash payments from the borrower.

- A real asset, in contrast, is something that generates products that people use directly. Real assets include such physical entities as factories, land, and machines, as well as intangibles, such as ideas and brand names.
- Every financial asset is connected somehow to a real asset. Many economists believe that this connection means that the uncertainty in financial assets should be more or less equal to the uncertainty in the physical assets to which they are connected. However, although there is much uncertainty in real assets, the variability of prices and returns in financial markets is far greater than the variability in the value of real assets. That's the mystery.

Uncertain Value of Financial Assets

- One of the main reasons that the uncertainty in financial markets is far greater is that real assets generally aren't traded very often; thus, their prices don't have a chance to reflect the true level of uncertainty regarding their value. Financial markets do a better job of reflecting the true uncertainty in our economy than do other indicators.
- Because financial assets are so easy to trade, many investors with different agendas come into the markets. But that is a positive development; theoretically, the more people who trade in a market, the closer the market price should come to the true social value of a good, service, or asset.
- Economic theory tells us that in most markets, the market price should reflect both the cost of producing the product and the average value that people place on the product.
- Financial assets are different. First, the cost of producing the asset is generally very low because the asset itself is just a written contract. What's more, people can't agree on how to value financial assets. There is no anchor for the price of any financial asset. Without some true underlying value or other reference point, financial prices can drift up and down at random, soaring one day and crashing the next.

Reasons for Trading

- Just as there are multiple opinions about the value of any given financial instrument, there are multiple reasons for trading them; this fact also contributes to uncertainty in the financial markets.
- For example, consider a government bond. Some people want to buy government bonds because they need a safe place to save money for retirement. Other people buy government bonds because they think that the central bank will lower the interest rate, which will make the price of the bonds rise. Still others may think that the corporate bonds they've invested in have become too risky and want to move their money into safer investments.
- The prices and interest rates on government bonds depend on how many there are of each of these groups and how strong their beliefs are. A change in the size or beliefs of each of these groups can lead to large changes in the demand for government bonds, resulting in large swings in the market interest rates on bonds.
- Stock markets have a similar diversity of reasons for trading. Some people want to invest some of their retirement savings in a company's stock, while others are buying shares today and betting that the share price will go up in a couple of weeks when the company announces its quarterly profits. Still others buy shares of a company because they think it's going to be taken over by a competitor.

Extreme Behavior

- One of the main consequences of uncertainty is that financial markets are predisposed toward extreme behavior. Because there aren't any strong guides for what financial prices should be, they can be driven to extreme highs or lows very easily. Also, because there are so many opinions about how to value an asset and so many reasons to trade, people can become convinced by one of these stories and decide to join in a wave of selling or buying. For example, stock markets are prone to rise to extremely high values, only to crash suddenly.

- What's important to note here is that the extreme behavior in the financial market is connected in some way to real assets. Beliefs that the value of certain real assets are increasing at first can lead financial markets to expand and increase in value. Then, when beliefs about the value of these same assets change for the worse, a massive contraction in prices and lending can result.

Protecting against Uncertainty

- Several key strategies can help you reach your financial goals despite the uncertainty in the financial markets. One of the most important strategies is to give your investments enough time. Even though there is a great deal of variability in the financial markets, there is an underlying upward trend in virtually all financial markets. The longer you stay invested in the market, the more you see the upward trend and the less the fluctuations matter.
- This is the connection between real assets and financial assets at work. The forces of economic growth and development are creating more real assets over time. Moreover, these new generations of real assets have higher value because they're more productive.
- As an investor, you should resist the temptation to pull out of the market after a big crash or other setback. Large negative swings in the market are often followed by large positive swings. If you pull out of the market right after a loss, you're likely to miss the recovery.
- A second way to protect yourself against the uncertainty of the financial market is to use dollar cost averaging. This is simply the practice of investing a relatively small amount frequently, rather than large amounts on an annual basis. The idea behind dollar cost averaging is that you'll end up buying more assets when prices are low and fewer assets when prices are high.

- A third way to protect against uncertainty is to diversify your investments across different types of financial assets. Fortunately, even though financial markets show a great deal of volatility, they don't tend to move up and down together in a coordinated way. When one market is falling, other markets are rising in value. Taking advantage of this will help protect your investments against large losses and actually make it more likely that the value of your investments will match the slow and steady increase in value of the real assets to which they are connected.

Suggested Reading

Brown, *Red-Blooded Risk*.

Minsky, *Can "It" Happen Again?*

Questions to Consider

1. One possible source of uncertainty in the financial markets is something that Keynes called "animal spirits." What did Keynes mean by this phrase? Doing a quick search on "Keynes animal spirits" will bring you to many suggestions. How is the concept of animal spirits related to ideas that we learned earlier in the course, especially in Lecture 5?
2. What does it mean for a portfolio to be well diversified? What set of investments would you choose to create a well-diversified portfolio? What instruments are best suited for helping you diversify your portfolio?
3. In many employer-sponsored retirement savings plans, the default investment is a target-date mutual fund. What are these funds, and are they very well diversified? Does their degree of diversification satisfy you?

Regulation, Innovation, Excess

Lecture 20

When governments intervene in markets by imposing laws and regulations, this adds uncertainty to the economy rather than reduces it. Often, well-intended government policies to solve a problem backfire, actually making the crisis worse. Although we will always need government to reduce certain fundamental risks in our lives, many government policies can also increase risk and uncertainty. In this lecture, we discuss some positive effects of government policies and look at explanations for their negative effects, including the law of unintended consequences, public choice theory, and the Lucas critique.

Imperfect Information, Asymmetric Information

- If markets were perfect, they would deliver the best possible outcomes for society. But in reality, our markets are not perfect: They lack perfect information. In fact, imperfect information is one of the main reasons that economists use to justify government regulation and intervention into markets. Not only is there uncertainty in the markets—defined as a lack of information—but there is also a great deal of asymmetric information that causes adverse selection and moral hazard problems.
- For example, Securities and Exchange Commission (SEC) regulations require companies to disclose various kinds of information about their financial condition and activities. These regulations attempt to prevent company managers from hiding their actions from shareholders—which would present moral hazard problems.

