**Artificial Intelligence (AI) for Investments**
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**Lecture - 08**

Before development of the modern theories about risk and return; financial managers always knew that risky projects are less valuable than safe projects. Thus, they demanded high rates of return from risky projects or accounting for the risk of these projects through more conservative forecasts of projected cash flows. Modern organizations make use of company cost of capital or firm cost of capital as benchmark of risk adjusted discount rate for investing in new projects.

The company cost of capital is the right discount rate only for investments that have the same risk as the company's overall business. For riskier projects the opportunity cost of capital is greater than the company cost of capital, for safer projects it is less. The company cost of capital is usually estimated as a weighted average cost of capital that is as the average rate of return demanded by investors in the company's debt and equity.

The hardest part of estimating the weighted average cost of capital is figuring out the cost of equity that is the expected rate of return to investors in the firm's common stock. Many firms turn to capital asset pricing model like CAPM for this answer. The CAPM states that expected return equals the risk-free interest rate plus risk premium that depends on beta and the market risk premium. Also, CAPM requires estimates of beta that are computed using historical stock market returns.

Now assume that you are evaluating a project to estimate its cost of capital you need to know if the project is average risk or above or below average risk. You need to check whether the project's cash flows are more or less sensitive to business cycle than average project. You also need to check whether the project has higher or lower fixed operating cost that is higher or lower operating leverage.

And whether it requires large future investments also please remember that a project's cost of capital depends only on market risk. Diversifiable risk can affect project cash flows but does not increase the cost of capital. Often, we add fudge factors to account for discount rates these such factors often introduce noise and incorrect valuations. Project risk varies over time for a given project for example a project is riskier and often loss making in young early stage while safe and cash flow positive at maturity.

However, very often while estimating discount rates managers consider them constant that is same in all the financial years. Financial managers usually assume that project risk will be the same in every future period and they use a single risk adjusted discount rate for all the future cash flows.

Company and project cost of capital.
We will discuss the company cost of capital and how a firm should estimate the cost of capital for individual projects.

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The 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 and therefore the appropriate discount rate for the firm's average risk projects. If the firm has no debt outstanding then the company cost of capital is just the expected date of return on the firm 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.

Each project should in principle be evaluated at its own opportunity cost of capital. This is clear implication of the value identity principle. For a firm composed of assets A and B the firm value is equal to

$$Firm\ value = PV(AB) = PV(A) + PV(B)$$

that is sum of separate asset values is the sum of combined. Here PV of A and PV of B are valued just as if they were mini firms in which stockholders could invest directly.

Investors would value A by discounting its cash flows at a rate reflecting the risk of A. They would value B by discounting at a rate reflecting the risk of B. The two discount rates will in general be different.

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If the present value of an asset depends on the identity of the company that bought it present values would not add up and we know they do add up. Consider a portfolio of 1 million dollar invested in firm A and one million invested in firm B. Would any reasonable investor say that the portfolio is worth anything more or less than 2 million dollars. If the firm considers investing in a third project C it should also value C as if C were many firm.

That is the firm should discount the cash flows of C at the expected rate of return that investors would demand if they could make a separate investment in C. The opportunity cost of capital depends on the use to which that capital is put. Think of a project company A that has a massive health care and consumer products line and established consumer base. 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. However, estimating that cost of capital for a new project or business would be challenging.

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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 cost of capital.

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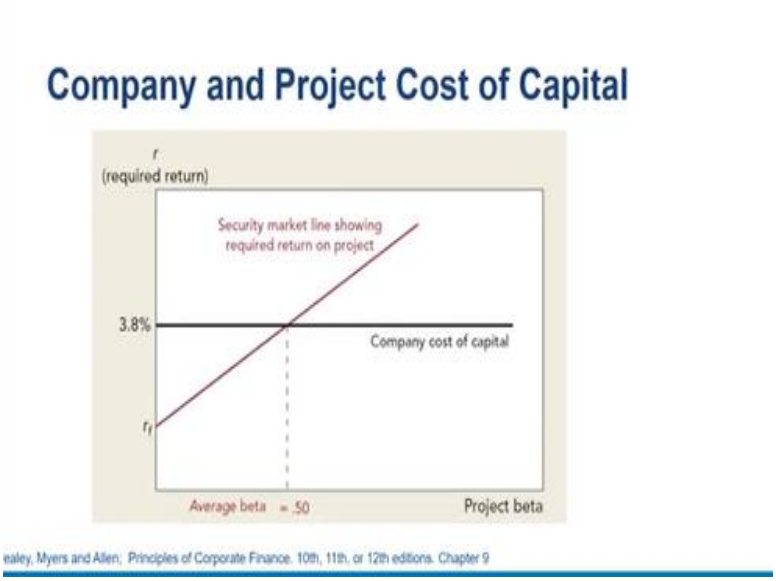


The company cost of capital rule tells the firm to accept any project above the horizontal line of capital line as shown in the figure here that is any project offering a return of more than 3.8 percent. A comparison between the company cost of capital rule and the required return from the capital asset pricing model rule shows and as provided in this figure the firm's company cost of capital is about 3.8 percent. This is the correct discount rate only if the project beta is 0.50.

In general, the correct discount rate increases as the project beta increases. The firm should accept projects with rates of return above the security market line relating required return to beta. It is clearly silly to suggest that the firm should demand the same rate of return from a very safe project from a very risky one. If the firm use the company cost of capital rule it would reject many good low risk projects and accept many high-risk poor projects.

It is also silly to suggest that just because another company has a low company cost of capital it is justified in accepting projects that the company would reject.

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The true cost of capital depends on project risk not on the company undertaking the project. So, why it is so much time spending in estimating the company cost of capital. There are two reasons, first many and maybe most projects can be treated as average risk projects that are neither more nor less risky than the average of the company's other assets. For these projects the company cost of capital is the right discount rate.

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 than to estimate each project's cost of capital from scratch.

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Business people have good intuition about relative risks. At least in industries they are used to but not about absolute risk or required rates of return. Therefore, they set a company-wide cost of capital as benchmark. This is not the right discount rate for everything the company does but adjustments can be made for more or less risky ventures. That said we have to admit that many large companies use the company cost of capital not just as benchmark but also as an all-purpose discount rate for every project proposal.

Measuring differences in risk is difficult to do objectively when firms force the use of a single company cost of capital risk adjustments shift from the discount rate to project cash flows. Top management may demand extra conservative cash flow forecast from extra risky projects. They may refuse to sign off an extra risky project unless NPV that is computed at the company cost of capital is well above zero whoever such rough and ready risk adjustments are better than none at all.

To summarize in this video, we discussed that company cost of capital is an appropriate discount rate as the appropriate opportunity cost of investing in the firm's assets that is the appropriate discount rate for average risk projects. However, if the projects are more riskier than the average firm risk, they should be discounted at appropriate rates that reflect the risk of these projects that is estimated using models such as CAPM.

Companies often use conservative cash flow forecast for risky projects. However, the appropriate approach requires them to use cost of capital which is efficient but difficult to estimate.

Computing company cost of capital. We discussed the computation of the company cost of capital or weighted average cost of capital.

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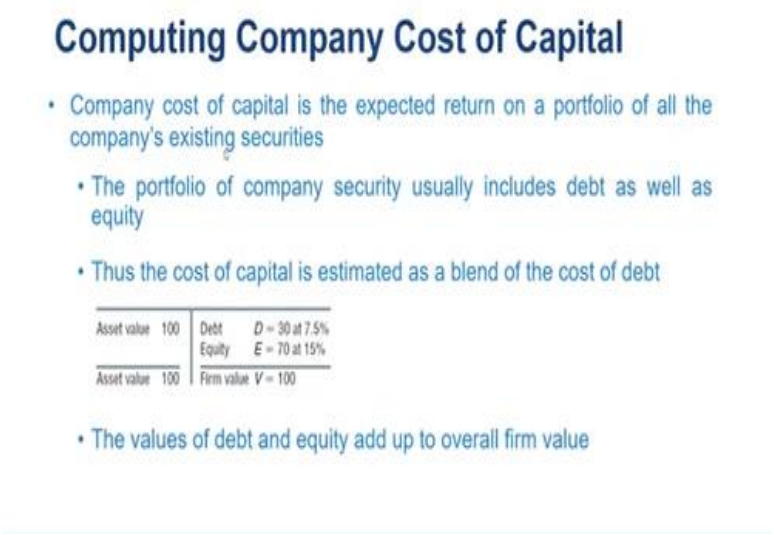


We defined the company cost of capital as the expected return on a portfolio of all the company's existing securities. That portfolio usually includes debt as well as equity. Thus, the cost of capital is estimated as a blend of the cost of debt that is the interest rate and the cost of equity. The expected rate of return demanded by investors in the firm's common stock. Consider a balance sheet of firm based on market values as shown here.

