ECON 134A

(Hopefully) Helpful Notes

Note: This material is purely supplemental, and is not a substitute for the actual course material. This does not include all course material, and contains additional material not necessary for the purposes of this course. If you find any typos please let me know at sherrard@umail.ucsb.edu.

Section 1:

Forms of Business:

1. Sole Proprietorship:
   - A sole proprietorship is a business owned by a single person.
   - Among the forms of business we are discussing, a sole proprietorship is the cheapest to form as there is no formal charter required.
   - No corporate taxes are levied on the proprietorship. All profits are taxed as personal income.
   - The proprietor faces unlimited liability for business debts and obligations.
   - Because the only money invested into the firm is that of the proprietor, the limit of the equity money that can be raised is the proprietor's personal wealth.
2. Partnership
   - There are two types of partnerships: General Partnerships and Limited Partnerships.
   - In a general partnership all partners agree to provide some work and cash, and share profits and losses. Each partner is fully liable for **ALL** the debts of the partnership. A partnership agreement specifies the nature of the agreement.
   - Limited Partnerships permit the liability of some of the partners to be limited to the cash each contributed to the partnership. Partnerships usually require at least one partner be a general partner. Limited partners do not participate in managing the business.
   - Partnerships are usually inexpensive and (legally) easy to form.
   - It can be difficult for partnerships to raise significant amounts of cash. Equity contributions are limited to whatever partners are able/willing to contribute.
   - A partnership's income is taxed as personal income. No corporate taxes are levied.
3. Corporation
   - Corporations are distinct legal entities. They are, in a sense, like legal citizens, and as such they have many of the same rights. They have a legal name, they can buy or sell property, they can sue or be sued, etc.
   - It can be difficult and costly to form a corporation. It requires formal articles of incorporation and a set of bylaws.
   - In general, corporations can be broken into three "tiers". There are shareholders (owners), directors, and management. Shareholders elect directors, who then hire the management.
   - Shareholder liability is limited to the amount invested in their shares.
   - It is relatively easy for corporations to raise cash. However,they face double taxation. Corporate income taxes are levied, and shareholder dividends are taxed as personal income.
4. LLC (Limited Liability Corporation)
   - LLCs are akin to a mixture of corporations and partnerships. All income is taxed as personal income, and owners retain limited liability.

Importance of Cash Flows:

In corporate finance we often focus on cash flows as opposed to accounting profits. This is because timing matters when it comes to money. Cash today is more valuable than the same amount of cash a year from now. To illustrate the difference between focusing on accounting profits and cash flows consider the following simple example:

Suppose that you work for a firm that produces high-end Beanie Babies. You've spent 100,000 dollars on production but already have a buyer lined up who claims they will pay you 200,000 dollars for your product. However, they have not payed you yet. If we were to take the standard accounting view of the firm we would have 100,000 dollars of cost, and 200,000 dollars of sales leaving us a net profit of 100,000 dollars.

However, from a cash flows perspective we get a very different picture. Our cash outflow will be 100,000 dollars (money already spent), but because the payment hasn't been delivered our cash inflow is 0. Thus from this perspective the net cash flow is -100,000 dollars. A much bleaker picture of the financial health of the firm.

Section 2:

Present and Future Value:

$$PV = \frac{C_t}{(1+r)^t}$$

$$FV = C_0(1+r)^t$$

Simple and Compound Interest:

Let A be the total amount accrued, P be the principal, r be the interest rate, and t be the number of periods. The formula for simple interest is:

$$A = P(1+rt)$$

Now let m be the number of compounding periods per unit t. The compound interest formula is:

$$A = P\left(1+\frac{r}{m}\right)^{mt}$$

APR and EAR:

It is important to fully understand the difference between the APR (Annual Percentage Rate) and the EAR (Effective Annual Rate). Consider an arbitrary compounding investment

$$C_0\left(1+\frac{r}{m}\right)^{mt}$$

The APR in this case is r, the annual interest rate without considering compounding. The EAR, in contrast, is the "actual" interest rate that incorporates the effects of compounding. We can calculate the EAR:

$$EAR = \left(1+\frac{r}{m}\right)^{m} - 1$$

Now suppose we want to to convert this EAR for one period into one that describes that n-period rate. We can perform the following calculation:

$$\text{Equivalent n-period Discount Rate } = (1+r)^n - 1$$

For example, suppose we have an EAR of 6%, and would like to find the monthly rate:

$$(1+0.06)^{\frac{1}{12}} - 1 = 0.004868$$

Note that here $n = \frac{1}{12}$ as we want $\frac{1}{12}$th of a period.

