

EE432 Monetary Theory and Policy



Lecture 2 Present Value, Interest Rate and Risk

Dr. Chamadanai Marknual

Faculty of Economics, Thammasat University

Semester 1/2019

Outline

- Future value and present value
- Relation between interest rate and bond price
- Risk defining and monitoring
- Source of risk and risk reducing

Chapter 4



Future Value, Present Value, and Interest Rates

Interest Rate

- **Credit** is one of the critical *mechanisms* we have *for allocating resources*.
- Although **interest** has historically been unpopular, this comes from the failure to appreciate the *opportunity cost of lending*.
- **Interest rates**
 - Link the *present* to the *future*.
 - Tell the *future reward for lending today*.
 - Tell the *cost of borrowing now and repaying later*.

Valuing Monetary Payments Now and in the Future

- We must learn **how to calculate and *compare rates on different financial instruments.***
- ***We need*** a set of tools:
 - Future value
 - Present value

Future Value and Compound Interest

- **Future value** is the *value* on some *future date* of an *investment made today*.
 - \$100 invested today at 5% interest gives \$105 in a year
 - So the *future value of \$100 today* at 5% interest is \$105 one year from now.
 - The \$100 yields \$5, which is why *interest rates* are sometimes called a **yield**.

Future Value and Compound Interest

- If the ***present value*** is \$100 and the ***interest rate*** is 5%, then the ***future value*** one year from now is:

$$\$100 + \$100(0.05) = \$105$$

- This also shows that the ***higher the interest rate, the higher the future value.***
- In general:

$$FV = PV + PV(i) = PV(1 + i)$$

Future Value and Compound Interest

- When *using one-year interest rates* to compute the **value repaid more than one year from now**, we must consider ***compound interest***.
 - **Compound** interest is the ***interest on the interest***.

Future Value and Compound Interest

- What if you leave your \$100 in the bank for two years at 5% yearly interest rate?
- The future value is:

$$\$100 + \$100(0.05) + \$100(0.05) + \$5(0.05) = \$110.25$$

$$\$100(1.05)(1.05) = \$100(1.05)^2$$

- In general

$$FV_n = PV(1 + i)^n$$

Future Value and Compound Interest

- Computing the future value of \$100 at 5% annual interest

Years into Future	Computation	Future Value
1	$\$100(1.05)$	\$105.00
2	$\$100(1.05)^2$	\$110.25
3	$\$100(1.05)^3$	\$115.76
4	$\$100(1.05)^4$	\$121.55
5	$\$100(1.05)^5$	\$127.63
10	$\$100(1.05)^{10}$	\$162.89

Present Value

- Financial instruments *promise future cash payments*, so we need to know *how to value those payments*.
- **Present value** is the **value today** (in the present) of a *payment* that is *promised to be made in the future*.
- Or, **present value** is the amount that must be *invested today* in order to *realize a specific amount on a given future date*.

Present Value

- Solve the Future Value Formula for PV:

$$FV = PV \times (1+i), \text{ so}$$

$$PV = \frac{FV}{(1+i)}$$

- This is just the ***future value calculation inverted.***

Present Value

- We can generalize the process as we did for future value.
- Present Value of **payment received n years** in the future:

$$PV = \frac{FV_n}{(1+i)^n}$$

Relation between Interest Rate and Bond Price

Internal Rate of Return

- Imagine that you run a **tennis racket company** and that you are considering ***purchasing a new machine.***
 - *Machine costs \$1 million* and can produce 3000 rackets per year.
 - You *sell the rackets for \$50, generating \$150,000 in revenue per year.*
 - Assume the machine is only input, have certainty about the revenue, no maintenance and *a 10 year lifespan.*

Internal Rate of Return

- If you *borrow \$1 million*, is the **revenue enough to make the payments?**
- We need to compare the **internal rate of return** to the cost of buying the machine.
 - The **interest rate** that **equates** the ***present value of an investment with its cost***.

Internal Rate of Return

- Balance the cost of the machine against the revenue.
 - \$1 million today versus \$150,000 a year for ten years.
- To find the internal rate of return, we take the **cost of the machine** and *equate* it to the **sum of the present value of each of the yearly revenues**.
 - Solve for i - the internal rate of return.

