Choice of Discount Rate

Discussion Plan

- **Basic Theory and Practice**
- **A common practical approach:**
  - **WACC = Weighted Average Cost of Capital**
- **Taking Uncertainty into account:**
  - **CAPM = Capital Asset Pricing Model**

Choice of Discount Rate: Basic Theory

- **The Principle**
- **Consequences**
- **Practice**
- **Application to Government**
- **Inflation**
- **Is Critical!**

Choice of DR: Principle

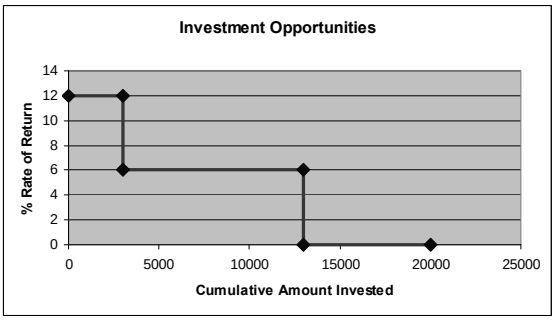
- DR should reflect rate at which money can increase in productive investments = productivity of capital
- Empirical definition -- depends on circumstances
  - What are the opportunities?
  - Opportunities with highest return define DR
  - If on desert island, no investments possible, DR = 0
- Test: What is rate at which current investments are producing, at margin?

Important Concept: "at the Margin"

- Comparable to "partial derivative", $\delta (f) / \delta x$, for infinitesimal changes δx
- Refers to substantial changes, Δx
- $\Delta(f) / \Delta x$ depends on size, and direction, of Δx
  - Importance to us of extra \$1000, \$10,000?
  - Does gain of \$10,000 have same value to you as loss of \$10,000?
- Value "at the margin" thus depend on specifics

Example of Application (Opportunities)

- A person could invest up to
  - $ 3,000 in an enterprise to get 12%
  - $ 10,000 in saving account at 6%
- How do we think about this?



What about debts?

- This person also has loans, and can repay up to:
  - $ 500 at store 18%
  - $ 5,000 for tuition 9%
- How do we think about this?

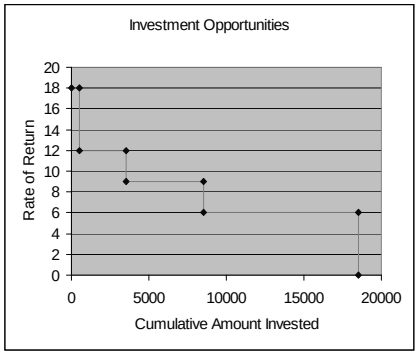
Repaying debt = Investment Opportunity

- **Paying off a debt is a form of investment**
- **WHY IS THIS CORRECT?**
- **Debt repayment and investment both lead to a similar increase in cash flow**
- **Example: Suppose you have a monthly salary S and debt charges C: Your net is [S – C]**
- **Suppose a gift allows you either to repay debt or invest to get C per month. Your new net is then:**

$$\{[S - C] + C\} = S \quad \text{or } S$$

Example of Application (Calculation)

	Investment	Return %
Projects	500	18
	3000	12
	5000	9
	10000	6
Cumulative	0	18
	500	18
	501	12
	3500	12
	3501	9
	8500	9
	8501	6
	18500	6
	18501	0



What is the DR if person only has 400? 6500?

Answer: (a) 18% (b) = alternative return of $6500
= (90 + 360 + 270)/6500 = ~11%

Consequences of Principle

- DR peculiar to situation of decision-making unit
  - depends on opportunities
- DR not a precise measure
  - except in classroom examples, exact return difficult to obtain precisely; ± 1 or 2% quite acceptable
- DR ≥ interest rate paid
  - repaying debt always one possible investment, so DR at least equals interest
  - actually you borrow because: value of money > interest
- Since DR = minimum acceptable profitability, NPV > 0 indicates a "good" project (may not be best)

DR Used in Practice

- A nice round number, generally
  - recognition of imprecision in measurement
  - For example: US Government uses 2 significant figures (next slide and tables in Engineering Economy lecture)
- Where rate must be defended legally, as to regulatory groups - by precise formula
  - not subjective
  - illusory precision -- not accurate
- Research, industry reports indicate real profitability, with no inflation ≈ 10 to 15%/year worldwide

Discount rates by OMB Circ. A-94, Appendix C
[Ref: www.whitehouse.gov/omb/circulars/a094/a094_appx-c.html]

Nominal Discount Rates. A forecast of nominal or market interest rates for 2007 based on the economic assumptions from the 2008 Budget are presented below. These nominal rates are to be used for discounting nominal flows, which are often encountered in lease-purchase analysis.

Nominal Interest Rates on Treasury Notes and Bonds of Specified Maturities (in percent)

3-Year	5-Year	7-Year	10-Year	20-Year	30-Year
4.9	4.9	4.9	5.0	5.1	5.1

Real Discount Rates. A forecast of real interest rates from which the inflation premium has been removed and based on the economic assumptions from the 2008 Budget is presented below. These real rates are to be used for discounting real (constant-dollar) flows, as is often required in cost-effectiveness analysis.