Section 3-4:

Perpetuities and Annuities:

Perpetuity: An asset that offers a constant stream of cash flow, C, forever.

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

Annuity: An asset that offers a constant stream of cash flow, C, for a fixed number of periods T.

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

Growing Perpetuity: A perpetuity whose annual payment starts at C and increases by a fraction g in each subsequent period.

$$PV = \frac{C}{r-g}, \quad \text{for } r > g$$

Growing Annuity: An asset that offers a constant stream of cash flow, C, that increases each year by a fraction g for a fixed number of periods T.

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

Loan Amortization:

To begin it is worth reviewing the definitions we will be working with. An amortized loan is a loan with scheduled periodic payments. Often times the payments require the borrower to pay off any interest accrued, in addition to some sort of principal reduction, but we will be examining four different types of amortized loans.

- Principal reduced by the same amount each period:

  Say a T-year loan: Each period, simply pay 1/T of the principal + simple interest on the loan balance and finish the loan amortization in T years. For example, consider a 3,000 dollar loan to be paid back over 3 years with SAIR of 20%.

  - Year 1: Pay back $1000 of the principal in addition to the interest incurred this period ($600).
  - Year 2: There is now $2000 remaining. Pay back $1000 of the remaining principal in addition to the interest incurred this period ($400).
  - Year 3: There is now $1000 remaining. Pay back $1000 of the remaining principal in addition to the interest incurred this period ($200).

- Payments are the same each period:

  Somewhat self explanatory. Returning to our previous example of a 3,000 dollar loan to be paid over 3 years and SAIR of 20%. We use the formula for annuity:

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

  And solve for C. Plugging in our numbers:

  $$\$3000 = C[2.10645]$$

  Which gives us C = 1,424.18 which will be the payment each period.

- Loans with a Balloon Payment:

  Loan that allows you to pay less than the amount required to reach a zero balance at the end of the loan. The extra amount is a "balloon" payment that is due at the end of the loan. Returning to our previous example, suppose that we first assume that we will be paying our 3 year loan over a 10 year period. Using our annuity formula with T = 10 and solving for C:

  $$3,000 = C\left[\frac{1}{.2} - \frac{1}{.2(1+.2)^{10}}\right]$$

  Will give us C = $715.57. Thus for the first three years we will pay that amount. However at the end of the third year we must also pay the balance of the loan for our "balloon payment". To calculate the balance we return to our trusty annuity formula, but we input our C and change T to the remaining amount of years (7):

  $$\text{Loan Balance} = 715.57\left[\frac{1}{.2} - \frac{1}{.2(1+.2)^{7}}\right]$$

  Giving us our balloon payment of $2,579.34. To get a better sense of the timing consider the following table:

Year	Beginning Balance	Total Payment	Interest Paid	Principal Paid	Ending Balance
1	$3,000	$715.57	$600	$115.57	$2,884.43
2	$2,884.43	$715.57	$576.89	$138.68	$2,745.75
3	$2,745.75	$715.57	$549.14	$166.42	$2,579.33

- Negative Amortization Loans:

  Loans that are set up so that the loan payment is not even enough to pay the previous period's interest. Thus the balance is increasing at an increasing rate. To see this consider the following example. Suppose you take on an $80,000 loan. the SAIR is 6%, compounding monthly. Thus the monthly interest rate is 0.5%. The terms of the loan require you to pay 0.3% of the balance of the loan each period.

  The first month's interest charged: 80,000 * 0.005 = $400

  The first month's payment: 80,000 * 0.003 = $240

  The second month's interest charged:80,160 * 0.005 = $400.80

  The second month's payment: 80,160 * 0.003 = $240.28

  And so the balance of the loan continues to increase at an increasing rate. Banks usually have a few different mechanisms to ensure repayment.

  - The remaining balance is due on a given date
  - Negative amortization ends after a specified time frame. After that the loan is amortized to be repaid over the remaining life of the loan.

Investment Rules:

- NPV (Net Present Value):

  $$NPV = PV - PVCost$$

  Accept if NPV greater than zero. Reject if less than 0.