Internal Rate of Return: Example

- Solving for i , $i = 0.0814$ or 8.14%

$$\$1,000,000 = \frac{\$150,000}{(1+i)^1} + \frac{\$150,000}{(1+i)^2} + \frac{\$150,000}{(1+i)^3} + \dots + \frac{\$150,000}{(1+i)^{10}}$$

- So long as your ***interest rate*** at which *you borrow* the money is **less than 8.14%**, then *you should buy the machine.*

Bond Basics

- A **bond** is a *promise to make a series of payments on specific future dates*.
- Bonds create obligations, and are therefore thought of as *legal contracts* that:
 - *Require the borrower to make payments to the lender, and*
 - Specify **what happens if the borrower fails** to do so.

Bond Basics

- The most common type of bond is a **coupon bond**.
 - Issuer is required to *make annual payments*, called **coupon payments**.
 - The *annual interest* the borrower pays (i_c), is the **coupon rate**.
 - The date on which the *payments stop* and the **loan is repaid** (n), is the **maturity date** or term to maturity.
 - The *final payment* is the **principal, face value, or par value** of the bond.

Valuing the Principal

- Assume a bond has a **principle payment of \$100** and its **maturity date is n years** in the future.
- The ***present value*** of the **bond principal** is:
 - The higher the n , the lower the value of the payment.

$$P_{BP} = \frac{F}{(1+i)^n} = \frac{\$100}{(1+i)^n}$$

Valuing the Coupon Payments

- These resemble **loan payments**.
- The ***longer*** the **payments** go, the ***higher*** their **total value**.
- The ***higher*** the **interest rate**, the ***lower*** the **present value**.
- The present value expression gives us a general formula for the ***string of yearly coupon payments*** made **over n years**.

$$P_{CP} = \frac{C}{(1+i)^1} + \frac{C}{(1+i)^2} + \frac{C}{(1+i)^3} + \dots + \frac{C}{(1+i)^n}$$

Valuing the Coupon Payments Plus Principal

- We can just combine the previous two equations to get:

$$P_{CB} = P_{CP} + P_{BP} = \left[\frac{C}{(1+i)^1} + \frac{C}{(1+i)^2} + \frac{C}{(1+i)^3} + \dots + \frac{C}{(1+i)^n} \right] + \frac{F}{(1+i)^n}$$

- The value of the **coupon bond**, P_{CB} , *rises* when
 - The yearly **coupon payments**, C , *rise* and
 - The **interest rate**, i , *falls*.

Relationship between Bond Price and Interest Rate

- Bonds promise fixed payments on future dates, so the ***higher the interest rate***, the ***lower their present value***.
- ***The value of a bond varies inversely with the interest rate used to calculate the present value of the promised payment.***

Real and Nominal Interest Rates

- **Borrowers** care about the *resources required to repay*.
- **Lenders** care about the *purchasing power of the payments* they received.
- *Neither cares solely about the number of dollars, they care about what the dollars buy.*

Real and Nominal Interest Rates

- **Nominal Interest Rates (i)**
 - The *interest rate expressed in current-dollar (or Baht) terms.*
- **Real Interest Rates (r)**
 - The **inflation adjusted interest rate.**