Missing Market Problem

- The missing market problem is another market imperfection that increases economic uncertainty. If a market is missing, we need government intervention or regulation to create the market or to give the private sector the incentive to create it. In fact, one way

to think about government is that it is a tool for citizens to create goods and services that they want and need but that the private market will not—or cannot—deliver.

- For example, private markets have trouble providing such services as law enforcement and national defense. These services reduce an important source of uncertainty and increase people’s individual security. Law enforcement and national security services are missing markets because of the public-goods problem, also known as the free-rider problem.
- Everyone benefits from having these systems in place, even if people won’t pay for them. And if nobody is willing to pay, then the market doesn’t develop and goes missing. Therefore, we need the government to provide these services.
- We also ask our government to reduce economic uncertainty by managing the economy, including the financial markets. For example, in the United States, the Federal Reserve has a mandate from Congress to keep inflation low, keep employment high, and maintain the stability of the financial market.

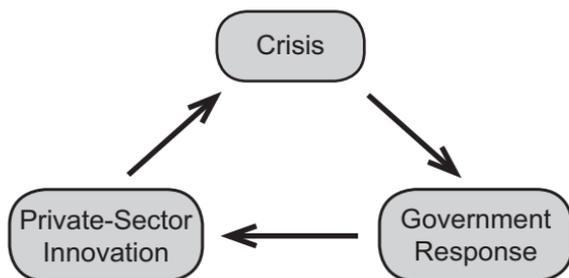
Law of Unintended Consequences

- In many cases, the government’s good intentions lead to policies that do more damage than the problems they were trying to solve. In fact, people refer to the law of unintended consequences, which observes that government interference in the economy, or in any other complex situation, will result in unforeseen and generally negative consequences.
- When the government intervenes in a market, it either explicitly changes the rules of that market or it changes people’s expectations about how the government will enforce these rules in the future. In short, government interventions change people’s incentives. And when you change incentives, you change people’s behavior.

- One of the most powerful ways that governments influence incentives is through their tax systems. The ways in which activities are taxed—or not taxed—create both uncertainty and unintended consequences. Government regulations also function like taxes because they impose additional compliance costs on individuals and businesses.

The Regulatory Cycle

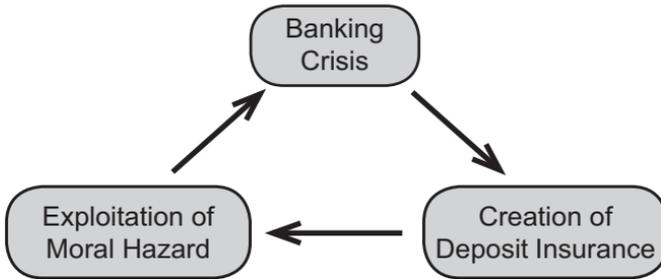
- A model for thinking about the effects of government policies comes from the field of political science, but variations of this model are frequently used by economists to study the effects of regulation. The model is called the regulatory cycle (see below).



- The cycle starts when there's some kind of crisis in a market. People are either harmed directly or their economic interests are damaged; thus, they call on the government for help. That call for help leads to a government intervention, including regulation or deregulation.
- Government action, in turn, changes incentives. In response to changes in incentives, people change their behavior and figure out new ways to benefit from the changes in the system. In other words, they innovate. The innovation might be finding a loophole in one of the new regulations or designing a new way to do business. These innovations lead to further consequences—some good and some counterproductive or even destructive. Sometimes, the innovations lead back to a crisis.

The Regulatory Cycle—A Case Study

- Let's look at a case study illustrating the regulatory cycle (summed up in the diagram below). The story starts in the early 1930s, when an economic downturn produced a massive wave of bank failures between 1931 and 1933. Millions of people lost all their savings.



- Because the crisis was so serious, there was an unprecedented government response. One of the main actions the federal government took was to introduce deposit insurance. The creation of deposit insurance and the many other bank regulations that were introduced at this time seemed to fix the problem. But in the background, the government had fundamentally changed the incentives of bank managers and depositors.
- Deposit insurance acts as insurance against bad lending decisions made by bank managers. Before deposit insurance, the bank's own depositors had to discipline the bank managers when they started to make too many risky loans. But after deposit insurance was introduced, depositors no longer paid any attention to the bank's lending activities because if the bank made too many bad loans and failed, deposit insurance would give them back the full value of their deposits.
- Bank managers' incentives also changed in an important way. Because the managers didn't have to worry about the consequences of their actions, they had the incentive to make more risky loans. If too many of these loans defaulted, the government would step in and bail banks out. This is a classic moral hazard problem.

- Because of this moral hazard problem, the stage was set for disaster. Specifically, in the 1970s and 1980s, bankers realized they could start making riskier loans to compensate for the low interest rates they were earning on their existing loans. Eventually, the high-risk loans started to default, pushing thousands of banks into bankruptcy.
- Because savings and loan associations (S&Ls) were especially hard hit by the defaults, the resulting banking crisis became known as the S&L crisis. The crisis ended up costing about \$200 billion but only because the government was able to earn back the bailout money.

Public Choice Theory

- Another reason that government intervention can increase economic uncertainty is that the success of any regulation or program depends on the skill and judgment of the people whose job it is to design, implement, and enforce these interventions. This includes both elected officials and the people who staff government departments, agencies, and bureaus.
- The people working at government agencies have special training and expertise, but in the end, they're still human beings. They don't have all the answers, and they make mistakes. But the problem goes deeper than that: Just like everyone else, regulators respond to incentives. And in some cases, regulators have the incentive to take the wrong actions, such as being too lenient in enforcing the rules.
- The Nobel prize-winning economist James Buchanan devised the public choice theory to explain how regulators act based on their incentives. Much of the time, regulators have the incentive to act in the public interest, but sometimes, they have the incentive to act in ways that benefit themselves at the expense of the public interest.
- No one ever wants to be the person in charge when a problem or a crisis comes to light. That gives regulators, especially the ones in charge, the incentive to ignore or cover up problems, sometimes for years.