Where asset value of 100 which is the total value of asset that is 100, debt D = 30 at 7.5 percent cost, and equity E = 70 at 15 percent cost. So, the firm value on the liability side is also equal to 100. The values are debt and equity add up to the overall form value that is D + E = V and firm value V equals asset value here. These figures are all market values not book or accounting values. The market value of equity is often larger than the book value.

So, the market debt ratio debt by value D by V is often much lower than a debt ratio computed from the book balance sheet. The 7.5 percent cost of debt is the opportunity cost of capital for investors who hold the firm stake. The 15 percent cost of equity is the opportunity cost of capital for the investors who hold the firm shares. Neither measures the company cost of capital that is the opportunity cost of investing in the firm's assets.

The cost of debt is less than the company cost of capital because debt is safer than the assets. The cost of equity is greater than the cost of capital because the equity of a firm that borrows is riskier

than the assets. Equity is not a direct claim on from free cash flow it is a residual claim that stands behind the debt.

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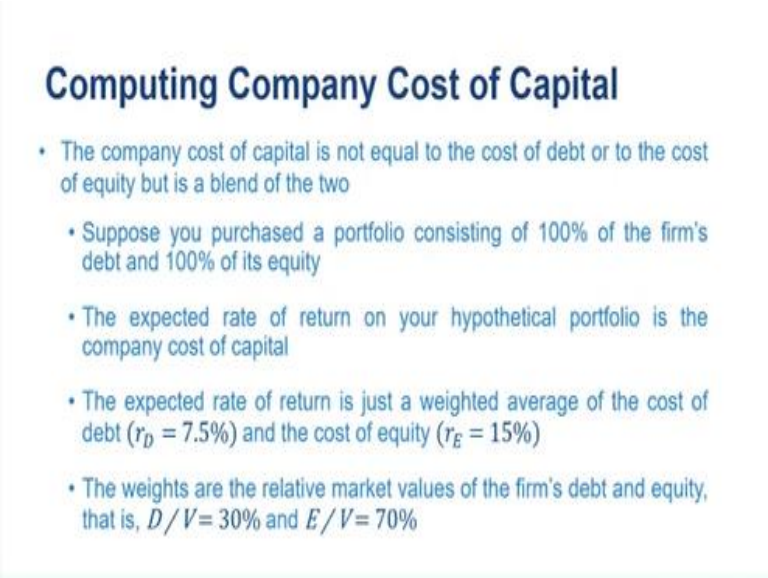


The company cost of capital is not equal to the cost of debt or to the cost of equity but is a blend of the two. Suppose you purchase a portfolio consisting of 100 % of the firms debt and 100 % of its equity then you would own 100 percent of its assets lock stock and barrel. You would not share the firm's fee cash flow with anyone. Every dollar that the firm pays out would be paid to you. The expected date 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 that is $r_D$ = 7.5 percent and the cost of equity that is $r_E$ = 15 percent. The weights are the relative market values of the firm's debt and equity that is $\frac{D}{V}$ = 30 %and $\frac{E}{V}$ = 70 %. Also please notice if the marginal corporate tax rate that is $T_c$ = 35 percent then after tax weighted average cost of capital that is WAAC or company cost of capital can be computed as shown here.

For example, WACC or company cost of capital = $r_D * (1 - T_c) * \frac{D}{V} + r_E * \frac{E}{V} = 7.5\% * (1 - 0.35) * 0.30 + 15 * 0.70 = 12.00\%$

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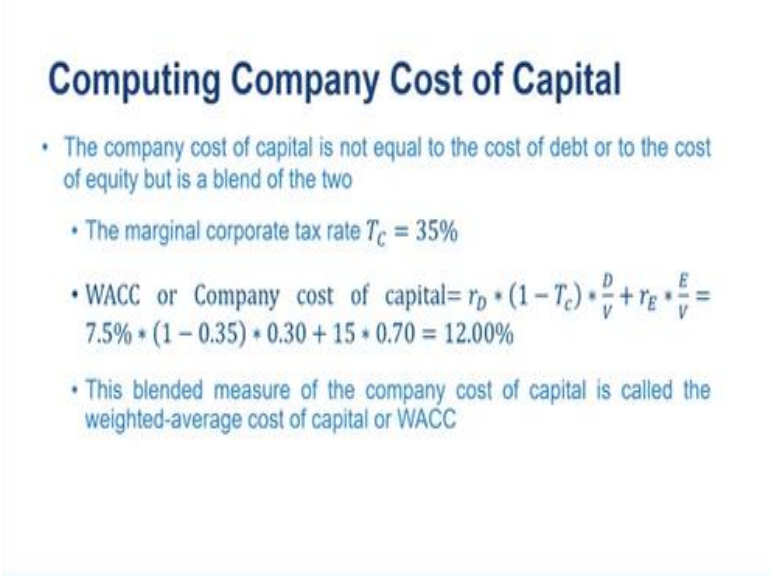


This blended measure of company cost of capital is called the weighted average cost of capital. To summarize in this video, we discussed how to compute company's cost of capital or WAAC using cost of debt, cost of equity, taxes and debt and equity proportions in market value terms. For a firm while cost of equity was considered as given in these computations, in subsequent videos, we will also examine the estimation of cost of equity.

Estimating the components of WAAC, that is, weighted average cost of capital. We will discuss the estimation of the components of WAAC that is risk free rate beta and risk premium. We will also discuss the estimation of asset beta a measure of the risk of company assets.

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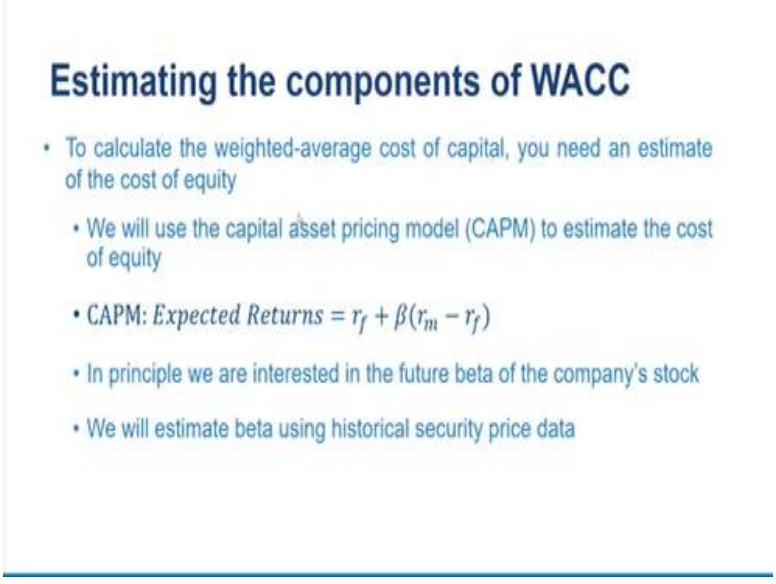

To calculate the weighted average cost of capital you need an estimate of the cost of equity. We will use the capital asset pricing model that is CAPM to estimate the cost of equity. As per CAPM

$Expected\ return = r_f + \beta(r_m - r_f)$

$r_m$ here is expected returns on market and $r_m - r_f$ is the risk premium. Let us start by estimating beta. In principle we are interested in the future beta of the company's stock. However, we will estimate beta using historical security price data.

