

ECO358 – Lecture 2 & Lecture 3

Valuation: World without Uncertainty

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Lecture Outline

- First Principal of Valuation
 - The concept
 - The rules
- Bond Valuation
 - Zero rates
- **Forward Rates**
- **Term Structure**
- **Stock Valuation**

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First Principal of Valuation

- We are interested in finding what a dollar is worth, if it is paid some years in the future.
 - It depends on the **opportunity cost**.
- The opportunity cost depends on the underlying asset.
 - In the world without uncertainty, the opportunity cost is interest forgone.

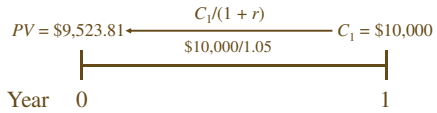
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The One-Period Case: Present Value

- In the one-period case, the formula for PV can be written as:

$$PV = \frac{C_1}{1+r}$$

Where C_1 is cash flow at date 1 and r is the appropriate interest rate.



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The One-Period Case: Net Present Value

- In the one-period case, the formula for NPV can be written as:

$$NPV = -Cost + PV$$

If we had *not* undertaken the positive NPV project considered on the last slide, and instead invested our \$9,500 elsewhere at 5-percent, our FV would be less than the \$10,000 the investment promised and we would be unambiguously worse off in FV terms as well:

$$\$9,500 \times (1.05) = \$9,975 < \$10,000.$$

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The Multiperiod Case: Future Value

- The general formula for the future value of an investment over many periods can be written as:

$$FV = C_0 \times (1+r)^T$$

Where:

C_0 is cash flow at date 0,

r is the appropriate interest rate, and

T is the number of periods over which the cash is invested.

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Multiple cash flows

- The PV of a stream of future cash flows (C_1, C_2, \dots, C_T) between year 1 and year T is:

$$PV = \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \dots + \frac{C_T}{(1+r)^T}$$

$$NPV = -C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \dots + \frac{C_T}{(1+r)^T}$$

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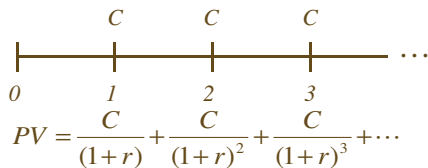
Simplifications

- Perpetuity
 - A constant stream of cash flows that lasts forever.
- Growing perpetuity
 - A stream of cash flows that grows at a constant rate forever.
- Annuity
 - A stream of constant cash flows that lasts for a fixed number of periods.
- Growing annuity
 - A stream of cash flows that grows at a constant rate for a fixed number of periods.

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Perpetuity

A constant stream of cash flows that lasts forever.



The formula for the present value of a perpetuity is:

$$PV = \frac{C}{r}$$

- Why?

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Perpetuity: Example

What is the value of a British consol that promises to pay £15 each year, every year until the sun turns into a red giant and burns the planet to a crisp?

The interest rate is 10-percent.

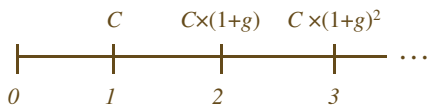


$$PV = \frac{\pounds 15}{.10} = \pounds 150$$

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Growing Perpetuity

A growing stream of cash flows that lasts forever.



$$PV = \frac{C}{(1+r)} + \frac{C \times (1+g)}{(1+r)^2} + \frac{C \times (1+g)^2}{(1+r)^3} + \dots$$

The formula for the present value of a growing perpetuity is:

$$PV = \frac{C}{r-g}$$

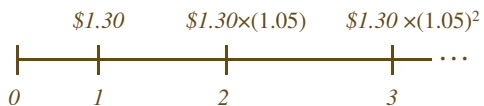
-Why?

-Do you see any condition for this formula to hold?

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Growing Perpetuity: Example

You are expected to get \$1.30 next period growing at a rate of 5% forever. If the discount rate is 10%, what is the value of this promised cash flow stream?

