Artificial Intelligence(AI) for Investments

NPTEL

Lesson 1: Goals of a firm

Introduction

In this lesson we will cover the following topics:

- Different forms of corporations
- Goals of a firm and the role of management
- Introduction to Firm value and Opportunity Cost of Capital
- Investment and Financing Decisions
- Agency Problems and Corporate Governance
- Summary and Concluding remarks

Organization of a Corporation

- Organization as a legal entity
- Proprietorship and Partnerships
- Private and Public (listed) Companies
- Unlimited vs Limited liability of stockholders

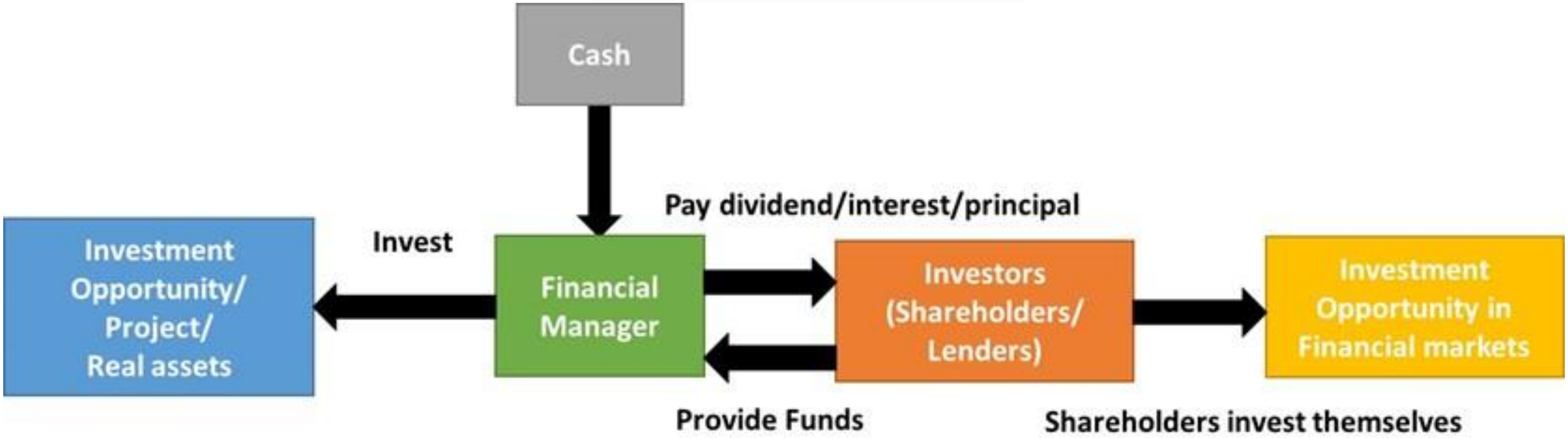
Introduction to Firm value and Opportunity Cost of Capital

- Maximization of firm value – appropriate target?
- What about maximization of profit or cash flows
- Short-term myopic objectives vs. long term value creation
- Role of financial markets
- Opportunity cost of capital

Investment and Financing decisions

- Two key decisions affect firm value: Investment decisions and Financial decisions
- Investment decisions: investing in real assets, plant and machinery, R&D, etc.
- Risk-return profile of the investment and opportunity cost of capital
- Financing decisions: Issue of debt and equity securities to raise finances
- Availability of liquid and efficient markets

Investment and Financing decisions



Agency Problems and Corporate Governance

- Managers are the agents of the shareholders as principals
- Are their interest aligned with each other?
- Will managers always act in the best interest of owners: Not always
- Classical principal and agent problem: how to mitigate?
- Goods systems of corporate governance ensure that the interest and objectives of managers are well aligned to those of owners
- These include: Institution of board of governors, compensation management, market discipline.

Summary and Concluding remarks

- Two important financial decisions: investment decision and financing decision
- Value maximization as the ultimate objective of managers
- Trade-off faced by financial managers and opportunity cost of capital
- Separation of ownership and control
- Principal agent problem
- Good systems of corporate governance

Thanks!

Artificial Intelligence (AI) for Investments

Lesson 2: Cash Flow Discounting

Introduction

In this lesson we will cover the following topics:

- Time value of money and cash flow discounting
- Discount rates and opportunity cost of capital
- Present value of annuities and perpetuities
- Valuation of growing annuities and perpetuities
- Impact of compounding frequency on present value computation
- Summary and concluding remarks

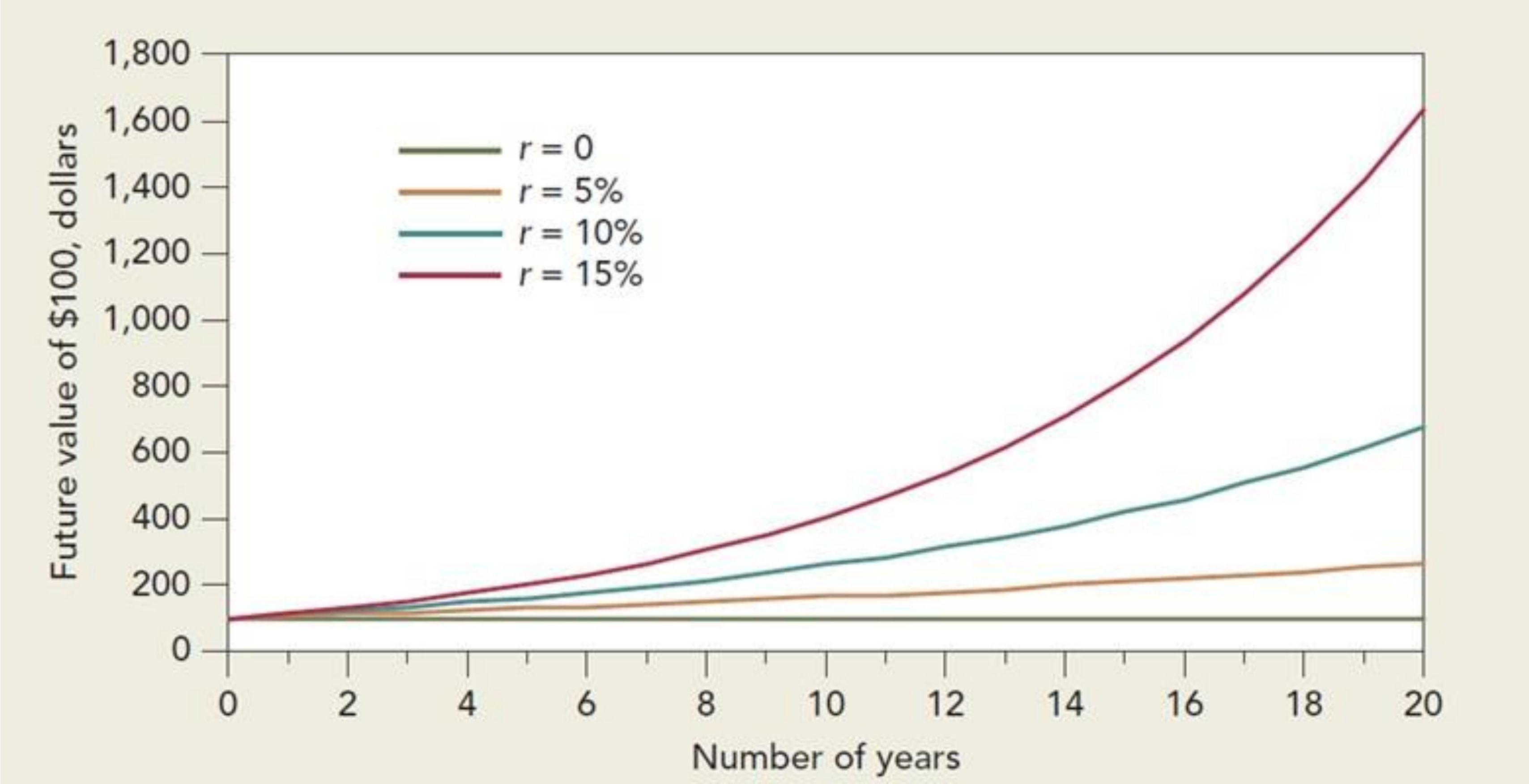
Time value of money

- Receive $100 today or one year later
- What would be that additional amount for which you would agree to delay your consumption of this $100 by a year
- This is called time-value of money
- A dollar worth today is more than the dollar worth tomorrow: but how much more

Time value of money

- An investment of \$100 into fixed deposit at 7% interest will grow to become \$107 in one year and \$114.49 in two years
- In second year, you earn interest on principal as well as on the interest earned in second year: power of compounding
- Similarly \$100, invested for 20 years at 10% will grow to become $100 * 1.10^{20} = \$672.75$

Time value of money



Assume an interest rate of r and a period of t. The future value of $100 invested today, will be: $100 * (1 + r)^t$

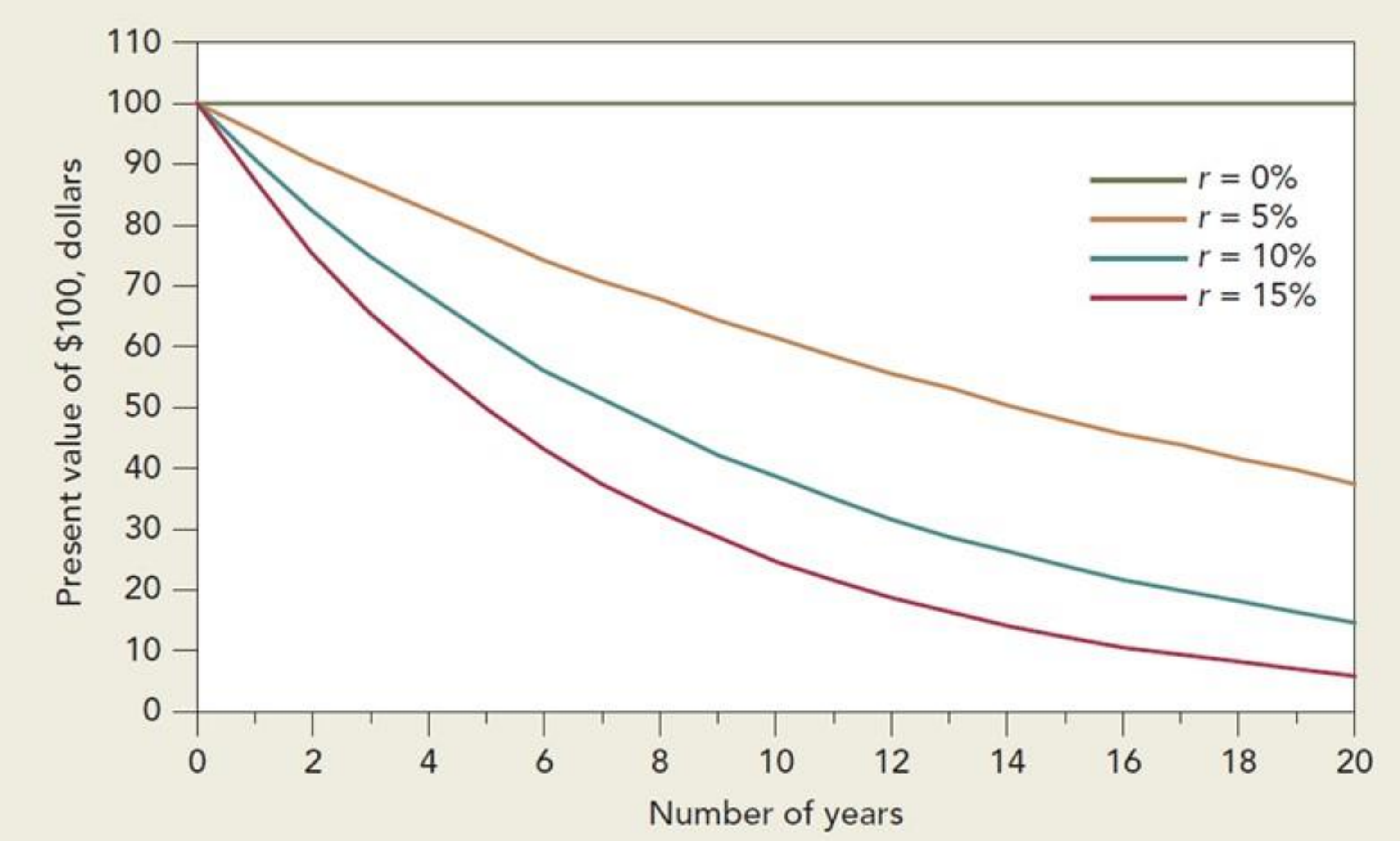
20 years, $100 invested at 10% interest. It will grow to become $100 * 1.10^{20} = \$672.75$

At 5% the money will grow to become $100 * 1.05^{20} = \$265.33$

Time value of money

- \$100 invested for two years at 7% will grow to a future value of $100 * 1.07^2 = \$114.49$
- So, if appropriate interest is 7%, then the present value of $\$114.49$ to be received two years from now is \$100 today!
- This can be simply computed as follows: Present Value (PV)= $\frac{114.49}{1.07^2}$=\$100
- Therefore the formula of present value can also be written simply as follows: $PV = \frac{C_t}{(1+r)^t}$.

Time value of money



A payment worth \$100 to be received in 20 years at an interest rate of 5% has a PV of $\frac{100}{1.05^{20}} = \$37.69$

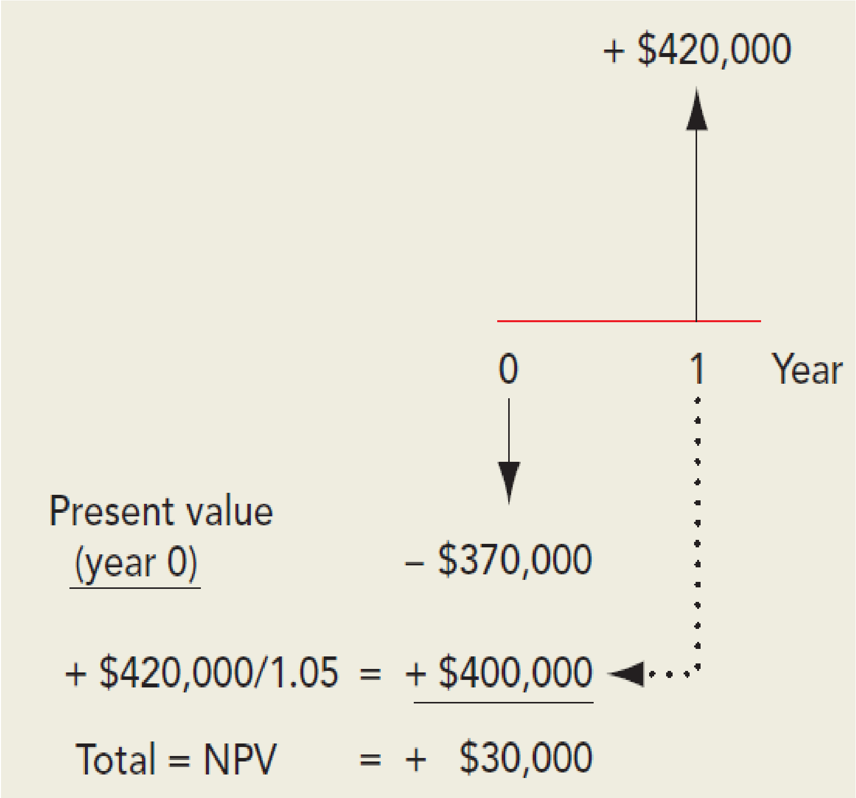
If the interest rate increases to 10%, the PV falls to $\frac{100}{1.10^{20}} = \$14.86$. A decline of more than 50%.

Time value of money

- A simple project: purchase of office space a cost of $370000
- Your advisor tells you that it is a sure thing with $42000 expected by the end of the year
- What is the appropriate opportunity cost: prevailing risk-free rate of r=5%
- The present value of this investment can be computed as $PV = \frac{420000}{1.05} = \$400000$
- Net-present value of this investment (NPV)=PV-investment=400000-370000=$30000

Time value of money

- This NPV formula can be easily represented as $NPV = C_0 + \frac{C_1}{1+r}$
- Accept the project if NPV>0 and reject the project if NPV is less than 0
- It is useful to perform the analysis through time-lines, as shown in the diagram here



Time value of money

- Let us now introduce risk
- In our previous office space example, now consider that you are not so certain about the revenues
- You consider it to be a risky venture and a 12% interest rate to be an appropriate opportunity cost
- The new NPV computation: $NPV = PV - 370000 = \frac{420000}{1.12} - 370000 = 5000$
- NPV of the project has come down as it has become riskier for you
- The present value of the office space has two aspects (1) The timelines of the cash flows; and (2) The risk of the cash flow

Time value of money

- There is another decision rule for evaluating such projects: Rate of return rule

- $\mathbf{Return} = \frac{\mathbf{Profit}}{\mathbf{Investment}} = \frac{\mathbf{420000-370000}}{\mathbf{370000}} = \mathbf{13.5\%}$

- Opportunity cost of capital> Project return then accept the project and vice-versa

- So now we have two rules for making investment decisions:

  - Net-present value rule (NPV) rule: Accept the investments that have positive NPVs

  - Rate of return rule: Accept the investments that have rate of returns higher than their opportunity cost of capital.

Computing NPVs with multiple cash flows

- Present values can be simply added up

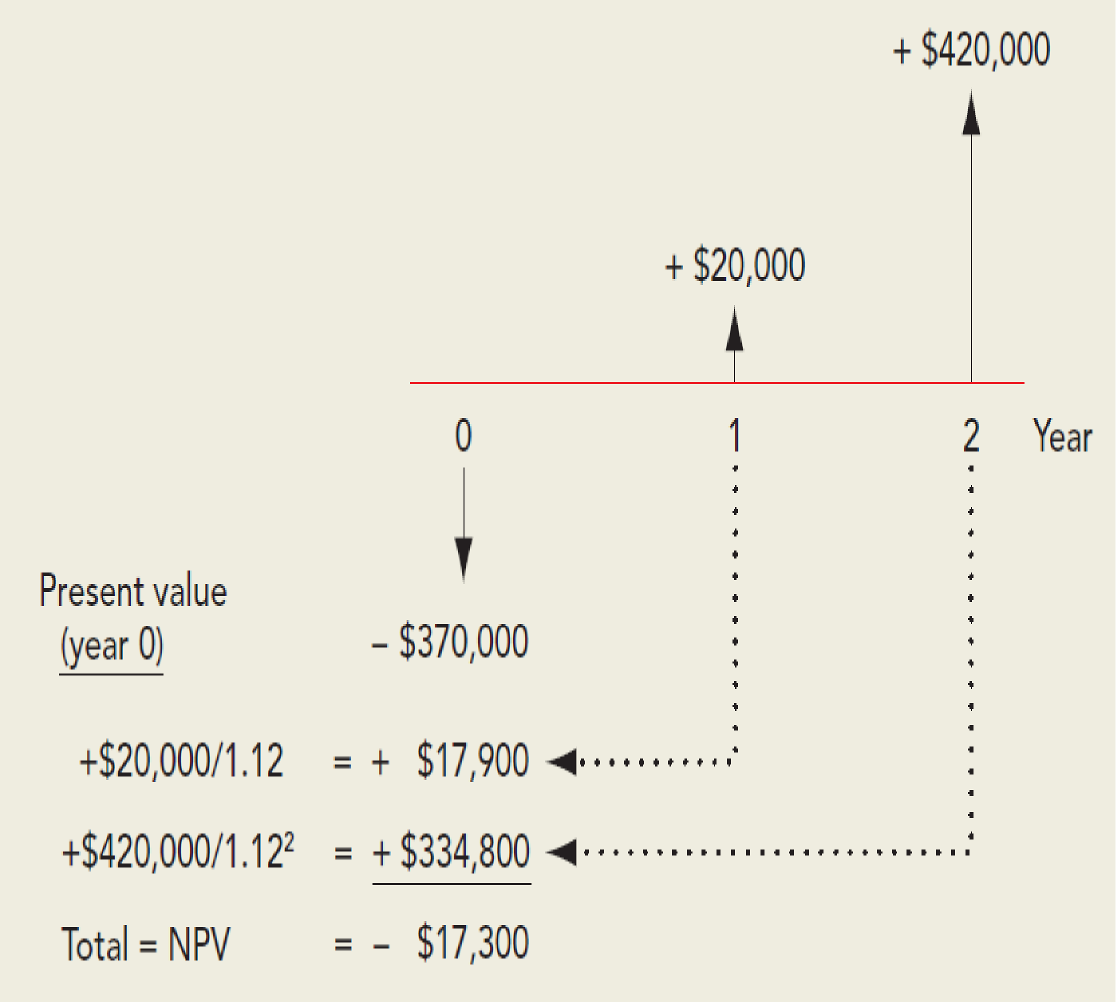
- Suppose that a cash flow stream spread over 't' years is provided as follows, $C_i, for\ i = 1\ to\ T$. Also assume a discount rate 'r'

- $PV = \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \cdots + \frac{C_T}{(1+r)^T} = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t}$

- $NPV = C_0 + PV = C_0 + \sum_{t=1}^{T} \frac{C_t}{(1+r)^t}$

Computing NPVs with multiple cash flows

- You are planning to rent out your recently purchased office premises for $20000 a year for two years (acquired at a cost of $370000)
- Also at the end of second year you plan to sell the premise and receive an expected cash flow of $400000 at the end of the year
- The appropriate discount rate is 12%. The timelines for these cash flows are shown in the Figure here

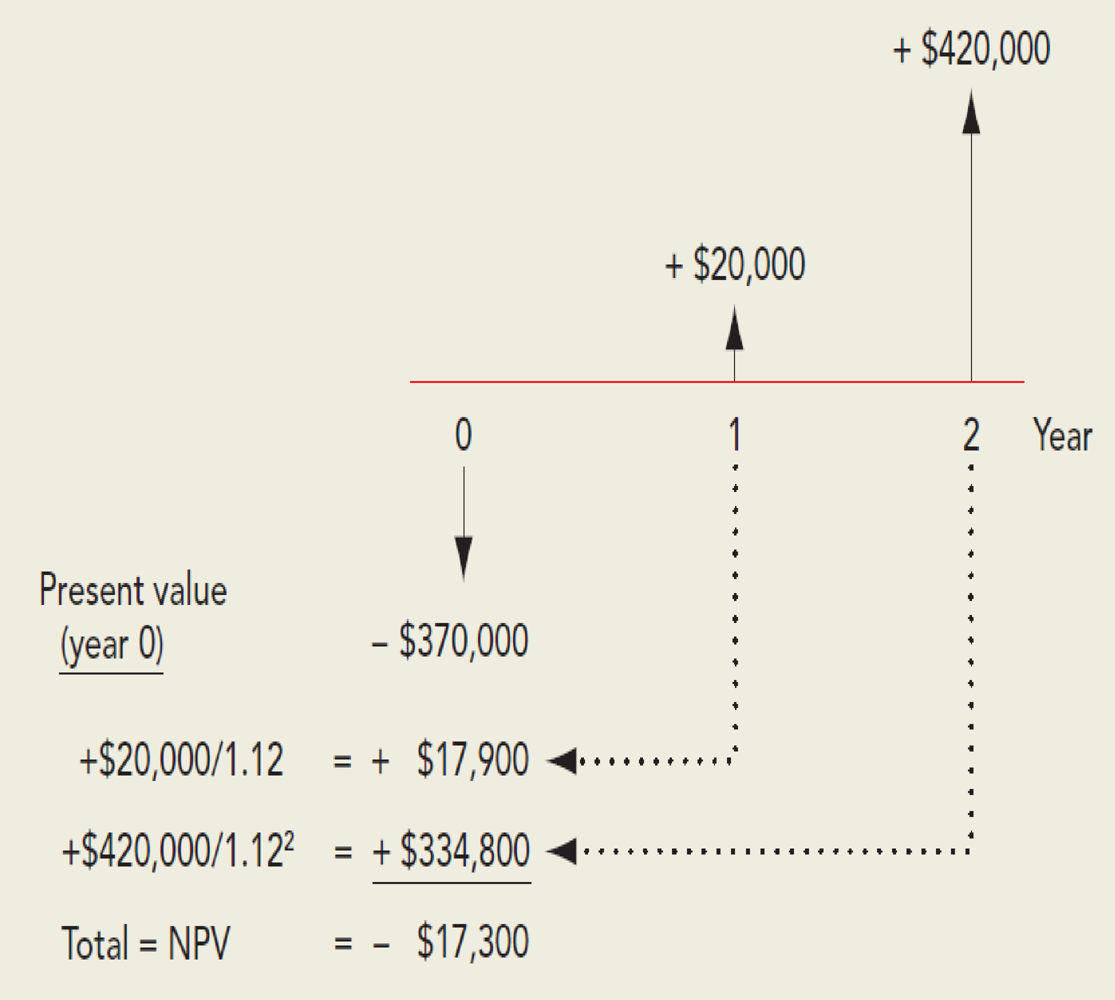


Computing NPVs with multiple cash flows

- You expect to earn \$20000 in the first year and \$420000 at the end of the second year. The present value of these cash flows can be computed as per the following scheme.

- $PV = \frac{20000}{1.12} + \frac{420000}{1.12^2} = 17900 + 334800 = 352700$

- The NPV of this investment is = $352700 - 370000 = -17300$.



Valuing perpetuities and annuities

- A perpetuity is a security that pays periodic cash flows over infinite time intervals
- Consider a perpetuity with annual cash flows amounting to 'C' and an appropriate discounting rate of r
- The present value of this perpetuity is provided here: $PV = \frac{C}{r}$
- Consider a simple example as follows. You are a billionaire and would like to fund the education at your alma-mater with \$1 Mn each year in perpetuity, starting with next year. If the interest rate is 10%, you would need to provide the following amount: $\frac{1}{0.1} = \$10Mn$
- In case you want this perpetuity to start right now immediately. Then you would need to shell-out an additional \$1Mn, i.e., \$11 Mn total.