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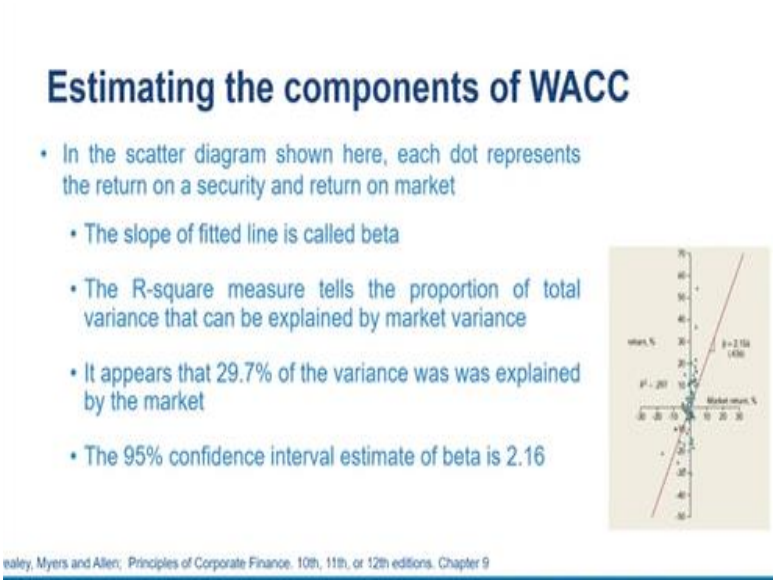


In this scatter diagram shown here each dot represents the return on a security and return on market. The slope of fitted line that is line fitted using ordinary least square regression that is OLS is called beta. That is how much on average the stock price has changed when the market change by 1 percent. The R square measure tells us the proportion of total variance that can be explained by market variance, that is, the risk of security that is on account of market risk or systematic part of risk.

It appears that 29.7 percent of the variance was explained by the market that is out of the total risk of the security 29.7 percent was on account of market risk and remaining was on account of stock specific risk or idiosyncratic risk or what we called as diversifiable risk.

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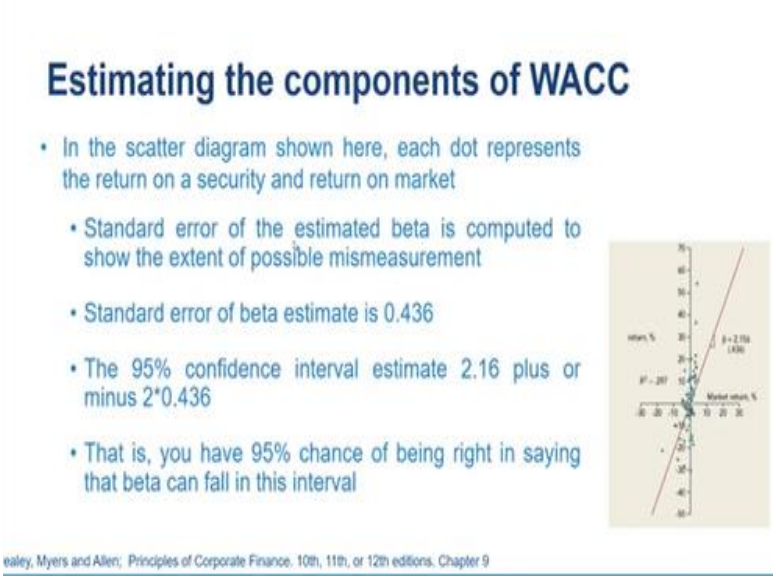


The noise in these returns can obscure the true beta. Therefore, statisticians calculate the standard error of the estimate beta to show the extent of possible mismeasurement. Then they set up a confidence interval of the estimated value plus or minus two standard errors. For example, in this case standard error of beta estimate is 0.436. Thus the 95 confidence interval estimate that is $2.16 \pm 2 * 0.436$.

This is the interval that you have 95 chance of being right in saying that beta can fall in this interval. There is always a large margin of error when estimating the beta for individual stocks. Fortunately, the estimation errors tend to cancel out when you estimate betas of portfolios. That is why financial managers often turn to industry betas that is betas of portfolios of securities from the same industry.

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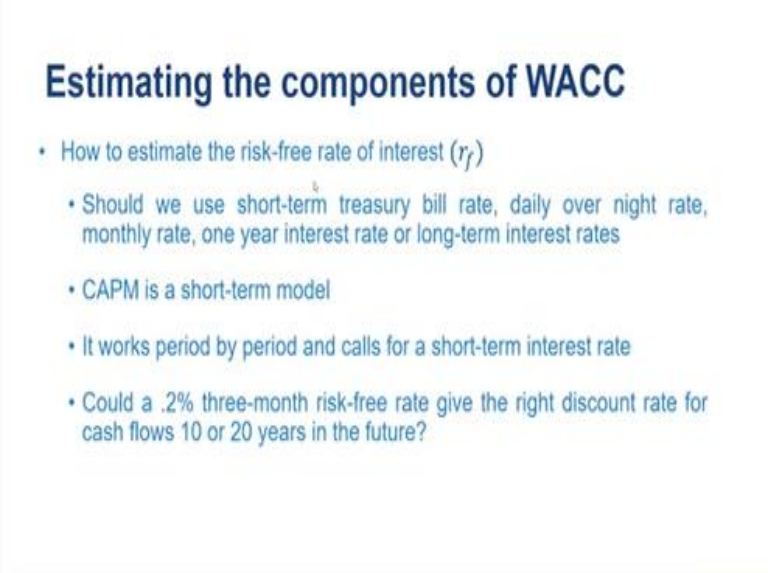


The next issue is what value to use for the risk-free interest rate. Should we use short-term treasury bill rate, daily overnight rate, monthly rate, one year interest rate or long term interest rates? These rates are to be used in CAPM. CAPM here is a short-term model it works period by period and calls for a short-term interest rate but could 0.2 percent three month risk free rate give the right discount rate for cash flows from 10 to 20 years in the future.

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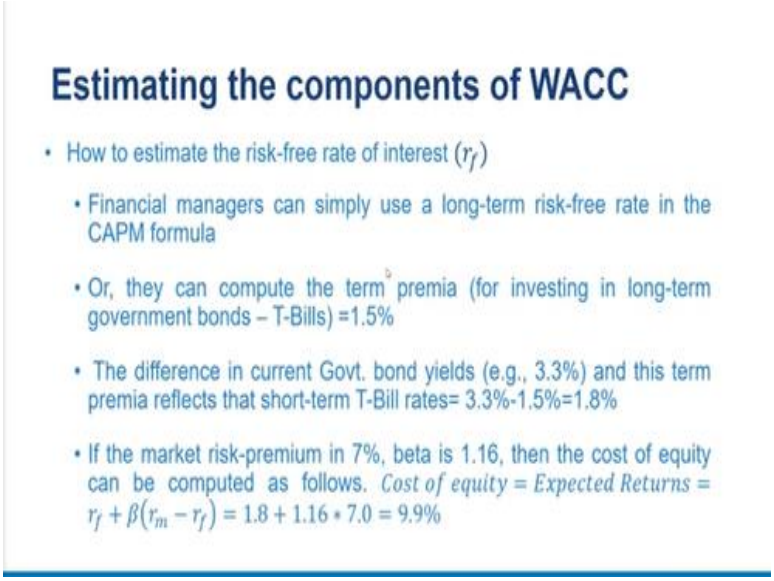


Financial managers muddle through this problem in one of the two ways. Either they first simply use a risk-free long-term rate in the CAPM formula. If this shortcut is used then the market is premium must be restated as the average difference between market returns and returns on long-

term treasuries. The second way retains the usual definition of the market risk premium as the difference between the market returns and returns on short-term treasury bill rates.