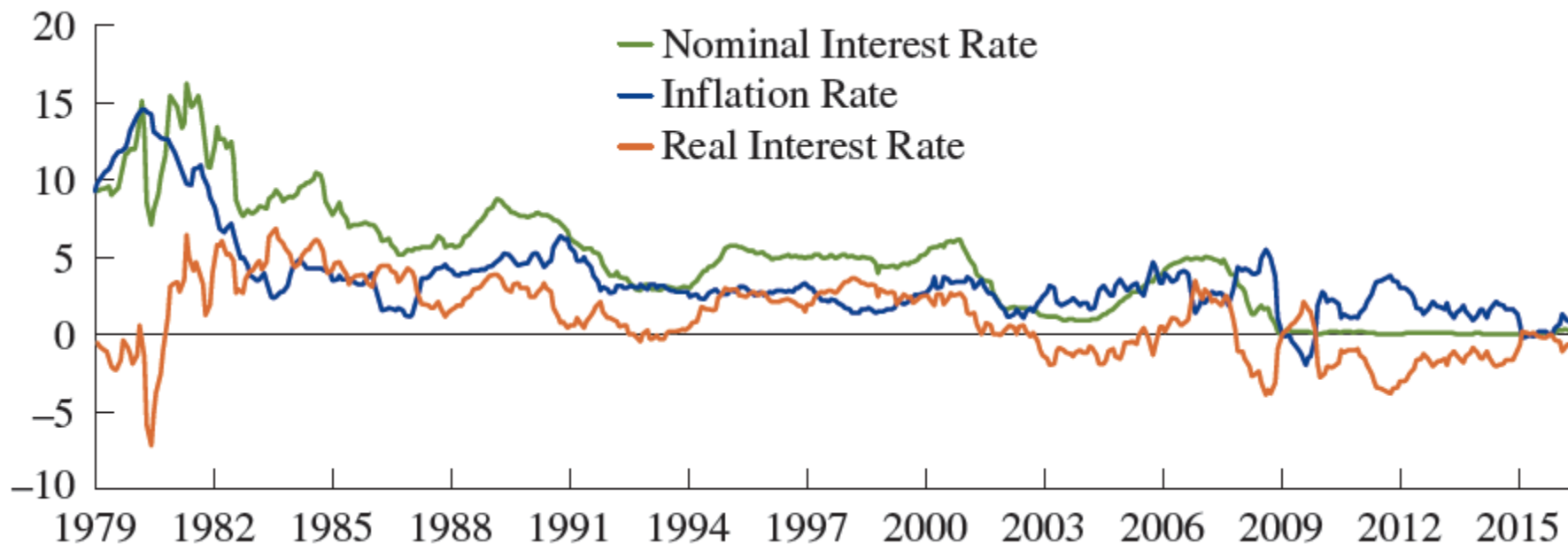
Real and Nominal Interest Rates

- The **nominal interest rate** you agree on (i) must be **based on *expected inflation* (π^e)** over the term of the loan **plus the real interest rate** you agree on (r).

$$i = r + \pi^e$$

- This is called the **Fisher Equation**.
- The ***higher expected inflation***, the ***higher the nominal interest rate***.

Nominal Interest Rate, Inflation Rate and Real Interest Rate



Real and Nominal Interest Rates

- Financial markets quote ***nominal interest rates***.
- *When people use the term interest rate, they are simply referring to the **nominal rate**.*
- We cannot directly **observe** the **real interest rate**; we have to estimate it.

$$r = i - \pi^e$$

Chapter 5



Understanding Risk

Risk Defining and Measuring

Defining Risk

- Risk is “*the possibility of loss.*”
- For outcomes of financial and economic decisions

Risk is a measure of uncertainty about the future payoff to an investment, assessed over some time horizon and relative to a benchmark.

Defining Risk

- 1. Risk is a *measure* that *can be quantified*.**
 - The *riskier* the investment, the *less desirable* and the *lower the price*.
- 2. Risk arises from *uncertainty about the future*.**
 - We do not know *which of many possible outcomes will follow in the future*.
- 3. Risk has to do with the *future payoff* of an *investment*.**
 - We must imagine all the **possible payoffs** and the **likelihood** of each.

Defining Risk

4. *Definition of **risk** refers to an **investment** or group of investments.*
 - Investment described very broadly.
5. **Risk must be assessed over some *time horizon*.**
 - In general, **risk over *shorter periods* is *lower*.**
6. **Risk must be measured *relative to some benchmark* - not in isolation.**
 - A good **benchmark** is the *performance of a group of experienced investment advisors* or money managers.

Measuring Risk

- In determining *expected inflation* or *expected return*, we need to understand **expected value**.
 - The investments return out of *all possible values*.

Possibilities, Probabilities, and Expected Value

- **Probability theory** states that considering uncertainty requires:
 - Listing *all* the ***possible outcomes***.
 - Figuring out the ***chance of each one occurring***.
- **Probability** is a ***measure of the likelihood*** that an ***event will occur***.
 - It is always **between zero and one**.
 - Can also be ***stated as frequencies***.