Valuing perpetuities and annuities

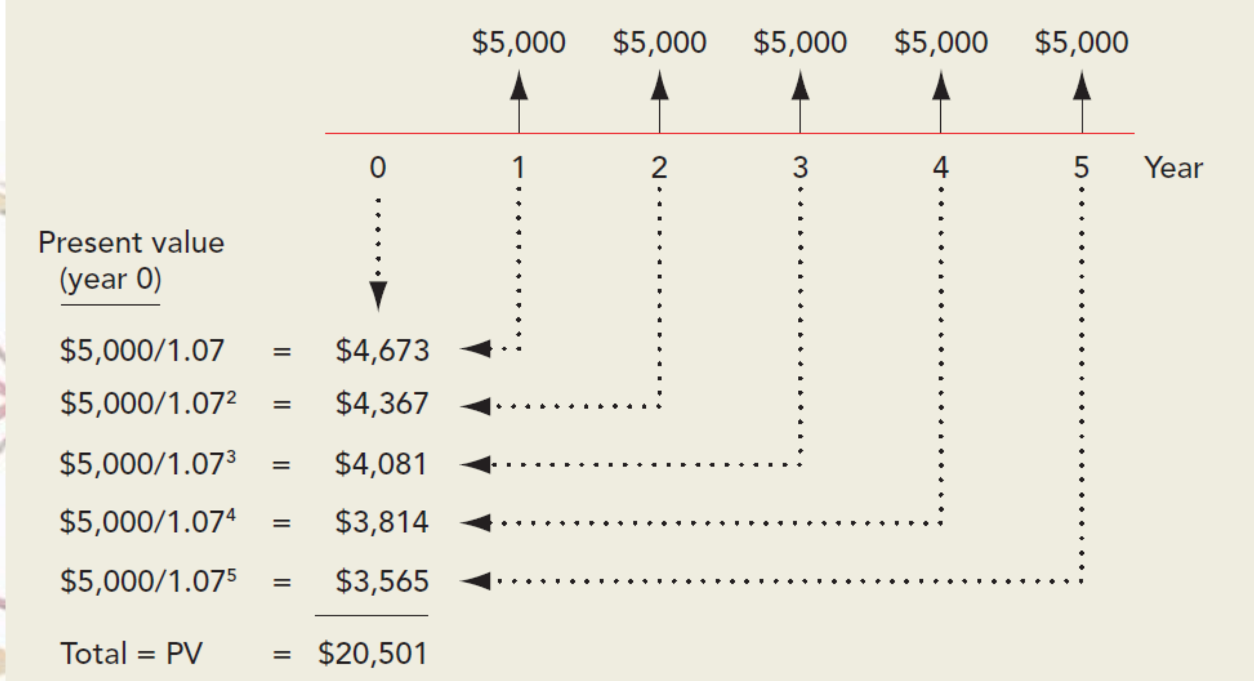
- Annuity has a finite life of a specified number of years
- The annuity computation formula can be derived with the help of perpetuity formula as shown in the diagram here

	Cash flow						
Year:	**1**	**2**	**3**	**4**	**5**	**6 . . .**	**Present value**
1. Perpetuity A	$1	$1	$1	$1	$1	$1 . . .	$\frac{1}{r}$
2. Perpetuity B				$1	$1	$1 . . .	$\frac{1}{r(1+r)^3}$
3. Three-year annuity (1 − 2)	$1	$1	$1				$\frac{1}{r} - \frac{1}{r(1+r)^3}$

- Similarly, we can value an annuity that pays C amount at the end of year for each of the t years, starting from the year end. This will be : $\frac{C}{r}[1 - \frac{1}{(1+r)^t}]$

Valuing perpetuities and annuities

- Consider an example of an annuity that pays $5000 a year, paid at the end of year, for each of the next five years
- If the appropriate discount rate is 7%, what is the present value of this annuity.
- $PV = \frac{5000}{0.07}\left[1 - \frac{1}{1.07^5}\right] = \$20501$



Valuing perpetuities and annuities

- Often these cash flows do not remain constant and exhibit a certain growth rate.
- If a perpetuity is growing at a rate of 'g' the simple formula for this perpetuity becomes: $\frac{C}{r-g}$; where r>g
- A $1Mn perpetuity, starting from the year end, that grows at an interest of 4%. If the appropriate discount rate is 10%, the present value of this perpetuity will be $\frac{1}{0.10-0.04} = \$16.67\ Mn$
- The simple formula for annuities (C) growing at a *rate* 'g' for 't' years is provided below: $PV = \frac{C}{r-g}[1 - \frac{(1+g)^t}{(1+r)^t}]$
- Consider a 3-year $5000 annuity with 10% discount rate and a growth rate of 6%
- Then its PV would be $PV = \frac{5000}{0.10-0.06}\left[1 - \frac{1.06^3}{1.10^3}\right] = \$13146$

A short lesson on compounding

- Sometimes cash flows are not received annually but at higher frequencies, e.g., quarterly, weekly, monthly
- If you get an interest of 10% per annum on $100. You will get an interest amount of $10
- However, if a 5% interest is paid at 6-monthly intervals you get an overall amount of 1.05*105= $110.25 by the end of this year
- Therefore, 10% interest compounded semi-annually results in an effective interest of $1.05^2 - 1 = 10.25\%$
- The compounding frequency increases to m periods, the resulting formula becomes: $\left[1 + \left(\frac{r}{m}\right)\right]^m$
- if m-> ∞, then the resulting formula becomes e^r, where is e=2.718

Summary and Concluding remarks

- Cash flows are discounted for two simple reasons
- (1) Dollar is worth more today than a dollar tomorrow
- (2) A safe dollar is worth more than a risky dollar
- Managers can maximize the firm-value by accepting projects with positive net present values (NPVs)
- $NPV = C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} \ldots\ldots$
- C_0 here is the initial investment, which is expected to be negative, that is outflow of cash. Discount rate 'r' is obtained by examining the prevailing interest rates in financial markets, on the instruments with the same risk

Thanks!

Artificial Intelligence (AI) for Investments

Lesson 3: Making investment decisions

Introduction

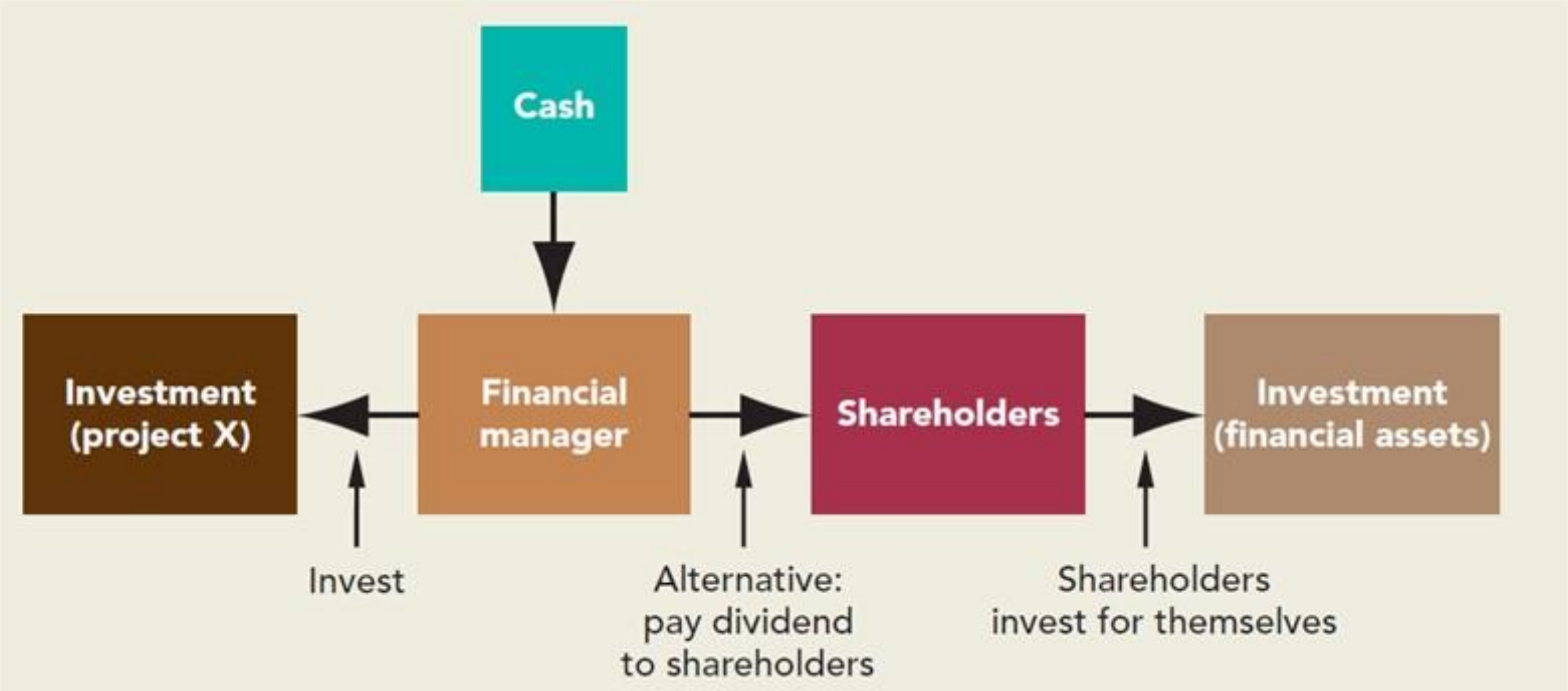
In this lesson we will cover the following topics:

- Review of NPV basics
- Alternatives to NPV rule – Payback period method
- Alternatives to NPV rule – Internal rate of return (IRR) method
- Pitfalls of IRR
- Capital investments with limited resources
- Summary and concluding remarks

Review of NPV basics

- Consider yourself in a position of a CFO where you are analyzing $1 million investment in a new venture called project P
- That the current market value of your firm is $10 million, which includes $1 million cash that you plan to invest min project P
- You find the NPV of this project by discounting the cash flows, adding them up to compute there PV, and subtracting the initial investment of $1 million
- It is easy to understand if PV>9 this project has a positive NPV

Review of NPV basics



Review of NPV basics

- NPV rule recognizes that a dollar today is worth more than a dollar tomorrow
- Any decision rule that is affected by managers' tastes, choice of accounting method, profitability of existing business, or that of other projects will lead to an inefficient decision
- NPV(A+B) =NPV(A)+NPV(B)
- Book incomes are not necessarily the same as cash flows
- Profitability measures such as book rate of returns, heavily depend on the classification of various items as capital investment and their rate of depreciation

Alternatives to NPV rule – Payback period method

- A project's payback period is simply found by estimating the years it takes for the project cash flows to meet the initial investment
- A washing machine is costing $800. You spend $300 a year on washing your clothes. As a thumb rule, if this machine is purchased, it will recover its expenses in 3 years
- The payback rule states that a project should be accepted if its payback period is less than some cut-off period
- Consider a simple example here

Project	C0	C1	C2	C3	Payback Period (years)	NPV at 10%
A	-2,000	500	500	5,000	3	+2,624
B	-2,000	500	1,800	0	2	-58
C	-2,000	1,800	500	0	2	+50

Alternatives to NPV rule – Discounted Payback period method

- An improved version of payback period is to employ discounted cash flows
- This discounted payback rule examines that how many years it takes for the discounted cash flows to recover the initial investment, i.e., become NPV positive
- Let us examine our previous example, with the help of discounted cash flows

Project	C0	C1	C2	C3	Discounted Payback Period (years)	NPV at 10%
A	-2,000	$\frac{500}{1.1} = 455$	$\frac{500}{1.1^2} = 413$	$\frac{5{,}000}{1.1^3} = 3757$	3	+2,624
B	-2,000	$\frac{500}{1.1} = 455$	$\frac{1{,}800}{1.1^2} = 1488$	-	-	-58
C	-2,000	$\frac{1{,}800}{1.1} = 1636$	$\frac{500}{1.1^2} = 413$	-	2	+50

Alternatives to NPV rule – Internal rate of return (IRR) method

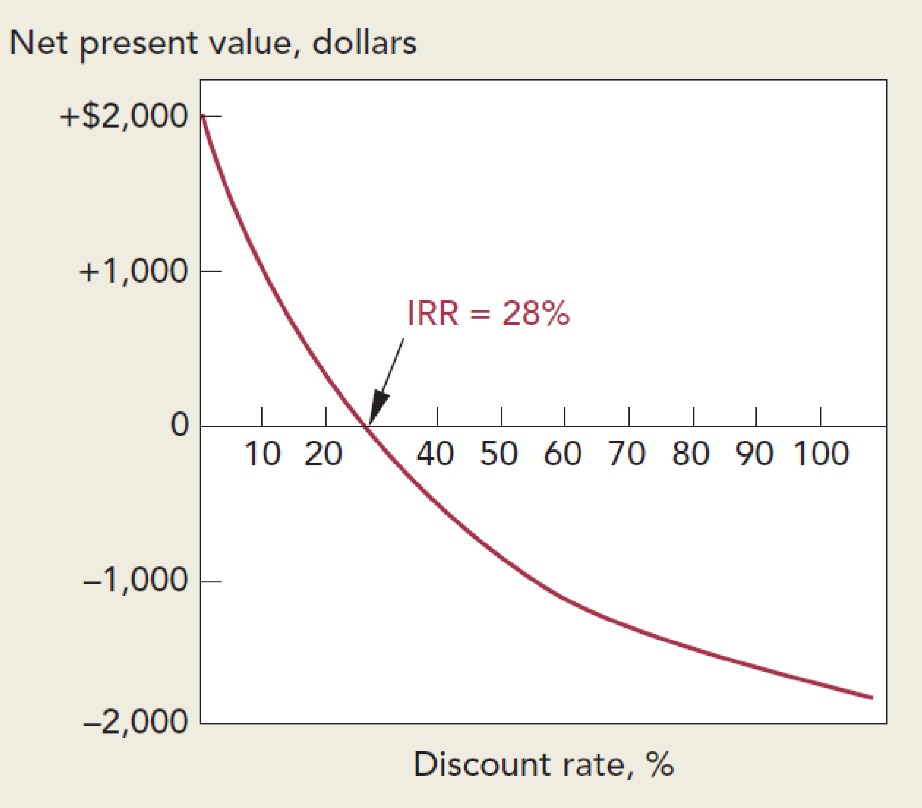
- IRR rule comes from the simple return measure
- $\text{Project return} = \frac{\text{Profit}}{\text{Investment}} = \frac{\text{Payoff}}{\text{Investment}} - 1$; or $-\text{Investment} + \frac{\text{Payoff}}{1+\text{Project Return}} = 0$
- IRR is the return or discount rate at which NPV=0
- $\text{NPV} = \text{C}_0 + \frac{\text{C}_1}{(1+\text{IRR})} + \frac{\text{C}_2}{(1+\text{IRR})^2} + \cdots + \frac{\text{C}_\text{T}}{(1+\text{IRR})^\text{T}}$=0

C_0	C_1	C_2
-4000	+2000	+4000

- $NPV = -4000 + \frac{2000}{1+IRR} + \frac{4000}{(1+IRR)^2} = 0$; solving for this, we get IRR= 28.08%

Alternatives to NPV rule – Internal rate of return (IRR) method

- If the opportunity cost of capital is less than the 28.08% IRR, then the project has a positive NPV
- If opportunity cost of capital is greater than the IRR, the project has a negative NPV
- Please note that IRR is a profitability measure and depends solely on the timing of the project cash flows
- The opportunity cost of capital is the standard of profitability to judge the worth (or NPV) of the project



Pitfalls of IRR

- Pitfall 1: Problem of Lending vs borrowing
- Consider the project cash flows from projects A and B as shown here

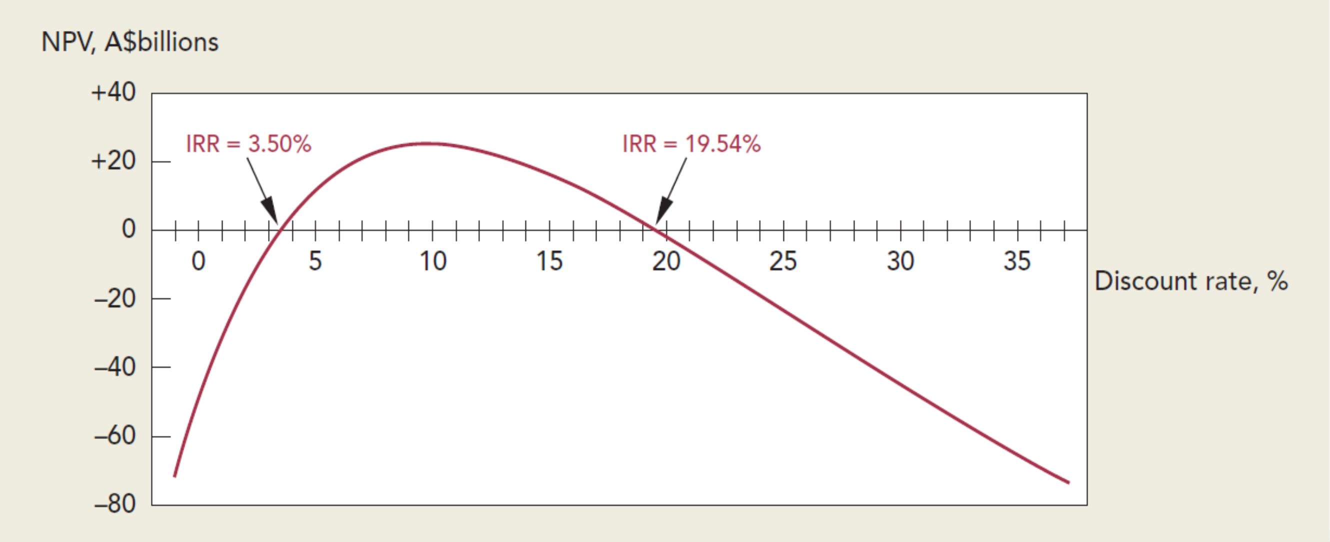
Projects	C_0	C_1	IRR	NPV at 10%
A	-1000	+1500	50%	+364
B	1000	-1500	50%	-364

- Both of these projects will give you the same IRR
- In project A, we are paying out $1000 initally, and getting $1500 later - Case of lending
- While in case of B, we are initially getting $1000 and paying back $1500 later- Case of borrowing
- When you lend money, you want a higher return and when you borrow money money you want a lower return

Pitfalls of IRR

- Pitfall 2: Multiple rates of return
- Consider another project that involves an initial investment of $3 Billion and then produce a cash flow $1 Billion per year, for next nine years
- At the end of the project, the company will incur $6.5 billion of cleanup costs

C_0	C_1	C_2	C_3	C_4
-3	1	1	1	1
C_5	C_6	C_7	C_8	C_9
1	1	1	1	1



Pitfalls of IRR

- Pitfall 3: Mutually exclusive projects
- Firms often have to choose from mutually exclusive projects, since it may not be feasible to take all of them
- In the project cash flows shown here, it seems IRR and NPV are contradicting each other

Projects	C_0	C_1	IRR (%)	NPV at 10%
D	-10000	+20000	100	8182
E	20000	+35000	75	11818

- In such cases, IRR can still be salvaged by examining incremental cash flows as shown here

Projects	C_0	C_1	IRR (%)	NPV at 10%
E-D	-10000	+15000	50	3636

IRR in Conclusion

- Many things can go wrong with IRR, but it is still a very useful benchmark
- To see its utility, have a look at the project cash flows, NPV, and IRR estimates for two projects X and Y as shown here ($, thousands)

Projects	C_0	C_1	C_2	C_3	NPV at 8%	IRR (%)
X	-9.0	2.9	4.0	5.4	1.4	15.58
Y	-9000	2560	3540	4530	1.4	8.01

- Both of these projects offer the same positive NPV of $1400
- As rational individuals you would select X over Y (Why?)
- The higher IRR associated with X (15.58%) reflects the low risk and efforts involved as compared with Y

Capital investments with limited resources

- Capital is a scarce resource, thus it is not possible to select all the positive NPV projects

- Thus, firms would like to select those projects that offer highest NPV per dollar of investment

- $\text{Profitability index (PI)} = \dfrac{\text{NPV}}{\text{Initial Investment}}$

Cash Flows ($ Mn)					
Project	**C0**	**C1**	**C2**	**NPV at 10%**	**PI**
A	-10	+30	+5	21	2.1
B	-5	+5	+20	16	3.2
C	-5	+5	+15	12	2.4

Capital investments with limited resources

- Let us add another project D, which needs $40 Mn investment in second year

Project	C0	C1	C2	NPV at 10%	PI
A	-10	+30	+5	21	2.1
B	-5	+5	+20	16	3.2
C	-5	+5	+15	12	2.4
D	0	-40	+60	13	0.4

- The firm can only raise $10 Mn in the second year: additional constraint of capital rationing
- The simple way of ranking projects as per PI may not work here
- This particular problem is rather simple, as A and D combined offer a higher NPV than B and C combined
- However, more complex problems are solved with linear programming (LP) techniques

Summary and concluding remarks

- In addition to NPV, other rules are also employed to examine alternate investments
- These include book rate of return, payback period, and IRR method
- Book rate of return is simply computed as book income divided by book value of investment
- Payback method examines the project cash flows against a certain specific cut-off period
- Only those projects with payback period is less than cut-off period, are considered
- Lastly, IRR is the discount rate at which the firm NPV is zero
- As per the IRR rule, firms should accept those projects that have an IRR greater than opportunity cost of capital

Thanks!

Artificial Intelligence (AI) for Investments

Lesson 4: Valuation of fixed income securities

Introduction

In this lesson we will cover the following topics:

- Introduction to fixed income securities (FIS)
- Valuation of FIS through DCF methods
- Theories of term structure of interest rates
- Concept of yield to maturity
- Duration of an FIS and interest rate risk
- Summary and concluding remarks

Simple valuation of fixed income securities (FIS)

- If you own a fixed income security like a bond you are entitled to fixed set of payoffs called interest or coupons; and at maturity you get the face value or the principal
- Consider a simple bond that pays 8.5% interest. If you have invested \$100, you will get \$8.50 annually, if the coupons are annual, and at maturity you will also get the principal amount, i.e., total \$108.5. Also assume a 3% discount rate
- The PV of this bond can be easily computed as provided here
- $PV = \frac{8.50}{1.03} + \frac{8.50}{1.03^2} + \frac{8.50}{1.03^3} + \frac{108.50}{1.03^4} = \$120.44$; or in the manner provided below
- PV (Bond)=PV (annuity of bond coupon payments)+PV(Principal payment)
- PV (Bond)=$\frac{8.5}{0.03} * \left(1 - \frac{1}{1.03^4}\right) + \frac{100}{1.03^4} = 31.59 + 88.85 = \$120.44$

Simple valuation of fixed income securities (FIS)

- Another very important concept for FIS is yield-to-maturity (YTM)
- In the previous example, if the bond under discussion, has a present value of \$120.44 then what is the current interest rate or yield of this bond to the buyer
- This YTM can be easily computed as with expression shown here
- $120.44 = \frac{8.50}{1+ytm} + \frac{8.50}{(1+ytm)^2} + \frac{8.50}{(1+ytm)^3} + \frac{108.50}{(1+ytm)^4}$
- In this case, the answer is ytm=3%, since we assumed the discount rate of 3% at the beginning

Simple valuation of fixed income securities (FIS)

- Consider the example of a simple bond with the following cash-flow profile

T=6m	T=12m	T=18m	T=24m	T=30m	T=36m
24.375	24.375	24.375	24.375	24.375	1024.375

- If the bond is currently trading at \$1107.95, then the current ytm of the bond can be simply computed from this equation provided here

- Coupons amounting to \$24.375 are paid semi-annually and at the end of the period, a principal payment of \$1000 is paid at the end of 3-years