- Career concerns also have a major impact on regulators' incentives. Many regulators move from their government jobs into private-sector jobs. In the United States, this is called the revolving door—and it's not necessarily a negative phenomenon. For example, former regulators can help private companies figure out how to be as profitable as possible while still playing by the rules. But think about what the revolving door does to regulators' incentives. A regulator may be soft on a certain company if there is a chance for a job there in the future.

Lucas Critique

- Another Nobel prize-winning economist, Robert Lucas, came up with a powerful warning about what can happen if we ignore the fact that government action changes people's incentives. This warning is known as the *Lucas critique*.
- Lucas pointed out that many economic policies are made by looking for economic relationships that held in the recent past, then trying to make policies that exploit this relationship. But these policies change people's incentives, causing them to react in ways that make the policies ineffective or even damaging to the economy.
- For example, in the 1960s, economists found that there was an inverse relationship between inflation and unemployment, which was called the *Phillips curve*. Economists would use past history to estimate an exact tradeoff between inflation and unemployment, then policymakers would try to set inflation at a rate that would deliver the desired level of unemployment.
- Policymakers in the government found that the policy worked well at first, but after a while, the unemployment rate started to creep up. They looked at the data again and re-estimated the relationship between inflation and unemployment; they found that they now needed to use a slightly higher rate of inflation to hold unemployment down. But this process kept repeating itself.

- What happened was that the government's actions changed the public's expectations about future inflation, and this, in turn, changed their incentives with respect to wage demands and spending habits. People started to expect higher and higher inflation rates, which gave them an incentive to do whatever they could to protect themselves from inflation. They demanded wage increases, and they spent money rather than saving it.
- Both these responses, of course, only made the inflation problem worse by driving prices up faster. This experience makes a strong case for keeping the Lucas critique in mind when the government designs interventions in the markets.

Suggested Reading

Kane, "Interaction of Financial and Regulatory Innovation."

Sheridan, *Best Laid Plans*.

Questions to Consider

1. In Lecture 9, we learned that in certain strategic situations, we may want to introduce uncertainty into our actions rather than reveal information. Are there times when policymakers may make us better off by introducing uncertainty into their actions? For a possible example, see Jeremy Stein's paper "Cheap Talk and the Fed: A Theory of Imprecise Policy Announcements" (<http://scholar.harvard.edu/files/stein/files/aer-1989.pdf>).
2. In many countries, including the United States, new regulations must undergo a cost-benefit analysis before they are implemented. What does the existence of unintended consequences mean for the results of these cost-benefit analyses? Are there practical ways that governments could test their policies for unintended consequences and change them if necessary?

Global Trade in Employment

Lecture 21

Foreign trade is a powerful source of uncertainty. Although many people think that international trade is driven by differences in wages, labor costs do not represent the full story. All trade—whether between two people in the same town or two companies on opposite sides of the world—is driven by comparative advantage. Comparative advantage leads to specialization, which creates uncertainty. In this lecture, we'll explore the phenomena of comparative advantage and specialization and examine other issues related to the economics of international trade, such as offshoring, reshoring, and the crucial importance of efficiency, quality control, and innovation.

Barter Prices

- Let's begin by considering an example of an opportunity for trade between the United States and China. Although both China and the United States produce t-shirts and frozen chickens, the United States is more efficient at producing frozen chickens and China is more efficient at producing t-shirts. Economists say that the United States has a comparative advantage at producing frozen chickens, and China has a comparative advantage at making t-shirts.
- Suppose that, in the United States, a U.S.-made t-shirt costs \$12 and a U.S. farm-raised chicken costs \$3. That means that inside the United States, we can effectively trade one t-shirt for four chickens. Also suppose that in China, a Chinese-made t-shirt costs ¥10 (yuan), and a frozen Chinese chicken costs ¥5. This means that inside China, people can effectively trade one t-shirt for two chickens.
- In other words, a t-shirt is relatively more expensive in the United States than it is in China, but chickens are relatively cheap in the United States and relatively expensive in China. These effective barter prices are the basis of comparative advantage. The barter

prices include such factors as wages paid to workers, labor productivity, and all other costs of production. The country that has the lower effective barter price for a product has a comparative advantage in that product.

- Because the prices are different between the two countries, there's room for people to bargain. Americans put more resources into raising chickens and less into making t-shirts. Similarly, in China, the Chinese put fewer resources into raising chickens and more into making t-shirts. On net, trade makes it possible for both countries to have more of both t-shirts and chickens because each country focuses more resources on making its own specialized product.

Specialization

- Economists use the term *specialization* to describe the diversion of resources to a more efficient industry. Specialization is the reason that trade causes so much uncertainty in the job market. Expansion in some industries comes at the expense of others that are less efficient. In our example, chicken farming and processing will expand in the United States, but the production of t-shirts will contract. That means that American companies in the t-shirt business will close factories and lay off workers.
- One of the main implications of specialization is that for every industry that loses as a result of trade, there must be at least one other industry that wins. Otherwise, there would be nothing to trade. Thus, when there are major job losses in one industry as a result of competition from imports, there should be other industries that are enjoying export-driven growth.

Characteristics of Comparative Advantage

- In our example, poultry (and other agricultural products) have been successful exports for the United States. The reason leads us more deeply into the question of comparative advantage. Three characteristics give an industry and its products comparative advantage.

- First, production costs are low. Although low production costs are commonly associated with low wages, overall costs can be low even in high-wage countries, such as the United States. In these cases, the industry is usually capital intensive—that is, producers use capital and the technology embedded in capital to substitute for labor. In addition, these industries use large production facilities to take advantage of economies of scale.
- Second, quality is high. If products are significantly better than those of the competition—or they are perceived to be significantly better—this can also bestow a comparative advantage on an industry.
- Third, products are innovative. Novel and innovative products have comparative advantage because they cannot be duplicated anywhere else at any price.
- Unfortunately, even though some industry wins through trade, this may not completely offset the job loss and uncertainty caused in the industry that loses. Ideally, the people who lose jobs as a result of trade would find new jobs in the companies that are exporting and expanding, but there may be a skills mismatch. This problem is one of the largest obstacles that countries face in adjusting to the consequences of international trade.