  - Accepting Positive NPV benefits the stockholders by increasing the firms value.
  - The value of the firm rises by the NPV of the project.
  - The NPV rule uses the correct discount rate.

- Payback Periods Rule:

  A cutoff date is selected. All investment projects that have payback periods less than our cutoff payback period are accepted, all others are rejected. For example, suppose that an investment has an initial cost of 50,000 dollars. The project gives cash flows of $30,000, $20,000, and $10,000 in the first three years respectively. The payback period for this investment is 2 years. Thus we only accept this investment project if our cutoff date we set is 2 years or more.

  This can be a naive, and potentially problematic rule to determine investments. First of all, there is no way to distinguish between projects with high payoffs and low payoffs that reach their payback period in the same year. Second, when using the payback period rule there is typically no adjustment for discounting.

- Internal Rate of Return (IRR):

  The IRR is the rate that causes the NPV to be zero. The rule goes as follows: We accept a project if the IRR is greater than the discount rate, and reject if it is not. Consider the following simple example. Suppose there is a project that costs $100, and pays $110 in the following period. We use the NPV formula, but set the NPV to 0 and solve for the interest rate:

  $$0 = -100 + \frac{110}{1 + IRR}$$

  Giving us:

  $$IRR = 10\%$$

  There are a number of issues with the IRR:

  - When a the future cash flow contains both positive and negative values there could be multiple IRRs that satisfy the equation.
  - The IRR doesn't give any sense of scale to the investment.

- Profitability Index (PI):

  The profitability index is the ratio of the present value of future expected cash flows after the initial investment over the initial investment:

  $$PI = \frac{\text{PV of cash flows subsequent to initial investment}}{\text{Initial investment}}$$

  To illustrate this consider the following example: Suppose you are evaluating a project that has an initial cost of $20 dollars, but gives cash flows of $40 dollars in each of the subsequent two periods. We would first calculate the present value of the cash flows. Assume a discount rate of 10%:

  $$\frac{40}{1.1} + \frac{40}{(1.1)^2} \approx 69.42$$

  We then take the ration of this value over the investment cost:

  $$PI = \frac{69.42}{20} = 3.471$$

  We then accept the project if the PI is greater than one, and reject if it is less than one. Note that a PI $> 1 \Rightarrow$ NPV > 0.

- Equivalent Annual Cost (EAC):

  Suppose we are trying to decide between multiple investments that have unequal lifespans. Returning to our Beanie Baby factory, let's pretend that you are deciding between two sewing machines. The first costs $1,000 upfront, and has a yearly $100 maintenence fee for the duration of its lifespan of 4 years. The second costs $1,200 dollars and has a maintenance fee of $120, but its lifespan is 5 years. Thus the cash flows are as follows:

Machine	0	1	2	3	4	5
1	$1,000	$100	$100	$100	$100	0
2	$1,200	$120	$120	$120	$120	$120

  While the first machine is cheaper, the second machine lasts longer. So which is better? One way of comparing the two is to calculate their EAC. To do so we implement the following steps:

  1. Find the present value of the outflow of each project
  2. Determine the equivalent annual cost by finding an annuity payment so that we get the same present value

Returning to our example, we first calculate the PV of the outflows. Assume a discount rate of 10%:

$$\text{Machine 1} : 1,000 + \frac{100}{1.1} + \frac{100}{(1.1)^2} + \frac{100}{(1.1)^3} + \frac{100}{(1.1)^4} \approx \$1316.99$$

$$\text{Machine 2} : 1,200 + \frac{120}{1.1} + \frac{120}{(1.1)^2} + \frac{120}{(1.1)^3} + \frac{120}{(1.1)^4} + \frac{120}{(1.1)^5} \approx \$1654.89$$

Next, we determine the equivalent annual cost for the first machine:

$$1316.99 = EAC\left[\frac{1}{.1} - \frac{1}{.1(1.1)^4}\right]$$

Solving for EAC:

$$EAC = \$415.47$$

Next, we determine the equivalent annual cost for the second machine:

$$1654.89 = EAC\left[\frac{1}{.1} - \frac{1}{.1(1.1)^5}\right]$$

Solving for EAC:

$$EAC = \$436.56$$

Thus we would choose Machine 1.