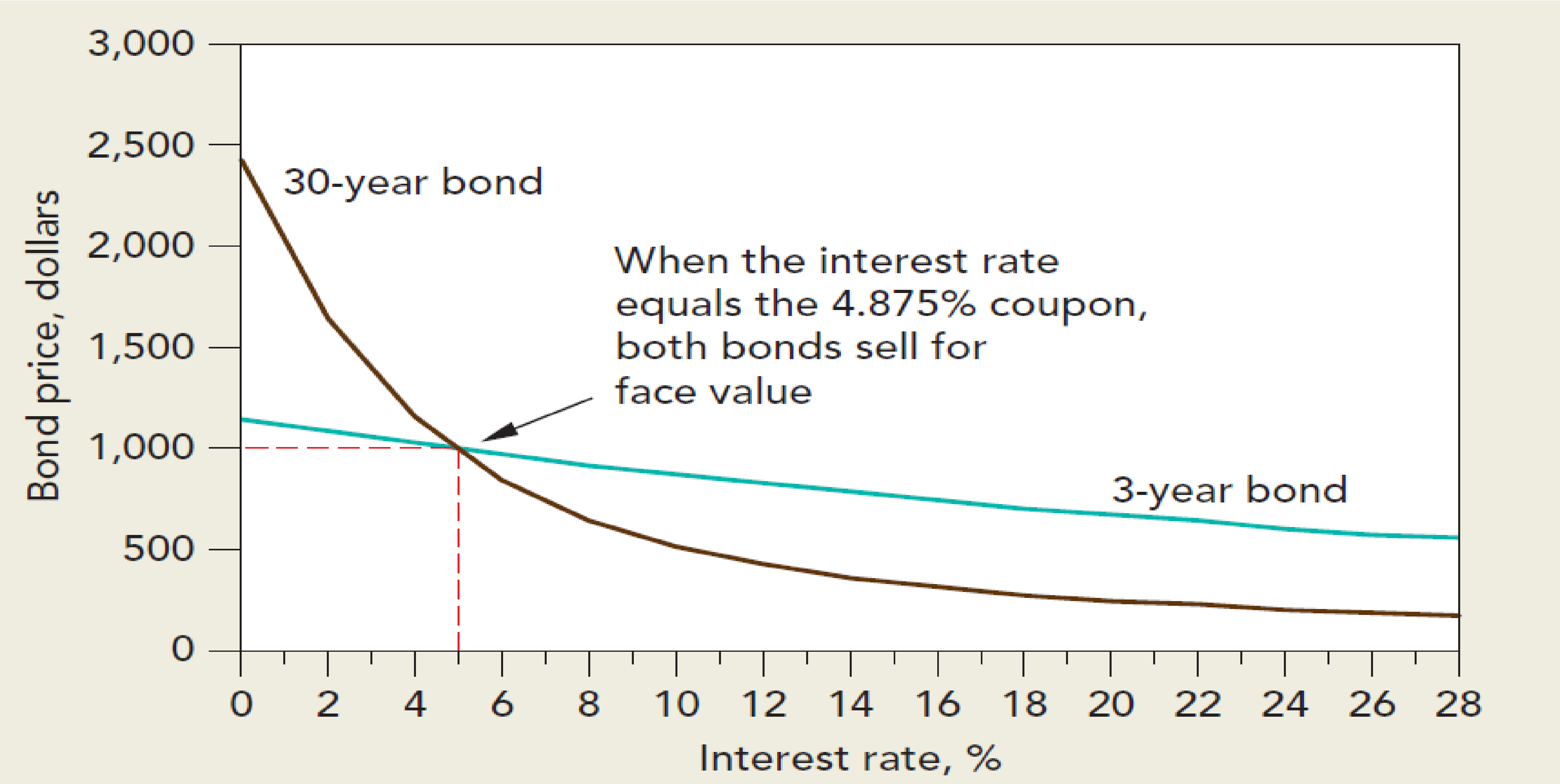
- $PV = \frac{24.375}{1+\frac{ytm}{2}} + \frac{24.375}{\left(1+\frac{ytm}{2}\right)^2} + \frac{24.375}{\left(1+\frac{ytm}{2}\right)^3} + \frac{24.375}{\left(1+\frac{ytm}{2}\right)^4} + \frac{24.375}{\left(1+\frac{ytm}{2}\right)^5} + \frac{1024.375}{\left(1+\frac{ytm}{2}\right)^6}$; here ytm/2=0.6003%; ytm=1.2006%

- The effective annual yield (EAF) would be (1.6003)^2-1=1.2042%

Bond prices and interest rates

- Bond prices change with interest rates
- In the previous example, where the semi-annual yield was 0.6003%, assume investors start demanding a semi-annual yield of 4%, that is annual percentage quoted rate of 8%
- The price of this bond will fall to reflect this change in yield, as per the computation shown here
- $PV = \frac{24.375}{1.04} + \frac{24.375}{(1.04)^2} + \frac{24.375}{(1.04)^3} + \frac{24.375}{(1.04)^4} + \frac{24.375}{(1.04)^5} + \frac{1024.375}{(1.04)^6} = \$918.09$

Bond prices and interest rates



Duration of a bond

- We saw that changes in interest rates have greater impact on the prices of long-term bonds that short-term bonds
- Separate Trading of Registered Interest and Principal Securities (STRIPS) are special instruments, created by stripping the cash flows from treasury instruments and government securities
- These are often called as zero-coupon bonds, and have the maturity same as duration

Duration of a bond

- Consider three bonds, one strip and two coupon paying bonds with cash flow profile as provided here

	Price (%)	Cash payments %			
Bond	**Feb. 2015**	**Aug. 2015**	**Feb. 2016. . .**	**. . . Aug. 2016**	**Feb. 2021**
Strip for Feb. 2015	88.74	0	0 . . .	. . . 0	100.00
Feb. 2015 (4% p.a.)	111.26	2.00	2.00 . . .	. . . 2.00	102.00
Feb. 2015 (11.25% p.a.)	152.05	5.625	5.625 . . .	. . . 5.625	105.625

- All of these bonds have a ytm of 2%

- The two coupon paying bonds offer a considerable proportion of their cash flows earlier than maturity. Thus it is very easy to observe that the strip has the longest duration

- Bond with 11.25% coupon (i.e., 5.625% semi-annual coupon) offers a larger proportion of cash flows earlier than maturity, as compared to the bond with lower coupon of 4% (i.e., 2% semi-annual coupon)

Duration of a bond

- However, we need a more concrete measure of duration
- The duration measure also indicates the sensitivity of a fixed income security to interest rate changes
- The simple measure of duration is computed as a weighted average of times, with weights being the present value of cash flows received at these times
- Consider a bond with a maturity of T years. The corresponding cash flows in each of these years being $C_1, C_2 \ldots. C_T$ being received at the end of year 1, 2, 3,…,T
- $Duration = 1 * \frac{PV(C_1)}{PV} + 2 * \frac{PV(C_2)}{PV} + 3 * \frac{PV(C_3)}{PV} + \cdots + T * \frac{PV(C_T)}{PV}$

Duration of a bond

- Let us understand this through one example

- Consider a fixed income security with coupons of $8.5 paid at the end of each year and a final principal payment in the final year, that is fourth year

- Also assume the appropriate interest rate of 3%

Year (t)	1	2	3	4	
Cash payment (C t)	8.5	8.5	8.5	108.5	PV
PV(Ct) at 3%	8.25	8.01	7.78	96.4	120.44
Fraction of total value [PV(Ct)/PV]	0.069	0.067	0.065	0.8	Total=Duration
Year x Fraction of total value [t x PV(Ct)/PV]	0.069	0.134	0.195	3.2	3.6 years

- $Modified\ Duration = \frac{Duration}{(1+yield)}$

Duration of a bond

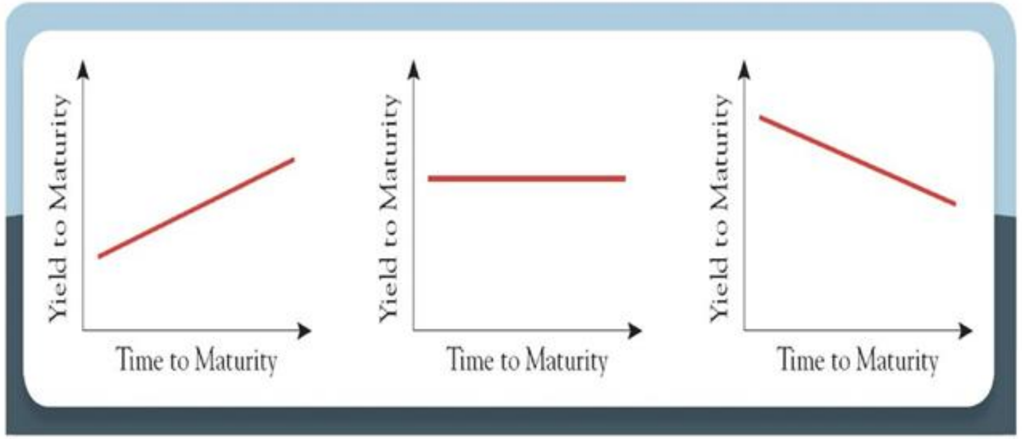
- This modified duration measures the percentage change in price a one percentage change in yield (or interest rates)
- For our bond of duration 3.6 years. This measure works out to 3.6/1.03= 3.49%
- Now consider a scenario where interest rates rise by 0.5% and fall by the same amount

Year (*t*)	**1**	**2**	**3**	**4**	**PV**	**Change (%)**
Cash payment (*C t*)	8.5	8.5	8.5	108.5		
PV(*Ct*) at 3%	8.25	8.01	7.78	96.4	120.44	
PV(*Ct*) at 3.5%	8.21	7.93	7.67	94.55	118.37	-1.72%
PV(*Ct*) at 2.5%	8.29	8.09	7.89	98.30	122.57	1.77%

- The total magnitude of change works out to 1.72%+1.77%= 3.49%
- This is the same amount as our modified duration measure

Term structure of interest rates

- Interest rates vary over different tenors, and short-term interest rates are different from long-term interest rates
- This variation in interest rates over short-term and long-term and across periods, is often referred to as term structure of interest rates



Interest rates are expected to **rise.** Interest rates are expected to **remain unchanged.** Interest rates are expected to **fall.**

Term structure of interest rates

- Consider a term structure of interest rates $r_1, r_2, r_3, \dots r_t$ for time periods 1, 2, 3,…,t
- A simple cash-inflow of $1 in the first year will have a value of $PV = \frac{1}{1+r_1}$. Here r_1, would be called the one-year spot rate
- Similarly, a loan that pays $1 at the end of two years, will have a present value of $PV = \frac{1}{(1+r_2)^2}$
- For simple illustration purposes assume that $r_1 = 3\%$ and $r_2 = 4\%$. A security that offers only these two cash flows will have a present value of $PV = \frac{1}{1.03} + \frac{1}{(1.04)^2} = 1.895$
- P$V = \frac{1}{1+ytm} + \frac{1}{(1+ytm)^2} = 1.895$
- Solving for this equation, we get ytm= 3.67%

Term structure of interest rates

- In a well-functioning liquid and efficient markets, all safe (that is risk-free cash flows) must be discounted at the same risk-free spot: Law of one price

		1	2	3	4	Bond Price (PV)	Ytm
	Spot rates	3.50%	4%	4.20%	4.40%		
	Discount factor	0.97	0.92	0.88	0.84		
A	8% coupon-2year	80	1080				
	PV	77.29	998.52	-	-	1,075.82	3.98%
B	11%-coupon-3year	110	110	1110			
	PV	106.28	101.70	981.11	-	1,189.10	4.16%
C	6% coupon-4year	60	60	60	1060		
	PV	57.97	55.47	53.03	892.29	1,058.76	4.37%
D	STRIP				1000		
					841.78	841.78	4.40%

Term structure of interest rates

- A 10-year strip with face-value of $1000 at then end of maturity is selling at $714.18
- $F_0 = \frac{1}{(1+r_{10})^{10}} = 0.71418$; solving for this, $r_{10} = 3.42\%$
- **Expectations theory of term structure:** Term-structure of interest rates reflect the expectation of interest rates in future
- Assume that the spot rate for year 1, r_1 is 5% and spot rate for year 2, r_2 is 7%
- If you invest $100 for one year, you get $5 for interest. If you invest it for two years, you get $100 * 1.07^2$, that is, $114.49 after two years
- The extra return that you earn in second year can be computed as noted here. $\frac{1.07^2}{1.05}$-1=9.0%
- This means that if you invest for two years, you will get 5% in year 1 and 9% in year 2

Term structure of interest rates

- If you expect that bond prices in the year 2 will yield more, then you would prefer to invest at 1-year spot and then invest in second year at prevailing rate
- In equilibrium, long term spot rates are a combination of short-term spot and a series of forward rates
- Forward rates are future rates booked (contracted) today. For example, rate of interest for period T=1 to T=2 booked at T=0; or interest rate for T=2 to T=4 booked at T=0
- **Liquidity preference theory** suggests that investors prefer to invest in short-term as they fear the additional volatility, risk, and uncertainty associated with the long-term instruments

Summary and concluding remarks

- Fixed income securities like bonds are simply long-term loans
- These instruments include regular interest (or coupon) payments and at the maturity you get back the face-value (or principal)
- These instruments can be easily valued through discounting cash flow valuation method
- Also, it is appropriate to discount each of these cash flows with its on spot rate corresponding to the duration of the cash flows
- The spot rate is observed on the term structure of interest rates. The term structure of interest rates is computed using the STRIPs

Summary and concluding remarks

- Once the present value of a bond is computed, using bond cash flows, one can also calculate the ytm of the bond
- Duration reflects the average time associated with cash-flows of a fixed income security
- The expectations theory of interest rates suggests that rising interest rates reflect the future expectations of investors
- The theory of liquidity preference suggests that investors prefer to hold short-term instruments as compared to long-term instruments

Thanks!

Artificial Intelligence (AI) for Investments

Lesson 5: Valuation of common stocks

Introduction

In this lesson we will cover the following topics:

- Introduction to common stocks and trading operations
- Fundamental principles of stock valuation
- Single-period and multi-period DCF approaches to stock valuation
- Valuation of common stock for growth and income stocks
- Dividend discount model and cost of equity
- Summary and concluding remarks

Trading of securities on exchanges

- Market microstructure and trading operations
- Primary and secondary markets
- Trading in modern financial markets: electronic communication networks and limit order books
- Role of designated market makers in quote driven markets

Market value of common stocks

	Market-to-Book-Value Ratio		Price–Earnings Ratio	
	Company	Competitors*	Company	Competitors*
Johnson & Johnson	3.4	3.0	11.3	10.9
PepsiCo	6.4	3.0	15.6	12.9
Campbell Soup	9.0	4.6	8.8	11.3
Wal-Mart	3.0	2.1	14.6	13.4
Exxon Mobil	2.9	1.2	7.6	5.3
Dow Chemical	0.5	3.0	12.5	10.6
Dell Computer	4.5	3.7	7.9	11.1
Amazon	11.2	2.7	46.9	22.2
McDonald's	4.4	3.1	14.1	13.6
American Electric Power	1.1	1.1	8.1	11.0
GE	1.0	1.7	4.6	8.8

Fundamental valuation of stocks-I

- The comparable valuation method provides estimates of value that are more aligned to the current market expectations
- Fundamental valuation methods provide estimates, independent of market valuation, and depend on the assumptions
- What are these factors that affect stock prices?
- PV of Stock = PV of expected future dividend income
- Expected Returns= $r = \frac{DIV_1 + P_1 - P_0}{P_0}$

Fundamental valuation of stocks-I

- Consider a company ABC with the current price P_0= \$100; dividend $DIV_1 = \$5$, and an expected price of \$110 at the end of the year. Then the expected returns by shareholders would be computed as shown here
- $r = \frac{DIV_1 + P_1 - P_0}{P_0} = \frac{5+110-100}{100} = 15\%$
- Assume that 15% is the interest that you (or other investors) are expected from this stock and those stocks having similar risk
- $P_0 = \frac{DIV_1 + P_1}{1+r} = \frac{5+110}{1.15} = \$100$
- $P_0 = \frac{DIV_1 + P_1}{1+r}$

Fundamental valuation of stocks-II

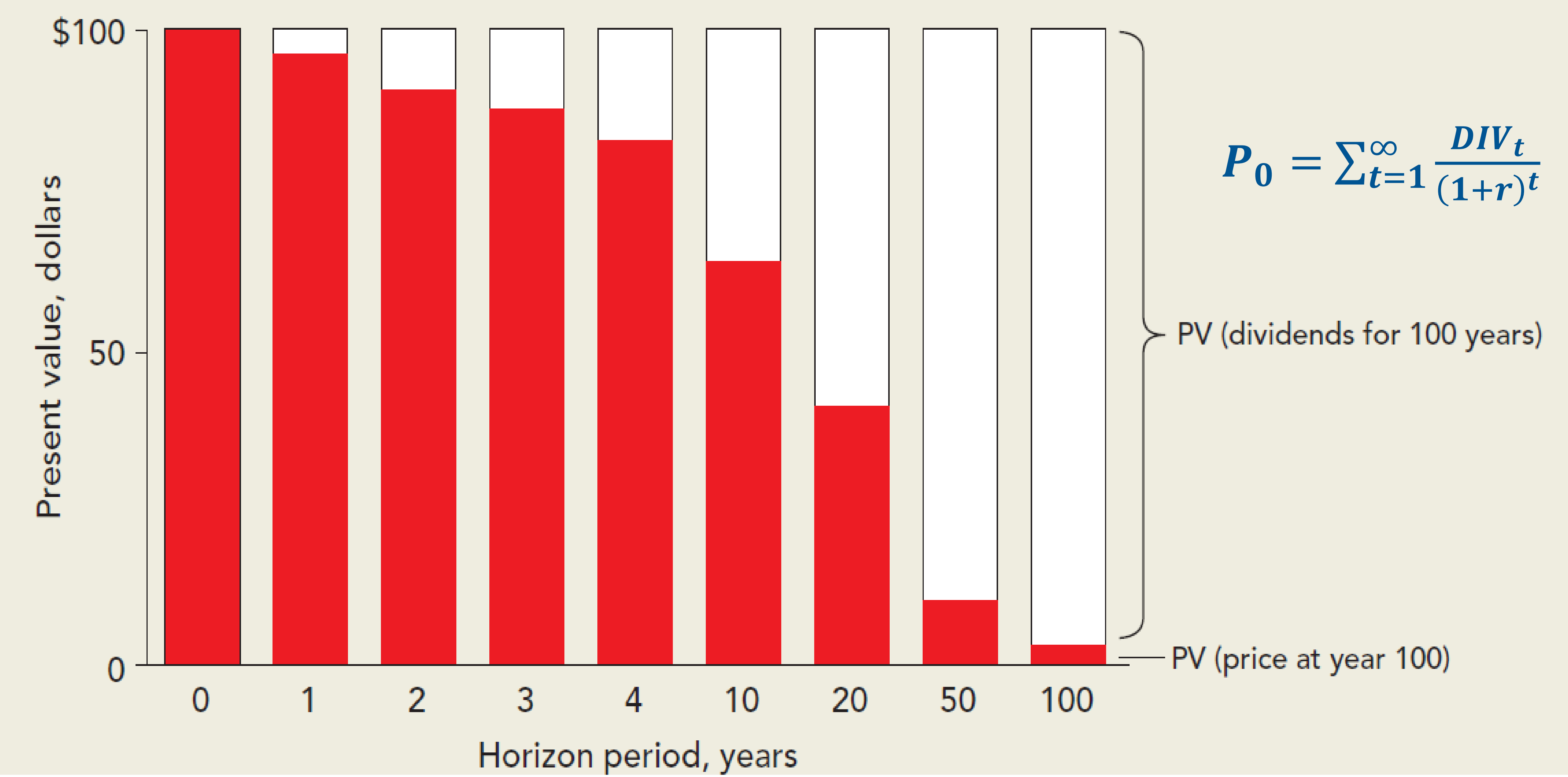
- Let us examine the price of stock next year P_1. Similar to P_0, we can also write this price P_1 in terms of dividend DIV_1 and the discount rate r
- $P_1 = \frac{DIV_2 + P_2}{1+r}$
- Subsequently, we can also write the current price (P_0) in terms of dividends for next two years, DIV_1 and DIV_2
- $P_0 = \frac{DIV_1}{1+r} + \frac{DIV_2}{(1+r)^2} + \frac{P_2}{(1+r)^2}$
- Let us further consider the previous example of the company ABC. The investors are expecting a dividend of \$5.50 in year 2 a price of \$121 at the end of year 2
- $P_0 = \frac{5.00}{1.15} + \frac{5.50}{1.15^2} + \frac{121}{1.15^2} = 100$
- $\mathbf{P_0 = \frac{DIV_1}{1+r} + \frac{DIV_2}{(1+r)^2} + \frac{DIV_3}{(1+r)^3} + \cdots + \frac{DIV_H + P_H}{(1+r)^H} = \sum_{t=1}^{H} \frac{DIV_t}{(1+r)^t} + \frac{P_H}{(1+r)^H}}$

Fundamental valuation of stocks-II

- For company ABC, let us consider a 100-period horizon with 10% growth in dividends and prices year-on-year

	Expected Future Values		Present Values		
1.HorizonPeriod (H)	2.Dividend (DIVt)	3.Price (Pt)	4.Cumulative Dividends	5.Future Price	6.Total
0	—	100	—	—	100
1	5.00	110	4.35	95.65	100
2	5.50	121	8.51	91.49	100
3	6.05	133.10	12.48	87.52	100
4	6.66	146.41	16.29	83.71	100
10	11.79	259.37	35.89	64.11	100
20	30.58	672.75	58.89	41.11	100
50	533.59	11,739.09	89.17	10.83	100
100	62,639.15	1,378,061.23	98.83	1.17	100

Fundamental valuation of stocks-II



$$P_0 = \sum_{t=1}^{\infty} \frac{DIV_t}{(1+r)^t}$$

Dividend discount model and cost of equity capital

- Assume a constant long-term growth rate of ‘g’ in dividends and an appropriate discount rate ‘r’
- Assuming a dividend of DIV_1 in the first year, this perpetuity can be valued using the formula shown here: $P_0 = \frac{DIV_1}{r-g}$
- If the current price (P_0) is observed, this formula can be used to estimate ‘r’ as shown here: $r = \frac{DIV_1}{P_0} + g$

Dividend discount model and cost of equity capital

- Firm XYZ has a share price of \$42.45 at the start of the period, expected dividends starting from the year end amount to \$1.68 per share, payout ratio is 60%
- he dividend yield for this stock can be simply computed as Dividend yield= $\frac{DIV_1}{P_0} = \frac{1.68}{42.45} = 4.0\%$
- $\text{Plowback raio} = 1 - \text{payout ratio} = 1 - \frac{\text{DIV}}{\text{EPS}} = 1 - .60 = 0.40$
- Then your overall estimate of cost of equity capital: r= $\frac{DIV_1}{P_0} + g = 4.0\% + 4.0\%$=8.0%
- Such estimates are often noisy and prone to errors of estimation
- Constant growth dividend discount formula employed earlier is extremely sensitive to changes in the values of ‘g’ and ‘r’

Dividend discount model and cost of equity capital

- Consider the example of a firm with equity of $25, $DIV_1 = \$0.5$ and $P_0 = \$50.0$. The firm has an ROE of 25% and payout ratio of 20%
- Let us first compute the cost of equity for this firm
- (1) Dividend growth rate= (1-Payout ratio)*ROE= (1-0.20)*0.25= 20%
- $r = Dividend\ yield + g = \frac{0.5}{50} + 20\% = 1\% + 20\% = 21\%$
- No firm can sustain a growth rate of 21% infinitely into future. In real life such growth rates drop gradually over the years and attain that lower long-term growth that is sustainable

Dividend discount model and cost of equity capital

- To simplify things here, assume that the firm ROE drops to 16% in the third year. Also that the payout ratio increases to 50%
- So now we have new growth figure, i.e., g= 0.50*16%= 8%.

Years	1	2	3	4
Equity	10.00	10*1.20=12.00	12*1.20=14.40	14.40*1.08=15.55
Return on equity, ROE	0.25	0.25	0.16	0.16
Earnings per share, EPS	10*0.25=2.50	12*0.25=3.00	14.40*0.16=2.30	15.55*0.16=2.49
Payout ratio	0.20	0.20	0.50	0.50
Next year growth= (1-Payout)*ROE	-	(1-0.2)*0.25=0.20	(1-0.5)*0.16=0.08	(1-0.5)*0.16=0.08
Dividends per share, DIV	2.5*0.2=0.50	3*0.20=0.60	2.30*0.5=1.15	2.49*0.5=1.245

Dividend discount model and cost of equity capital

- In order to compute the current price (P_0), one needs to use the DCF formula in two stages
- In the high-growth phase, we need to value the three dividend inflows in year 1, 2, and 3.
- Present value of dividends obtained in years 1, 2, and 3: $\frac{DIV_1}{1+r} + \frac{DIV_2}{(1+r)^2} + \frac{DIV_3}{(1+r)^3}$
- Steady state growth phase with cash flows in perpetuity: $\frac{P_3}{(1+r)^3} = \frac{DIV_4}{(r-g)} * \frac{1}{(1+r)^3}$
- $50 = \frac{0.50}{1+r} + \frac{0.60}{(1+r)^2} + \frac{1.15}{(1+r)^3} + \frac{1.245}{(r-0.08)} * \frac{1}{(1+r)^3}$; current price is \$50
- Solving for above equation, we get a value of r=9.94%

Stock price, growth, and earnings per share

- Investors often contrast growth with income stocks
- Growth stocks offer capital gains; Contrast this to income stocks that offer regular income in the form of cash dividends
- Consider the example of a company that doesn't grow and pay most of the earnings as dividends ($10), it is currently valued at $100
- Expected returns = dividend yield = $\frac{DIV_1}{P_0}$=$\frac{10}{100} = 10.0\%$
- Also, if one discounts the dividends of this company, till perpetuity $(P_0 = \frac{DIV_1}{r})$, one should be able to obtain the current price that is $100

Stock price, growth, and earnings per share

- Let us consider the case of a growth firm
- The firm invests most of its earnings internally, investment of \$10 at the end of year t=1
- The company also expects that this investment opportunity has a return of 10%, same as market capitalization rate
- NPV of this project= $-C_0 + \frac{DIV_1}{r} = -10 + \frac{1}{0.10} = 0$
- Investors were expecting a return of 10% on their investment in the firm
- Even if the firm distributed these cash flows to investors, they would've obtained the same 10% returns by investing in financial market instruments

Stock price, growth, and earnings per share

- Let us consider four examples of different returns from this project

Project Rate of Return	Incremental Cash Flows	Project NPV in year 1	Project contribution to firm value at T=0	Share Price at T=0, P0	P0/EPS1	r
0.05	.50	-10+0.5/0.10=- 5.00	-4.55	95.45	9.545	0.10
0.10	1.00	-10+1.0/0.10=0	0	100.00	10.000	0.10
0.15	1.50	-10+1.5/0.10= 5.00	+ 4.55	104.55	10.455	0.10
0.20	2.00	-10+2.0/0.10= 10.00	+ 9.09	109.09	10.909	0.10

- Please observe that in those cases where NPV is negative, the price to earnings ratio is less than 10 and more than 10 where NPV is positive

- The value of price can be distributed in two components. First component, the capitalized value of earnings under no-growth policy; Second component, is the present value of growth opportunities (PVGO)

- $P_0 = \frac{EPS_1}{r} + PVGO$ or $\frac{EPS_1}{P_0} = r(1 - \frac{PVGO}{P_0})$

Stock price, growth, and earnings per share

- Consider a company COM with market capitalization rate of 15% and ROE=25%. COM has earnings of \$8.33 and a payout ratio of 0.6. The company is expected to pay a divided of \$5 in the next year, and thereafter, the dividend is expected to increase indefinitely by 10% a year