Tradable and Non-Tradable Products

- In trying to maintain a competitive edge against imported products, there is an alternative strategy: Instead of working in an industry with a tradable product, companies and individuals can go into non-tradable products instead. Many services fall in this category.
- However, as technology improves, increasing numbers of products have moved from the non-traded category to the traded category. For example, not too long ago, many fresh foods were non-tradable because they wouldn't be edible at the end of the trip from one country to another. Fresh fruits, seafood, and meats fell in this

category. But as transportation and food-preservation technology improved, these products became traded on global markets.

- Similarly, because of improvements in information and communication technologies, more formerly non-traded services are being traded internationally. Services that don't require someone to be physically present, such as answering customer service calls, can now be exported.



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Increasing numbers of jobs are vulnerable to foreign competition; even some highly skilled jobs, such as reading x-rays, have been outsourced to foreign companies.

Offshoring

- Much of international trade is related to offshoring, in which a domestic company moves its production facilities abroad or simply contracts with foreign producers to manufacture products under the company's name. At first glance, offshoring seems to have the same ultimate result as head-to-head competition between domestic and foreign companies—jobs that are lost for good. But offshoring has its own set of uncertainties that make that outcome less of a given.
- Offshoring actually can cut both ways. Although some firms in a country move their production overseas and cut jobs, other companies from other countries move their production here at the same time. A case in point for the United States is the automobile industry. In the 1980s, Japanese car companies began to build factories in the United States, in large part to save on shipping costs.
- American companies that move their production offshore sometimes find out the hard way that offshoring opens up new uncertainties. In particular, offshoring production creates principal-agent problems on a massive scale. The American company is the principal, but it

must rely on agents—foreign factories or companies—to reach its goals. There is a situation of asymmetric information, especially when the production is outsourced to foreign contractors. In other words, there are plenty of opportunities for the agents to pursue their own goals at the principal's expense.

- Quality control has also proved to be a major issue for companies that outsource or offshore their production. Contractors have an incentive to substitute cheaper materials and implement manufacturing shortcuts that increase their profits but lower the overall quality of the product.
- Another way that the principal-agent problem manifests itself is through dangerous or inhumane working conditions in foreign factories. These situations can damage the reputation of the Western companies that are the principals.
- A final cost of offshoring is associated with the long lead times required to produce and transport products over long distances. This long lead time creates at least two major risks for offshoring companies. First, the company must guess nearly a year in advance what products will sell well. Second, if a company orders a product that turns out to be a blockbuster, it may have no flexibility to increase production to take advantage of the increased demand.

Reshoring

- One of the more interesting developments in recent years has been the return of some manufacturing to the United States—in other words, reshoring. Reshoring demonstrates that job losses from international trade aren't necessarily inevitable or permanent.
- When companies reshore production, they must still follow the rules of the game. They must either find a way to be just as efficient as their foreign competitors or they must produce an innovative product that isn't yet subject to competition. In other words, avoiding the principal-agent costs and other uncertainties involved with outsourcing can be part of a comparative advantage.

Determining Your Own Comparative Advantage

- The economic uncertainties caused by international trade really are no different from the uncertainties created by any kind of economic competition. Every business must maintain its competitive edge, or eventually, it loses market share and is forced to change in order to survive. International trade accelerates this process by exposing companies to more intense competition than they would otherwise face.
- To deal with uncertainties related to trade, there are two general strategies workers can take for long-term success. One is to become as efficient as possible at the work you do. It's always a positive goal to try to be more efficient, but people can reach the limits of this strategy fairly quickly.
- The second strategy is based on quality and innovation. Most directly, it means improving the set of skills that you have already developed and learning new ones. In other words, you need to actively manage your own professional development. And don't ignore the possibility of innovating in an entirely new direction by trying another line of work or even starting your own business.
- Comparative advantage drives trade. If people, companies, or countries have a comparative advantage in some economic activity, they'll be able to thrive and specialize in that line of business. Take time to seriously consider your own comparative advantage. Think carefully about what it is you do better than most other people.
- As we have learned in this lecture, foreign trade is a powerful source of uncertainty, and the economics of trade means that more jobs than ever are vulnerable to direct foreign competition and offshoring. Although we cannot control or even predict which businesses will benefit from trade and which ones will suffer, we do have the ability to discern our own personal comparative advantage in the labor market. It's our responsibility to find a way to make a living based on that comparative advantage and to protect our advantage by investing in our own skills.

Suggested Reading

Christensen, *The Innovator's Dilemma*.

Greenwald and Kahn, *Globalization*.

Oatley, *Debates in International Political Economy*.

Questions to Consider

1. One of the processes that results in changes in comparative advantage is moving up the value chain. That is, businesses get their start by producing cheap, low-value products and, over time, learn how to produce more expensive, higher-value products. What countries' industries have moved up the value chain significantly during your lifetime? What does this mean for trade and jobs in developed countries?
2. One technological source of uncertainty for companies and their employees is disruptive innovations. This term, which was coined by Harvard professor Clayton Christensen, has come into wide usage as a result of the rapid introduction of new (and disruptive) technologies, such as the mobile web. A good overview of Christensen's ideas can be found in the article "Disruptive Genius" (<http://harvardmagazine.com/2014/07/disruptive-genius>). What disruptive innovations have you used as a consumer? Are disruptive innovations occurring in your industry? If so, how should you react to this development?

No Limits to Growth

Lecture 22

Human beings are very effective at identifying trends, and it seems as if those who predict negative trends get the most attention. Quite often, though, these pessimistic projections never turn out as badly as expected. In fact, our theories and models cannot project trends into the future with any kind of accuracy, mainly because aspects of our economy and our society are so complex and interconnected. In this lecture, we'll explore the implications of some recent attempts to model the future and examine two significant trends that may change our society in ways that we cannot predict.