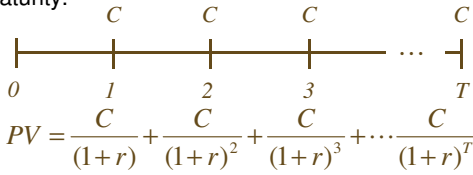


$$PV = \frac{\$1.30}{.10 - .05} = \$26.00$$

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Annuity

A constant stream of cash flows with a fixed maturity.



$$PV = \frac{C}{(1+r)} + \frac{C}{(1+r)^2} + \frac{C}{(1+r)^3} + \dots + \frac{C}{(1+r)^T}$$

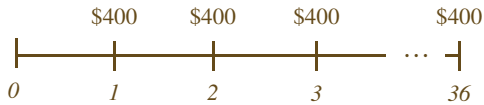
The formula for the present value of an annuity is:

$$PV = \frac{C}{r} \left[1 - \frac{1}{(1+r)^T} \right] \quad \text{- Why?}$$

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Annuity: Example

If you can afford a \$400 a period car payment, how much car can you afford if interest rates are 1% on 36-period loans?

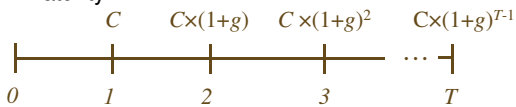


$$PV = \frac{\$400}{.01} \left[1 - \frac{1}{(1+0.01)^{36}} \right] = \$12,043$$

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Growing Annuity

A growing stream of cash flows with a fixed maturity.



$$PV = \frac{C}{(1+r)} + \frac{C \times (1+g)}{(1+r)^2} + \dots + \frac{C \times (1+g)^{T-1}}{(1+r)^T}$$

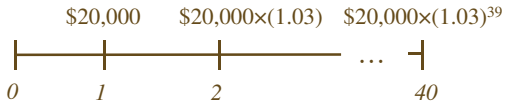
The formula for the present value of a growing annuity:

$$PV = \frac{C}{r-g} \left[1 - \left(\frac{1+g}{1+r} \right)^T \right]$$

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Growing Annuity: Example

A retirement plan offers to pay \$20,000 per year starting next year for 40 years and increase the annual payment by 3-percent each year. What is the present value at retirement if the discount rate is 10-percent?



$$PV = \frac{\$20,000}{.10 - .03} \left[1 - \left(\frac{1.03}{1.10} \right)^{40} \right] = \$265,121.57$$

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Summary

- The formula for the net present value of an investment that pays \$C for N periods is:

$$PV = \frac{C}{(1+r)} + \frac{C}{(1+r)^2} + \dots + \frac{C}{(1+r)^N} = \sum_{t=1}^N \frac{C}{(1+r)^t}$$

$$FV = PV \times (1+r)^T$$

- Four simplifying formulae:

Perpetuity: $PV = \frac{C}{r}$

Growing Perpetuity: $PV = \frac{C}{r-g}$

Annuity: $PV = \frac{C}{r} \left[1 - \frac{1}{(1+r)^T} \right]$

Growing Annuity: $PV = \frac{C}{r-g} \left[1 - \left(\frac{1+g}{1+r} \right)^T \right]$

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Bonds

- Definition:**

Is a promise from the issuer to pay the holder

- the principal, or face value, at maturity.
- Interest, or coupon payments, at intervals up to maturity.

- Named after the issuer:

- Federal Government (treasury)
- Provincial Government
- Municipal Government
- Banks & corporations

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Bond (YTM)

- Traded in the market like any other asset:
 - the price will be known at any point in time.
 - First principal of valuation
 - => Price should be equal to the PV of payments
 - => The discount rate that makes P = PV can be found
 - => That discount rate is called YTM

Example: A 7% three-year bond with a face value of 100 is selling for 88.431.

$$88.43 = \frac{7}{(1+YTM)^1} + \frac{7}{(1+YTM)^2} + \frac{107}{(1+YTM)^3}$$

YTM = 11.8%

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Bond - Default

- The coupon and the principal is *known* to the buyer.
 - Does not mean that it will be necessarily paid.
 - **Issuer may default**
 - => Buyer receive partial payment or nothing.
- Bonds issued by the federal government are assumed default-free.
 - Because?
- The possibility of default implies that the **promised return** (YTM) for bonds issued by non-federal government entities has to be higher than the promised return of a comparable treasury bonds.
 - The difference is called ``Risk Premium``.
 - The amount of this risk premium depends on the quality of the bond – probability of default.