Possibilities, Probabilities, and Expected Value

- We can construct a table of all **outcomes** and **probabilities** for an *event*, like tossing a fair coin.

Table 5.1

A Simple Example: All Possible Outcomes of a Single Coin Toss

Possibilities	Probability	Outcome
#1	$\frac{1}{2}$	Heads
#2	$\frac{1}{2}$	Tails

Possibilities, Probabilities, and Expected Value

- If constructed correctly, *the values in the **probabilities** column will sum to one.*
- Assume instead we have an **investment** that *can rise or fall* in value.
 - *\$1,000 stock which can rise to \$1,400 or fall to \$700.*
 - The amount you could get back is the *investment's **payoff**.*
 - We can construct a similar table and determine the *investment's **expected value** - the **average** or **most likely** outcome.*

Possibilities, Probabilities, and Expected Value

Table 5.2

Investing \$1,000: Case 1

Possibilities	Probability	Payoff	Payoff × Probability
#1	$\frac{1}{2}$	\$ 700	\$350
#2	$\frac{1}{2}$	\$1,400	\$700

Expected value = Sum of (Probability × Payoff) = \$1,050

- **Expected value** is the *mean* - the sum of their probabilities multiplied by their payoffs.

$$\text{Expected Value} = 1/2(\$700) + 1/2(\$1,400) = \$1,050$$

Possibilities, Probabilities, and Expected Value

Now, suppose that \$1,000 Investment could

1. *Rise in value to \$2,000, with probability of 0.1*
2. *Rise in value to \$1,400, with probability of 0.4*
3. *Fall in value to \$700, with probability of 0.4*
4. *Fall in value to \$100, with probability of 0.1*

Possibilities, Probabilities, and Expected Value

Table 5.3

Investing \$1,000: Case 2

Possibilities	Probability	Payoff	Payoff × Probability
#1	0.1	\$ 100	\$ 10
#2	0.4	\$ 700	\$280
#3	0.4	\$1,400	\$560
#4	0.1	\$2,000	\$200

Expected value = Sum of (Probability × Payoff) = \$1,050

Expected Value =

$$0.1 \times (\$100) + 0.4 \times (\$700) + 0.4 \times (\$1,400) + 0.1 \times (\$2,000) = \$1,050$$

Possibilities, Probabilities, and Expected Value

- Using percentages allows ***comparison of returns*** regardless of the size of initial investment.
 - The **expected return** in *both cases* is \$50 on a \$1,000 investment, or *5 percent*.
- Are the two investments the same?
 - No - the **second investment** *has a wider range of payoffs*.
- **Variability** equals **risk**.

Measures of Risk

- It seems intuitive that the *wider the range of outcomes*, the *greater the risk*.
- A **risk free asset** is *an investment whose future value is known with certainty and whose return is the risk free rate of return*.
 - The payoff you receive is guaranteed and cannot vary.
- **Measuring the spread** allows us to **measure the risk**.

Variance and Standard Deviation

The variance is the *average of the squared deviations of the possible outcomes* from their *expected value*, weighted by their *probabilities*.

1. Compute **expected value**.
2. **Subtract expected value** from each of the **possible payoffs** and **square the result**.
3. **Multiply** each result *times* the **probability**.
4. **Add up** the results.

Variance and Standard Deviation

1. Compute the **expected value**:

$$(\$1400 \times \frac{1}{2}) + (\$700 \times \frac{1}{2}) = \$1,050.$$

2. **Subtract this from each of the possible payoffs** and then **square** the results:

$$\$1,400 - \$1,050 = (\$350)^2 = 122,500(\text{dollars})^2 \text{ and}$$

$$\$700 - \$1,050 = (-\$350)^2 = 122,500(\text{dollars})^2$$

3. **Multiply each result times its probability**, and **add up the results**:

$$\frac{1}{2} [122,500(\text{dollars})^2] + \frac{1}{2} [122,500(\text{dollars})^2] = 122,500(\text{dollars})^2$$