- $P_0 = \frac{DIV_1}{r-g} = \frac{5}{15\%-10\%} = \$100$

- The company is plowing back 40% of earnings with an ROE of 25%. Growth rate of the firm 'g'= 0.40*25%=10%

- Assume a no-growth policy: $\mathrm{P}' = \frac{EPS}{r} = \frac{8.33}{0.15} = \$55.56$

- Thus, $\mathrm{PVGO}=P_0 - \mathrm{P}' = 100-55.56=44.44$

Stock price, growth, and earnings per share

- Let us try and break-down this figure of $44.44

- The company plows back 40% of earnings. In the first year, this amount is 8.33-5=$3.33. This amount is invested at a return of 25%, that is 3.33*25%=$0.83 earnings starting from year 2

- The present value of this investment at T=1 can be computed as shown here: $-3.33+\frac{0.83}{0.15}=\$2.22$

- Also, it is known to us that firm earnings are growing at 10%. Therefore, we can expect this $2.22 additional earnings to also grow at the same rate of 10%. That means, in the second year, we will have additional earnings of 2.22*1.10= $2.44 and 2.44*1.10=$2.69 in the third year and so on

- At 10% capitalization rate, let us compute the present value of all these incremental cash flows, starting from year 1 at $2.22

- $\mathbf{PVGO}=\frac{2.22}{0.15-0.10}=\$44.44$ or $\mathbf{P_0}=\frac{\mathbf{EPS_1}}{\mathbf{r}}+\mathbf{PVGO}=\mathbf{55.56+44.44=100}$

A simple example of business valuation

- Let us start with some basic information and assumptions about this business

- The business has an appropriate discount rate of 10%. The business grows at a rapid pace of 20% per annum for five years, the falls to 13% for years 6-7, and finally settles down at a 6% steady state growth rate thereafter. Returns on asset (RoA) amount to a constant 12%. The plowback ratio is derived from the expected growth of the business, using the formula g= RoA (or RoE)* Plowback ratio. Starting with a size of $10Mn in the first year, the cash flows are provided here

Years	1	2	3	4	5	6	7	8	9	10
Growth (%)	20%	20%	20.0%	20.0%	20.0%	13%	13%	6%	6%	6%
Asset value ($Mn)	10.00	12.00	14.40	17.28	20.74	23.43	26.48	28.07	29.75	31.54
RoA*	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%
Earnings ($Mn)	1.20	1.44	1.73	2.07	2.49	2.81	3.18	3.37	3.57	3.78
Plowback	167%	167%	167%	167%	108%	108%	50%	50%	50%	50%
Net investment ($Mn)	2.00	2.40	2.88	3.46	2.70	3.05	1.59	1.68	1.79	1.89
Free cash flows ($Mn)	-0.80	-0.96	-1.15	-1.38	-0.21	-0.23	1.59	1.68	1.79	1.89

A simple example of business valuation

- There are two components to this value
- Pre-steady state growth period value: $\mathbf{PV\ (cash\ flows\ )} = -\frac{\mathbf{0.80}}{\mathbf{1.10}} - \frac{\mathbf{0.96}}{(\mathbf{1.10})^{\mathbf{2}}} - \frac{\mathbf{1.15}}{(\mathbf{1.10})^{\mathbf{3}}} - \frac{\mathbf{1.38}}{(\mathbf{1.10})^{\mathbf{4}}} - \frac{\mathbf{0.21}}{(\mathbf{1.10})^{\mathbf{5}}} - \frac{\mathbf{0.23}}{(\mathbf{1.1})^{\mathbf{6}}}$ =-3.59
- Steady state growth period value or horizon value: $PV\ (Horizon\ value\ ) = \frac{1.59}{(0.10-0.06)} * \frac{1}{(1.1)^6}$ =22.42
- Total value= -3.59+22.42=$18.83 Mn.
- If you observe in financial markets that the average PE ratio for a mature business with similar profile is 11
- $PV\ (Horizon\ value\ ) = 11 * 3.18 * \frac{1}{(1.1)^6}$ =19.75
- If you observe that average market to book asset values for the similar mature companies is 1.4
- $PV\ (Horizon\ value\ ) = 1.4 * 26.48 * \frac{1}{(1.1)^6}$ =20.93

Summary and concluding remarks

- The value of stock is equal to the discounted dividend payments expected to be received in perpetuity
- $PV = \sum_{t=1}^{\infty} \frac{DIV_t}{(1+r)^t}$
- However, investors often do not plan to hold the stock for eternity and have finite investment horizons
- These investment horizons involve returns in the form of dividends and capital gains
- The value of the stocks with infinite stream of growing dividends: $P_0 = \frac{DIV_1}{r-g}$
- Price in terms of capitalized value of earnings and PVGO and $P_0 = \frac{EPS_1}{r} + PVGO$

Thanks!

INDIAN INSTITUTE OF TECHNOLOGY KANPUR

Artificial Intelligence (AI) for Investments

Lesson 6 : Introduction to Risk and Return

Introduction

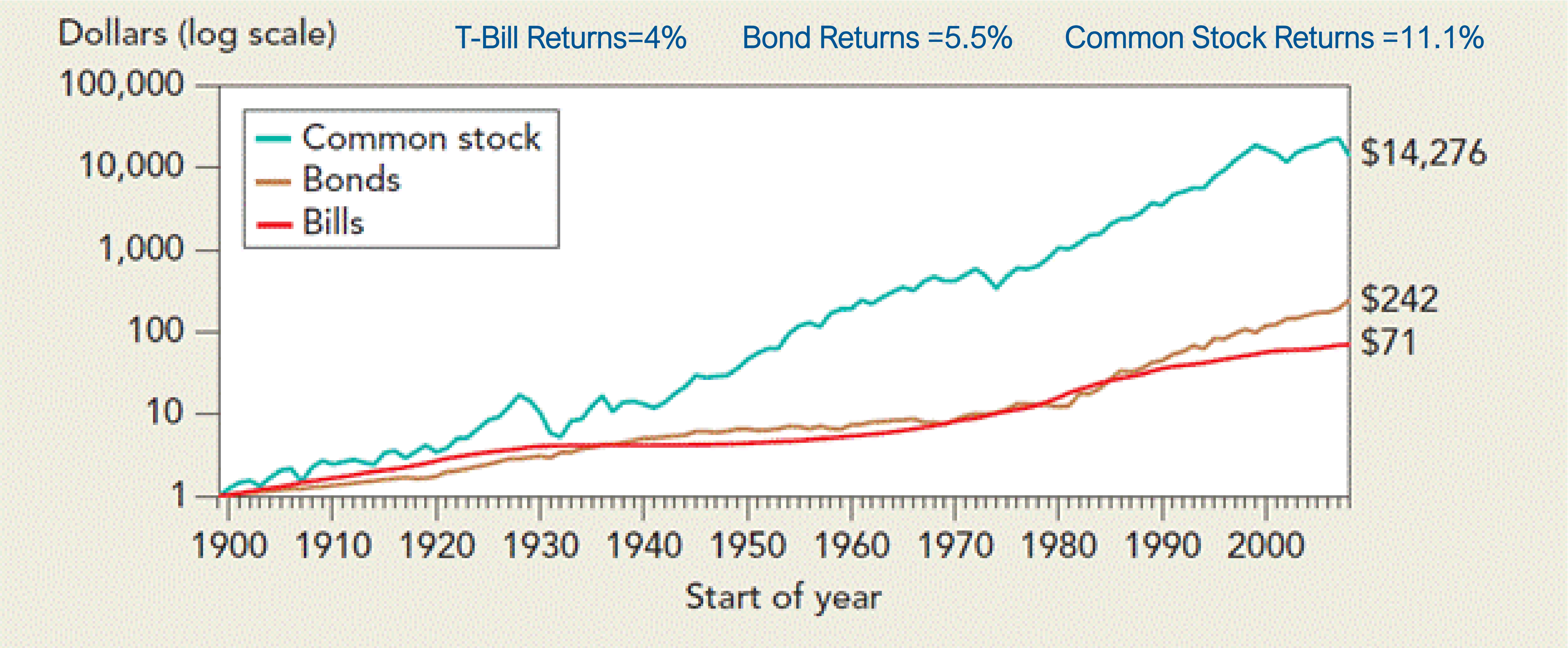
In this lesson, we will cover the following topics:

- Basics of risk-return framework
- Measures of risk
- Diversification of risk
- Computing portfolio risk
- Impact of individual securities on portfolio risk
- Summary and concluding remarks

Basics of Risk-Return Framework

- Consider three instruments: T-Bills, government bonds, and common stock.
- T-Bills are short maturity instrument with almost no risk of default.
- Bond is a rather long-term instrument and fluctuates with the interest rates.
- Common stocks are infinite maturity instruments.

Basics of Risk-Return Framework



Basics of Risk-Return Framework

- Notice the difference between the returns on T-Bills and common stocks is 11.1 - 4 = 7.1 percent.
- This additional return can also be called the risk-premium received by investors.
- If on a given year T-Bill rate was 0.2 percent, and you are asked to estimate the expected return on common stocks. A reasonable estimate would be obtained by adding this to 7.1 percent to obtain the total return of 7.30 percent.
- However, this assumes that there is a stable risk premium on the common stock portfolio, that is, future risk premium can be measured by the average past risk premium.
- But (a) Economic and financial conditions change over time; (b) Risk perceptions change; (c) Investors' risk tolerance and return expectations also change over time.

Basics of Risk-Return Framework

- Consider a stock with \$12 dividend expected by the end of the year
- Investors are expecting a 10% return on this stock
- P$V = \frac{DIV_1}{r-g} = \frac{12}{0.10-0.07} = \$400$; Dividend yield = 12/400 = 3%
- If dividend yield changes to 2%, and investors demand an expected return = 2% + 7% = 9%
- $PV = \frac{12}{0.09-0.07} = \$600$
- Expected returns on the stock reflect the dividend yields and the growth rate of dividends: $r = \frac{DIV_1}{P_0} + g$
- Risk-premium= $r - r_f$; this risk premium can change overtime
- Often dividend yield is a good indicator of risk-premium

Measures of Risk

- A very prominent statistical measure of risk is variance (or standard deviation)
- $Variance\ (r_t) = Expected\ value\ of\ (r_t - \bar{r})^2$
- Where r_t is the actual return and $\bar{r}$ is the expected returns
- $Standard\ deviation\ (SD) = \sqrt{Variance\ (r_t)}$
- Standard deviation is often denoted by the symbol σ and variance by σ^2

Measures of Risk

- Let us understand this concept with a small coin toss game
- The following probabilities are observed
  - (a) H + H: Gain 40%; (b) H + T: Gain 10%;
  - (c) T + H: Gain 10%; (d) T + T: Lose 20%
- Thus, there is a 25% chance that your return will be 40%, 50% chance that your return will be 10%, and 25% chance that you will lose 20%
- Expected return : $\bar{r}$=0.25*40% + 0.5*10% + 0.25*(-20%) = 10%.

Measures of Risk

- Now let us compute the variance and standard deviation of these returns.

Returns (%)	Mean Deviation $\mathbf{r_t} - \bar{\mathbf{r}}$)	Mean Square Deviation $(\mathbf{r_t} - \bar{\mathbf{r}})^2$	Probability	Probability Squared Deviation
40	30	900	0.25	225
10	0	0	0.50	0
-20	-30	900	0.25	225
			Total	450

- Variance = 225 + 225 = 450 and Standard Deviation (σ) = $\sqrt{(450)}$ = 21%
- An event is considered risky if there are many possibilities of outcomes associated with it.
- As these possibilities increase, that is, the spread of possible outcomes increases, the event is said to have become riskier.
- Standard deviation or variance is a summary measure of these possibilities, that is spread in the possible outcome.

Measures of Risk

- The risk of an asset can be completely expressed, by writing all the possible outcomes and the possible payoffs associated with each of the outcomes.
- If the outcome was certain, that is, it had no risk, then the standard deviation would have been zero
- One of the challenges in performing such computations is the estimation of probability associated with each outcome
- One way to go about this is to observe past variability
- For example, consider the historical volatilities of three different kinds of securities.

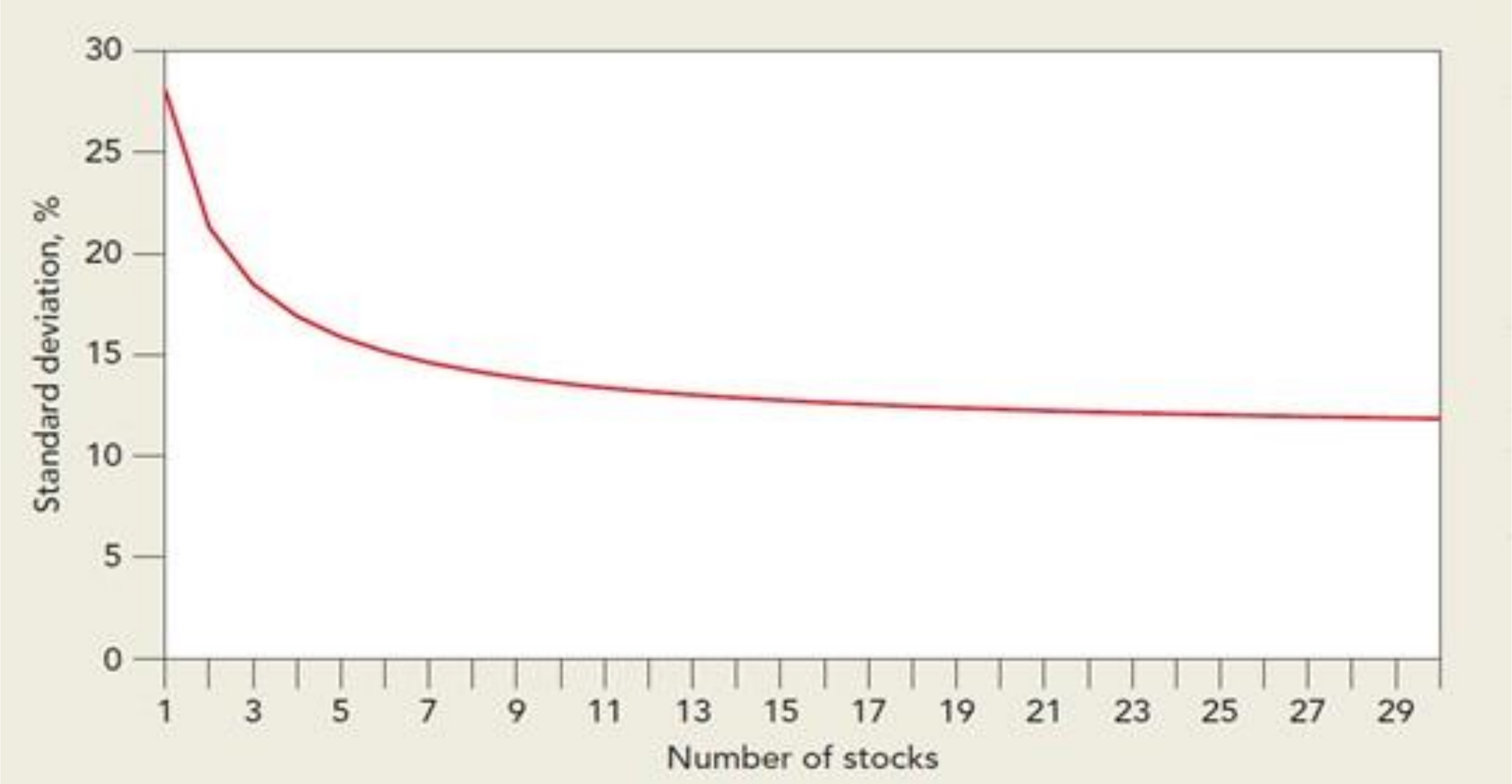
Portfolio	Standard Deviation (σ)	Variance (σ^2)
Treasury Bills	2.8	7.7
Government Bonds	8.3	69.3
Common Stocks	20.2	406.4

- It appears that T-Bills are the least variable and common stocks are the most variable

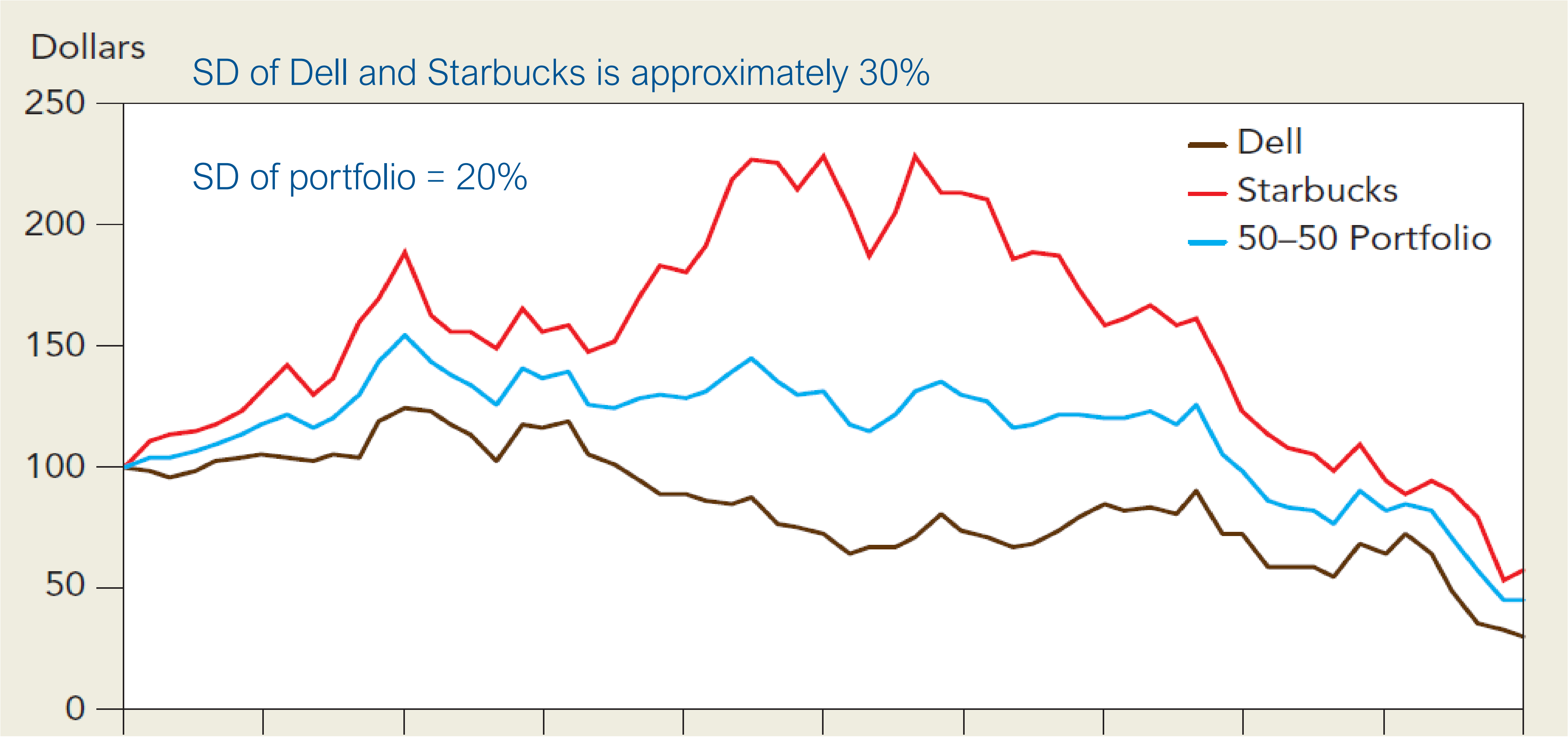
Diversification of Risk

- One can compute the measure of variability for individual securities as well as a portfolio of securities.
- The standard deviation of selected U.S. Common stocks (2004-08) such as Amazon (50.9%), Ford (47.2%), Newmont (36.1%), Dell (30.9%), and Starbucks (30.3%) was much less than the standard deviation of a market portfolio, that is, 13% during this period.
- It is well known that individual stocks are more volatile than the market indices.
- The variability of market doesn’t reflect or is the same as the variability of individual stock components.
- The simple answer to this question is that diversification reduces variability.

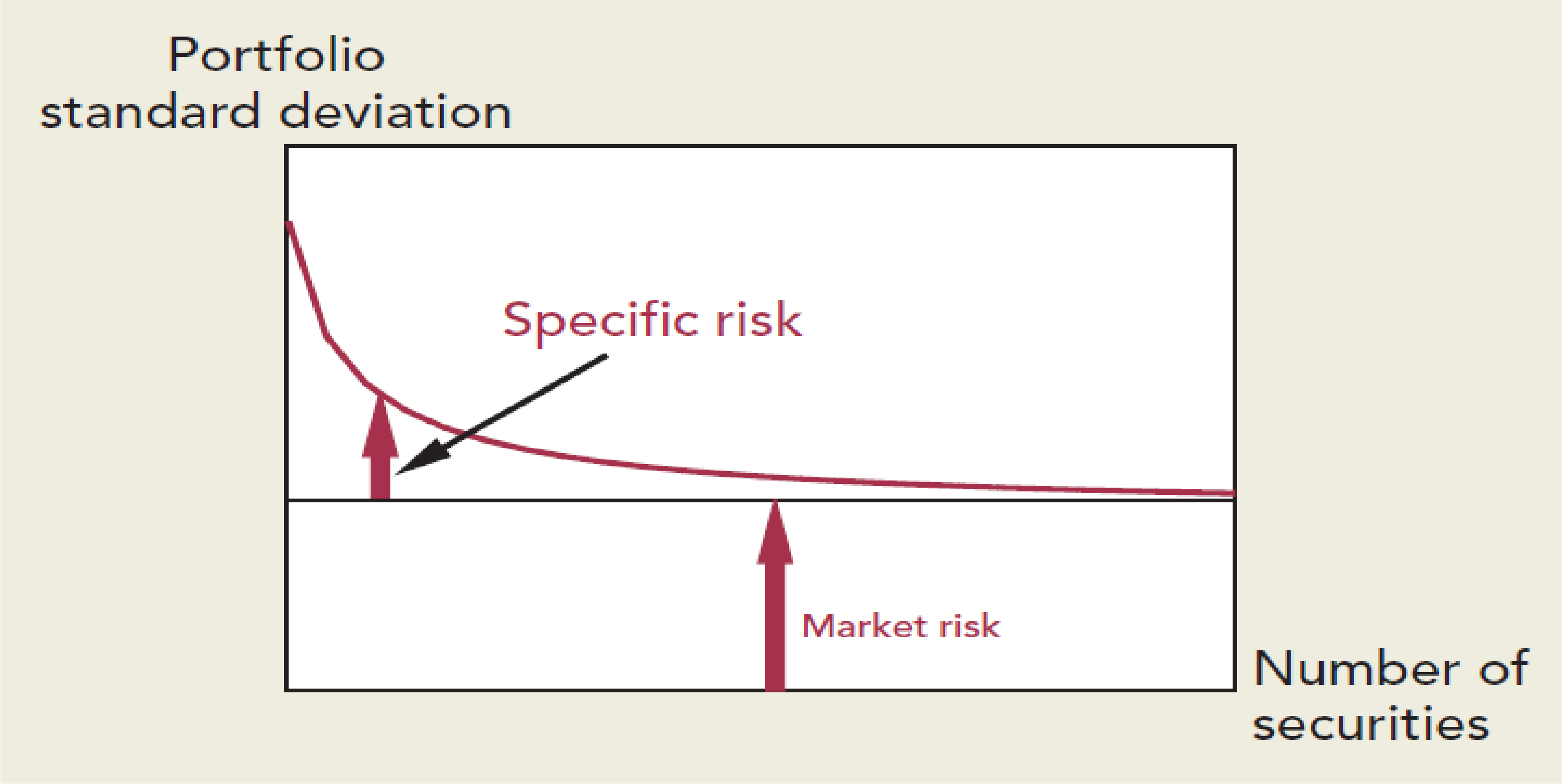
Diversification of Risk



Diversification of Risk



Diversification of Risk



Computing Portfolio Risk

- We now know that diversification reduces the risk of a portfolio
- Consider a portfolio comprising two stocks, A (60%) and B (40%)
- A has expected returns of 3.1%, and B has expected returns of 9.5%
- $Expected\ portfolio\ return = 0.6 * 3.1 + 0.40 * 9.5 = 5.7\%$
- Standard deviation of A is observed as 15.8% for A and 23.7% for B
- Therefore, the standard deviation of this portfolio: 0.6*15.8% + 0.4*23.7% = 19.0%?
- This would be incorrect

Computing Portfolio Risk

$$Portfolio\ Variance = x_1^2\sigma_1^2 + x_2^2\sigma_2^2 + 2(x_1 x_2 \rho_{12}\sigma_1\sigma_2)$$

$$Covariance\ (\sigma_{12}) = \rho_{12}\sigma_1\sigma_2$$

Correlation coefficient $(\boldsymbol{\rho_{12}})$

$= \rho_{12}\sigma_1\sigma_2$

	Stock 1	**Stock 2**
Stock 1	$x_1^2\sigma_1^2$	$x_1x_2\sigma_{12} = x_1x_2\rho_{12}\sigma_1\sigma_2$
Stock 2	$x_1x_2\sigma_{12} = x_1x_2\rho_{12}\sigma_1\sigma_2$	$x_2^2\sigma_2^2$

Computing Portfolio Risk

- Let us fill the above box with some numbers; assume a correlation coefficient of 1

	Stock A	Stock B
Stock A	$x_1^2\sigma_1^2 = 0.6^2 * 15.8^2$	$x_1x_2\sigma_1\sigma_2 = 0.6 * 0.4 * 1 * 15.8 * 23.7$
Stock B	$x_1x_2\sigma_1\sigma_2 = 0.6 * 0.4 * 1 * 15.8 * 23.7$	$x_2^2\sigma_2^2 = 0.4^2 * 23.7^2$

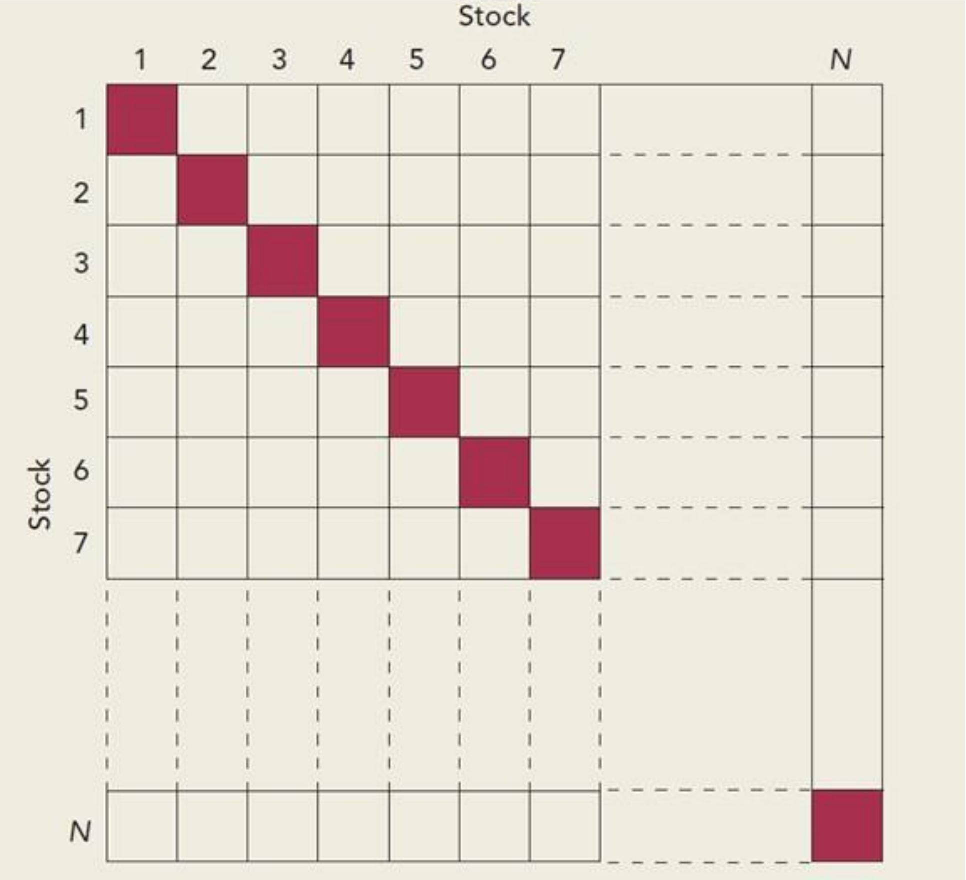
- Portfolio variance = $0.6^2 * 15.8^2 + 2 * 0.6 * 0.4 * 1 * 15.8 * 23.7 + 0.4^2 * 23.7^2 = 359.5$
- The standard deviation is $\sqrt{359.5} = 19\%$
- Let us now assume a correlation coefficient of $\rho_{12} = 0.18$
- Portfolio variance= $0.6^2 * 15.8^2 + 2 * 0.6 * 0.4 * 0.18 * 15.8 * 23.7 + 0.4^2 * 23.7^2 = 212.1$
- The standard deviation is $\sqrt{212.1} = 14.6\%$

Computing Portfolio Risk

- Let us consider a very hypothetical case of extreme negative correlation $\rho_{12} = -1$
- Portfolio variance = $0.6^2 * 15.8^2 + 2 * 0.6 * 0.4 * (-1) * 15.8 * 23.7 + 0.4^2 * 23.7^2 = 0!$
- However, perfect negative correlations do not exist in real markets.