Section 6-7:

Bond Basics:

First note that there are two basic types of bond payback methods:

- Coupon: Those which pay interest each year.
- Zero-coupon: Those which pay all interest upon maturity.

Bond Terminology:

- Maturity: Lifetime of the bond.
- Face Value: Amount paid to the bond owner at the date of maturity
- Coupon Rate/Yield: Percentage of face value paid to the bondholder in interest each year.
- Coupon Payment: Dollar amount of interest payment.

Bond Value:

Let C be the coupon payment, F be the face value, r be the discount rate, and T be the number of periods until maturity:

$$\text{Bond Value} = \frac{C}{r}\left[1 - \frac{1}{(1+r)^T}\right] + \frac{F}{(1+r)^T}$$

Or in other words:

$$\text{Bond Value} = \text{PV of the coupons} + \text{PV of the face amount}$$

Interest Rate Risk:

Interest rate risk is the risk that arises for bond owners from fluctuating interest rates. Note:

- All else equal, the longer the time to maturity the greater the interest rate risk.
- All else equal, the lower the coupon rate the greater the interest rate risk.

Inflation and Interest Rates:

We define the relationship between nominal rates (R), real rates (r), and inflation (h) as:

$$1 + R = (1 + r) \cdot (1 + h)$$

Valuation of Different Types of Stocks:

We differentiate between stocks with different dividend growth models:

- Zero Growth:

$$P_0 = \frac{Div}{R}$$

- Constant Growth:

$$P_0 = \frac{Div}{R - g}$$

- Differential Growth:

$$P_0 = \sum_{t=1}^{T} \frac{Div(1 + g_1)^t}{(1 + R)^t} + \frac{Div_{T+1}}{R - g_2} \left(\frac{1}{(1 + R)^T} \right)$$

Arithmetic and Geometric Average Returns:

Remember that in the course of this class we utilize two different kinds of averages, each in different situations: the arithmetic average and the geometric average. In particular, we use these when examining returns. Let R_i denote a given return.We define each average as:

$$\text{Arithmetic Average Return} = \frac{1}{T} \sum_{i=1}^{T} R_i$$

$$\text{Geometric Average Return} = [(1 + R_1)(1 + R_2)...(1 + R_T)]^{\frac{1}{T}} - 1$$

Each of these averages tells us something different about the data. To quote our textbook, "The geometric average return answers the question, '*What was your average compound return per year over a particular period?*'... The arithmetic average return answers the question, '*What was your return in an average year over a particular period.*'"

Section 8:

In this section we're going to focus on portfolio analysis, and in particular the Capital Asset Pricing Model (CAPM). First let's review some of our basic PSTAT equations in the context of analyzing returns:

Expected Returns:

For a given security:

$$\mathbb{E}[R_i] = \bar{R} = \frac{1}{T} \sum_{i=1}^{T} R_i$$

Variance of a distribution, with each outcome having the same probability of occurring:

$$\frac{1}{T} \sum_{t=1}^{T} (R_i - \bar{R})^2$$

Sample Variance:

$$\frac{1}{T-1} \sum_{t=1}^{T} (R_i - \bar{R})^2$$

Standard Deviation:

$$SD(R) = \sqrt{Var(R)}$$

Covariance:

$$\sigma_{XY} = Cov(X, Y) = \frac{1}{N} \sum_{i=1}^{N} (X_i - \mathbb{E}[X])(Y_i - \mathbb{E}[Y])$$

Correlation of two Random Variables:

$$\rho_{X,Y} = Corr(X, Y) = \frac{Cov(X, Y)}{SD(X) \cdot SD(Y)} = \frac{\sigma_{X,Y}}{\sigma_X \cdot \sigma_Y}$$

Helpful Variance Identities:

Let X and Y be random variables, and let a and b be any constants:

$$Var(X + a) = Var(X)$$

$$Var(aX) = a^2 Var(X)$$

$$Var(aX + bY) = a^2 Var(X) + b^2 Var(Y) + 2abCov(X, Y)$$

Portfolio Analysis:

Turning to portfolio analysis, note that a portfolio can be represented as the weighted average of different securities, where the weights are the proportion of funds allocated to each security. When applying our above equations note that the securities are random variables and the weights are constants. For the following definitions suppose there is a two stock portfolio with stocks A and B. Denote the portfolio weight by X.