4. The **Standard deviation** is the **square root of the variance**:

$$= \sqrt{\text{Variance}} = \sqrt{122,500 \text{ dollars}^2} = \$350$$

Variance and Standard Deviation

- **Standard deviation** is the (positive) *square root of the variance*

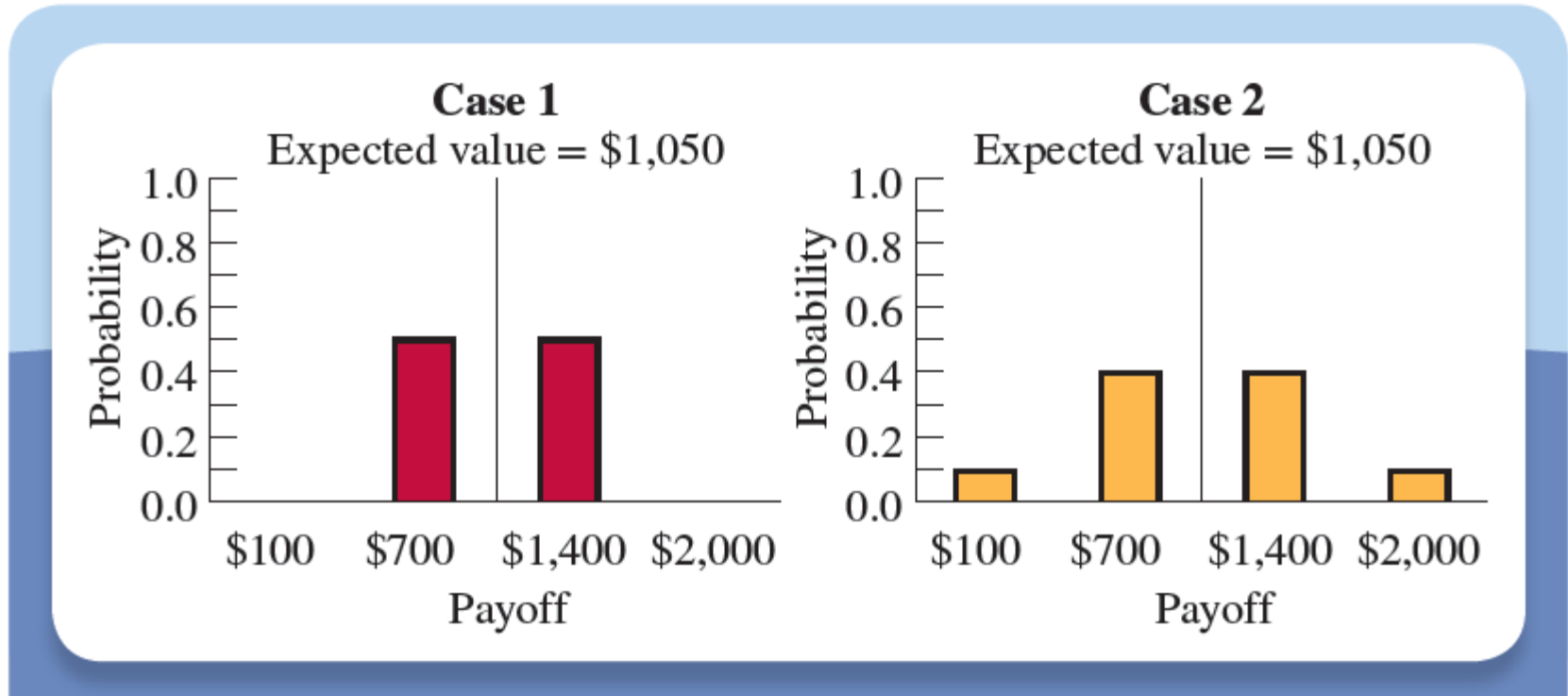
$$\text{standard deviation} = \sqrt{\text{Variance}}$$

- The **standard deviation** is more useful because it deals in *normal units*, not squared units (like dollars-squared).
- We can **calculate standard deviation** into a **percentage of the initial investment**.
- We can *compare other investments* to this one.
- *Given a choice between two investments with equal expected payoffs*, most will **choose the one with the lower standard deviation**.
 - *The greater the standard deviation, the higher the risk.*

Variance and Standard Deviation

Figure 5.1

Investing \$1,000



- We can see **Case 2 is more spread out** - *higher standard deviation* - therefore it carries **more risk**.