But now you have to forecast the expected return from holding treasury bills over the life of the project. We know that investors require a risk premium for holding long-term bonds rather than bills. To get a rough but reasonable estimate of the expected long-term return from investing in treasury bills we need to subtract the difference in premium between long-term government bonds and T bills that is 1.5 percent, assuming the T Bill rate is 1.5 percent, from the current yields on the long-term bonds assuming that is 3.3 percent. In this case expected long-term return on bills will be equal to yield on long-term bonds minus 1.5 percent which will be equal to $3.3 - 1.5 = 1.8\ \%$. This is a plausible estimate of the expected average future return on treasury bills.

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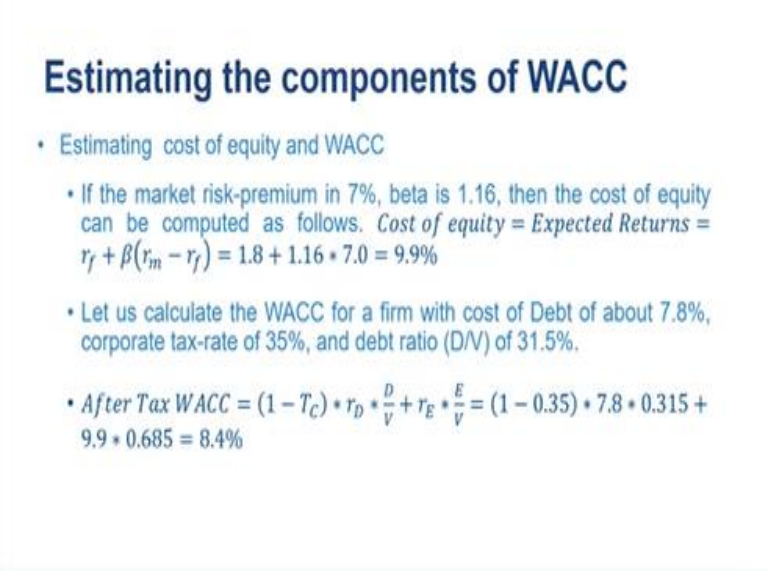


If the market risk premium is 7 percent, beta is 1.16, then the cost of equity can be computed as follows.

$Cost\ of\ equity\ = Expected\ returns\ = r_f + \beta(r_m - r_f) = 1.8 + 1.16 * 7 = 9.9\ \%$

Let us calculate the WACC for a firm with cost of debt about 7.8 percent, corporate tax rate of 35 percent and debt to value ratio of 31.5 percent.

$After\ tax\ WACC = (1 - T_c) * r_D * \frac{D}{V} + r_E * \frac{E}{V} = (1 - 0.35) * 7.8 * 0.315 + 9.9 * 0.685 = 8.4\%$ Thus, the firm should set its cost of capital estimates to 8.4 percent.

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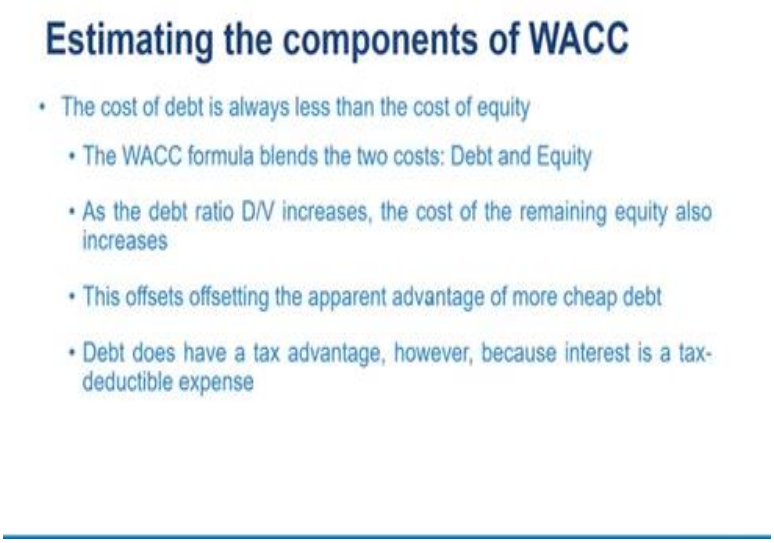


The cost of debt is always less than the cost of equity. The WAAC formula blends these two costs the formula is dangerous however because it suggests that average cost of capital could be reduced by substituting cheap debt for expensive equity. It does not work that way. As the debt ratio D by V increases the cost of the remaining equity also increases offsetting the apparent advantage of more cheap debt.

Debt does have a tax advantage however because interest is a tax-deductible expense that is why we use the after-tax cost debt in the after tax WAAC.

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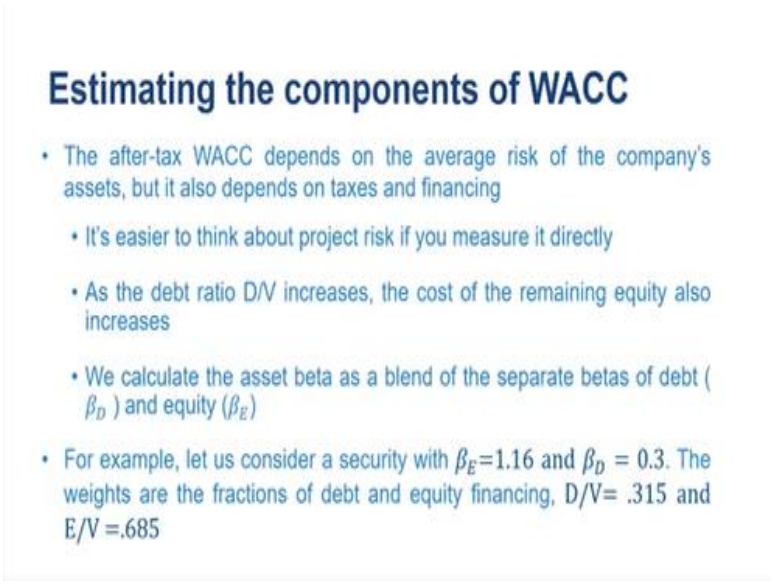

The after tax WAAC depends on the average risk of a company assets but it also depends on taxes and financing. It is easier to think about project risk if you measure it directly. The direct measure is called the asset beta. We calculate this asset beta as a blend of separate betas of debt and equity. For example, let us consider a security with $\beta_E$ = 1.16 and $\beta_D$= 0.3 the weights are the fractions of debt and equity financing that is $\frac{D}{V}$= 0.315 and $\frac{E}{V}$= 0.685.

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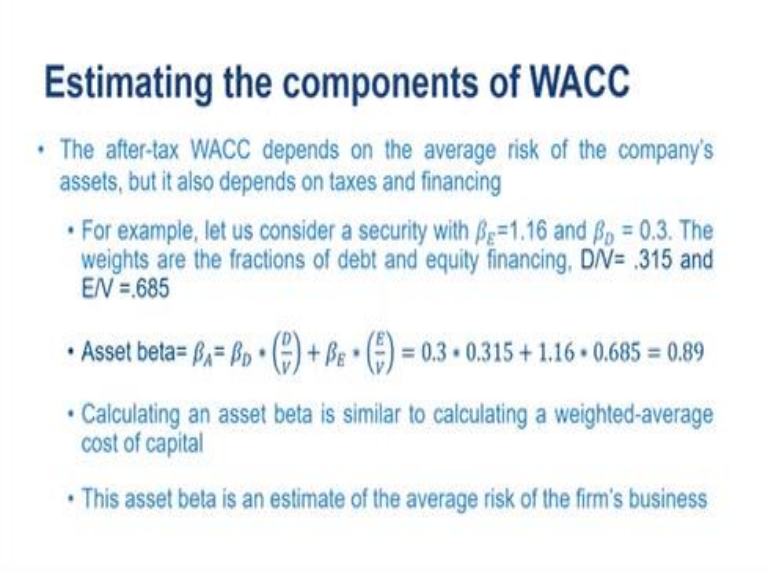


$$Asset\ beta = \beta_A = \beta_D * \left(\frac{D}{V}\right) + \beta_E * \left(\frac{E}{V}\right) = 0.3 * 0.315 + 1.16 * 0.685 = 0.89.$$

Calculating asset beta is similar to calculating a weighted average cost of capital. The debt and equity weights that is D by V and E by V are the same. The logic is also the same. Suppose you purchase the portfolio consisting of 100 percent of firm's equity and 100 percent of its debt then you would 100 percent of its assets lock stock and barrel and the beta of your portfolio would be equal to the beta of these assets, that is, weighted average of these assets.