Expected Return on a Portfolio:

$$\mathbb{E}[R_P] = \bar{R}_P = X_A\bar{R}_A + X_B\bar{R}_B$$

Variance of a Portfolio:

$$X_A^2\sigma_A^2 + 2X_AX_B\sigma_{AB} + X_B^2\sigma_B^2$$

Systematic vs. Idiosyncratic Risk:

- Idiosyncratic risk, also called firm-specific or diversifiable risk, is risk that affects a single or small group of assets.
- Systematic risk, also known as undiversifiable risk, is risk that affects all, or a large number of assets. In other words, this is the risk that cannot be removed through diversification.

A Security's Beta:

Mathematically we define the beta of a given security as:

$$\beta_i = \frac{Cov(R_i, R_M)}{Var(R_M)}$$

where R_M is the return of the market portfolio. But what exactly is this saying? This equation tells us the expected percent change in a security's return given a 1% change in the return of the market portfolio. In other words, beta measures how responsive a security is to movements in the market portfolio.

Capital Asset Pricing Model:

While discussions of CAPM often incorporate numerous models and equations, the CAPM itself is really just the equation which details the relationship between the expected return and beta of a given security:

$$\bar{R} = R_F + \beta(\bar{R}_M - R_F)$$

or in words:

Expected Return on a security = Risk-free rate + Beta of the security · Risk Premium

Here are some examples of CAPM problems you may see:

Solve for the Market Rate:

(Spring 2017, #3): Assume that the risk free return in the market is currently 10%, and a stock with beta of 5 has an expected return of 35%. What is the expected return on the market portfolio?

Using the CAPM:

$$.35 = .1 + 5(\bar{R}_M - .1)$$

Solving for $\bar{R}_M$:

$$\bar{R}_M = .15$$

Solve for the PV of a Security:

(Winter 2017 (10am) #7)Upside Down Country Jackets, Inc. (UDCJ), has stock issued with beta value of 2.5. Currently, the risk-free rate is 8% and the rate of return to the market (as defined in class) is 14%. Dividends of $2 per year will be paid forever by UDCJ, starting later today. What is the present value of the stock?

We begin by using CAPM to solve for the expected return of the security:

$$\bar{R}_i = .08 + 2.5(.14 - .08)$$

Giving:

$$\bar{R}_i = .23$$

Note that the dividend payments start today. Thus we know the value of the stock will be:

$$2 + \frac{2}{.23} = 10.7$$

Solve for the Risk-free rate:

(Fall 2016 #2)Two stocks whose returns are uncorrelated have the following characteristics: Stock A has an expected rate of return of 8%, its beta value is 0.25, and the standard deviation for its rate of return is 5%. Stock B has an expected rate of return of 15%, its beta value is 1.5, and the standard deviation for its rate of return is 12%.

First, note that the solution method presented here is different than the one posted in the solutions. They are both valid ways of answering the question. Here we are going to rely on the fact that given CAPM we know that all assets must have the same reward-to-volatility ratio, also known as the Treynor ratio. Thus we can solve for the risk free rate by setting equal the two reward-to-volatility ratios and solving for R_F:

$$\frac{0.08 - R_F}{0.25} = \frac{0.15 - R_F}{1.5}$$

Which, upon solving for R_f, gives us:

$$R_F = 0.0664$$

Notes on the Treynor Ratio:

The general formula for the Treynor Ratio is as follows:

$$\frac{\bar{R}_i - R_f}{\beta_i}$$

For the sake of clarity it will be useful to show why the above result, that if CAPM holds all stocks have an equal Treynor ratio, actually works. Suppose there are two stocks: Stock A and Stock B. Under CAPM we can write:

$$\bar{R}_A = R_f + \beta_A(\bar{R}_m - R_f)$$

and

$$\bar{R}_B = R_f + \beta_B(\bar{R}_m - R_f)$$

Note that some rearranging gives us:

$$\frac{\bar{R}_A - R_f}{\beta_A} = (\bar{R}_m - R_f)$$

and

$$\frac{\bar{R}_B - R_f}{\beta_B} = (\bar{R}_m - R_f)$$

Thus, combining these two equations, we get:

$$\frac{\bar{R}_A - R_f}{\beta_A} = \frac{\bar{R}_B - R_f}{\beta_B}$$

Section 8:

Efficient Market Hypothesis:

The Efficient Market Hypothesis is, in short, the idea that stock prices perfectly reflect all incorporate all relative information. If this hypothesis were true then it would be impossible to "beat market" as all stocks would be correctly values, removing the possibility of purchasing undervalued stocks or selling overvalued ones.