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Bond – Default Example-1

- A one-year treasury bill yields 3%. A commercial bank wants to issue a one-year commercial paper (CP). If the probability of default by this bank is 20%:
 - a) What would be the price of this CP?
 - b) What would be the promised return?
 - c) So far we assumed that a default by the Bank implies no payment. Now suppose the recovery rate is 60% (i.e. 60% of the promised payment will be delivered in the case of default). Repeat part a and part b.

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Bond – Default Example-2

- In September 2008, one-year US treasury bill yielded 0.5%. A similar Libor Yielded 2.5%.

- What was the implied probability of default if the recovery rate was zero?
- What was the implied probability of default if the recovery rate was 80%?

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Bond – Spot (Zero) Rates

- **Spot (zero) rates**
 - Referred to as Interest rate as well
 - Annualized YTM on a zero coupon federal government bond.
- YTM on one-year bond is one year spot rate. YTM on two year zero bond is two- year spot rate and so forth
- Suppose today at time 0 you observe the following three treasury bills:

Example:

T-Bill	Type	Par Value	Price	YTM
1-year	zero	\$100	\$92.593	8%
2-year	zero	\$100	\$82.645	10%
3-year	zero	\$100	\$71.178	12%

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Question-1

- The earlier 7% 3-year government bond had YTM of 11.8% while the YTM of the three year zero bond is found to be 12%. Is there an *arbitrage* opportunity where you you sell the 7% bond yielding 11.8% and buy the bond that yield 12%?
- *Remember: Arbitrage:* Generating risk-free cash-flow without investing your own fund. (generating cash flow out of thin air!)

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Question-1

- No because:

To have 7 in year one buy $\frac{7}{1.08} = 6.48$ worth of the 1-year bond

To have 7 in year two buy $\frac{7}{1.10^2} = 5.76$ worth of the 2-year bond

To have 7 in year three buy $\frac{107}{1.12^3} = 76.16$ worth of the 3-year bond

$$= 6.48 + 5.76 + 76.16 = 88.43$$

the price of the three year 7% bond.

Conclusion: This three-year coupon bond is equivalent to a portfolio consisting of three zero bonds, one-year, two-year, and three-year.

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Question-2

The following information about three Treasury bonds are given:

Treasury Bond	Type	Face Value	Maturity	Price
A	Zero Coupon	\$1000	1 years	\$952.381
B	Zero Coupon	\$1000	2 years	\$889.996
C	Zero Coupon	\$1000	3 years	\$827.849

- Find the 1, 2 and 3 year zero rates.
- Assume a three year 5% treasury bond (called D) with a face value of \$1000 is selling at par (at face value \$1000). Is there an arbitrage opportunity, if so indicate how you can take advantage of it

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Question-2

a) $952.382 = \frac{1000}{1+r_1} \Rightarrow (1+r_1) = \frac{1000}{952.381} \Rightarrow r_1 = 0.05$

$$(1+r_2)^2 = \frac{1000}{889.996} \Rightarrow r_2 = 0.06$$

$$(1+r_3)^3 = \frac{1000}{827.849} = r_3 = 0.065$$

b) $P_D = \frac{50}{(1+0.05)^1} + \frac{50}{(1+0.06)^2} + \frac{1050}{(1+0.065)^3} = 961.36$

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Creating the Theoretical Spot (Zero) Rate Curve

Two methods:

- Use yields on US treasury bills or quotes of **U.S. Treasury Strips**.
- Construct theoretical spot rates from the available yields on a T-bill, and the yields on coupon government bonds using the *bootstrapping method*.