Value at Risk

- Sometimes we are *less concerned with spread* than with the **worst possible outcome**
 - Example: We don't want a bank to fail
- **Value at Risk (VaR)**: The worst possible loss over a *specific horizon* at a *given probability*.
- For example, we can use this to *assess* whether a *fixed* or *variable-rate mortgage* is better.

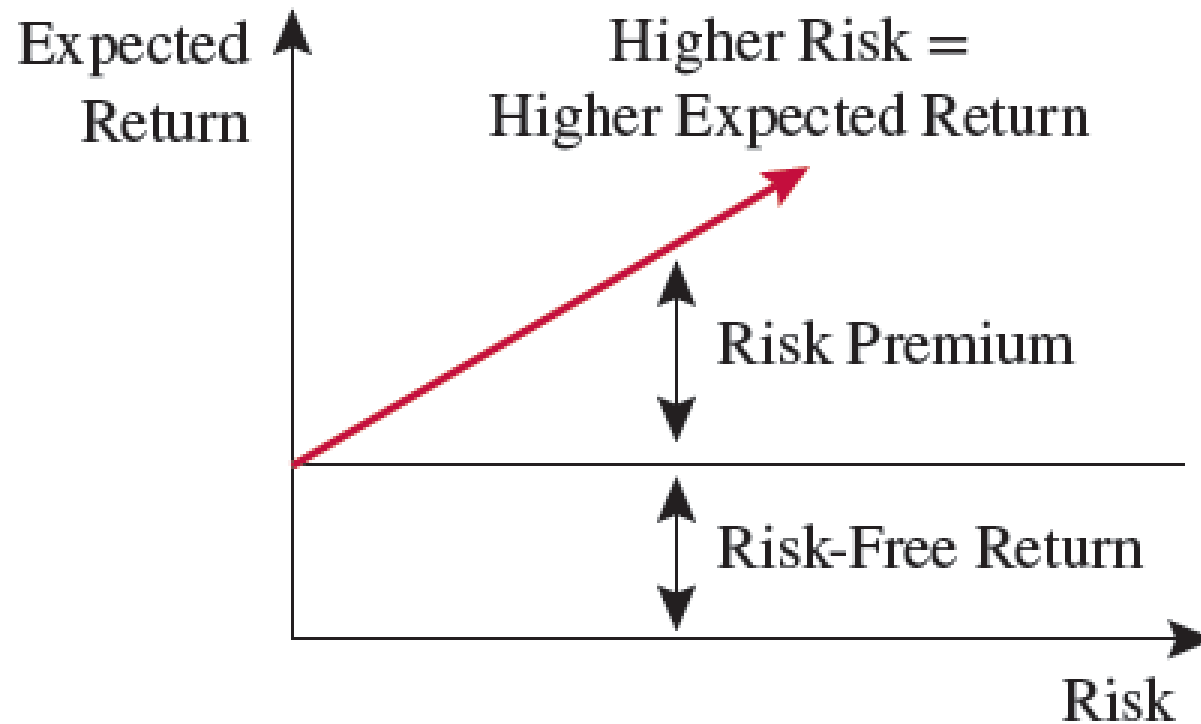
Value at Risk

- For a *mortgage*, the worst case scenario means you ***cannot afford your mortgage*** and will ***lose you home***.
 - *Expected value* and *standard deviation* do not really ***tell*** you the ***risk*** you face, in this case.
- **VaR** answers the question: ***how much will I lose*** if the *worst possible scenario* occurs?
 - Sometimes *this is the most important question*.

Risk Aversion, the Risk Premium, and the Risk-Return Tradeoff

- Most people do not like risk and will **pay to avoid** it because most of us are risk averse.
 - *Insurance* is a good example of this.
- A **risk averse** investor will always prefer an investment with a **certain return** to one with the same expected return but *any amount of uncertainty*.
- Therefore, the *riskier an investment*, the **higher the risk premium**.
 - The **compensation** investors **required to hold the risky asset**.