Computing Portfolio Risk

- Variances in diagonal boxes $(x^2\sigma^2)$
- Covariance terms in off-diagonal $(x_i x_j \sigma_{ij})$
- Let us consider a case of N securities and equal investment in all the securities $(\frac{1}{N})$
- Portfolio variance can be computed in the form of two components. That is, variance component and covariance component



Computing Portfolio Risk

- There will be N variance terms; then portfolio variance can be simply written as $N * \frac{1}{N^2} * (Average\ variance)$
- Remember $w_1 * w_2 * \sigma^2. Here\ w_1 = w_2 = \frac{1}{N}; and\ \sigma = average\ variance = \sigma_{Avg}$
- Also, $N^2 - N$ covariance terms where average covariance term $= \sigma_{Cov-Avg}$
- The sum of covariance terms is $(N^2 - N) * \frac{1}{N^2} * \sigma_{Cov-Avg}$
- $Portfolio\ Variance = N * \left(\frac{1}{N^2}\right) * (Average\ Varinace) + (N^2 - N) * \left(\frac{1}{N^2}\right) * (Average\ Covariance)$
- As the number of securities, N, in the portfolio increase, the specific-risk term, $N * \left(\frac{1}{N^2}\right) * (Average\ Varinace)$, approaches to a value of zero

Computing Portfolio Risk

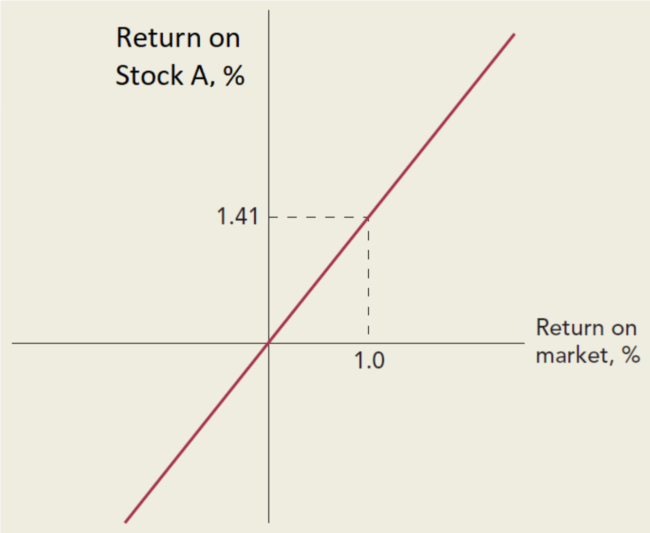
- Thus, the overall portfolio variance approaches the average covariance term
- This is also often referred to as portfolio diversification
- Thus, if these securities have very low correlation, then one can obtain a portfolio with very low risk
- That is, just by increasing the number of securities in a portfolio, one can eliminate the idiosyncratic (specific or diversifiable risk)
- The remaining risk is often called market risk or non-diversifiable risk
- That is why, this market risk (or average covariance or non-diversifiable risk) is what constitutes the bedrock of risk, that is risk that is there after eliminating all the specific risk

Impact of Individual Securities on Portfolio Risk

- Investors usually add many securities in their portfolio to diversify the stock-specific idiosyncratic risk
- It is not the risk of a security held individually but in a portfolio that is important
- To measure the impact of a security to the risk of portfolio, one needs to measure the market risk component of the security
- The market risk of a security is measured through its beta
- Stocks with beta of more than 1.0 tend to amplify the movements of market
- Stocks with beta between 0 to 1.0 tend to move in the same direction as market, but are considered less sensitive
- The market portfolio has a beta of 1.0 and reflects the average movement of all the stocks in the market

Impact of Individual Securities on Portfolio Risk

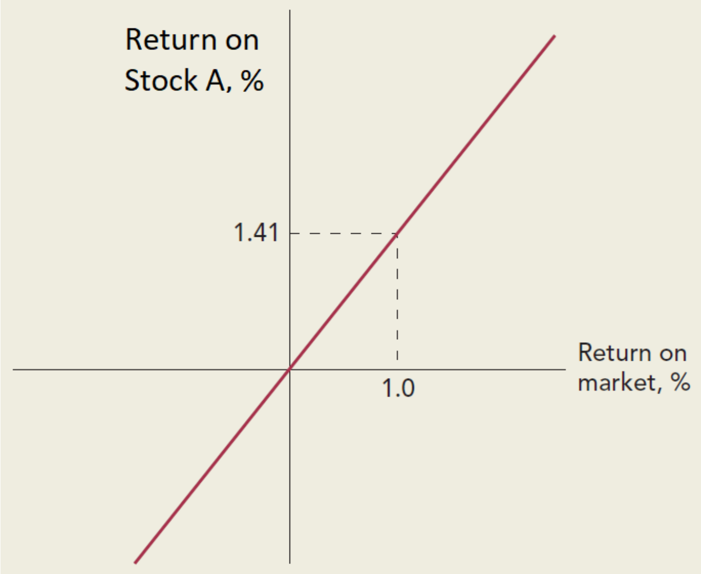
- Consider a stock A with beta of 1.41 over a given time-horizon
- This means that, on average, when market rises by 1%, stock A will rise by 1.41%
- The stock would also have some stock-specific risk



- When a stock is added to a well-diversified portfolio, the movements on account of idiosyncratic factors are expected to cancel each other out
- Therefore, for this portfolio what matters is only these systematic market related effects

Impact of Individual Securities on Portfolio Risk

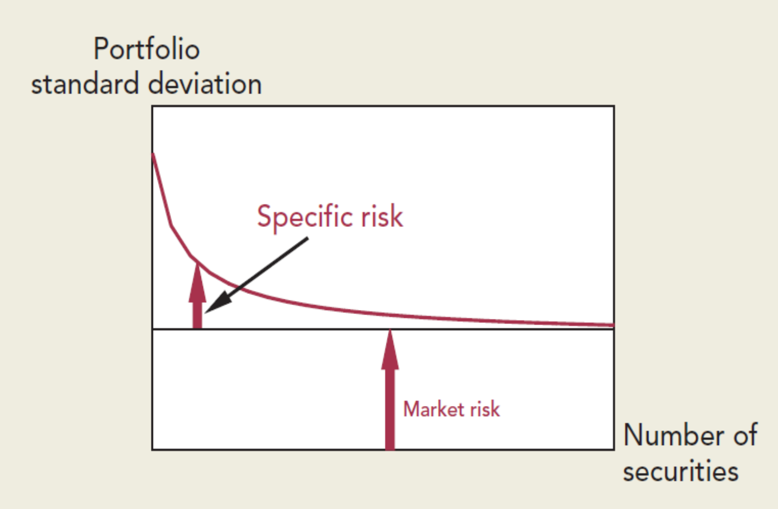
- Stocks like Stock A with high beta will have steep straight curve
- Stocks with small beta (e.g., beta = 0.3), the straight-line plot will be less steep
- A stock with high beta may also have less idiosyncratic risk and a stock with low beta may also have high idiosyncratic risk



- For example, a stock of gold-mining firm may have low beta and a very high idiosyncratic stock specific risk
- When added to a well-diversified portfolio, the idiosyncratic risk of this gold-firm will not matter

Impact of Individual Securities on Portfolio Risk

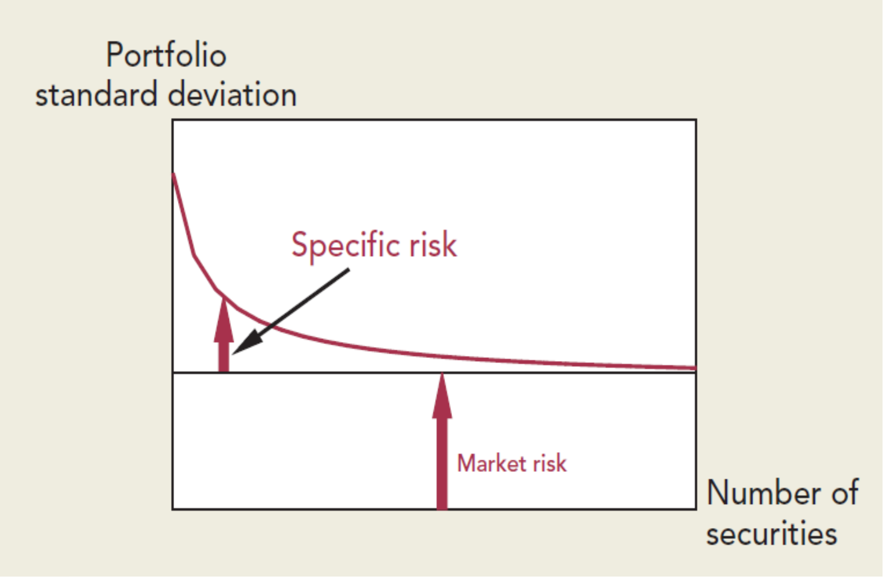
- So, let us now answer this question how security betas affect the portfolio risk
- Market risk accounts for most of the risk of a well-diversified portfolio
- Beta of an individual security measures its sensitivity to market movements



- Examine the figure shown here: the standard deviation (total risk) of the portfolio depends on the number of securities in the portfolio
- As the number of securities increase in the portfolio, more diversification is achieved

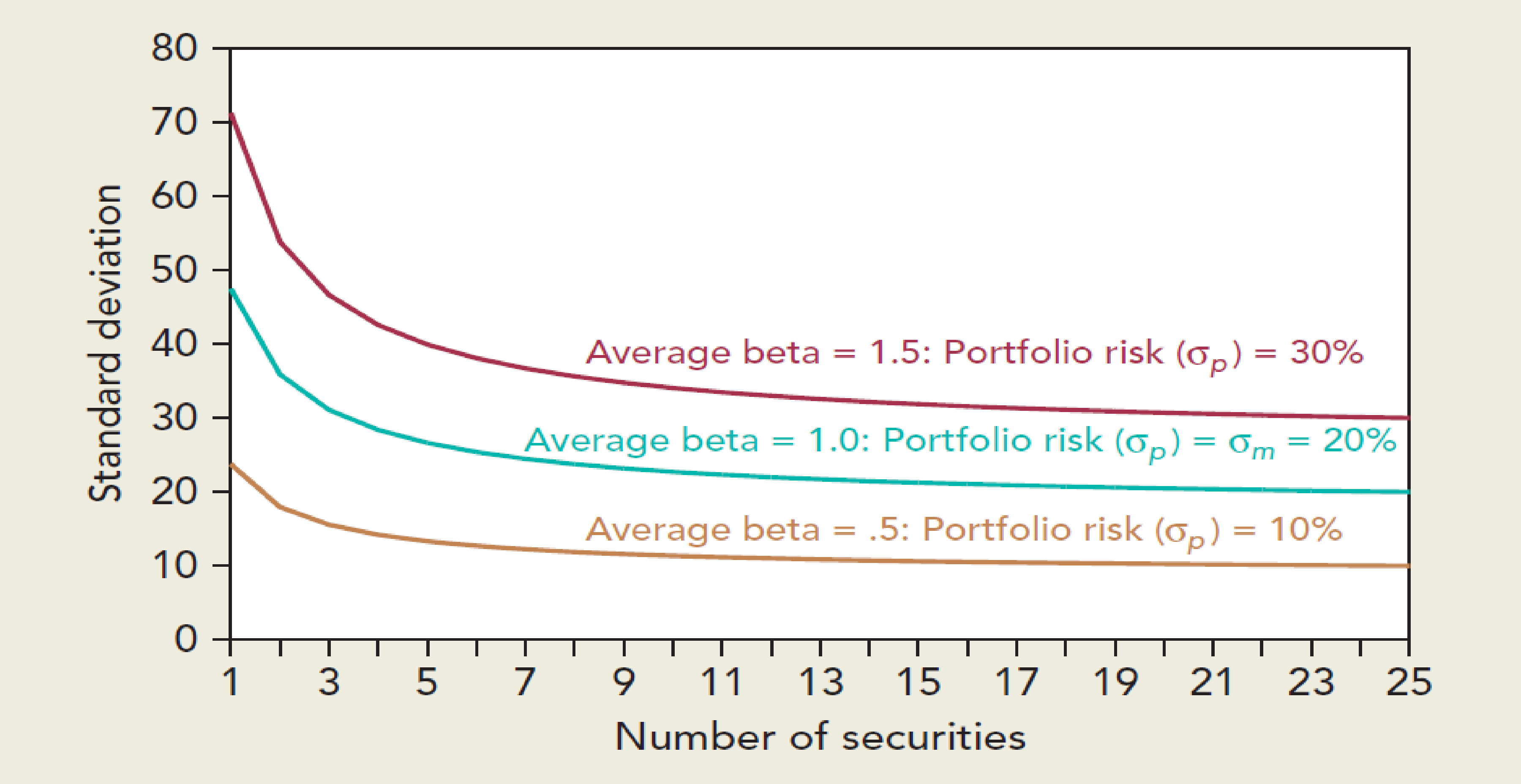
Impact of Individual Securities on Portfolio Risk

- With addition of more and more securities, the specific risk declines until all the stock specific risk is eliminated and only market risk remains
- Market risk depends on the average beta of the securities, that is, the portfolio beta
- If one selects a fairly large number of securities from a market, you diversify all the idiosyncratic risk



- Thus, you get the market portfolio with beta = 1.0
- If the market portfolio has a standard deviation of 20%, then this portfolio is expected to have a standard deviation of close to 20%

Impact of Individual Securities on Portfolio Risk



Impact of Individual Securities on Portfolio Risk

- Beta of a stock 'i' can be computed using the following formula. $\beta_i = \sigma_{im}/\sigma_m^2$. Here σ_{im} is the covariance between the stock returns and market returns. σ_m^2 is the variance of the returns on the market.

1	2	3	4	5	6	7
Month	Market Return (%)	Deviation in Market Returns	Squared Market Deviation	Stock A	Deviation in Stock A Returns	Deviation Product (3*6)
1	-8	-10	100	-11	-13	130
2	4	2	4	8	6	12
3	12	10	100	19	17	170
4	-6	-8	64	-13	-15	120
5	2	0	0	3	1	0
6	8	6	36	6	4	24
	Avg.= 2		Sum=304	Avg.= 2		Sum=456
Variance= $\sigma_m^2 = \frac{304}{6} = 50.67$						
Co-variance= $\sigma_{im} = \frac{456}{6} = 76$						
Beta= $\beta_i = \frac{\sigma_{im}}{\sigma_m^2} = \frac{76}{50.67} = 1.5$						

Impact of Individual Securities on Portfolio Risk

- Can we say that a diversified firm is more attractive to investors than an undiversified firm
- If diversification is a good objective for a firm to pursue then each new project's contribution to the firm's diversification should also add value to the firm.
- This seems to be not consistent with what we have studied about present values
- Investors can diversify for themselves more easily than firms.
- If investors can diversify on their own, they would not be paying anything extra to a firm for this diversification.
- The present value of any number of assets is equal to the present value of their parts. That is, PV (ABC) = PV(A) + PV(B) + PV(C): Value Additivity

Summary and Concluding Remarks

- Returns to investor vary depending upon the risk borne by them.
- Very safe instruments such as treasury securities provide the lowest returns.
- Equity securities are considered more riskier asset class and offer higher expected returns.
- Accordingly, the discount rates applied to a safe project versus risky project will also differ.
- Risk of a security means that there are many possible return outcomes for that security…
- The total risk of a stock has two components: stock-specific risk and systematic (or market) risk.

Summary and Concluding Remarks

- Investors eliminate a sizable portion of their specific (or diversifiable) risk, simply by adding more securities to their portfolio.
- A well diversified portfolio is only exposed to market risk.
- A security's contribution to a well diversified portfolio measured as the sensitivity of the security to market movements, that is, beta (β).
- A stock with high beta is more sensitive to market movements and vice-versa.
- Investors can diversify on their personal account; they do not want firms to pursue the diversification objective.

Thanks!

INDIAN INSTITUTE OF TECHNOLOGY KANPUR

Artificial Intelligence (AI) for Investments

Lesson 7: Portfolio Theory and Asset Pricing Model

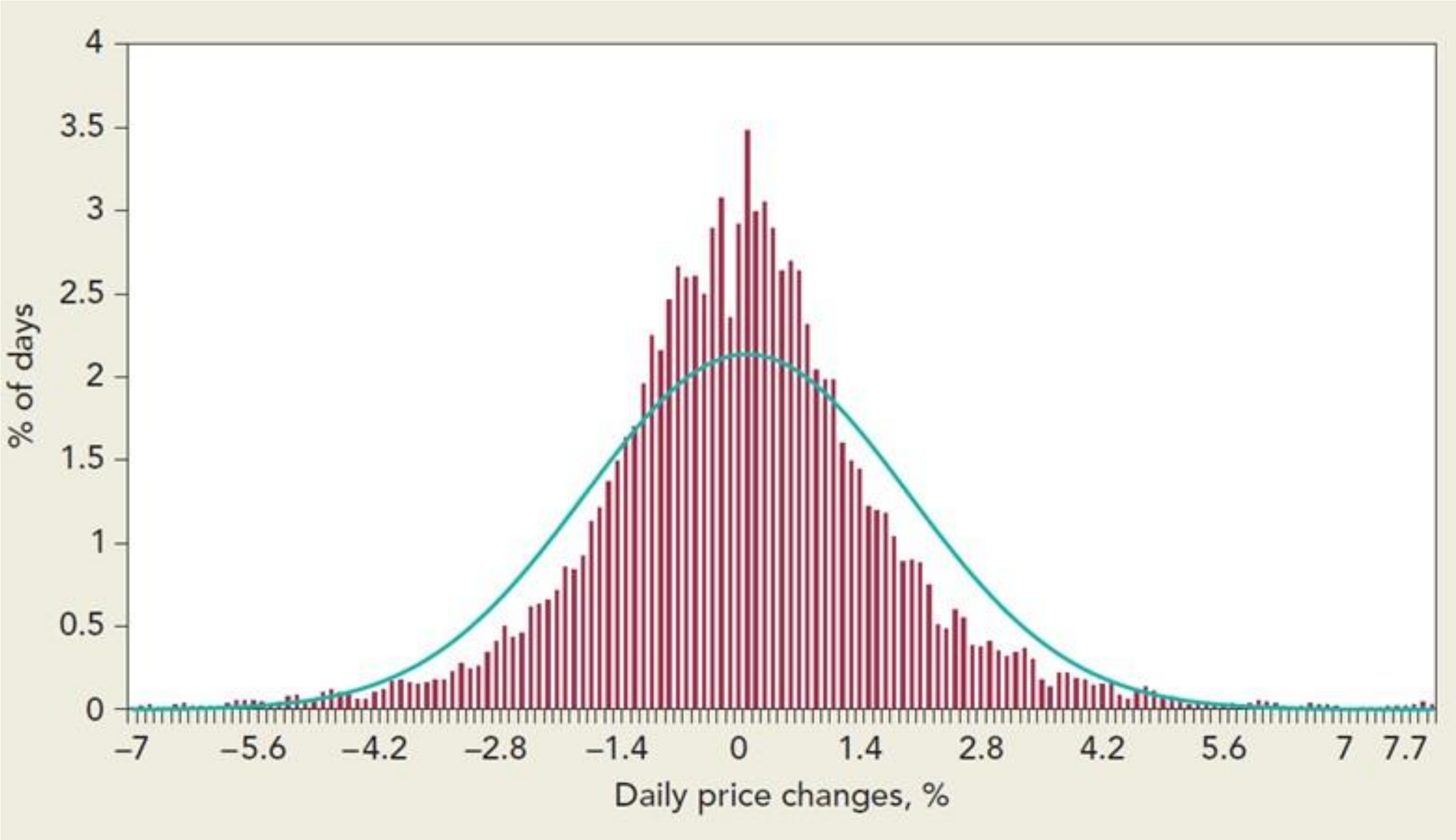
Introduction

In this lesson we will cover the following topics:

- Investment performance and return distribution
- Combining stocks with portfolios
- Introduction to CAPM
- Validity of CAPM
- Alternative theories of asset pricing
- Summary and concluding remarks

Investment Performance and Return Distribution

Investment Performance and Return Distribution



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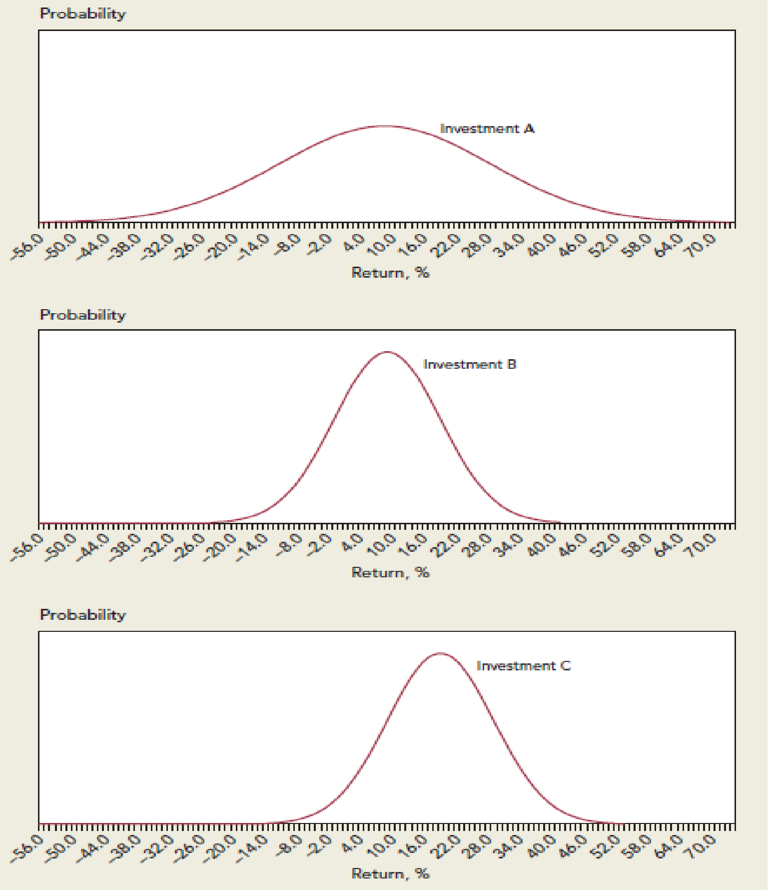
Investment Performance and Return Distribution

- Compare investments A and B. These investments offer an expected returns of 10%. But A has much wider spread of possible outcomes (SD of A is 15% and that of B is 7.5%).
- Compare investments B and C. Both of them have the same standard deviation. However, the expected returns from B (10%) and C (20%) are different.