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Bootstrapping Method (Example)

We have the following information about several treasury securities:

Maturity	Coupon Rate	Price	YTM
1.00	0.0000	92.59	0.0800
2.00	0.0000	85.26	0.0830
3.00	0.0850	98.99	0.0890
4.00	0.0900	99.35	0.0920
5.00	0.1100	106.16	0.0940
6.00	0.0950	99.12	0.0970

The first three columns are market information, while the final column is the out calculation of the YTM.

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Bootstrapping Method (Example)

- Find:

$$P_3 = \frac{8.5}{(1+0.08)^1} + \frac{8.5}{(1+0.083)^2} + \frac{108.5}{(1+r_3)^3} = 98.99$$

$$7.87 + 7.25 + \frac{108.5}{(1+r_3)^3} = 98.99$$

$$\frac{108.5}{(1+r_3)^3} = 83.87 \Rightarrow r_3 = 8.96$$

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Bootstrapping Method (Example)

• Then:

$$P_4 = \frac{9}{(1+0.08)^1} + \frac{9}{(1+0.083)^2} + \frac{9}{(1+0.0896)^3} + \frac{109}{(1+r_4)^4} = 99.35$$

$$r_4 = 9.30\%$$

$$P_5 = \frac{11}{(1+0.08)^1} + \frac{11}{(1+0.083)^2} + \frac{11}{(1+0.0896)^3} + \frac{11}{(1+0.0930)^4} + \frac{111}{(1+r_5)^5} = 106.16$$

$$r_5 = 9.54\%$$

$$P_6 = \frac{9.5}{(1+0.08)^1} + \frac{9.5}{(1+0.083)^2} + \frac{9.5}{(1+0.0896)^3} + \frac{9.5}{(1+0.0930)^4} + \frac{9.5}{(1+0.0930)^5} + \frac{109.5}{(1+r_6)^6} = 99.12$$

$$r_6 = 9.88\%$$

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Replicating Portfolios

1- Create a zero coupon 3-year zero bond synthetically:

$$100n_A + 0n_B + 8.5n_C = 0$$

$$0n_A + 100n_B + 8.5n_C = 0$$

$$0n_A + 0n_B + 108.5n_C = 100$$

$$n_C = 0.9217, n_B = -0.0783, n_A = -0.0783$$

2- The price of that bond will be:

$$n_A \times 92.59 + n_B \times 85.26 + n_C \times 98.99 =$$

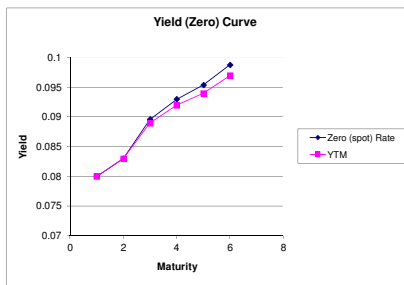
$$-0.0783 \times 92.59 - 0.0783 \times 85.26 + 0.9217 \times 98.99 = 77.302$$

3. Find the yield on this synthetic bond:

$$\frac{100}{(1+r_3)^3} = 77.302 \Rightarrow r_3 = 8.96\%$$

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The Yield Curve (Example)



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Forward Rates

- **Forward rate: is the implied rate from the available spot rates:**

Example: one-year rate, one year from now:

- The implied rate of return on an investment made between times $t+1$ and $t+2$, if today is t .

- $f_{t+1,t+2}$: the forward rate from year $t+1$ to $t+2$ (also be denoted by $f_{1,t+1}$ 1 year forward rate starting at year $t+1$).

- In general, a $j-i$ forward rate from year $t+i$ and $t+j$ is denoted by $f_{t+i,t+j}$ (or $f_{j-i,t+i}$).

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Forward Rates

- An investor who wants to invest \$100 for a total of two periods has two choices:

• Choice 1: Invest \$100 today at the 2-year spot rate, 8.3%.

• Choice 2: Invest \$100 today at the 1-year spot rate of 8%, and a year from now, re-invest the proceeds in prevailing 1-year spot rate.