The Club of Rome

- In 1972, an international group of academics calling themselves the Club of Rome published a book called *The Limits to Growth*. This group built a model to predict what would happen to the size of the world economy and global population over the next



Although our predictions are not always accurate, examining the effects of long-term trends is useful in order to identify problems, such as pollution, and spur action on the part of people and governments.

130 years—that is, all the way to the end of the 21st century. The model included the effects of several trends that have received increasing attention recently, including rapid population growth and environmental pollution.

- The book generated controversy because of its prediction that current rates of population and economic growth were unsustainable. Eventually, society would exhaust the world's limited resources—either by using them all up or by rendering them unusable as a result of pollution. According to the authors of *The Limits to Growth*, humankind's best hope for the future was to voluntarily limit population and economic growth.
- This book is a fascinating example of the uncertainty caused by slow-moving but powerful forces that we believe will reshape our world. Although the predictions in *The Limits to Growth* have proved to be off the mark, it took more than a decade for people to come to that realization.

Modeling Long-Term Growth

- Studying long-term trends has always had its place in economics. Starting in the 1950s, economic theorists developed mathematical models of the long-term fluctuations in the economy. These fluctuations, called *trend* or *secular fluctuations*, are associated with long-term economic growth.
- One of the first economists to develop a formal mathematical model of long-term economic growth was Robert Solow, who won a Nobel Prize for this work. The Solow growth model clearly identified two of the main drivers of long-term economic growth: population growth and technological innovation.
- Trends related to population and technology form the basis of many theories about future economic uncertainty. Although most of the big-picture drivers of long-term economic uncertainty remain the same, the specific problems associated with these drivers change over time—sometimes quite significantly.

Flawed Models

- One reason that predicted trends don't pan out is that our models may be wrong. Many basic forecasting models simply draw a line that fits the current trend, then extend that line out into the future, assuming that it will continue unchanged. That's a significant assumption.
- More sophisticated models use underlying economic relationships that show how different processes affect one another and change over time. Information is fed into these models based on observed trends to simulate how the economy will respond.
- Unfortunately, increasing the sophistication of the model also increases the number of assumptions. And because every assumption is at least somewhat inaccurate, a complex model will contain many small inaccuracies. These add up to larger inaccuracies, and in many cases, they're amplified by feedback loops built into the model, such as multiplier effects. The time factor amplifies inaccuracies, as well. Forecasting out 10, 20, or 100 years at a time multiplies the size of the errors.
- Even our most sophisticated models are still simplified versions of an incredibly complex reality. When models are used responsibly, they usually report a range of outcomes based on changing some of the values of the key inputs into the model. Robustness checks are used to determine how sensitive a model's predictions are to changes in the key assumptions.

Price Mechanism

- Another reason that trends don't necessarily pan out is a result of the effect of a powerful phenomenon: the *price mechanism*. The price mechanism automatically responds to long-term trends and can change their effects.
- Major trends that ripple through the economy tend to have major effects on prices, and significant changes in prices generally result in significant changes in behavior—both for consumers and

businesses. The changes in behavior in one market will lead to other price changes and other behavior changes in related markets. Collectively, the changes in consumer and business behavior across different markets change how trends affect the economy.

- Consider the example of one of the main forecasts of *The Limits of Growth*—that the world will run out of natural resources. People seriously worried about running out of oil in the 1970s and again in the mid-2000s. Some people today, including some oil industry experts, are convinced that we’ve reached “peak oil”—the maximum annual oil production.
 - When the price of oil starts to rise, however, a chain reaction with far-reaching consequences is set in motion. First, everyone who uses oil or products derived from it, such as gasoline, starts to conserve oil. As time goes by, consumers of oil move to the next phase of behavior, finding substitutes.
 - The increase in the price of oil also leads to innovation. Interest in developing alternative energy sources increases. People are also incentivized to find more oil or to obtain more oil out of existing fields. All these changes in behavior have drastically changed the forecast for oil. Even though we know that oil is a limited resource, the price mechanism has put off the day we reach peak oil, perhaps for quite some time.
- The pattern of conservation, substitution, and innovation applies to changes in the price of any resource. In fact, the author Matt Ridley argues that because of the price mechanism, the idea of scarcity is actually a fallacy. The price mechanism doesn’t just avert or mitigate a negative outcome; it also creates new opportunities.
- The effect of the price mechanism is incredibly difficult to factor into the projections based on observed trends, in part because it’s difficult to predict how people will take advantage of the opportunities that are created by these trends. This means that although we should be concerned about where an ominous trend will lead us, we have good reason to believe that none of these

trends will necessarily lead to catastrophe. As long as there's money to be made by solving problems, people will come up with solutions.

Population Trends

- Two current trends are especially important to shaping our future economy: population and technology.
- Even though population growth rates in many developing countries are still fairly high, these rates fall as economic growth improves. As people's incomes rise, they have fewer children and invest more in the success of each child. This is a pattern that we've seen in developed countries and in just about every country that has climbed up the development ladder.
- Actually, the most ominous population trend is that population growth rates will fall too far, too quickly. Younger generations are having fewer children, which means that the population growth rate may fall below the *replacement rate*—the rate that balances the number of deaths and the number of births each year. Older people will start to significantly outnumber the young.
- An aging population can be a problem for several reasons. First, older people simply don't consume as much as younger people. That affects economic growth because consumption is one of the main drivers of every economy.
 - In addition, in many countries, the elderly receive a share of their income in the form of government transfers, such as Social Security in the United States. In a *pay-as-you-go* system, young workers are taxed and the revenues are paid to the retirees.
 - The ratio of workers to retirees is called the *dependency ratio*. When the dependency ratio is high, perhaps five workers for each retiree, as we had in the United States in the 1960s, the system works well. But because of the fall in population

growth, there are now fewer workers to support each retiree. The dependency ratio in the United States may fall below two in the next decade. With an aging population, such pay-as-you-go social security systems may go bankrupt.