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Combining Stocks with Portfolios: Part 1

Combining Stocks with Portfolios

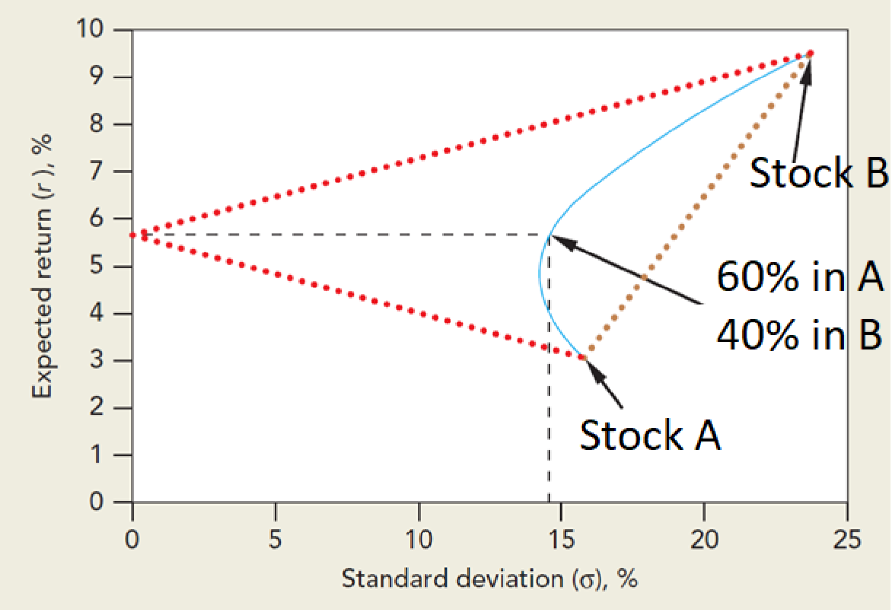
- Consider a scenario where you are examining stocks A and B as potential investments.
- Stock A offers 3.1% expected returns and Stock B offers 9.5% expected returns.
- Stock A has a standard deviation of 15.8% and stock B has a standard deviation of 23.7%.
- You can invest in a combination of these stocks.
- If you invest 60% in stock A and 40% in stock B then the expected return from this portfolio, is 0.60*3.1% + 0.40*9.5% = 5.66%.
- The same can not be said about the risk of the portfolio.

Combining Stocks with Portfolios

- The risk of a portfolio, that is standard deviation (SD), is less than the simple weighted average of individual stock SDs.
- $\mathrm{Variance} = x_1^2\sigma_1^2 + x_2^2\sigma_2^2 + 2 * x_1x_2\sigma_1\sigma_2 = 0.60^2 * 15.8^2 + 0.4^2 * 23.7^2 + 2 * (0.60 * 0.40 * 0.18 * 15.8 * 23.7) = 212.1;$ $\mathrm{Standard\ Deviation} = \mathrm{Sqrt}(212.1) = 14.6\%$
- The lower amount of SD reflects the diversification aspect, assuming a correlation of 0.18.

Combining Stocks with Portfolios

- The blue curve line shows all the possible expected risk and return combinations of these two stocks that one can achieve.
- A risk averse investor would hold A:B (50:50 or 60:40)
- A less risk-averse investor would invest most of their wealth in B.



- The brown line connecting A and B represents all portfolio combinations with correlation $(\rho) = 1.0$
- With $\rho = -1.0$ (red line), the stocks would move in exact opposite manner.

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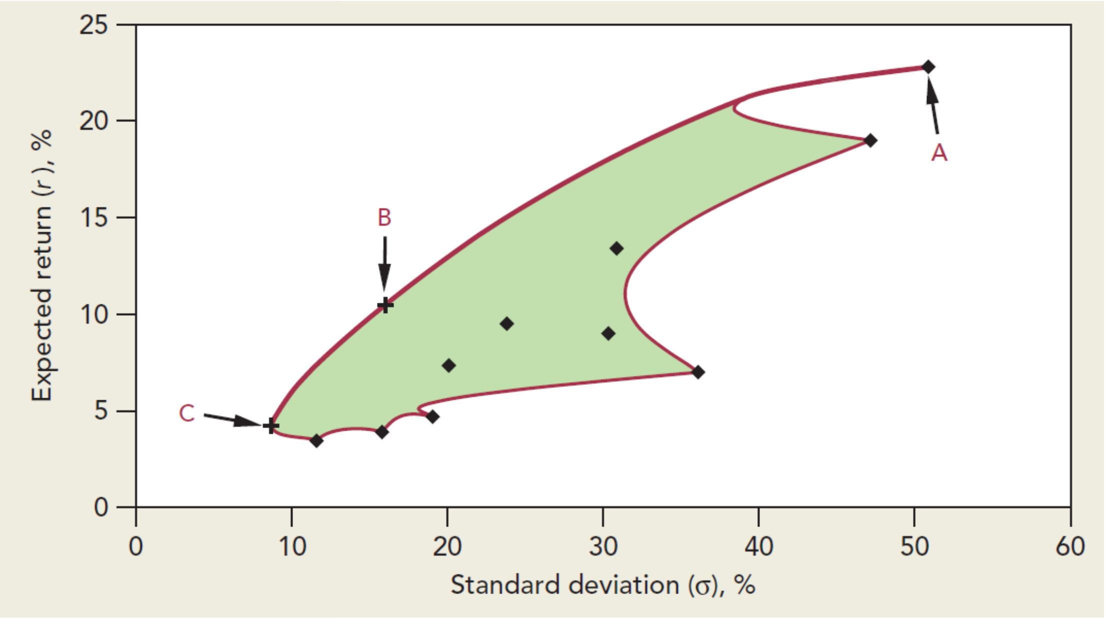
Combining Stocks with Portfolios

- In practice, you invest in many socks, by examining their historical risk-return related properties.
- For example, consider a portfolio of ten securities plotted here using risk-return data.
- The shaded green region shows the possible combinations of expected return and standard deviation by investing in a mixture of these stocks.



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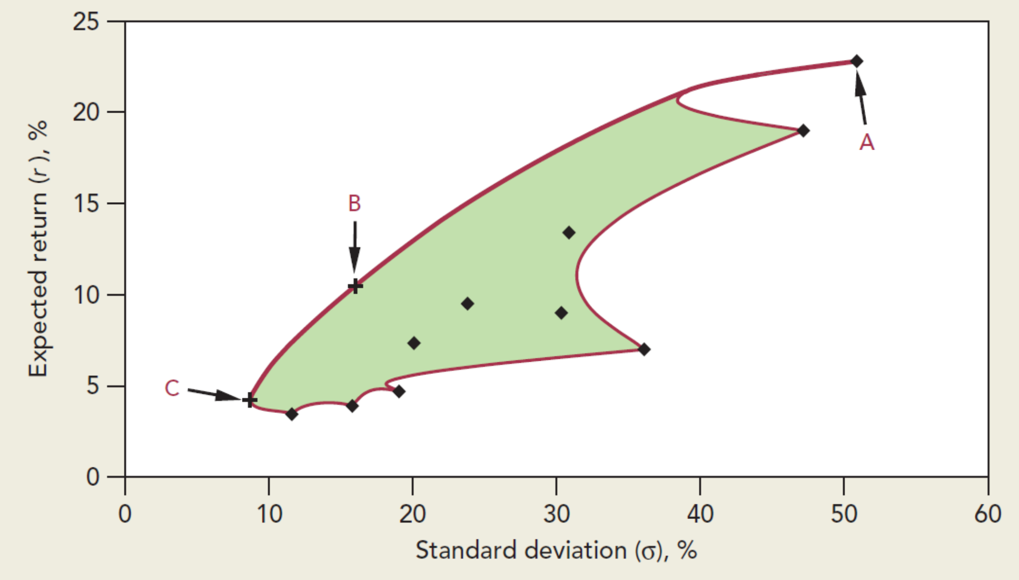
Combining Stocks with Portfolios

- Where would you want to be in that shaded region?
- You would want to go up, that is, increase the expected returns. You would also want to go left, that is, to reduce risk.
- As you move up and left, you end up at the solid dark brown line.



- The portfolio on this solid dark outer surface is often referred to as an efficient portfolio.

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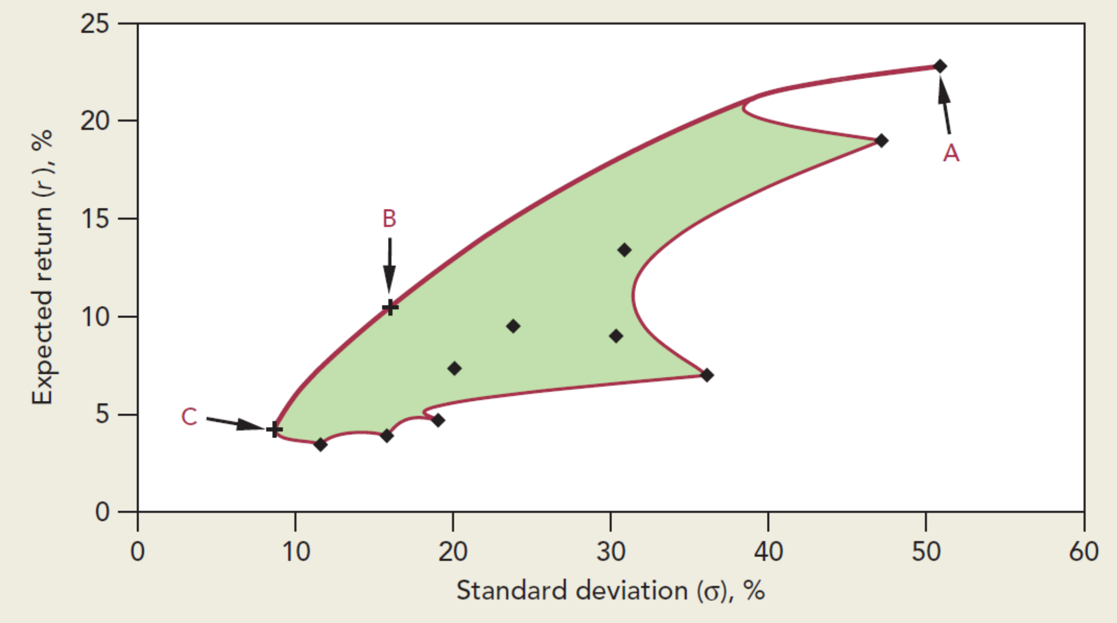
Combining Stocks with Portfolios

- For a given level of risk, these portfolios offer the highest return. And for a given level of return, these portfolios offer the lowest amount of risk.
- Three such portfolios (A, B, and C) are shown in the figure here.



- You want to deploy the investor's funds to generate maximum expected returns for a given level of risk.
- This solution to this problem requires quadratic programming (QP).

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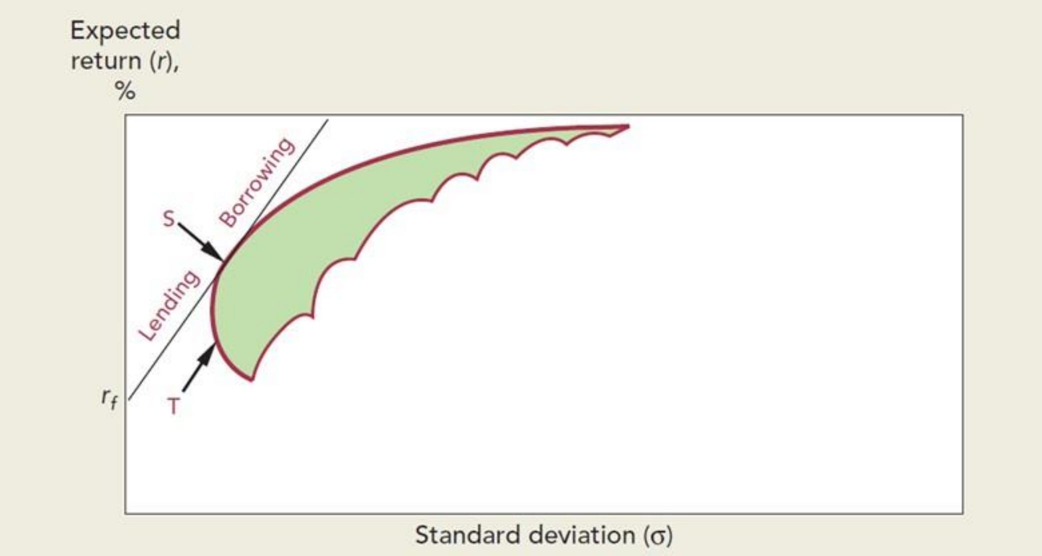
Combining Stocks with Portfolios: Part 2

Combining Stocks with Portfolios

- Now we introduce the possibility of lending and borrowing at a risk-free rate of interest (rf).
- Is this possibility a practical scenario?
- A combination of rf and any efficient portfolio (e.g., S) can offer various risk-return possibilities on the line rf-S.



- Investing in rf and S leads a portfolio on the line segment between rf and S.
- Borrowing at rf and investing the entire amount in S leads a position on rf-S towards the right of S.

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Combining Stocks with Portfolios

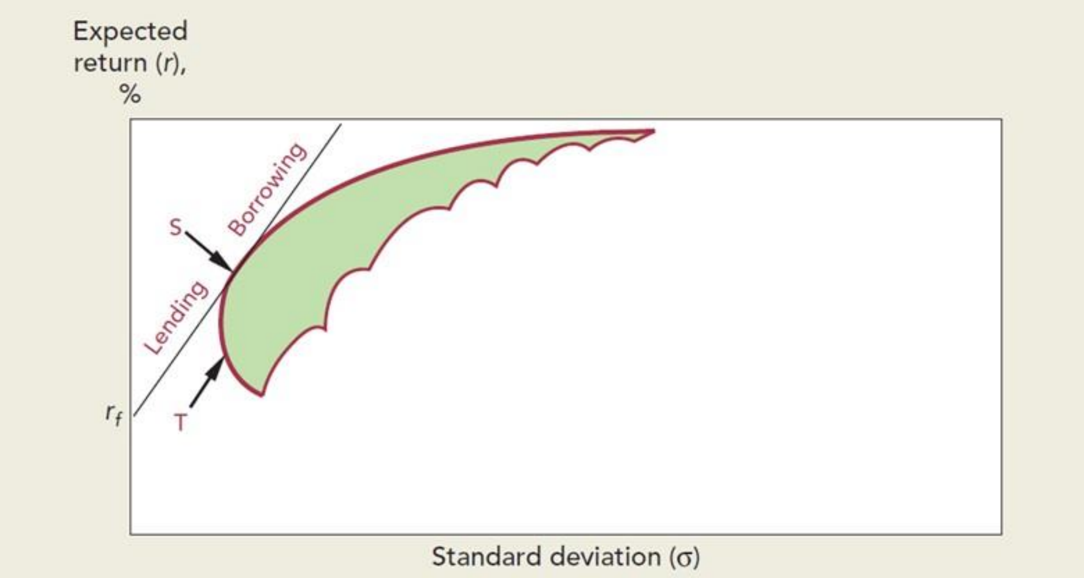
- Suppose that portfolio S has an expected return of 15% and a standard deviation of 16%.
- For risk-free instrument rf = 5% and risk = 0.
- If you decide to invest 50% in S and 50% in rf, the expected return and risk as computed here.
- $r = \frac{1}{2} * Expected\ Return\ on\ S + \frac{1}{2} * Interest\ Rate\ on\ Risk - free$ = 10%
- The formula for computation of risk: $SD = \sqrt{(x_1^2\sigma_1^2 + x_2^2\sigma_2^2 + 2x_1x_2\rho_{12}\sigma_1\sigma_2)}$ [Here, σ_2 = 0]
- $\sigma = \frac{1}{2} * SD\ of\ S$ = 0.5*15% = 8%

Combining Stocks with Portfolios

- Consider another scenario where you borrow at the risk-free rate an amount equal to 100% of your initial wealth.
- You invest your initial 100% wealth along with these borrowings in Portfolio S. That is double the amount of your initial wealth.
- Expected returns: $r = (2 * expected\ return\ on\ S) - (1 * Interest\ rate) = 25\%$
- Risk $\sigma = 2 * SD\ of\ S = 32\%$

Combining Stocks with Portfolios

- On the efficient region, you can always find a portfolio S that is the best efficient portfolio.
- How to find this portfolio?
- The steepest line (from rf) on the curve representing efficient portfolios: tangent line



- This tangent line has the highest ratio of risk-premium to standard deviation: Sharpe Ratio
- $Sharpe\ ratio = \frac{Risk-Premium}{Standard\ Deviatio} = \frac{r-r_f}{\sigma}$

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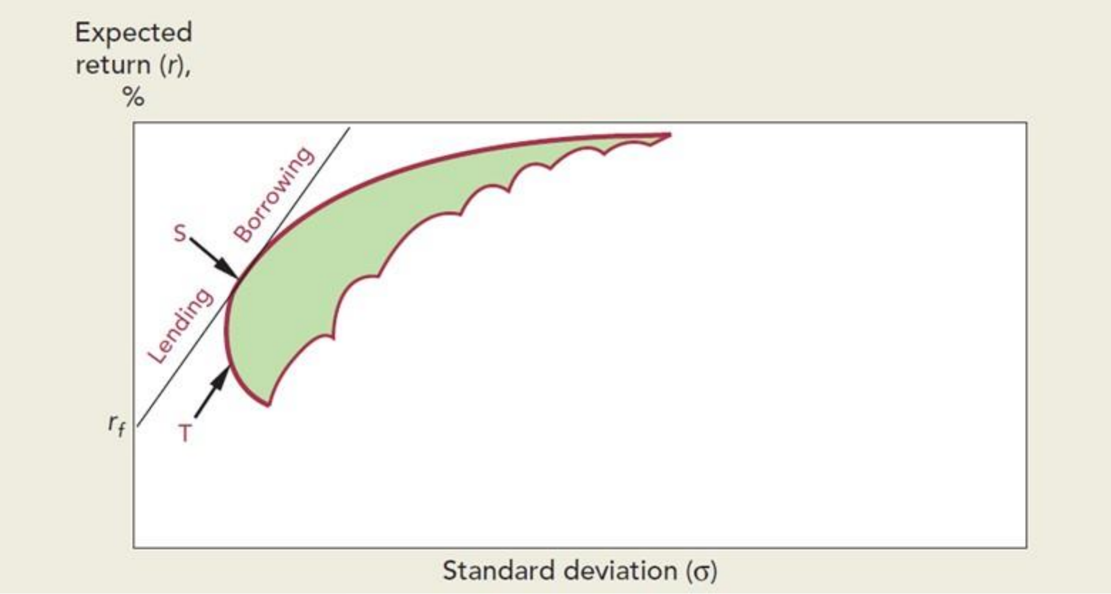
Combining Stocks with Portfolios

- In a competitive market, it is extremely difficult to find undervalued securities.
- Professional investors often investment in benchmark indices (e.g., S&P 500).
- This is often referred to as the passive strategy of investment.



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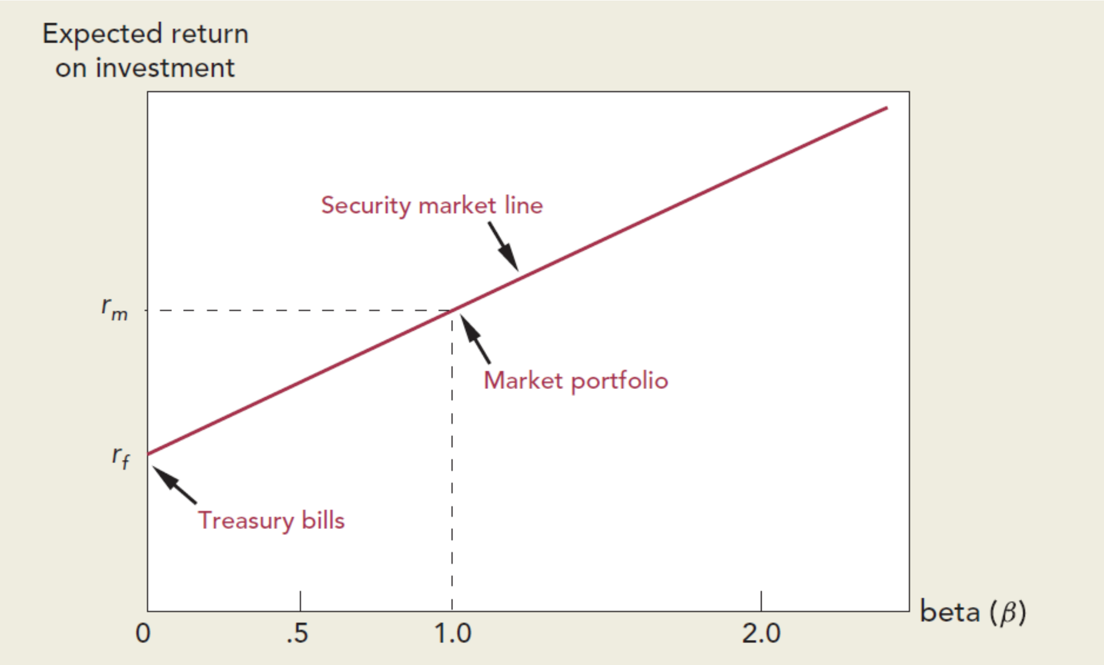
Introduction to CAPM

Introduction to CAPM

- We have previously examined the returns on different instruments.
- T-Bills have a beta = 0, and the market portfolio has a beta = 1.
- Difference between market risk (rm) and risk-free rate (rf) is often referred to as market risk premium.
- Using these benchmarks, we can determine the risk-premium for instruments for which beta is neither 0 nor 1.

Introduction to CAPM

- In 1960s, three economists, Sharpe, Lintner, and Treynor came-up with this model called Capital Asset Pricing Model (CAPM) that provides an extremely simple and easy to use solution for the asset pricing problem.
- In a competitive economy, the risk-premium is directly proportional to beta.



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Introduction to CAPM

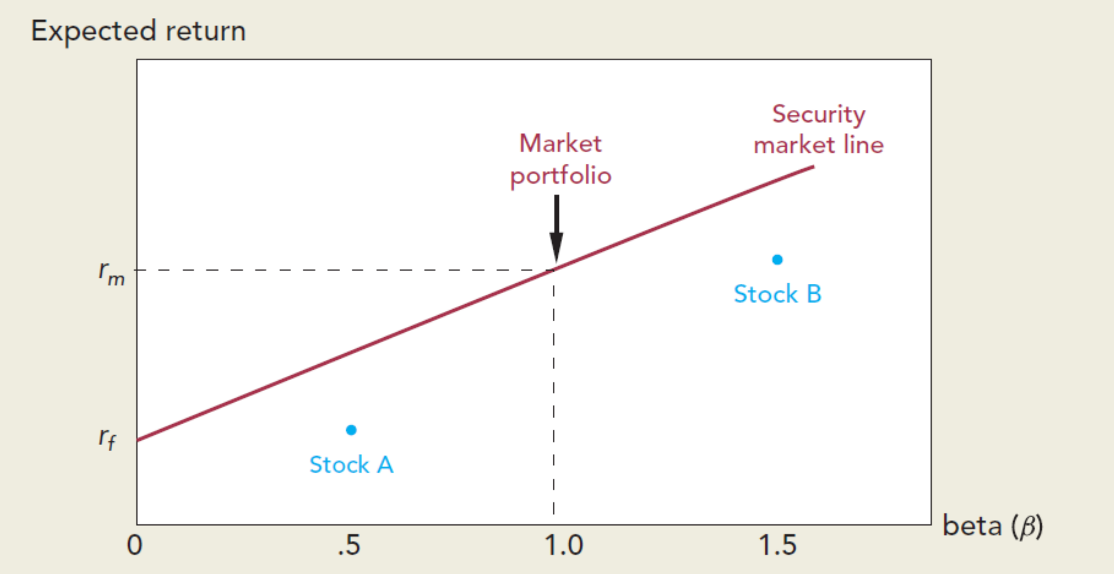
- The risk-premium on an investment with beta of 0.5 should be half of that available on the market.
- The expected risk-premium on an investment with beta of 2 is twice the risk-premium expected on the market.
- The resulting relationship is shown here: $r - r_f = \beta * (r_m - r_f)$
- Consider two stocks with beta of 0.30 (Stock A) and 2.16 (Stock B). You also observe that the market is offering a current risk-premium of 7% $(r_m - r_f)$ and the current treasury bill rate is 0.2%.
- $r_A = r_f + \beta * \left(r_m - r_f\right) = 0.20\% + 0.30 * 7\% = 2.30\%$
- $r_B = r_f + \beta * \left(r_m - r_f\right) = 0.20\% + 2.16 * 7\% = 15.32\%$

Introduction to CAPM

- CAPM can also be employed to estimate discount rates for risky projects and companies.
- To estimate discount rates, different risk factors, appropriate benchmark for risk-free rates needs to be estimated.
- The following principles are sacrosanct:
  - Investors like higher expected returns and low risk.
  - If the investors can lend and borrow at risk-free rate of interest, then one portfolio is better than all the other portfolios.
  - This best efficient portfolio depends on (a) expected returns, (b) standard deviation, and (c) correlations across securities.
  - In a well-diversified portfolio, only systematic risk matters.

Introduction to CAPM

- If stocks A and B (overvalued) do not fall on this line, then you will not buy them.
- Given the less demand and excess supply, the prices of A and B will fall until the expected returns lie on SML.
- The same logic applies to undervalued stocks as well.