Types of Efficiency:

- Weak Form Efficiency: states that present stock prices are a function of the price in the previous period, the expected return, and some random error term.

$$P_t = P_{t-1} + \text{Expected Return} + \text{Random Error}_t$$

- Semistrong Form Efficiency: states that present stock prices reflect all publicly available information. Note this includes past prices.
- Strong Form Efficiency: states that stock prices reflect all information relevant to a stock, including both public and private information. Note this is the strongest assumption of the three types of efficiency.

Option Terminology:

- Strike (or exercise) price: The fixed price in the option contract at which the option holder can buy or sell the underlying asset.
- Expiration date: The maturity date of the option.

- American Vs. European options: American options can be exercised any time before the expiration date. European options can only be exercised on the expiration date.
- Call option: gives the holder the right to buy an asset for a fixed strike (exercise) price.
- Put option: gives the holder the right to sell an asset for a fixed strike (exercise) price.

Valuing a Call/Put at Expiration:

The value of a call (or put) at expiration will be equal to the maximum amount of money one could get by either exercising or not exercising the option. Let S be the value of the underlying asset on the expiration date and let K be the strike price. We thus get:

$$\text{Call Value at Expiration} = C = \max[S - K, 0]$$

and consequently:

$$\text{Put Value at Expiration} = P = \max[K - S, 0]$$

To illustrate this consider the following example. Suppose you purchased a call option on a stock X with a strike price of \$50. The stock price on the expiration date is \$70. What is the value of your call on the expiration date?

$$\max[S - K, 0] = \max[70 - 50, 0] = \$20$$

Put-Call Parity:

$$\text{Price of underlying stock} + \text{Price of put} = \text{Price of call} + \text{Present value of exercise price}$$

Black-Scholes Model:

Let S be the current stock price, E be the exercise price of the call, R be the annual risk-free rate of return, σ^2 be the variance of the continuous return on the stock, and t be the time until the expiration rate. Then:

$$C = SN(d_1) - Ee^{-Rt}N(d_2)$$

where:

$$d_1 = [\ln(S/E) + (R + \sigma^2\ /2)t]\sqrt{\sigma^2 t}$$
$$d_2 = d_1 - \sqrt{\sigma^2 t}$$

and:

$$N(d) = \text{ Probability that a standard normal RV will be less than or equal to d}$$

Value of a Firm:

We will define the value of the firm with the following model, often called the pie model. Let V be the value of the firm, B be the market value of the debt (bonds), and S the market value of the equity (stocks):

$$V = B + S$$

Capital Structure Terminology:

- Unlevered: No debt issued.
- Levered: Debt issued.

Modigliani and Miller:

Suppose we are interested in maximizing the value of our firm. The question may arise, how should we structure our capital in order to maximize value? Well, according to Modigliani and Miller, a firm cannot change the value of their firm by altering the proportions of its capital structure. To see an example as to why this is true see pg. 495-496 of our textbook. This gives us:

MM Proposition I (no taxes): The value of the levered firm is the same as the value of the unlevered firm.

What's more, they show that the expected return on equity is positively related to leverage as the risk to equity holders increases with leverage. To see this let's first define the following:

A Firm's Weighted Average Cost of Capital:

$$R_{WACC} = \frac{S}{B+S} \cdot R_S + \frac{B}{B+S} \cdot R_B$$

where R_B is the cost of debt, R_S is the expected return on equity (also called the cost of equity), R_{WACC} is the firm's weighted average cost of capital, B is the value of the firm's bonds or debts, and S is the value of the firm's stock or equity.

Cost of Capital for an All-equity Firm:

$$R_0 = \frac{\text{Expected Earnings to Unlevered Firm}}{\text{Unlevered Equity}}$$

All of this leads to:

MM Proposition II (no taxes):

$$R_s = R_0 + \frac{B}{S}(R_0 - R_B)$$

thus we see that the required return on equity is a linear function of the firm's debt-equity ratio (see pg. 499).