The portfolio beta is of course just a weighted average of the betas of debt and equity. This asset beta is an estimate of the average risk of a firm's business, it is a useful benchmark but it can take you only so far. Not all investments of the firm will be of the same average risk and if you are the first to use railroad track network as an interplanetary transmission antenna you will have no asset betas to start with.

How can you make informed judgments about cost of capital for projects or lines of business when you suspect that risk is not average, it is unique. To summarize in this video, we discussed the

estimation of the components of CAPM model. First we estimated company beta by reducing the security returns on market returns. The slope of regression line represented the company beta that is the sensitivity of the security to market movements.

Next, we discuss the estimation of risk free rates. Though there are different ways to estimate the same one can estimate the difference between current government bond yields and short-term T bill rates as there is risk free interest rate that would represent the cost of holding long-term government securities. Next the estimates of expected market returns and risk free rates can be used for estimation of risk premium.

Analysing project risk. We will discuss how to analyse project risk. In this backdrop, we will also examine the role of asset betas.

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Suppose that a coal mining corporation wants to discuss the risk of investing in commercial real estate. For example, in a new company headquarters the asset beta for coal mining is not helpful. You need to know the beta of real estate. For the same we have to turn to Securities of real estate firms that are getting traded in financial markets. These would serve as a trader comparable for the proposed office building.

A company that wants to set a cost of capital for one particular line of business typically looks for pure place in that line of business. Pure play companies are firms that specialize in one activity.

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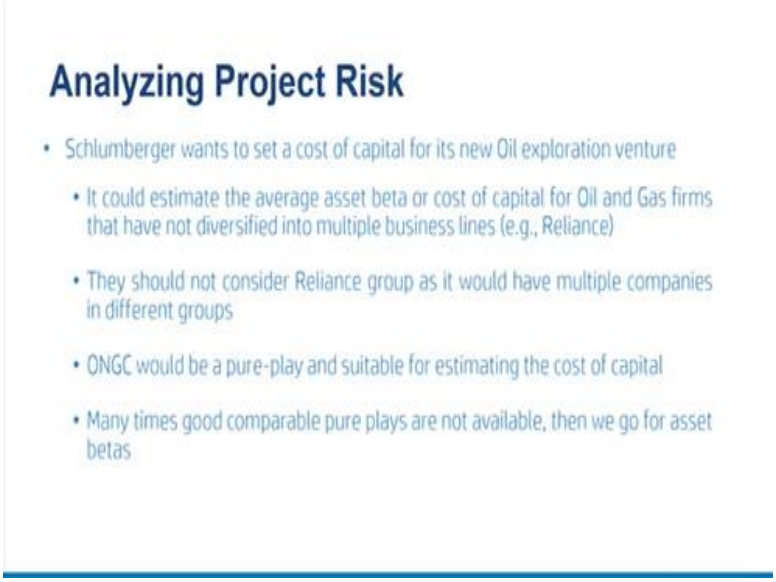


For example, suppose that Schlumberger wants to set a cost of capital for its new oil exploration venture. It could also estimate the average cost of beta or cost of capital for oil and gas firms that have not diversified into multiple business lines such as reliance. Overall company cost of capital are almost useless for conglomerates. Conglomerates diversify into several unrelated industries. So, they have to consider industry specific cost of capital.

They therefore look for pure place in the relevant industries. Consider Reliance group for example the group combines many different companies into different businesses including media software, oil and gas retail, telecom among others so it is not a pure play. However, if you look at ONGC it is a large company purely into oil and gas exploration. The trick is picking the comparable with business risks that are almost similar to Schlumberger new oil and gas exploration venture.

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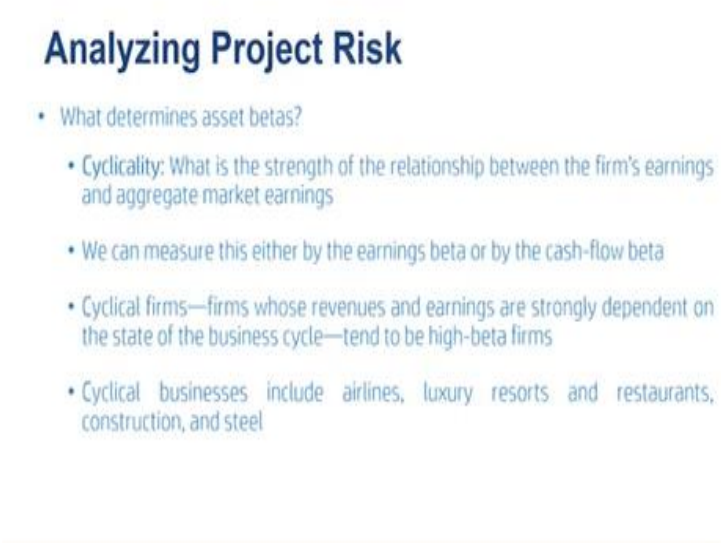


Sometimes good comparable are not available or are not good match to a particular project. Then the financial manager has to exercise his own judgment and the following considerations are made. Think about the determinants of asset betas, often the characteristic of a high or low beta assets can be observed when the beta itself cannot be. Next do not be fooled by the diversifiable risk. Say third avoid fudge factors.

Do not give in to the temptation to add fudge factors to the discount rate to offset things that could go wrong with the proposed investment adjust cash flow forecast first. Next, we try to answer the question what determines us betas. First cyclicality, many people intuition associates risk with the variability of earnings or cash flows but much of this variability reflects diversifiable risk.

Loan prospectors searching for gold look forward to extremely uncertain future outcome. But whether it is like it rich is unlikely and depends on the performance of market portfolio. Even if they do go find gold, they do not bear much market risk. Therefore, an investment in gold prospecting has a high standard deviation but relatively low beta, what really counts is the strength of the relationship between the firm's earnings and the aggregate earnings on all real assets.

We can measure this either by the earnings beta or by the cash flow beta. These are just like a real beta except that changes in earnings or cash flows are used in place of rates of return on securities. We would predict that firms with high earnings or cash flow betas should also have high asset

betas. This means that cyclical firms whose revenue and earnings are strongly dependent on the state of the business cycle tend to be high beta firms.

Thus, you should demand the higher rate of return from investments whose performance is strongly tied to the performance of the economy. Examples of cyclical businesses include airlines, luxury resorts and restaurants construction and steel. Much of the demand for steel depends on construction and capital investment. Examples of less cyclical businesses include food and tobacco products and pharmaceutical products.

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Next, we come to operating leverage. A production facility with high fixed costs related to variable cost is said to have high operating leverage. High operating leverage means a high asset beta. Let us see how this works. The cash flow is generated by an asset can be broken into revenue fixed costs and variable costs that is cash flow equal to revenue minus fixed cost minus variable cost. Costs are variable if they depend on the rate of output.

Examples are raw material costs, sales commissions and some labour and maintenance costs. Fixed costs are cash flows that occur regardless of whether the asset is active or ideal. For example, property taxes or the wages of workers under contract. We can break down the assets present value in the same way like present value of asset equal to present value of revenue minus present value of fixed cost minus present value of variable cost.

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Equivalently we can say present value of revenue equal to present value of fixed cost plus present value variable cost plus present value of assets. Those who receive the fixed costs are like debt holders in the project they simply get a fixed payment. Those who receive the net cash flows from the assets are like holders of common stock. They get whatever is left after payment of the fixed cost.