Risk Aversion, the Risk Premium, and the Risk-Return Tradeoff



Source of Risk and Risk Reducing

Sources of Risk: Idiosyncratic and Systematic Risk

All **risks** can be classified into two groups:

1. Those *affecting a small number of people* but no one else:

Idiosyncratic or *unique risks*

2. Those *affecting everyone*:

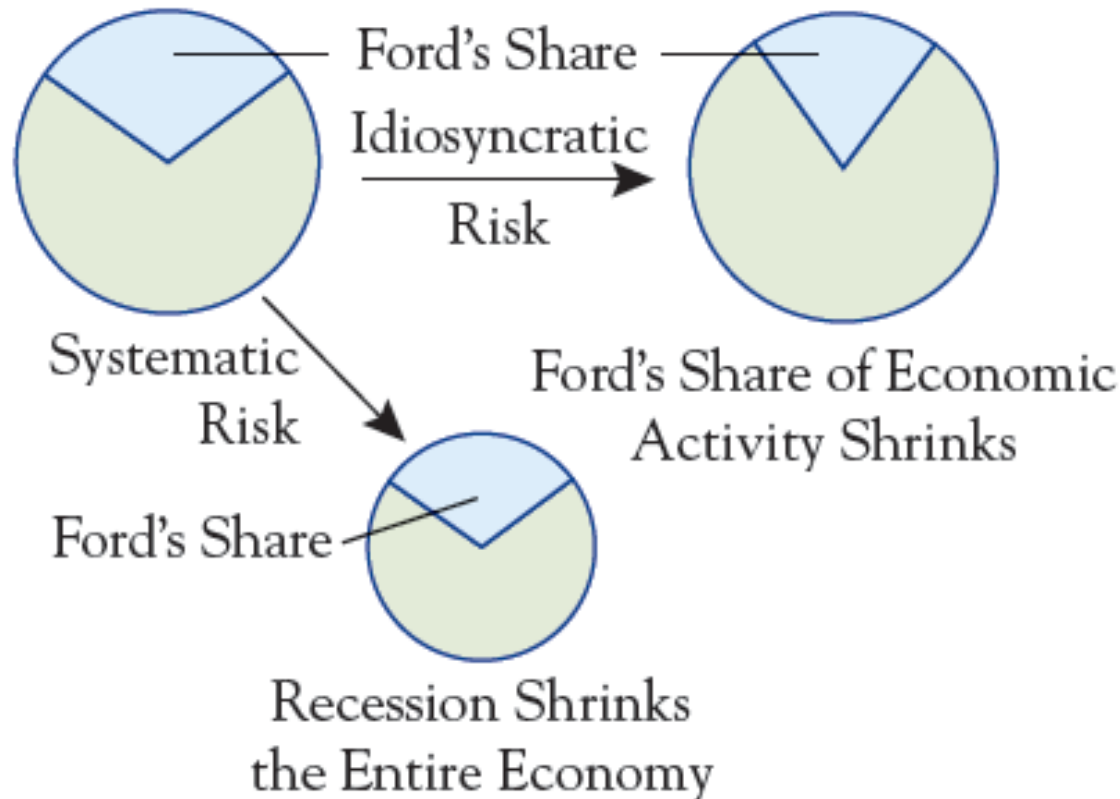
Systematic or *economy-wide risks*

Sources of Risk: Idiosyncratic and Systematic Risk

Idiosyncratic risks can be classified into two types:

1. A **risk is bad for one sector** of the economy but good for another.
 - A rise in oil prices is **bad for car industry** but **good for the energy industry**.
2. **Unique risks specific to one person or company** and no one else.

Sources of Risk: Idiosyncratic and Systematic Risk



Reducing Risk through Diversification

- Some people take on so much risk that a **single big loss** can wipe them out.
 - Traders call this “blowing up.”
- Risk can be *reduced through* **diversification**, the principle of **holding more than one risk** at a time.
 - This **reduces the idiosyncratic risk** an investor bears.
- One can ***hedge*** risks or ***spread*** them among many investments.