Technology Trends and Creative Destruction

- A second current trend has its origins in technology and the process of creative destruction. *Creative destruction* is a term that Joseph Schumpeter used to describe the evolution of capitalism. Companies that introduce innovative products grow, but in the process, they often destroy old businesses. For example, the typewriter business was destroyed by the introduction of personal computers and the film business was destroyed by the introduction of digital photography.
- Although creative destruction is the normal state of a healthy economy, the trend makes several assumptions of concern.
 - The first assumption is that as certain businesses are destroyed, the employees of those businesses can easily and quickly move to jobs in businesses that are growing. As technology improves and as the pace of technological improvement accelerates, however, it is more difficult for people to move from a dying industry to a growing one.
 - The minimum skill levels required for jobs in the expanding businesses are not only increasing, but they're also becoming more specialized. Even manufacturing jobs are increasingly requiring specific software skills that are needed to operate, monitor, and troubleshoot incredibly sophisticated production lines.
- The other assumption behind creative destruction is that new businesses will create at least as many jobs as are destroyed. Today, although we are clearly moving to an information-based economy, it's not clear that the fast-growing businesses in this economy will be creating nearly as many jobs as they destroy.

- For example, consider the social media companies that now have market values measured in the billions. Compare the size of their workforces to those of old-economy companies that have similar market values. Recently, General Electric had a market value of more than \$250 billion and employed more than 300,000 people. Facebook, in contrast, had a market value of more than \$200 billion but employed just over 7,000 people.
- These statistics indicate the difference between information-economy businesses and businesses from any other sector, such as services or manufacturing. The new companies run perfectly well with vastly fewer employees.
- Although both of these technology trends have negative aspects, they also create new business opportunities, such as in specialized training. As we've seen, we can't predict exactly where major trends in the economy will take us, but we need to think carefully about what threats they may pose to our economic security and what new opportunities they present.

Suggested Reading

Christensen, *The Innovator's Dilemma*.

Friedman, *Hot, Flat and Crowded*.

Lanier, *Who Owns the Future?*

Meadows, Meadows, Randers, and Behrens, *The Limits to Growth*.

Ridley, *The Rational Optimist*.

Questions to Consider

1. If we look back into recent history, two long-run problems that people worried about in the 1970s and 1980s were the destruction of the ozone layer around the earth and the destruction of rain forests, particularly in the Amazon basin. What happened to these problems? What lessons of the lecture does each example illustrate?
2. In this lecture, we learned that technology and population are the long-run drivers of economic growth and, thus, are two main sources of uncertainty in the long run. In addition, economics tells us that the large forces that determine economic outcomes are preferences and technology. The lecture discussed some of the ways that technology evolves to solve long-run problems. Do preferences also evolve to solve long-run problems? If so, how and why does this happen? Can you give an example in which people's preferences have changed in a way that solved or mitigated a long-run economic risk?

Hedging Business and Personal Risks

Lecture 23

In the face of financial uncertainty, investors can use hedging strategies to reduce risk. When we hedge a risk, someone agrees to absorb a loss that we would ordinarily have had to bear. However, there is a price to pay: We must give up any gains we might realize from this source of risk. In other words, in a hedging contract, we trade away any upside benefit from a source of risk in exchange for downside protection from the risk. In this lecture, we'll take a closer look at how professionals use hedging strategies and learn about a powerful hedging tool that is not for professionals alone.

Hedging

- *Hedging* refers to any action we take to reduce risk or to reduce the damage that a risk can do. There are actually several specific and distinct techniques that people use to reduce risks, and the term *hedging* also refers to one of these specific techniques.
- Consider the example of Southwest Airlines' jet fuel hedge. The price of jet fuel is a source of risk for Southwest. If the price of jet fuel goes up, Southwest must pay much more to fly its planes, which can cause the airline to lose money. Therefore, Southwest enters into a contract with an entity that agrees to make up Southwest's losses due to the increased price of jet fuel if the price of fuel goes up.
- But if the price of jet fuel falls, then Southwest's costs fall and profits go up. In a hedging contract, the entity that agrees to make up Southwest's losses also receives the benefit that Southwest would have earned if the price of jet fuel went down. The agreement enables Southwest to avoid losses if the price of jet fuel increases but also prevents the company from making extra profits if the price of jet fuel decreases.

- The hedging contract simply states that Southwest agrees to buy jet fuel at a fixed price from this other entity and specifies how much jet fuel and over what time frame the contract is in effect. In essence, hedging means locking in the future price of some good or service. Hedging is not only valuable for the protection it provides, but it also helps a company plan for the future.

Forward and Futures Contracts

- The type of contract that locks in a future price is called a *forward contract*. This is an agreement in which one party agrees to sell another party a fixed quantity of some good or service at a predetermined price at a certain time in the future.
- A hedging instrument similar to the forward contract is the *futures contract*. Like a forward contract, a futures contract is used to set a future price at which one party will sell something to another.
- Unlike a forward contract, which is usually a unique and customized agreement, a futures contract standardizes the amount of the good or service that is bought or sold and sets a single date when the product must change hands. Standardizing the amount of the good and the transaction date enables the contract to be used by thousands of people, and it enables the contract to be resold after it has been issued.

Options

- An option is a contract professionals use that gives someone the right to make a transaction at a predetermined price. For example, if you buy a call option, you have the right to buy a certain quantity of a good or service at a predetermined price. If you buy a put option, you have the right to sell at a predetermined price.
- The key difference between a forward contract and the option is flexibility. When you enter a forward contract, you're committed to doing what is in the contract. Under an option contract, you can agree to the same transaction, but you're not committing to going

through with it. Therein lies the flexibility—or what people in finance call *optionality*. The price specified by the option contract is called the *strike price*.

- Another way to view options is as a kind of insurance. If Southwest were to buy call options on jet fuel with a strike price of \$5 a gallon, under this special insurance policy, if the price of jet fuel rises above \$5 a gallon, the insurer will pay Southwest the difference between the market price of jet fuel and the \$5-per-gallon strike price. But if the price of jet fuel falls below \$5 per gallon, there's no payout from the insurer.