We can now figure out how the assets beta is related to the betas of the values of revenues and costs. The beta of PV revenue that is present value of revenues is a weighted average of the betas of its component parts that is

$$\beta_{revenue} = \beta_{fixedcost} * \frac{PV(fixedcost)}{PV(Revenue)} + \beta_{variablecost} * \frac{PV(variablecost)}{PV(Revenue)} + \beta_{asset} * \frac{PV(variable)}{PV(Revenue)}$$

The fixed cost beta should be zero. Whosoever receives the fixed cost receives a fixed stream of cash flows, the betas of the revenues and variable costs should be approximately the same because they respond to the same underlying variable that is rate of output. Therefore, we can substitute beta revenue or beta variable cost and solve for the asset beta. Remember we are assuming beta fixed cost equal to zero.

Also, PV revenue - PV variable cost = PV asset + PV of fixed cost.

$$\beta_{Asset} = \beta_{revenue} * \frac{PV(revenue) - PV(variablecost)}{PV(asset)} = \beta_{revenue}[1 + \frac{PV(fixedcost)}{PV(Asset)}$$

Beta asset = beta revenue into PV of revenue - PV of variable cost upon PV asset which is also equal to beta revenue times 1 + PV of fixed cost upon PV of asset. Thus, given the cyclicality of revenues as reflected in beta revenue the asset beta is proportional to the ratio of the present value of fixed cost to the present value of the project.

Other things being equal the alternative with the highest ratio of fixed cost to project value will have the higher project beta.

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Also do not be fooled by the diversifiable risk. We have defined risk as the asset beta for a firm industry or project but in everyday usage risk simply means bad outcome. People think of the risk of a project as a list of things that can go wrong. For example, a geologist looking for oil worries about the risk of a dry hole, a pharmaceutical company scientist worries about the risk that a new drug will have unacceptable side effects and so on.

Notice that these risks are all diversifiable risk. These hazards do not affect asset betas and should not affect the discount rate for the projects.

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Sometimes financial managers increase discount rates in an attempt to offset these risks. This makes no sense diversifiable risk should not increase the cost of capital. A simple example can be considered, a project Z that produces just one cash flow forecasted at one million dollar a year at the end of year one. It is regarded as average risk project suitable for discounting at a 10 percent company cost of capital.

And therefore, present value $PV = \frac{C_1}{1+r} = \frac{100000}{1.1} = 909100$. But now you discover that the company's engineers are behind the schedule in developing the technology required for the project. They are confident it will work but they admit to a small chance that it will not. You still see the most likely outcome as one million dollars.

But you also see some chance that the project Z will generate zero cash flow next year. The appropriate way to deal with the situation is to prepare unbiased cash flow forecast that give due weight to all possible outcomes favourable as well as unfavourable.

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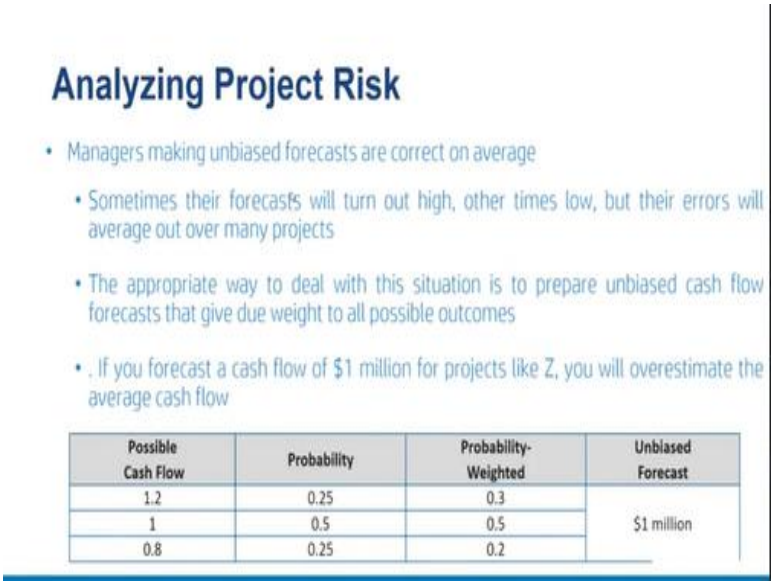


Managers making unbiased focus are correct on average. But sometimes their forecast may turn high and sometimes low but their errors will average out over many projects. If you forecast a cash flow of one million dollars for project like Z you will overestimate the average cash flow. You will overestimate the average cash flow because every now and then you will hit a zero. Those zeros should be averaged into your forecast.

Let us write the projected cash flows in probability terms and the unbiased forecast is the probability weighted average cash flows or expected cash flows as shown here in the table.

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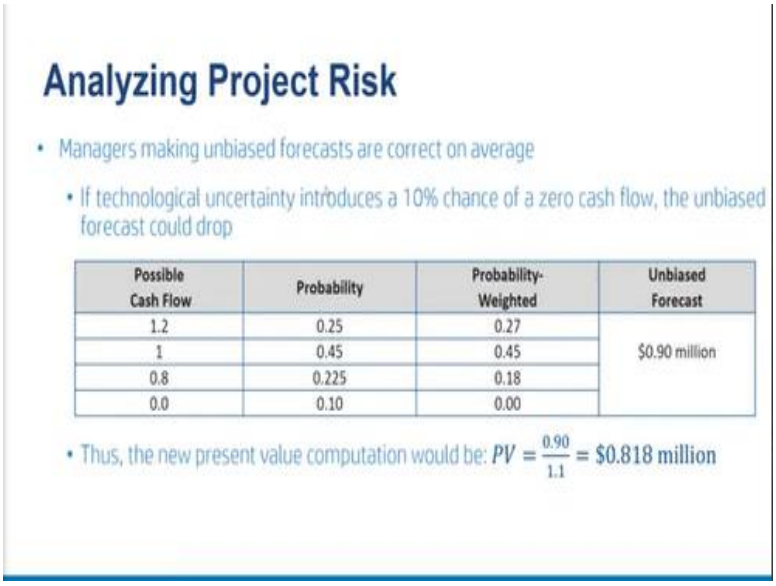

This might describe the initial prospects of project Z but if technological uncertainty introduces a 10 percent chance of zero cash flow the unbiased forecast could drop to 9 lakh dollars as shown in the table here. And therefore, the new present value computation would be

$$PV = \frac{0.90}{1.1} = \$0.818\, million$$

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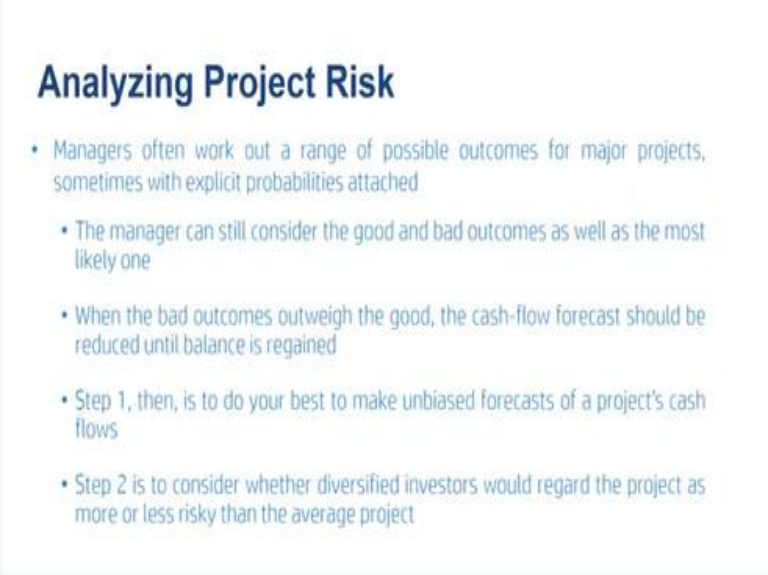


Managers often work out a range of possible outcomes for major projects sometimes with explicit probabilities attached. But even when outcomes and probabilities are not explicitly written down the manager can still consider the good and bad outcomes as well as the most likely one. When the bad outcomes outweigh the good the cash flow forecast should be reduced until the balance is regained.