Hedging Risk

- **Hedging** is the strategy of reducing idiosyncratic risk by *making two investments with **opposing risks***.
 - If one industry is volatile, the payoffs are stable.
- Let's compare three strategies for investing \$100:
 - Invest \$100 in GE.
 - Invest \$100 in Texaco.
 - **Invest half in each company – *splitting investment between two stocks with different payoff patterns to eliminate risk***

Hedging Risk

Table 5.6

Results of Possible Investment Strategies: Hedging Risk

Initial Investment = \$100

Investment Strategy	Expected Payoff	Standard Deviation
GE only	\$110	\$10
Texaco only	\$110	\$10
$\frac{1}{2}$ and $\frac{1}{2}$	\$110	\$0

- Investing \$50 in each stock to ensure your payoff.
- Hedging has *eliminated your risk entirely*.

Spreading Risk

- You can't always hedge as *investments don't always move in a predictable fashion.*
- The alternative is to **spread risk** around.
 - Find investments *whose payoffs are unrelated.*
- We need to *look at the possibilities, probabilities and associated payoffs of different investments.*

Spreading Risk

- Let's again compare three strategies for investing \$1,000:
 - Invest \$1,000 in GE.
 - Invest \$1,000 in Microsoft.
 - Invest half in each company – *there will be 4 possible outcomes*

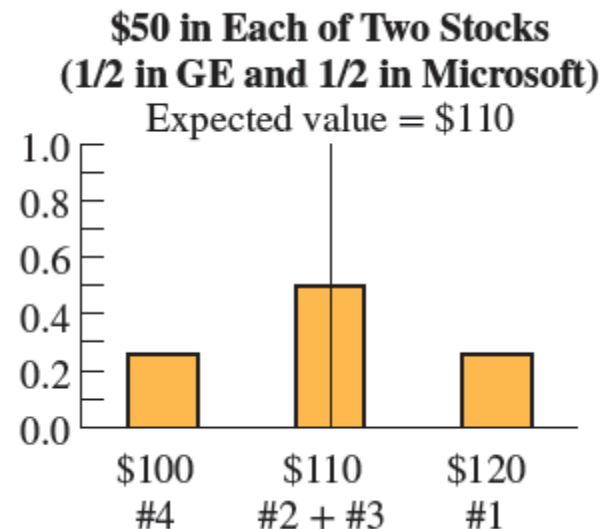
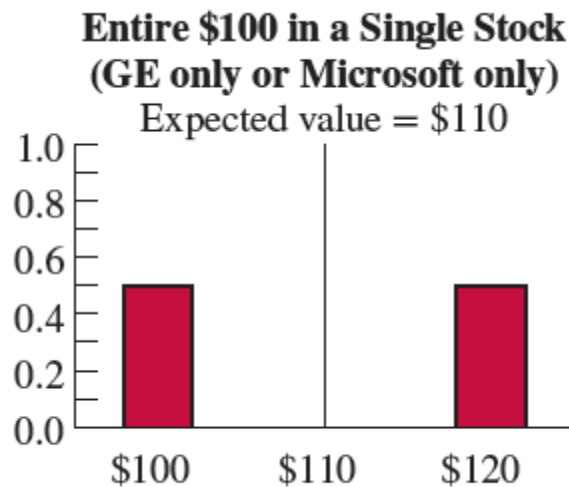
Table 5.7

Payoffs from Investing \$50 in Each of Two Stocks
Initial Investment = \$100

Possibilities	GE	Microsoft	Total Payoff	Probability
#1	\$60	\$60	\$120	$\frac{1}{4}$
#2	\$60	\$50	\$110	$\frac{1}{4}$
#3	\$50	\$60	\$110	$\frac{1}{4}$
#4	\$50	\$50	\$100	$\frac{1}{4}$

Spreading Risk

- We can see the distribution of outcomes from the possible investment strategies.
- This figure clearly shows **spreading risk- (*diversifying*) lowers the spread of outcome and *lowers the risk (standard deviation)*.**



Spreading Risk

- The **more independent sources of risk** you hold in your portfolio, the **lower your overall risk**.
 - *Never put all eggs in one basket*
- As we add more and more independent sources of risk, the ***standard deviation becomes negligible***.
- **Diversification** through the ***spreading of risk*** is the ***basis for the insurance business***.

End of lecture