-1-year spot rate one year from now is not available. But we can find a rate that makes these two investments identical.

=> This "implied rate" will be called one-year forward rate (one year from now) denoted by $f_{1,2}$.

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Forward Rates

Choice-1: $100 \times (1.083)^2$

=

Choice 2: $100 \times (1.080) \times (1 + f_{1,2}) \Rightarrow f_{1,2} = 8.6\%$

- Similarly one-year forward rate two years from now:

$100 \times (1.089)^3 = 100 \times (1.083)^2 \times (1 + f_{2,3}) \Rightarrow f_{2,3} = 10.11\%$.

- In general: $100(1 + r_j)^j = 100(1 + r_i)^i (1 + f_{i,j})^{j-i}$

$$f_{i,j} = \left[\frac{(1 + r_j)^j}{(1 + r_i)^i} \right]^{\frac{1}{j-i}} - 1$$

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Forward Rates

Question -1:

- Does this mean that next year the one-year spot rate is going to be 8.6%?
 - Only in the world without uncertainty?

Question-2:

- Can the forward rate (say $f_{1,2} = 8.6\%$) be secured today?
 - Yes?

Forward Rates

Strategy	now	in 1 year	in 2 years
Borrow 1 year at r_1	$+(X/(1+r_1))$	$-X$	0
Invest 2 year at r_2	$-(X/(1+r_1))$	-	$(X/(1+r_1))(1+r_2)^2$
Total cash flow	0	-X	X(1+f_{1,2})

Using our numbers we borrow $\frac{X}{1.08}$ (discounted value of X) and invested in two years yielding $(\frac{X}{1.08})(1.083)^2$ but we know that $\frac{1.083^2}{1.08}$ is 1+8.6%. Therefore this strategy works ensures that we guarantee today a return of 8.6% (one year forward rate) on our next year investment.

Theories of Term Structure of Interest Rate

- **In the world without uncertainty:** the forward rate is the future spot rate.
- **In the world with uncertainty:** what is the meaning of the forward rate.
 - Need Theories of Term Structure of Interest Rate to answer
 - Term structure of interest rate: refers to the shape of the yield (zero) curve.

Pure Expectation Theory

- Assumptions:
 - No transaction cost
 - Homogenous expectation.
 - Investors have no preference for bonds of one maturity to bonds of another maturity given similar HPR (Holding Period Return)
- **Term structure of the interest rate:** is based on the current expectations of future short-term interest rates.

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Pure Expectation Theory

- Assume the investor has \$1 to invest. We know that the returns of the two options are as follow:
 - i) Rolling over 1-year bonds $\text{Return} = (1 + r_1)(1 + E(r_{12}))$
 - ii) Buying a 2-year bond $\text{Return} = (1 + r_2)^2$

$$(1 + r_1)(1 + E(r_{12})) = (1 + r_2)^2$$
$$1 + E(r_{12}) = \frac{(1 + r_2)^2}{1 + r_1} = 1 + f_{12}$$

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Pure Expectation Theory

- The outcome of the expectation theory:
 - (a) The forward rate is the expected spot rate.
 - (b) If investors expect short-term interest rate to:
 - 1) Rise in the future, the yield curve would slope upward.
 - 2) Remain constant, the yield curve would be flat.
 - 3) Fall in the future, the yield curve would slope downward.

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Liquidity Preference (Liquidity Premium) Theory

- The long-term interest rate > short-term interest rate for the following reasons:

1. Compensation for giving up cash (i.e. liquidity).
2. Long-term bonds more sensitive to interest rate changes than short-term bonds.

=> The return for a longer-term bond needs to be higher than a shorter-term bond.

=> **Returns of long-term bonds should include a liquidity premium.**

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Liquidity Preference (Liquidity Premium) Theory

- Forward rate is not the expected rate rather the expected rate plus a positive premium.

$$f_{ij} = E(r_{ij}) + \pi_{ij}$$

- Since the liquidity premium is positive the forward rate is always higher than the expected future spot rate:

(a) **Rising curve:**

Forward Rate > Expected Spot rate

Forward rate > Current spot

=> Expected Spot rate > Current spot rate

(b) **Flat or falling yield curves:**

Forward rate > Expected spot rate

Forward rate < Current spot rate

=> Expected spot rate < Current spot rate 46

Stocks

- A claim on the equity of the company equal to the relative number of shares held.
- A corporation is a perpetual equity (unless declares bankruptcy).