Step one then is to do your best to make unbiased forecast of a project's cash flows. Unbiased forecasts incorporate all risks including diversifiable risk as well as market risks. Step two is to consider whether diversified investors would regard the project as more or less risky than the average project. In this step only market risks are relevant. Here we should note an important point to avoid fudge factors in discount rates.

Think back to our example of project Z where we reduce forecast cash flows from 1 million to 9 lakh dollars to account for a possible failure of technology. The project's present value that is PV was reduced from 909100 to 818000. You could have gotten the right answer by adding a fudge

factor to the discount rate and discounting the original forecast of one million dollars. But you have to think through the possible cash flows to get fudge factor. And once you forecast the cash flows directly and correctly you do not need the fudge factor.

Fudge factors in discount rates are dangerous because they disappear and display the clear thinking about the future cash flows. To summarize in this video, we discussed the estimation of cost of capital for a project with the risk that is different from the average risk of the firm. For the same it is often useful to look for pure play companies with the same risk as that of the project.

In this backdrop often the asset betas are used to understand the risk of the project. These asset betas are primarily affected by the variability of earnings or cash flows and operating leverage. Also, the diversifiable component of this should not be considered for estimating asset beta and finally with the help of a simple yet interesting example we examine how to value these uncertain risky project cash flows and account for the dynamic nature of the risk that changes as time passes.

Certainty equivalents. We will discuss the concept of certainty equivalents. First, we work through an example showing what certainty equivalents are then we use certain equivalents to uncover what you are really assuming when you discount a series of future cash flows at a single risk adjusted discount rate. We also value a project when risk changes over time and ordinary discounting fails.

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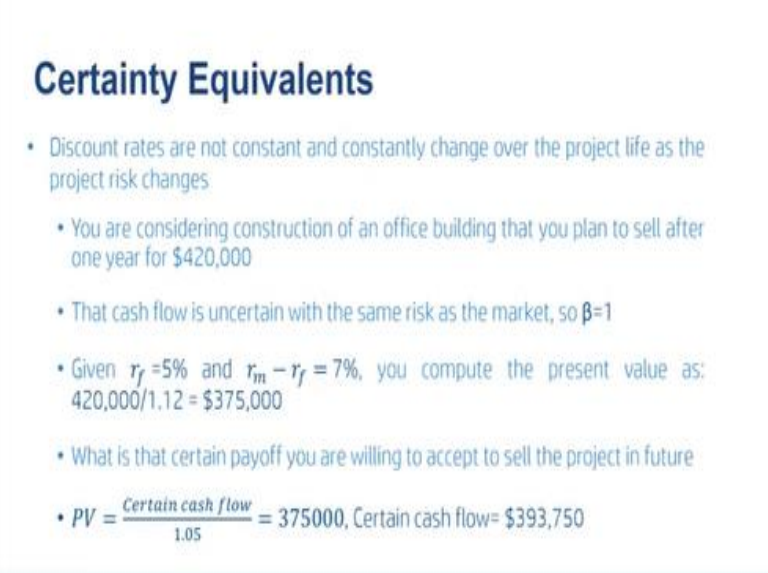


In practical capital budgeting a single risk adjusted discount rate is used to discount all future cash flows. This assumes that project list does not change over the time and remains constant year in and year out. We note that this cannot be strictly true for this the risk that companies are exposed to are constantly shifting. We are venturing here onto something difficult ground but there is a way to think about risk that can suggest a route through.

It involves converting the expected cash flows to certainty equivalents. Your discount at a risk adjusted discount rate of 5% + 1 * 7%= 12% rather than the 5 % risk period of interest. This gives the present value of $\frac{420000}{1.12} = \$375000$. Suppose a real estate company now approaches you and offers a fixed price at which it will buy the building from you at the end of the year. This guarantee would remove any uncertainty about the payoff on your investment.

So, you would accept a lower figure than the uncertain payoff for 420000 dollars. But how much less? If the building has a present value of 375000 dollars and the interest rate is 5 percent then $PV = \frac{certaincashflow}{1.05} = 375000\ dollars$ and a $certain\ cash\ flow = \$393750$

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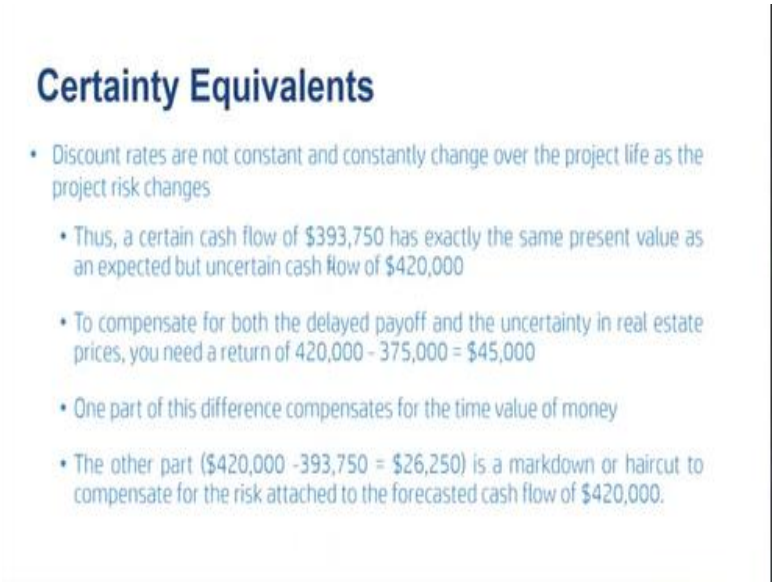


In other words, a certain cash flow of 393750 dollars has exactly the same present value as an expected but uncertain cash flow of 420000 dollars. The cash flow of 393750 is therefore known as the certainty equivalent cash flow to compensate for both the delayed payoff and uncertainty in real estate crises. You need a return of $420{,}000 - 3{,}75{,}000 = \$45000$. One part of this difference compensates for the time value of money.

The other part that is $420000 - 393750 = \$26250$ is a markdown or haircut to compensate for the risk attached to the forecasted cash flow of $420000.

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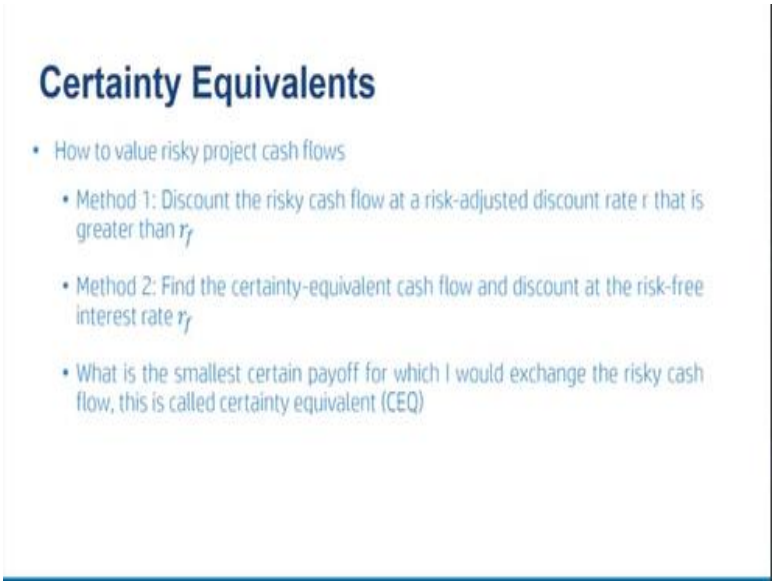

The following example illustrates two ways to value a risky cash flow. First method one discount the risky cash flow at the risk adjusted discount rate r that is greater than r f. The risk adjusted discount rate adjusts for both time and risk. This is illustrated by the clockwise route in the figure shown here. Method 2, find the certainty equivalent cash flow and discount at the risk-free interest rate r f.

When you use this method, you need to ask what is the smallest certain payoff for which I would exchange the risky cash flow. This is called a certainty equivalent denoted by CEQ. Since CEQ is the value equivalent of save cash flow it is discounted at the risk-free rate. The certainty equivalent method makes separate adjustments for risk and time and we can see this in the counter clockwise figure shown here.