Option Premiums

- Another important difference between forward contracts and options is in the price of each contract. The flexibility built into an option contract has an upfront cash price called the *option premium*. In contrast, forward contracts are much cheaper, at least in terms of their upfront cash costs.
- In a forward contract, you agree to buy or sell something in the future at a price that you set today. The cost of making that agreement is trivial; thus, in most forward agreements, no cash changes hands immediately. For this reason, true hedging contracts, such as forwards and futures, are much cheaper to use than insurance contracts, such as options.
- When you buy an option, you pay a cash price up front, which is the premium. What's more, there is no guarantee that you'll exercise the option. You could be spending a great deal of money in the present only to have the option turn out to be worthless later on. Of course, that's also how insurance works.

Real Options

- Most hedging tools, such as forward contracts and options, are best left to the professionals. Aside from the technical details, which can be daunting, employing these tools can get very expensive, very quickly. However, there is still a way for you to use the insights

you've learned about hedging to help manage the risks you face. In particular, everyone can use something called real options to make decisions about taking on risk.

- The essence of an option is flexibility. An explicit options contract, also called a *financial option*, gives you an opportunity to buy or sell but also gives you the flexibility to walk away from the transaction later. That built-in flexibility creates insurance and gives options a great deal of value.
- The theory of real options focuses on the flexibility that an option provides. According to real options theory, you have a real option if you have some flexibility about how to take on a risk.
- For example, think about starting your own business. At the beginning, you can test the waters by starting your own business on a limited basis without even quitting your current job. If the business takes off, you can then leave your job to work on the business full-time. And if the business doesn't work out, then you shut it down, focus on your day job, and start thinking about your next billion-dollar idea.
- In this example, starting your business is like buying an option because you have the flexibility to walk away from it if it doesn't work out. Starting the business gives you the right—but not the obligation—to turn the business into the main source of your income later. A financial economist would call this a *real option*.
- Another common real option is the option to prepay your mortgage. In the United States, standard mortgages must allow the borrower to prepay all or part of the mortgage at any time during the life of the loan. However, you are not required to refinance your mortgage, and that flexibility tells you that prepayment is a real option. In general, refinancing doesn't become worthwhile until mortgage rates have fallen by at least half a percent below the rate that you're currently paying.

The Time Element

- A real option that is related to time is the ability to invest in phases, rather than having to commit the full amount of the investment up front. For example, think about investing for retirement. Suppose you want to add some shares in startup companies to your retirement account. That's a fairly risky investment because the value of the shares could skyrocket, but they could also collapse.
- If you have one of two additional resources, though, then you could buy these shares and treat them like a real option. The first additional resource is savings. If you have significant savings invested in other assets, presumably safer ones, you have the option to sell the startup shares if their value falls.
- The other resource that can enable you to treat this investment as a real option is time. If you still have a couple of decades or more of working and saving ahead of you, then your savings have the time to recover from one or two speculative investments that don't work out. Investing in stages is a way to take advantage of an opportunity while still limiting the downside. That's a real option.
- The real options way of thinking allows us to take a look at our total resources and to think about the flexibility these resources provide. Too many of us reject good opportunities because we focus only on what we could lose. We don't think enough about whether we have the flexibility to take advantage of these opportunities in ways that limit the potential losses. The real options way of thinking can also help you realize when you don't have enough flexibility and you need to act conservatively or avoid taking on a particular risk.

Suggested Reading

Carter, Rogers, and Simkins, “Fuel Hedging in the Airline Industry.”

Copeland and Keenan, “How Much Is Flexibility Worth?”

Durbin, *All about Derivatives*.

McDonald, *Fundamentals of Derivatives Markets*.

Questions to Consider

1. In this lecture, we learned about some of the ways that businesses use hedging tools to reduce the risks they face. One important question for businesses is whether they should hedge a given risk. Should businesses hedge all the risks they can, or are there some risks they shouldn't hedge? What does that imply for individuals?
2. We've all heard the expression “Time is money,” usually used to urge someone or something to hurry up. But how would you interpret this expression from a real options point of view?

Stress Testing Your Finances

Lecture 24

Confidence is one of the most powerful tools we have for dealing with uncertainty. If we are confident that we can deal with uncertainty and risks, then we can come up with creative and effective solutions. Stress testing is a way we can build up our own confidence. In this lecture, we'll learn to apply the process of stress testing to our own lives. We will also reexamine the two main themes of this course. The first of these is that human beings will never be able to fully conquer uncertainty. The second theme is that much of the capital we use to deal with risk is not financial but human capital, which provides a key protection against uncertainty: flexibility.

Bank Stress Tests

- To understand how we can put stress tests to work in our own lives, consider how bank stress tests work. In a financial stress test, bank examiners dream up harsh financial scenarios for the banks, and bank managers then demonstrate what these scenarios mean for the financial health of their institutions. In other words, a stress test intentionally exposes the weaknesses of a bank.
- Financial stress tests always include scenarios with deep recessions and high unemployment because these situations will force many more bank customers to default on their loans. Banks take the adverse scenarios thought up by the Federal Reserve and other bank regulators and calculate how many of their various types of loans would default because of those stresses.
- In the second part of the stress test, the banks then estimate their capacity to absorb losses in these adverse scenarios. The final step is for the bank to make a specific plan for how to address the potential shortfalls it discovers in the stress tests.



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Stress testing your finances gives you confidence that you can deal with whatever surprises the economy may spring on you.

Individual Stress Tests

- To perform a stress test for your own life and finances, start by identifying your biggest exposures to risk. Make a list of the uncertainties that are the most significant threats to your financial well-being; then, for each of those threats, choose a stress scenario. Following that, estimate the damage that these surprises would do to your finances.
- In other words, calculate how much money these shocks could cost you, then compare those losses with the amount of resources you've set aside to protect yourself from losses. The shortfalls you find, if any, will show you the weaknesses you need to address.

Stocks Stress Test

- To help you start identifying risks to stress test, ask yourself a number of what-if questions. For example, consider the question: What if the stock market crashes?