=> Valuing the common stock will be some form of valuing a perpetual stream of income.

=> That stream of income is the dividend, that is paid to the equity holders.

- In the world without uncertainty this stream of dividends is assumed know.

- Suppose $D_1, D_2, D_3,$

=> The current price of one = discounted value all future cash dividends.

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Valuation of Stocks

- First Principles:
 - Value of financial securities = PV of expected future cash flows
- To value stocks we need to:
 - Estimate future cash flows:
 - Size (how much) and
 - Timing (when)
 - Discount future cash flows at an appropriate rate:
 - *The rate should be appropriate to the risk presented by the security.*

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Valuation of Common Stocks

- Three types of dividend offerings:
 - Zero Growth
 - Constant Growth
 - Differential Growth

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Case 1: Zero Growth

- Assume that dividends will remain at the same level forever

$$D_1 = D_2 = D_3 = \dots$$

- Since future cash flows are constant, the value of a zero growth stock is the present value of a perpetuity:

$$P_0 = \frac{D_1}{(1+r)^1} + \frac{D_2}{(1+r)^2} + \frac{D_3}{(1+r)^3} + \dots$$

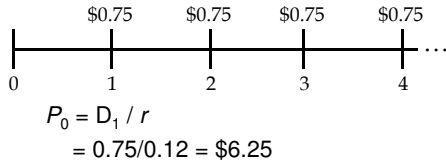
$$P_0 = \frac{D_1}{r}$$

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A Zero Growth Example

ABC Corp. is expected to pay \$0.75 dividend per annum, starting a year from now, in perpetuity. If stocks of similar risk earn 12% annual return, *what is the price of a share of ABC stock?*

The stock price is given by the present value of the perpetual stream of dividends:



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Case 2: Constant Growth

- Assume that dividends will grow at a constant rate, g , forever. *i.e.*

$$D_2 = D_1(1 + g)$$

$$D_3 = D_2(1 + g) = D_1(1 + g)^2$$

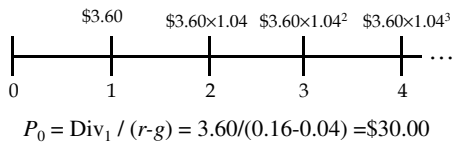
- Since future cash flows grow at a constant rate forever, the value of a constant growth stock is the present value of a growing perpetuity:

$$P_0 = \frac{D_1}{(1+r)} + \frac{D_1(1+g)}{(1+r)^2} + \dots + \frac{D_1(1+g)^{n-1}}{(1+r)^n} + \dots = \frac{D_1}{r-g}$$

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A Constant Growth Example

- XYZ Corp. has a common stock that paid its annual dividend this morning. It is expected to pay a \$3.60 dividend one year from now, and following dividends are expected to grow at a rate of 4% per year forever. If stocks of similar risk earn 16% effective annual return, *what is the price of a share of XYZ stock?*
- The stock price is given by the the present value of the perpetual stream of growing dividends:



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Case-3: Differential Growth Model

- Assumes that the company and its dividend payments grow much faster (g_1) for a certain period at the beginning and then settles to a constant growth rate (g_2). We have:

$$P_0 = \frac{D_1}{(1+r)} + \frac{D_1(1+g_1)}{(1+r)^2} + \dots + \frac{D_1(1+g_1)^{n-1}}{(1+r)^n} + \frac{D_1(1+g_1)^{n-1}(1+g_2)}{(1+r)^{n+1}} \dots$$