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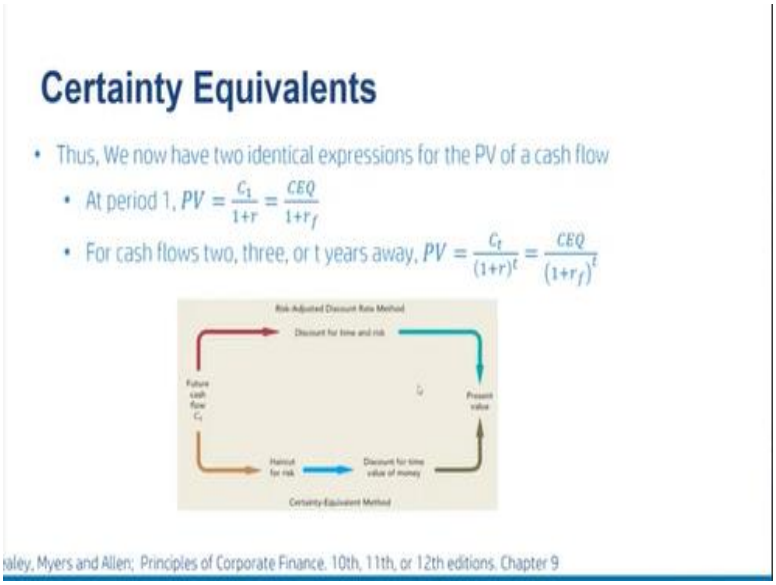


Thus, we have two identical expressions for the PV of a cash flow at the period one. First one is $PV = \frac{C_1}{1+r} = \frac{CEQ}{1+r_f}$. F

For cash flows 2, 3 or t years away, we have $PV = \frac{C_t}{(1+r)^t} = \frac{CEQ_t}{(1+r_f)^t}$

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## 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 |

Consider the following example now. Consider two simple projects project A is expected to produce a cash flow of 100 million dollars for each of the three years. There is free interest rate is 6 percent, the market risk premium is 8 percent and project A beta is 0.75. Therefore, calculate opportunity cost of capital as shown here that is $r = r_f + \beta(r_m - r_f) = 6 + 8 * 0.75 = 12\%$ Discounting at 12 percent gives us the present value for each cash flow as shown here in the table and the overall PV of 240.2.

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## 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 |

Now compare these figures with the cash flows of project B. Notice that B's cash flows are lower than is but these cash flows are safe and therefore they are discounted at the risk-free interest rate. The present value of each year's cash flow is identical for the two projects.

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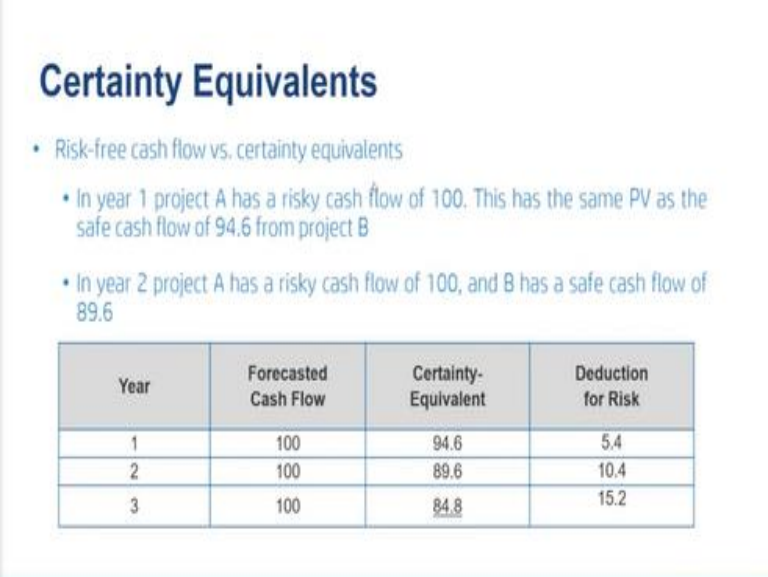


In year one project A has a risky cash flow of 100 this has the same PV as the safe cash flow of 94.6 from project B. Therefore 94.6 is the certainty equivalent of 100. Since the two cash flows have the same PV, investors must be willing to give up 100 - 94.6 that is equal to 5.4 in expected year one income in order to get rid of the uncertainty. In year two project A has a risky cash flow of 100 and B has a risky cash flow of 89.6.

Again, both flows have the same PV thus to eliminate the uncertainty in year two investors are prepared to give up 100 - 89.6 = 10.4 of future income. To eliminate uncertainty in year three they are willing to give up 100 - 84.8 = 15.2 of future income. To value project A, you discounted each cash flow at the same risk adjusted discount rate of 12 percent. Now you can see that what is implied when you did that, by using a constant rate you effectively made a larger deduction for risk from the later cash flows.

This can also be seen in the table shown here. The second cash flow is riskier than the first because it is exposed to two years of market risk. The third cash flow is riskier still because it is exposed to three years of market risk. This increased risk is reflected in the certainty equivalents that decline by a constant proportion each period. Therefore, use of a constant risk adjusted discount rate for a stream of cash flow assumes that risk accumulates at a constant rate as you look further into the future.

To summarize in this video, we discuss the concept of certainty equivalents C's or CEQ these are the certain cash flows that you consider receiving in lieu of a given risky cash flows. Quite obvious to say that they are lower than risky cash flows and thus discounting C is at risk free rates results in the same equivalent cash flow as when the corresponding risky cash flows are discounted at appropriate discount rate.

Through a couple of examples we have shown how C's are useful in examining the risky and risk free cash flow components of a project. This lesson shows us how to apply the cost of capital concept in valuing risky projects. Suppose the project has the same market risk as the company's existing assets. In this case the project cash flows can be discounted at the company cost of capital. The company cost of capital is the rate of return that investors require on a portfolio of all of the company's outstanding debt and equity.

It is usually calculated as an after-tax weighted average cost of capital that is after tax WACC that is as the weighted average of the after tax cost of debt and the cost of equity. The weights are the relative market values of debt and equity. The cost of debt is calculated after tax because interest is a tax-deductible expense. The hardest part of calculating the after tax WAAC is estimation of the cost of equity.

Most large public corporations use capital asset pricing model or CAPM to do this they generally estimate the firm's equity beta from past rates of return for the firm's common stock and for the market and they check their estimate against the average beta of similar firms. The after tax WAAC is the correct discount rate for projects that have the same market risk as the company's existing business.

Many firms however use the after tax WAAC as the discount rate for all the projects. This is a dangerous procedure if the procedure is followed strictly,the firm will accept too many high-risk projects and reject too many low-risk projects. It is project risk that counts the true cost of capital depends on the use of which the capital is put. Managers therefore need to understand why a particular project may have above or below average risk.

You can often identify the characteristics of a high or low beta project even when the beta cannot be estimated directly. For example, you can figure out how much the Project's cash flows are affected by the performance of the entire economy. Cyclical projects are generally high beta projects you can also look at the operating leverage fixed production costs increase beta. Do not be fooled by the diversifiable risk, diversifiable risk do not affect asset betas or the cost of capital.

But the possibility of bad outcomes should be incorporated in the cash flow forecast. Also be careful not to offset worries about the project's future performance by adding a fudge factor to the discount rate. Fudge factors do no work and they may seriously undervalue long-lived projects. There is one more sense to jump most projects produce cash flows for several years. Firms generally use the same risk adjusted rate to discount each of these cash flows.

When they do this, they are implicitly assuming that cumulative risk increases at a constant rate as you look further into the future. That assumption is usually reasonable, it is precisely true when the project's future beta will be constant that is when risk per period is constant. But exceptions sometime prove the rule. Be on the alert for projects with risk clearly does not increase steadily.

In these cases, you should break the project into segments within which the same discount rate can be reasonably used or you should use the certainty equivalents version of DCF model which allows separate risk adjustment to each period cash flow.