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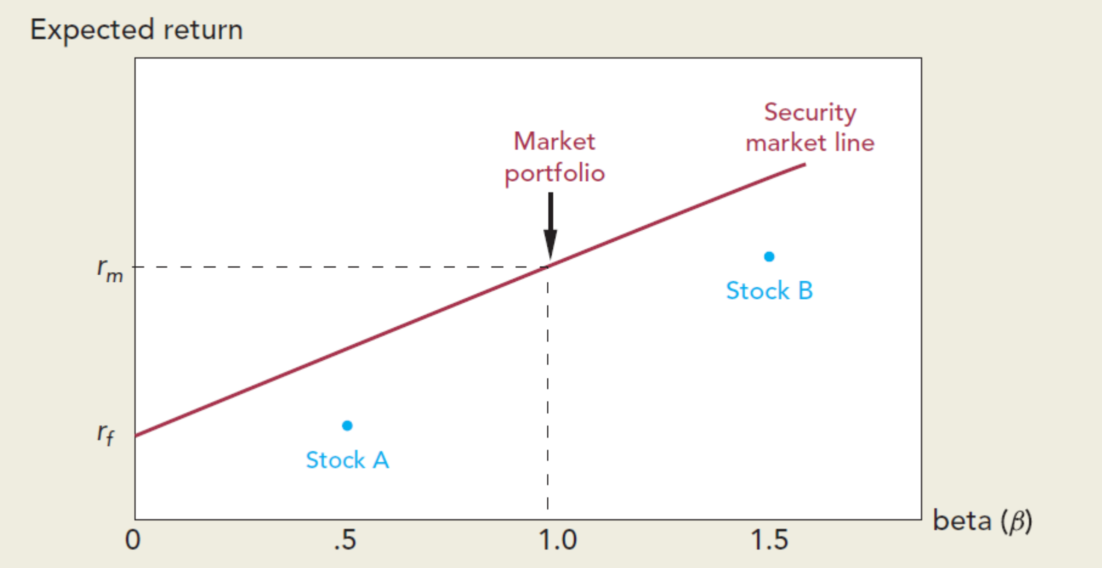
Introduction to CAPM

- Investors can hold a combination of market portfolio M and risk-free rate rf, to obtain an expected return $\bar{R} = r_f + \beta(r_m - r_f)$
- In well-functioning liquid and efficient markets, nobody will hold a stock that offers anything less.



- Equilibrium is obtained from the arbitrage mechanism, which drives prices towards efficient values, that is, towards this SML.

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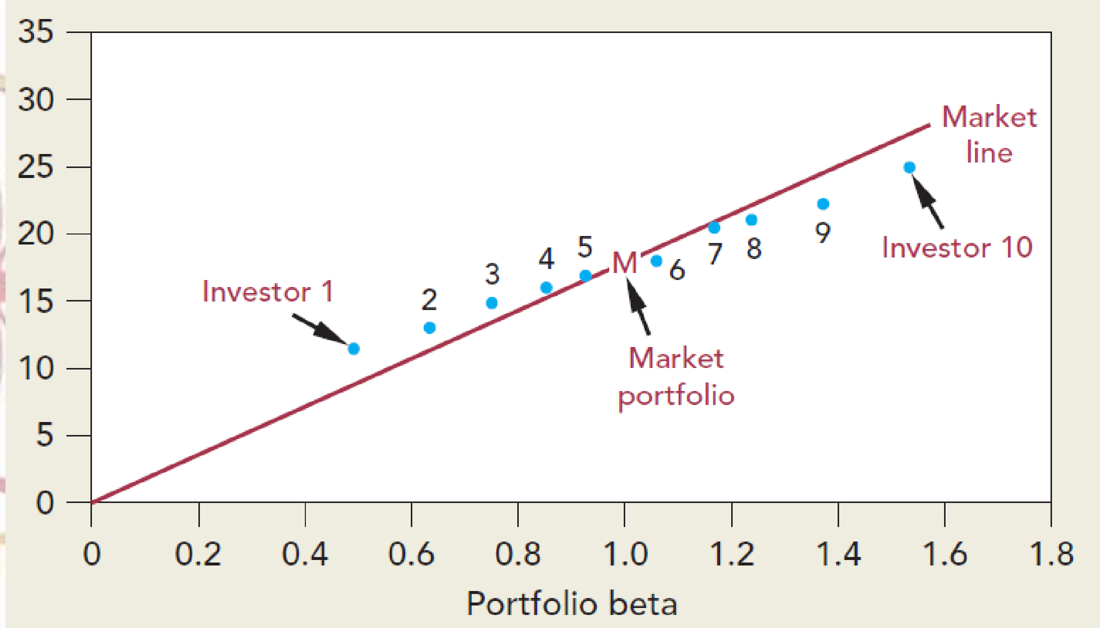
Validity of CAPM

Validity of CAPM

- Any economic model aims to provide a simple view of actual and real-world scenarios.
- There is a trade-off that the real thing may be far-away from the model if the model is too simple.
- Otherwise, the complexity has to be increased to make it closer to the real thing.
- Investors are rational, risk-averse individuals that require extra-return for taking on additional risk.
- Investors do not worry about those risks that can be diversified.
- The power of CAPM lies in its extreme simplicity, and it also has some pitfalls.

Validity of CAPM

- Ten investors portfolio returns are plotted.
- Investor 1 has a portfolio of mostly small stocks and Investor 10 has a portfolio of large-cap stocks.
- One can obtain by combining Investor 1 (long) and investor (10) to generate a zero-risk portfolio that offers excess abnormal returns.



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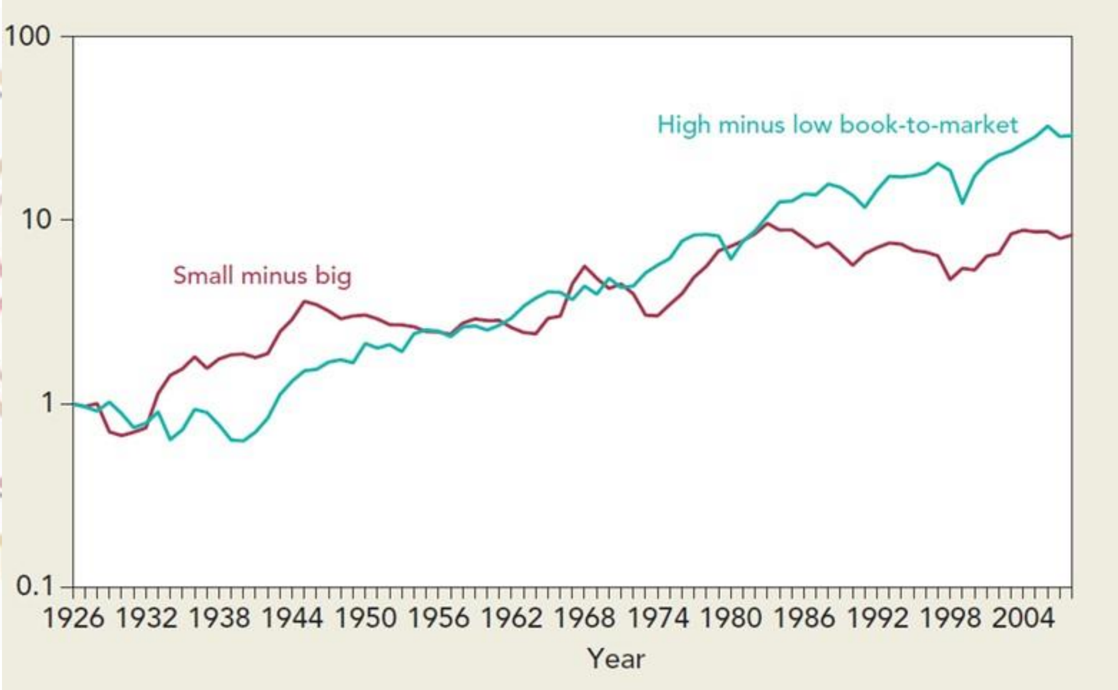
Validity of CAPM

- The red line shows the cumulative difference between small and large cam firms.
- The green line shows the cumulative difference between high book to value (Value stocks) minus low book to value stocks (Growth stocks).
- The figure does not fit well with CAPM postulations: that is beta is the only factor causing returns to differ across instruments.



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Validity of CAPM

- Value stocks are underpriced cheap stocks. They may be underpriced at current P/E ratios for different reasons.
- Growth stocks are not cheap stocks at current P/E levels.
- The returns on value stocks minus growth stocks, on average, are often positive, and significant over long-term.
- This does not fit well with CAPM.

Alternative Theories of Asset Pricing

Alternative Theories of Asset Pricing

- CAPM considers investors are rational risk-averse investors that only consider expected return, risk, and correlation structure as relevant factors.
- However, investors often behave in irrational manner.
- Arbitrage Pricing Theory (APT) incorporates broad macroeconomic factors in asset pricing.
- It does not require efficient portfolios.
- $Return = a + b_1\left(r_{factor_1}\right) + b_2\left(r_{factor_2}\right) + b_3\left(r_{factor_3}\right) + \cdots + noise\ term$

Alternative Theories of Asset Pricing

- The APT theory does not provide any information on what these factors may be
- One set of risks, that are on account of these APT factors can not be eliminated with diversification
- PT theory suggests that expected risk premium on a stock should depend on the risk-premium associated with each of these factors and the stock's sensitivity $(b_1, b_2, b_3..)$
- $Expected\ risk - premium = r - r_f = b_1\left(r_{factor_1} - r_f\right) + b_2\left(r_{factor_2} - r_f\right) + \cdots b_n\left(r_{factor_n} - r_f\right)$

Alternative Theories of Asset Pricing

- As per APT, a well diversified portfolio that is not sensitive to any risk factor must be priced to offer a return that is same as risk-free rate.
- A portfolio's expected return is directly proportional to its sensitivity to these risk factors.
- A stock's contribution to a portfolio depends upon its sensitivity to the broad macroeconomic influences, often referred to as factors in APT parlance.
- CAPM and APT give similar results if the factors considered in APT have sensitivity to market portfolio.

Alternative Theories of Asset Pricing

- In CAPM, market portfolio plays a very important role as it is supposed to capture all the relevant influences.
- Identifying this portfolio is difficult, however, APT does not require identification of this market portfolio.
- APT can be tested only with a small number of risky assets.
- APT does not tell any information about these factors.
- Fama-French three-factor model is a very prominent example of APT.
- $r - r_f = b_{market}(r_{market}) + b_{size}(r_{size}) + b_{btm}(r_{btm})$

Summary and Concluding Remarks

Summary and Concluding Remarks

- Investors try to increase the expected returns and reduce the risk on their portfolios.
- A portfolio that gives the highest expected return for a given standard deviation, or the lowest standard deviation for a given expected return, is known as an efficient portfolio.
- The best efficient portfolio (tangent) has the highest risk-premium to standard deviation, i.e., Sharpe ratio.
- As per CAPM, the expected return and risk-premium are defined by the following model:

$$\bar{R} = r_f + \beta(r_m - r_f)$$

- A stock's marginal contribution to portfolio risk is measured by its sensitivity to changes in the value of the portfolio.

Summary and Concluding Remarks

- The capital asset pricing theory is the best-known model of risk and return
- However, other risk factors appear to explain the returns as well
- APT offers an alternative theory of risk and return, i.e., expected risk premium depends on the exposure of a portfolio to various macroeconomic systematic factors
- One example of APT is Fama-French three factor model which considers: (a) Market, (b) Size, (c) Book-to-market (BTM).

Thanks!

INDIAN INSTITUTE OF TECHNOLOGY KANPUR

Artificial Intelligence (AI) for Investments

Lesson 8: Cost of Capital

Introduction

In this lesson we will cover the following topics:

- Introduction Company and Project Cost of Capital
- Computing Company Cost of Capital
- Estimating the components of WACC
- Analyzing Project Risk
- Certainty Equivalents
- Summary and concluding remarks

Company and Project Cost of Capital

Company and Project Cost of Capital

- Company cost of capital is defined as the expected return on a portfolio of all the company's existing securities
  - It is the opportunity cost of capital for investment in the firm's assets
  - If the firm has no debt outstanding, then the company cost of capital is just the expected rate of return on the firm's stock
  - The company cost of capital is not the correct discount rate if the new projects are more or less risky than the firm's existing business
  - $Firm\ Value = PV(AB) = PV(A) + PV(B)$
  - The two discount rates will, in general, be different

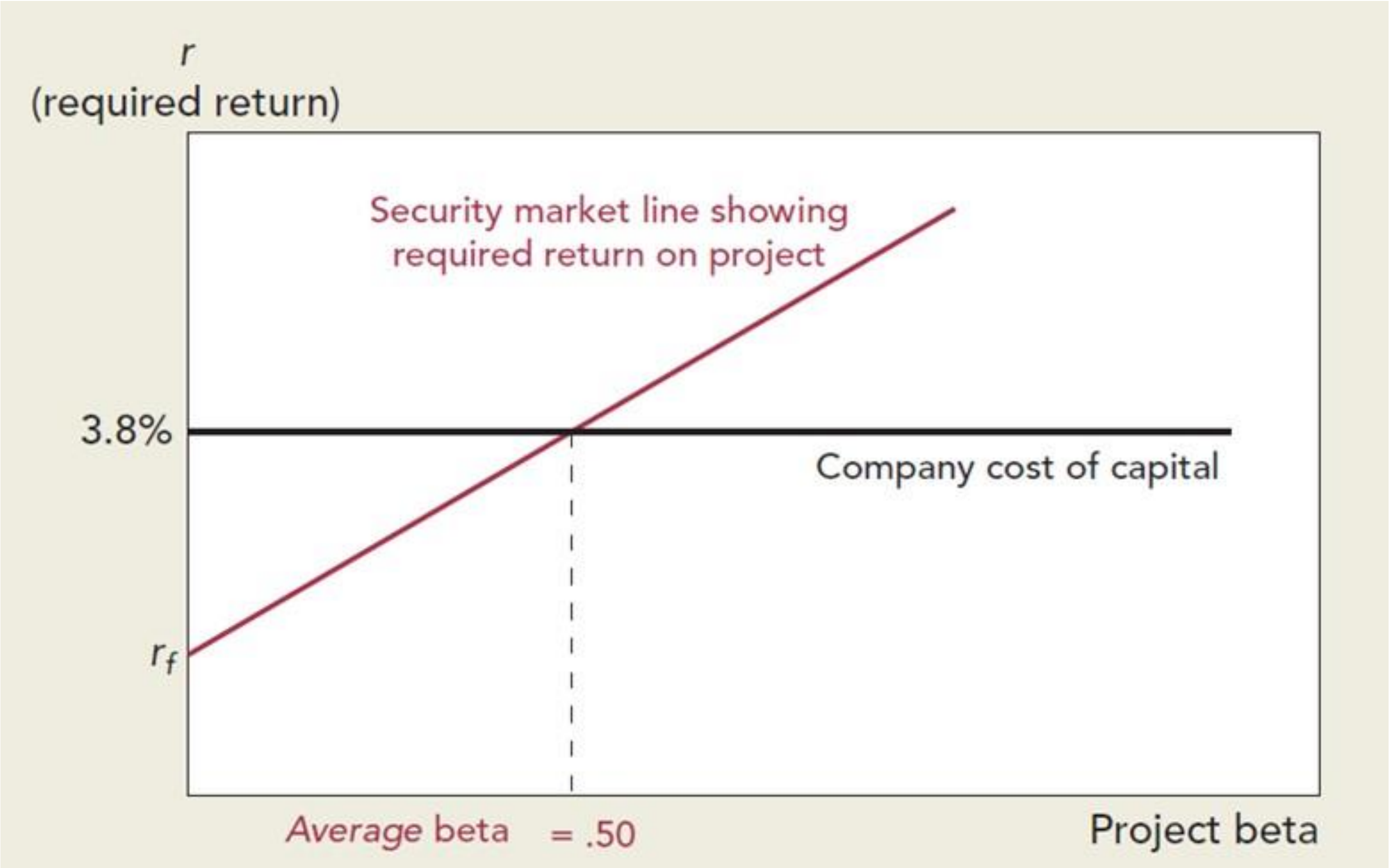
Company and Project Cost of Capital

- If the present value of an asset depended on the identity of the company that bought it, present values would not add up
  - Consider a portfolio of $1 million invested in firm A and $1 million invested in firm B
  - If the firm considers investing in a third project C, it should also value C as if C were a mini-firm
  - The opportunity cost of capital depends on the use to which that capital is put
  - A new division with different risk profile, considerable uncertainty and customer demand that is yet to be established, should of course have different cost of capital

Company and Project Cost of Capital

- Suppose we measure the risk of each project by its beta
  - Then a firm should accept any project lying above the upward-sloping security market line that links expected return to risk
  - If the project is high-risk, the firm needs a higher prospective return than if the project is low-risk
  - That is different from the company cost of capital rule, which accepts any project regardless of its risk as long as it offers a higher return than the company’s cost of capital

Company and Project Cost of Capital



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Company and Project Cost of Capital

- The true cost of capital depends on project risk, not on the company undertaking the project
  - Why is so much time spent estimating the company cost of capital?
  - First, many (maybe most) projects can be treated as average risk
  - Second, the company cost of capital is a useful starting point for setting discount rates for unusually risky or safe projects
  - It is easier to add to, or subtract from, the company cost of capital

Company and Project Cost of Capital

- Businesspeople have good intuition about relative risks
  - They set a companywide cost of capital as a benchmark
  - Many large companies use the company cost of capital not just as a benchmark, but also as an all-purpose discount rate for every project proposal
  - Measuring differences in risk is difficult to do objectively
  - Top management may demand extra- conservative cash-flow forecasts from extra-risky projects
  - Top management may demand extra- conservative cash-flow forecasts from extra-risky projects

Computing Company Cost of Capital

Computing Company Cost of Capital

- Company cost of capital is the expected return on a portfolio of all the company's existing securities
  - The portfolio of company security usually includes debt as well as equity
  - Thus the cost of capital is estimated as a blend of the cost of debt

Asset value	100	Debt	$D = 30$ at 7.5%
		Equity	$E = 70$ at 15%
Asset value	100	Firm value	$V = 100$

  - The values of debt and equity add up to overall firm value

Computing Company Cost of Capital

- The company cost of capital is not equal to the cost of debt or to the cost of equity but is a blend of the two
  - Suppose you purchased a portfolio consisting of 100% of the firm's debt and 100% of its equity
  - The expected rate of return on your hypothetical portfolio is the company cost of capital
  - The expected rate of return is just a weighted average of the cost of debt $(r_D = 7.5\%)$ and the cost of equity $(r_E = 15\%)$
  - The weights are the relative market values of the firm's debt and equity, that is, $D/V = 30\%$ and $E/V = 70\%$

Computing Company Cost of Capital

- The company cost of capital is not equal to the cost of debt or to the cost of equity but is a blend of the two
  - The marginal corporate tax rate $T_C = 35\%$
  - WACC or Company cost of capital$= r_D * (1 - T_c) * \frac{D}{V} + r_E * \frac{E}{V} = 7.5\% * (1 - 0.35) * 0.30 + 15 * 0.70 = 12.00\%$
  - This blended measure of the company cost of capital is called the weighted-average cost of capital or WACC

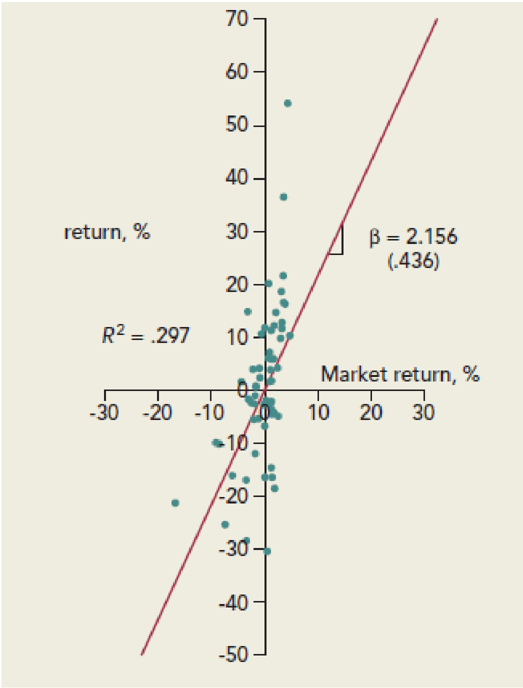
Estimating the components of WACC

Estimating the components of WACC

- To calculate the weighted-average cost of capital, you need an estimate of the cost of equity
  - We will use the capital asset pricing model (CAPM) to estimate the cost of equity
  - CAPM: $Expected\ Returns = r_f + \beta(r_m - r_f)$
  - In principle we are interested in the future beta of the company's stock
  - We will estimate beta using historical security price data

Estimating the components of WACC

- In the scatter diagram shown here, each dot represents the return on a security and return on market
  - The slope of fitted line is called beta
  - The R-square measure tells the proportion of total variance that can be explained by market variance
  - It appears that 29.7% of the variance was was explained by the market
  - The 95% confidence interval estimate of beta is 2.16



Estimating the components of WACC

- In the scatter diagram shown here, each dot represents the return on a security and return on market
  - Standard error of the estimated beta is computed to show the extent of possible mismeasurement
  - Standard error of beta estimate is 0.436
  - The 95% confidence interval estimate 2.16 plus or minus 2*0.436
  - That is, you have 95% chance of being right in saying that beta can fall in this interval

Estimating the components of WACC

- How to estimate the risk-free rate of interest (r_f)
  - Should we use short-term treasury bill rate, daily over night rate, monthly rate, one year interest rate or long-term interest rates
  - CAPM is a short-term model
  - It works period by period and calls for a short-term interest rate
  - Could a .2% three-month risk-free rate give the right discount rate for cash flows 10 or 20 years in the future?

Estimating the components of WACC

- How to estimate the risk-free rate of interest (r_f)
  - Financial managers can simply use a long-term risk-free rate in the CAPM formula
  - Or, they can compute the term premia (for investing in long-term government bonds – T-Bills) =1.5%
  - The difference in current Govt. bond yields (e.g., 3.3%) and this term premia reflects that short-term T-Bill rates= 3.3%-1.5%=1.8%
  - If the market risk-premium in 7%, beta is 1.16, then the cost of equity can be computed as follows. $Cost\ of\ equity = Expected\ Returns = r_f + \beta(r_m - r_f) = 1.8 + 1.16 * 7.0 = 9.9\%$

Estimating the components of WACC

- Estimating cost of equity and WACC
  - If the market risk-premium in 7%, beta is 1.16, then the cost of equity can be computed as follows. $Cost\ of\ equity = Expected\ Returns = r_f + \beta(r_m - r_f) = 1.8 + 1.16 * 7.0 = 9.9\%$
  - Let us calculate the WACC for a firm with cost of Debt of about 7.8%, corporate tax-rate of 35%, and debt ratio (D/V) of 31.5%.
  - $After\ Tax\ WACC = (1 - T_C) * r_D * \frac{D}{V} + r_E * \frac{E}{V} = (1 - 0.35) * 7.8 * 0.315 + 9.9 * 0.685 = 8.4\%$

Estimating the components of WACC

- The cost of debt is always less than the cost of equity
  - The WACC formula blends the two costs: Debt and Equity
  - As the debt ratio D/V increases, the cost of the remaining equity also increases
  - This offsets offsetting the apparent advantage of more cheap debt
  - Debt does have a tax advantage, however, because interest is a tax-deductible expense

Estimating the components of WACC

- The after-tax WACC depends on the average risk of the company's assets, but it also depends on taxes and financing
  - It's easier to think about project risk if you measure it directly
  - As the debt ratio D/V increases, the cost of the remaining equity also increases
  - We calculate the asset beta as a blend of the separate betas of debt (β_D) and equity (β_E)
- For example, let us consider a security with β_E=1.16 and β_D = 0.3. The weights are the fractions of debt and equity financing, D/V= .315 and E/V =.685

Estimating the components of WACC

- The after-tax WACC depends on the average risk of the company's assets, but it also depends on taxes and financing
  - For example, let us consider a security with β_E=1.16 and β_D = 0.3. The weights are the fractions of debt and equity financing, D/V= .315 and E/V =.685
  - Asset beta= β_A= $\beta_D * \left(\frac{D}{V}\right) + \beta_E * \left(\frac{E}{V}\right) = 0.3 * 0.315 + 1.16 * 0.685 = 0.89$
  - Calculating an asset beta is similar to calculating a weighted-average cost of capital
  - This asset beta is an estimate of the average risk of the firm's business

Analyzing Project Risk

Analyzing Project Risk

- Suppose that a coal-mining corporation wants to assess the risk of investing in commercial real estate
  - The asset beta for coal mining is not helpful
  - You need to know the beta of real estate
  - A company that wants to set a cost of capital for one particular line of business typically looks for pure plays in that line of business
  - Pure-play companies are public firms that specialize in one activity

Analyzing Project Risk

- Schlumberger wants to set a cost of capital for its new Oil exploration venture
  - It could estimate the average asset beta or cost of capital for Oil and Gas firms that have not diversified into multiple business lines (e.g., Reliance)
  - They should not consider Reliance group as it would have multiple companies in different groups
  - ONGC would be a pure-play and suitable for estimating the cost of capital
  - Many times good comparable pure plays are not available, then we go for asset betas

Analyzing Project Risk

- What determines asset betas?
  - **Cyclicality:** What is the strength of the relationship between the firm's earnings and aggregate market earnings
  - We can measure this either by the earnings beta or by the cash-flow beta
  - Cyclical firms—firms whose revenues and earnings are strongly dependent on the state of the business cycle—tend to be high-beta firms
  - Cyclical businesses include airlines, luxury resorts and restaurants, construction, and steel

Analyzing Project Risk

- What determines asset betas?
  - **Operating Leverage:** A production facility with high fixed costs, relative to variable costs, is said to have high operating leverage
  - High operating leverage means a high asset beta
  - Cash flow = revenue - fixed cost - variable cost
  - Fixed costs are cash outflows that occur regardless of whether the asset is active or idle
  - PV(asset)= PV(revenue)- PV(fixed cost) – PV(variable cost)