- If you have a retirement account, such as an IRA or a 401(k) plan through your employer, chances are that you hold a significant amount of your retirement savings in stocks. You can stress test these investments by looking back in history for examples of stock market crashes or significant bear markets in which stock prices fell over longer periods of time.
- For instance, the most recent stock market crash was the so-called Black Monday of 1987, in which the stock market fell by 20% in one day. More recently, we've experienced significant bear markets in which stock prices fell by 40% to 50% within a matter of months.
- Simply ask yourself what it would mean for your financial well-being if the stock market fell by 20% tomorrow or by 50% over the next year. Your actual shortfall depends on whether you need to dig into savings any time in the near future. What's more, many people have a special resource that they can use to absorb a stress event like this without damage to their financial well-being: time. The problem with major declines in the stock market is not so much the fall in prices but, rather, the timing of the recovery.
- If you don't need to cash in your stocks within the next few years—say, seven years, to be on the safe side—then you have a sufficient amount of time to allow your stock holdings to bounce back from a bear market. But if you're planning to withdraw these savings sooner, then you should estimate the potential shortfall.
- In the case of stock investments, a quick way to do this would be to compare what 4% of your stocks are worth today versus what 4% would be worth after a fall in the stock market. The 4% is based on the rule of thumb that people should withdraw 4% of their savings each year in order to make the savings last throughout retirement. The difference between the two numbers gives you an estimate of what this shortfall actually means for your financial well-being.

Time and Flexibility

- The next step is to take action to remedy any shortfall that the stress test identifies. To do this, think about what other resources you could use to absorb or prevent a shortfall. A simple strategy is to shift part of your portfolio out of stocks and into safe assets, such as government bonds. If a market crash or bear market occurred, you would sell off the safe assets first and give your stock investments the time they need to recover in value.
- In the case of stocks and, indeed, most assets, time is one of the most valuable resources for absorbing a decline in value. Similarly, flexibility is another resource that can absorb risk. The ability to fund your retirement spending using both safe and risky assets is a very valuable kind of flexibility. Whenever you have flexibility, you're holding a real option of some kind.

Income Stress Test

- Another important what-if question is: What if you got laid off? In the case of losing your job, one of the main resources you'll need to absorb this risk is money. Use some of the ideas about real options we learned in a previous lecture to help set aside a prudent amount of money.
- A real options approach is useful to thinking about this situation because in addition to living expenses, you need to have flexibility. There may be some extra actions you need to take in order to make sure that your job search is successful, such as traveling to meet potential employers or attend job fairs or paying for additional training courses or specialized credentials. In other words, you're buying a real option on these extra activities that may make the difference between landing a new job and missing an opportunity.
- Another key resource that helps absorb the shock from losing your job unexpectedly is your own human capital—your unique set of knowledge, skills, abilities, and experience. It is important to consider how your human capital matches up with the demands of the job market and to market your human capital effectively.

A Second-Chance Society

- Although we should design stress tests that are tough, they should not be excessively harsh. In other words, we should intentionally ignore black swan events that have the potential to completely wipe us out. There are two main reasons for this.
- First, we'll never have enough financial or other resources to completely protect us from black swan shocks, such as a total collapse of the financial markets or a depression that lasts half a decade. The best we can do with unexpected severe losses is to try to cover the vast majority of them and leave ourselves exposed to these infrequent and highly unlikely but nonetheless devastating events.
- A second reason for ignoring black swans is that if we're unlucky enough to be affected by such an event, we can turn to social institutions that will help us rebuild our lives. One of the most important ways that social institutions can help us recover from black swan events is simply by giving people the opportunity to start over.
- For example, in many countries it's extremely difficult to rebuild your financial life after declaring bankruptcy, because of both legal and social obstacles. In the United States, however, bankruptcy isn't socially stigmatized, and the bankruptcy code is aimed more at helping people and businesses get back on their feet than at punishing them.
- In many respects, the United States is a second-chance society. That is, its social and economic institutions enable people who have experienced a significant economic setback to start over and get back to where they were. Of course, the flipside of that is that the responsibility for getting back on your feet rests heavily on the individual.

Opening Up Your Options

- As we bring this course to a close, let's reexamine its two main themes. The first of these is that human beings will never be able to fully master or conquer uncertainty. There are too many sources of uncertainty rooted in the basic features of our economy and in human nature. In fact, the very complexity of the economy is the key feature that produces economic uncertainty. Our goal should not be to eliminate uncertainty itself; instead, we should focus our energy on preventing or limiting the damage that uncertainty can do to our economic lives.
- The second theme is that human beings have built up an impressive set of resources that help us deal with economic uncertainty. Because capital is what ultimately absorbs risk and protects us from the harm that uncertainty can wreak, these resources are called *human capital*. Human capital includes understanding where the uncertainty in our lives comes from and knowing various techniques to limit the impact of different types of uncertainty.
- Human capital also provides flexibility—an extremely useful tool to protect against the effects of uncertainty. A standard piece of advice is that we should keep our options open. To make that advice even more powerful, we'll turn it around: "Keep opening up your options."
- What this means is that we should always strive to recognize the flexibility we already have available to us and, more importantly, to create future flexibility that will help protect us against the effects of uncertainty. One of the key ways that we can create future flexibility is to add to our human capital—the more knowledge and skills we have, the more new opportunities to work, invest, and enjoy life will open up to us.

Suggested Reading

Board of Governors of the Federal Reserve System, “The Supervisory Capital Assessment Program.”

Gigerenzer, *Risk Savvy*.

Lopez, “Stress Tests.”

Questions to Consider

1. In most cases, we rely on past events to provide the stress scenarios on which to base our tests. What are the weaknesses of using past experience as the basis of stress tests? What steps can we take to make our stress tests more forward looking?
2. The end of this lecture stresses the economists’ definition of *human capital*—knowledge, skills, and experience—as one of the main resources we have to mitigate uncertainty. But the lecture also mentions another, more literal type of human capital: the potential of our family, friends, and professional networks to help us limit the damage from the risks we face. What are your main sources of this more literal type of human capital? Are there certain types of human capital that are in limited supply in your life? How can you compensate for these weaknesses?

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