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A Differential Growth Model

- A stock expected to pay dividend of \$4.2 per share next year, and the dividend grows at 8% per year for the next 4 years then growth slows to 5% indefinitely. If the discount rate is 12%, this stock estimated value would be:

$$P_0 = \frac{4.2}{(1+0.12)} + \frac{4.2(1+0.08)}{(1+0.12)^2} + \dots + \frac{4.2(1+0.08)^4}{(1+0.12)^5} + \frac{4.2(1+0.08)^4(1+0.05)}{(1+0.12)^6} \dots$$

$$P_0 = \frac{4.2}{0.12-0.08} \left(1 - \left(\frac{1.08}{1.12}\right)^5\right) + \frac{4.2(1+0.08)^4(1+0.05)}{(1.12)^5}$$

$$P_0 = 17.4577 + 48.63 = 66.09$$

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A Note on DDM Model

- Obviously, no investor holds a stock forever.
 - The DDM can be modified to allow for that possibility as well.
 - Suppose an investor buys a stock holds it for a year and then sells the stock right after receiving the first dividend payment for P_1 . In the case of constant dividend model DDM will be:

- But $P_0 = \frac{D_1}{1+r} + \frac{P_1}{1+r}$

$P_1 = \frac{D_1}{1+r} + \frac{P_2}{1+r}$

=> $P_0 = \frac{D_1}{(1+r)^1} + \frac{D_1}{(1+r)^2} + \frac{P_2}{(1+r)^2}$

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HPR for stocks

- **Constant Dividend:** When the investor buys the stock for P_0 and then sells the stock after holding it for a full year for P_1 . The HPR is:

$$HPR = \frac{D_1 + (P_1 - P_0)}{P_0} = \frac{D_1}{P_0} + \frac{P_1 - P_0}{P_0} = r$$

$HPR = \text{Dividend Yield} + \text{Capital Gain}$

- **Growing Dividend:**

$$P_0 = \frac{D_1}{r-g}, P_1 = \frac{(1+g)D_1}{r-g} \Rightarrow \frac{P_1 - P_0}{P_0} = g$$

$$HPR = \frac{D}{P_0} + g$$

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Estimates of Parameters in the DDM Model

- The value of a firm depends upon its growth rate, g , and its discount rate, r .
 - Where does g come from?
 - **Where does r come from?**

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Where does g come from?

Formula for Firm's Growth Rate (g):

- The firm will experience earnings growth if its net investment (total investment-depreciation) is positive.
- To grow, the firm must retain some of its earnings.
- This leads to:

$$\text{Earnings}_{\text{next Year}} = \text{Earnings}_{\text{this Year}} + \left[\begin{array}{l} \text{Retained} \\ \text{earnings} \times \\ \text{this Year} \end{array} \text{Return on} \right. \left. \begin{array}{l} \text{retained} \\ \text{earnings} \end{array} \right]$$

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Where does g come from?

- Dividing both sides by this year's earnings, we get:

$$\underbrace{\frac{\text{Earnings next Year}}{\text{Earnings this Year}}}_{1 + g} = 1 + \underbrace{\left(\frac{\text{Retained earnings this Year}}{\text{Earnings this Year}} \times \text{Return on retained earnings} \right)}_{\text{Retention ratio}}$$

- This leads to the formula for the firm's growth rate:
 $g = \text{Retention ratio} \times \text{Return on retained earnings}$
- The *return on retained earnings* can be estimated using the firm's historical ROE.
- ROE**: Return on Equity (earnings /value of equity)₆₀

Where does g come from? An Example

Ontario Book Publishers (OBP) just reported earnings of \$1.6 million, and it plans to retain 28-percent of its earnings.

If OBP's historical ROE was 12-percent, *what is the expected growth rate for OBP's earnings?*

With the above formula:

$$g = 0.28 \times 0.12 = 0.0336 = 3.36\%$$

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Historical data

- Often you want to compute the fundamental value of the current stock given past behavior and thus must compute the historical growth rate on dividends.
- One measure to use is the following (assumes a long investment period):

$$\left(\frac{\text{dividend today}}{\text{dividend starting time}} \right)^{\frac{1}{\text{number of years that passed}}} - 1$$

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