Analyzing Project Risk

- What determines asset betas?
  - **Operating Leverage:** PV(revenue) = PV(fixed cost)+ PV(variable cost)+PV(Asset)
  - $\beta_{revenue} = \beta_{fixedcost} * \frac{PV(fixedcost)}{PV(Revenue)} + \beta_{variablecost} * \frac{PV(variablecost)}{PV(Revenue)} + \beta_{asset} * \frac{PV(variable)}{PV(Revenue)}$
  - $\beta_{asset} = \beta_{revenue} * \frac{PV(revenue) - PV(variablecost)}{PV(Asset)} = \beta_{revenue}[1 + \frac{PV(fixedcost)}{PV(Asset)}]$
  - Given the cyclicality of revenues ($\beta_{revenue}$), the asset beta (β_{asset}) is proportional to the ratio of the present value of fixed costs to the present value of the project

Analyzing Project Risk

- What determines asset betas?
  - Don’t Be Fooled by Diversifiable Risk
  - In everyday usage, “risk” simply means “bad outcome”
  - People think of the risks of a project as a list of things that can go wrong
  - Risks such as a pharma-company finding side-effects of a new drug are diversifiable risks
  - Thus, these hazards should not affect the discount rates

Analyzing Project Risk

- Sometimes financial managers increase discount rates in an attempt to offset these risks
  - Consider a project Z that produces just one cash flow, forecasted at $1 million at year 1
  - $PV = \frac{C_1}{1+r} = \frac{100000}{1.1} = 909{,}100$
  - Company discovers a small hazard, which may cause a small chance that project will have zero cash flow
  - The appropriate way to deal with this situation is to prepare unbiased cash flow forecasts that give due weight to all possible outcomes

Analyzing Project Risk

- Managers making unbiased forecasts are correct on average
  - Sometimes their forecasts will turn out high, other times low, but their errors will average out over many projects
  - The appropriate way to deal with this situation is to prepare unbiased cash flow forecasts that give due weight to all possible outcomes
  - . If you forecast a cash flow of $1 million for projects like Z, you will overestimate the average cash flow

Possible Cash Flow	Probability	Probability-Weighted	Unbiased Forecast
1.2	0.25	0.3	$1 million
1	0.5	0.5	
0.8	0.25	0.2	

Analyzing Project Risk

- Managers making unbiased forecasts are correct on average
  - If technological uncertainty introduces a 10% chance of a zero cash flow, the unbiased forecast could drop

Possible Cash Flow	Probability	Probability-Weighted	Unbiased Forecast
1.2	0.25	0.27	\$0.90 million
1	0.45	0.45	
0.8	0.225	0.18	
0.0	0.10	0.00	

  - Thus, the new present value computation would be: $PV = \frac{0.90}{1.1} = \$0.818 \text{ million}$

Analyzing Project Risk

- Managers often work out a range of possible outcomes for major projects, sometimes with explicit probabilities attached
  - The manager can still consider the good and bad outcomes as well as the most likely one
  - When the bad outcomes outweigh the good, the cash-flow forecast should be reduced until balance is regained
  - Step 1, then, is to do your best to make unbiased forecasts of a project's cash flows
  - Step 2 is to consider whether diversified investors would regard the project as more or less risky than the average project

Certainty Equivalents

Certainty Equivalents

- Discount rates are not constant and constantly change over the project life as the project risk changes
  - You are considering construction of an office building that you plan to sell after one year for $420,000
  - That cash flow is uncertain with the same risk as the market, so β=1
  - Given r_f =5% and $r_m - r_f$ =7%, you compute the present value as: 420,000/1.12 = $375,000
  - What is that certain payoff you are willing to accept to sell the project in future
  - $PV = \frac{Certain\ cash\ flow}{1.05} = 375000$, Certain cash flow= $393,750

Certainty Equivalents

- Discount rates are not constant and constantly change over the project life as the project risk changes
  - Thus, a certain cash flow of $393,750 has exactly the same present value as an expected but uncertain cash flow of $420,000
  - To compensate for both the delayed payoff and the uncertainty in real estate prices, you need a return of 420,000 - 375,000 = $45,000
  - One part of this difference compensates for the time value of money
  - The other part ($420,000 -393,750 = $26,250) is a markdown or haircut to compensate for the risk attached to the forecasted cash flow of $420,000.

Certainty Equivalents

- How to value risky project cash flows
  - Method 1: Discount the risky cash flow at a risk-adjusted discount rate r that is greater than r_f
  - Method 2: Find the certainty-equivalent cash flow and discount at the risk-free interest rate r_f
  - What is the smallest certain payoff for which I would exchange the risky cash flow, this is called certainty equivalent (CEQ)

Certainty Equivalents

- Thus, We now have two identical expressions for the PV of a cash flow
  - At period 1, $PV = \frac{C_1}{1+r} = \frac{CEQ}{1+r_f}$
  - For cash flows two, three, or t years away, $PV = \frac{C_t}{(1+r)^t} = \frac{CEQ}{(1+r_f)^t}$

Certainty Equivalents

- Consider two simple projects
  - Project A is expected to produce a cash flow of $100 million for each of three years. The risk-free interest rate is 6%, the market risk premium is 8%, and project A's beta is .75
  - Cost of capital for A as per CAPM: $= r_f + \beta(r_m - r_f) = 6 + 8 * 0.75 = 12\%$

Year	Cash Flow	PV at 12%
1	100	89.3
2	100	79.7
3	100	71.2
		Total PV 240.2

Certainty Equivalents

- Consider two simple projects
  - Project B is a safe project and the cash flows can be discounted at risk-free rate
  - The discounted cash flows are shown here

Year	Cash Flow	PV at 6%
1	94.6	89.3
2	89.6	79.7
3	84.8	71.2 **Total PV 240.2**

Certainty Equivalents

- Risk-free cash flow vs. certainty equivalents
  - In year 1 project A has a risky cash flow of 100. This has the same PV as the safe cash flow of 94.6 from project B
  - In year 2 project A has a risky cash flow of 100, and B has a safe cash flow of 89.6

Year	Forecasted Cash Flow	Certainty-Equivalent	Deduction for Risk
1	100	94.6	5.4
2	100	89.6	10.4
3	100	84.8	15.2

Summary and Concluding remarks

Summary and Concluding remarks

- If the project has the same risk as the average company risk, then company cost of capital is good benchmark to discount project cash flows
- Company cost of capital is measured with after-tax weighted-average cost of capital (after-tax WACC)
- When the project risk is considerably different from average company risk, then asset betas are often employed t estimate the project risk
- Overtime as the project risk changes, discount rates also change
- In such scenarios, we may use certainty equivalents (CEQ) to discount at risk-free rate to value the project

Thanks!

Artificial Intelligence (AI) for Investments

NPTEL

Lesson 9: Theory of Efficient Capital Markets

Introduction

In this lesson, we will cover the following topics:

- NPV computation for financing decision
- Differences between investment and financing decisions
- What is an efficient market
- Theory of market efficiency
- The evidence against market efficiency
- Investor psychology and behavioral finance
- Key implications of market efficiency
- Summary and concluding remarks

NPV Computation for Financing Decision

Net Present Value (NPV) : Computation for Financing Decision

- It is helpful to separate investment and financing decisions
  - There are certain similarities between these decisions
  - The decisions to purchase a machine tool and to sell a bond each involves the valuation of a risky asset
  - In both cases, we end up computing the net present value
  - As part of its policy of encouraging small businesses, the government offers to lend your firm $100,000 for 10 years at 3%. This means that the firm is liable for interest payments of $3,000 in each of the years, 1 through 10 years, and responsible for repaying the $100,000 in the final year

NPV Computation for Financing Decision

- Should you accept this offer?
  - We can compute the NPV of the loan agreement in the usual way
  - NPV = amount borrowed – present value of interest payments – present value of loan repayment
  - $NPV = +100{,}000 - \sum_{t=1}^{10} \frac{3000}{(1+r)^t} - \frac{100000}{(1+r)^{10}}$
  - The only missing variable is r, the opportunity cost of capital
  - You need that to value the liability created by the loan

NPV Computation for Financing Decision

- The government's loan to you is a financial asset
  - We can compute the NPV of the loan agreement in the usual way
  - A piece of paper representing your promise to pay $3,000 per year plus the final repayment of $100,000
  - It would sell for the present value of those cash flows discounted at r
  - The only missing variable is r, the opportunity cost of capital
  - What interest rate would my firm need to pay to borrow money directly from the capital markets rather than from the government?

NPV Computation for Financing Decision

- Suppose that this rate is 10%
  - $\text{NPV} = +100{,}000 - \sum_{t=1}^{10} \frac{3000}{(1.10)^t} - \frac{100000}{(1.10)^{10}}$
  - $\text{NPV} = +100{,}000 - 56{,}988 = +\$43{,}012$
  - NPV calculations tell you just how much that opportunity is worth ($43,012)
  - You don't need any arithmetic to tell you that borrowing at 3% is a good deal when the fair rate is 10%

Differences Between Investment and Financing Decisions

Differences Between Investment and Financing Decisions

- Investment decisions and financing decisions differ from each other in contrasting ways
  - Financing decisions do not have the same degree of finality as investment decisions
  - It's harder to make money through smart financing strategies
  - Financial markets are more competitive than product markets
  - It is more difficult to find positive-NPV financing strategies than positive-NPV investment strategies

Differences Between Investment and Financing Decisions

- Capital investment decisions do not face competitive markets
  - Markets for financing are highly competitive
  - Numerous smart investors supply financing
  - Money flows across different financial markets in a seamless manner
  - Thus, it is expected that financing instruments would be fairly priced

What Is an Efficient Market

What Is an Efficient Market

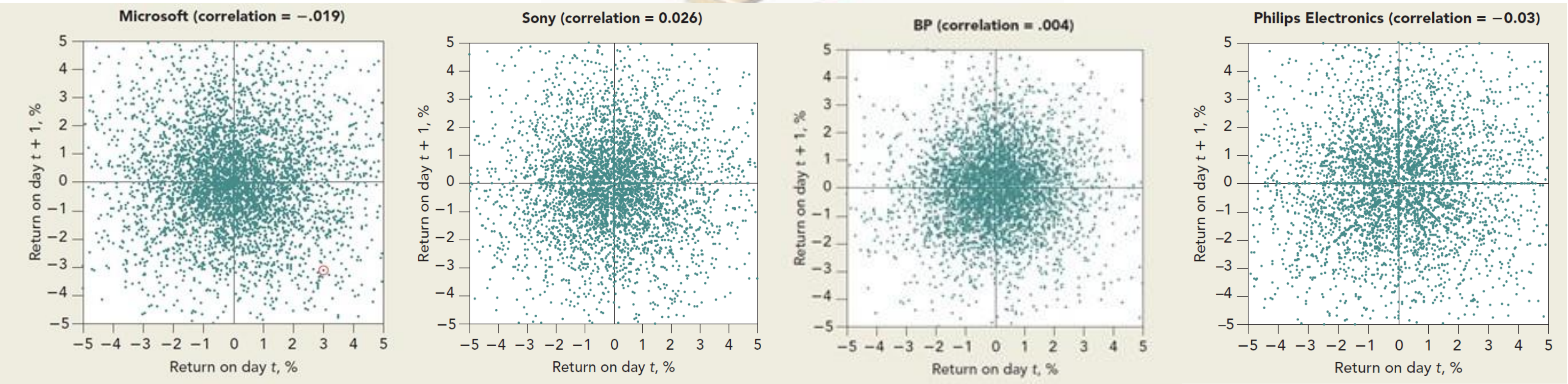
- Security prices seem to follow a random walk
    - A process is a random walk process if the successive changes are independent
    - Consider a simple example of a coin-toss game
    - If it comes up heads, you win 3% of your investment; if it is tails, you lose 2.5%
    - The odds each week are the same, regardless of the value at the start of the week or of the pattern of heads and tails in the previous weeks

What Is an Efficient Market

- As per the random walk model, the price changes are independent of one another
  - One can compute correlation coefficients between price changes at each of the successive days
  - If prices persist, then one can expect to find some correlation across price changes
  - No correlation if there is purely a random walk-in price changes

What Is an Efficient Market

- Consider the following four correlation examples

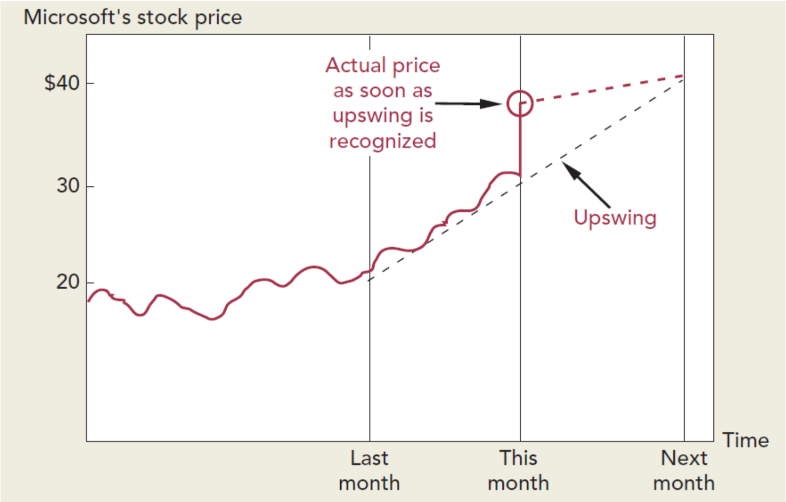


  - For example, the correlation between successive price changes in Microsoft was -0.019
  - For Philips, this correlation was also negative at - 0.030
  - However, for BP and Sony, the correlations were positive at +0.004 and +0.026

Brealey, Myers and Allen; *Principles of Corporate Finance*. 10th, 11th, or 12th editions. Chapter 13

What Is an Efficient Market

- The Fig. shown here provides an example of such a predictable cycle
    - An upswing in Microsoft's stock price started last month when the price was $20, and it is expected to carry the price to $40 next month
    - Since Microsoft stock is a bargain at $30, investors will rush to buy
    - As soon as a cycle becomes apparent to investors, they immediately eliminate it by their trading



Brealey, Myers and Allen; *Principles of Corporate Finance*. 10th, 11th, or 12th editions. Chapter 13

Theory of Market Efficiency

Theory of Market Efficiency

- Prices in competitive markets must follow a random walk
  - If past price changes could be used to predict future price changes, investors could make easy profits
  - All the information in past prices will be reflected in today's stock price, not tomorrow's
  - No one earns consistently superior returns in competitive markets
  - Thus, collecting more information may not help

Theory of Market Efficiency

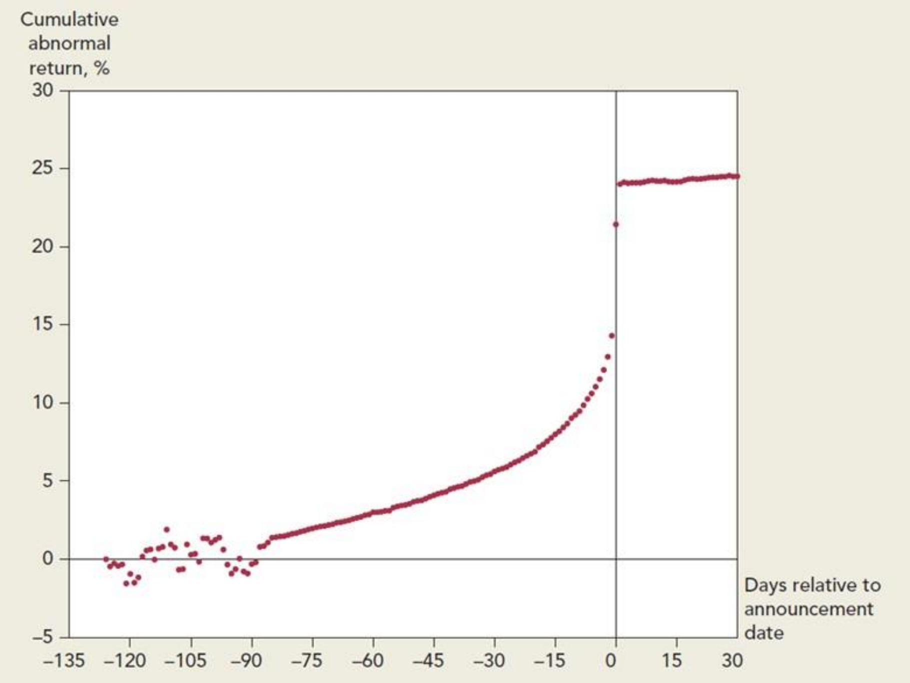
- Economists define three levels of market efficiency
  - **Weak market efficiency:** prices reflect the information contained in the record of past prices
  - **Semi-strong form of efficiency:** prices reflect all the public information
  - **Strong form of efficiency:** prices reflect all the available information, including historical prices, public information, and private information
  - In a strong form efficient market, investment managers cannot consistently beat the market

Theory of Market Efficiency

- How to test different forms of efficiencies
  - **Weak market efficiency:** researchers examine the profitability of various technical trading rules employing historical price information
  - **Semi-strong form of efficiency:** researchers examine how fast public information (such as dividend announcements) is incorporate into prices
  - To analyze the semi-strong form of the efficient-market hypothesis, researchers measure how rapidly security prices respond to different items of news, such as earnings or dividend announcements, news of a takeover, or macroeconomic information

Theory of Market Efficiency

- Consider an example of news that a company being a target of acquisition coming into public
- The graph shows the abnormal returns on the firms that are target take-overs
- The prices of the target stocks jump up on the announcement day, but from then on, there are no unusual price movements
- The announcement of the takeover attempt seems to be fully reflected in the stock price on the announcement day



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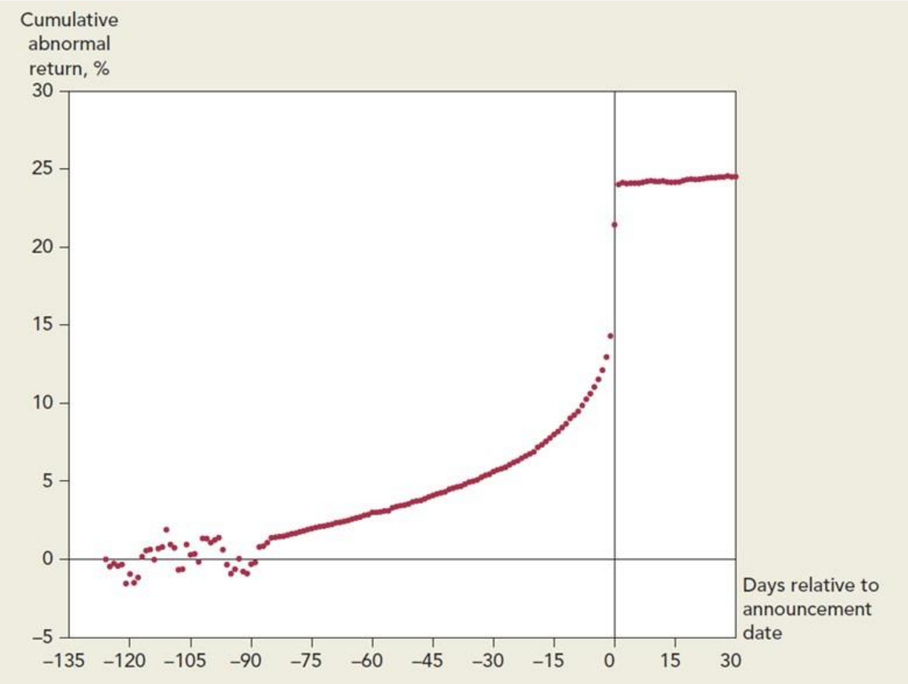
Theory of Market Efficiency

- The graph shows the abnormal returns on the firms that are target takeovers
- The acquiring firms usually must pay a substantial takeover premium to get the deal done
- Stock prices drift up before date zero, as investors gradually realize that a takeover may be coming
- Within the day, the new stock prices reflect (at least on average) the magnitude of the takeover premium



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Theory of Market Efficiency

- **Strong form of efficiency:** tests of the strong form of the hypothesis have examined the recommendations of professional security analysts
- Researchers examine whether mutual funds and pension funds can outperform the market
- Evidence suggests that professionally managed funds fail to recoup the costs of management
- It appears that in some years they do well and not so well in others
- It would be difficult to believe that some managers possess superior abilities to others

Theory of Market Efficiency

- The evidence of efficient markets has convinced many professional and individual investors to give up the pursuit of superior performance
- The implication is less focus on active management as more and more people follow passive investment strategies by investing in market indices over long horizons
- However, if everybody invests in index funds, then nobody will collect new information
- An efficient market needs some smart investors who gather information and attempt to profit from it
- There must be some profits available to allow the costs of information to be recouped

The Evidence Against Market Efficiency

The Evidence Against Market Efficiency

- Research suggests that there are indeed anomalies that can be exploited and contradict the notion of market efficiency
  - What exactly is an anomaly?
  - In an efficient market, it is not possible to find expected returns greater (or less) than the risk-adjusted opportunity cost of capital
  - $P = \sum_{t=1}^{\infty} \frac{C_t}{(1+r)^t}$; future cash flows (Ct) and the opportunity cost of capital (r)
  - If price equals fundamental value, the expected rate of return is the opportunity cost of capital, no more and no less

The Evidence Against Market Efficiency

- The principle tells us that you can’t identify a superior return unless you know what the normal expected return is
  - We need an asset pricing model to determine the relationship between the risk and expected returns
  - The most used asset pricing model is the CAPM
  - Several CAPM violations have been found in the literature
  - This includes the abnormally high returns on the stocks of small firms vis-à-vis large firms
  - Investors may demand higher returns for bearing the risk associated with small stocks

The Evidence Against Market Efficiency

- If these anomalies offer easy pickings, you expect to find a number of investors eager to take advantage of them
  - However, this seems to be surprisingly difficult for investors to get rich by picking these
  - Some of the calendar anomalies include day of the week effect
  - Long-term investors are usually less concerned with these short-term mispricing
  - They are more interested in long-lasting inefficiencies such as the earnings announcement puzzle and new issue puzzle

The Evidence Against Market Efficiency

- Another interesting phenomenon is bubbles and market efficiency
  - Bubbles: prices can no longer be justified with fundamentals
  - Valuation of stocks from scratch through methods such as dividend growth model is extremely difficult
  - Easier to estimate tomorrow's price relative to today’s price
  - When investors lose confidence in prices, prices become inefficient and volatile
  - Most of the tests of market efficiency are concerned with relative prices and focus on whether there are easy profits to be made

The Evidence Against Market Efficiency

- It may be impossible to prove that market levels are, or are not, consistent with fundamentals
    - Now and again investors seem to be caught up in a speculative frenzy, and asset prices are inflated much beyond fundamentals
    - Bubbles can result when prices rise rapidly, and more and more investors join the game on the assumption that prices will continue to rise
    - Lots of money is lost when these bubbles burst

Investor Psychology and Behavioral Finance

Investor Psychology and Behavioral Finance

- Often, prices depart from fundamental values
  - This may be so because people are not rational all the times
  - This manifests in their attitude toward risk: people are particularly loath to incur losses
  - Prospect theory: investors are more averse to losing than their affinity toward gain
  - Beliefs about probabilities: investors often make errors in assessing the probability of uncertain events
  - They place higher weights on more recent events

Investor Psychology and Behavioral Finance

- Also, investors are slow in updating their beliefs in the presence of new evidence
- Most investors are systematically biased due to overconfidence and consider themselves better-than-average stock pickers
- Such biases help in anomalies and bubbles
- Limits to arbitrage: these are limits to which smart investors can carry out arbitrage and drive prices toward efficient values
- Arbitrage is an investment strategy aimed to generate guaranteed superior returns without any risk
- However, these are not as risk-free as the theory might suggest

Investor Psychology and Behavioral Finance

- For example, trading costs can be significant, and some trades are difficult to execute
- To sell a stock short, you borrow shares from another investor’s portfolio, sell them, and then wait hopefully until the price falls and you can repurchase the stock back for less than you sold it for
- If you’re wrong and the stock price increases, then sooner or later, you will be forced to repurchase the stock at a higher price (therefore at a loss) to return the borrowed shares to the lender
- In addition, there are costs and fees to be paid, and in some cases, you will not be able to find shares to borrow

Key Implications of Market Efficiency

Key Implications of Market Efficiency

- The efficient-market hypothesis emphasizes that arbitrage will rapidly eliminate any profit opportunities and drive market prices back to fair value
  - Lesson 1: Markets Have No Memory: the weak form of the efficient-market hypothesis states that the sequence of past price changes contains no information about future changes
  - Lesson 2: Trust Market Prices: in an efficient market, you can trust prices, for they impound all available information about the value of each security
  - Lesson 3: Read the Entrails: if the market is efficient, prices impound all available information; and therefore, can tell us a lot about future worldview of that stock

Key Implications of Market Efficiency

- The efficient-market hypothesis emphasizes that arbitrage will rapidly eliminate any profit opportunities and drive market prices back to fair value
    - Lesson 4: There Are No Financial Illusions: investors are only concerned with the firm's cash flows and the portion of those cash flows to which they are entitled
    - Lesson 5: The Do-It-Yourself Alternative: in an efficient market, investors will not pay others for what they can do equally well themselves
    - Lesson 6: Seen One Stock, Seen Them All: investors don't buy a stock for its unique qualities; they buy it because it offers the prospect of a fair return for its risk. This means that stocks are like perfect substitutes for each other

Key Implications of Market Efficiency

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Summary and Concluding remarks

Summary and Concluding remarks

- Competition between investors will tend to produce an efficient market
- In such a market, prices will rapidly impound any new information, and it will be difficult to make consistently superior returns
- The efficient-market hypothesis comes in three different flavors: weak form, semi-strong form, and strong form
- Limits to arbitrage can explain why asset prices may get out of line with fundamental values
- Limits to arbitrage can explain why asset prices may get out of line with fundamental values

Thanks!