Real Interest Rates on Treasury Notes and Bonds of Specified Maturities (in percent)

3-Year	5-Year	7-Year	10-Year	20-Year	30-Year
2.5	2.6	2.7	2.8	3.0	3.0

Example of Corporate thinking

"B&W… seeks an after tax return on assets of 25% …

"if … return on net assets was less than 15%, we would go into a fix or exit mode…

"…a rule that any new product had to meet a hurdle rate … an internal rate of return (IRR) of 30% …

"It's not going to come as any surprise that any new product… was better than 30%.

"The problem … is that managers knew which levers to tweak to project the required returns…

Source: http://findarticles.com/p/articles/mi_m3870/is_nt_vol14/ai_20860069/pg_4

CFO: Magazine for Senior Financial Executive, May 1998

Application to Government

- Where does Government Money come from?
- Taxes: Government can use money to reduce taxes – and increase private spending or investment
- Thus, from national perspective, Government DR should equal that of private sector (thus around 10% to 15%)
- Such rates would stop many Government investments? Does this mean Nation should cut back on schools, etc?

Implications of Higher Government DR

- DR to be used for economic investments.
- Value of many government actions not monetary (e.g.: defense, justice, ...)
- DR not appropriate to decide if schools should be built at all; is appropriate for choice of design
- Is appropriate to decide about design elements with financial benefits
  - Low or High Efficiency Heating System
  - Choice of Building Materials, etc
  - See Asphalt vs Concrete Case

US Govt base position on Discount rate (OMB Circular A-94, 1992 revised annually)

1. Base-Case Analysis.
Constant-dollar benefit-cost analyses of proposed investments and regulations should report net present value … determined using a **real discount rate of 7 percent**. This rate approximates the marginal pretax rate of return on an average investment in the private sector in recent years.
[R de N note: statement about average return is not universally held]

2. Other Discount Rates.
Analyses should show the **sensitivity of the discounted net present value** and other outcomes to variations in the discount rate. The importance of these alternative calculations will depend on the specific economic characteristics of the program under analysis. For example, in analyzing a regulatory proposal whose main cost is to reduce business investment, net present value should also be calculated using a higher discount rate than 7 percent.

http://www.whitehouse.gov/omb/circulars/a094/a094.html
NOTE: This is pre 2000 version. Later ones indicate DR around 5%, as shown.

Discount Rate and Inflation

- **Issue is Comparability**
  - **the idea is to place all B, C on current basis of value**
- **Two factors**
  - **Productivity, p % / year**
  - **Change in purchasing power, i % / year**
    Inflation, same item costs more each period -- usual case
    Deflation, same item costs less each period -- rare
- **Procedure depends on whether B, C stated in constant or changing purchasing power**
  - **If constant: r = p this is "real" return**
  - **If varying: r = p + i this is "nominal" return**

Examples of Constant and Nominal $

- Consider the valuation of the benefits of a new more efficient machine that saves 1,000 hours of labor a year.
- Suppose current cost of labor = $25 / hour

- If we value benefits at $25,000 / year we would be using constant $ and should use the "real" discount rate
- If we recognize that cost of labor increases with inflation [to be $ 26 /year next year etc] and use these rates in cash flow, then we are should use the "nominal" discount rate

Examples: Which DR? p or (p + i) ?

1) Build Bridge, Tolls $1/car

r = p + i Tolls unlikely to adjust with inflation

Revenues are in "nominal" terms. If inflation were taken into account, they would be decreasing by i %/year in "real" terms

2) Build Hospital, Fee $1000/bed/day

r = p Rates here (in US) do adjust with inflation, therefore you get $ equal to current $. You do analysis using "real" revenues, that you expect will be adjusted upward according to inflation.

Examples: Which DR? p or (p + i) ?

3) Buy New Furnace, Save 2000 gallons fuel / year

r = p So long as fuel costs vary with inflation

Same rationale as above. You do the analysis in "real" terms, and use the "real" DR.

If you had tried to account for inflation in your estimates of future savings (thus looking at nominal returns), you would want to use a "nominal" DR.

Note that US Government publishes DR for both "real" and "nominal" cases (In OMB Circular A-94, mentioned earlier).

US Government Guidance on Inflation

7. **Treatment of Inflation**. Future inflation is highly uncertain. Analysts should avoid having to make an assumption about the general rate of inflation whenever possible.

a. **Real or Nominal Values**. Economic analyses are often most readily accomplished using *real* or *constant-dollar* values, i.e., by measuring benefits and costs in units of stabl purchasing power. (Such estimates may reflect expected future changes in relative prices however, where there is a reasonable basis for estimating such changes.) Where future benefits and costs are given in *nominal* terms, i.e., in terms of the future purchasing powe of the dollar, the analysis should use these values rather than convert them to constant dollars as, for example, in the case of lease-purchase analysis.

Nominal and real values must not be combined in the same analysis. Logical consistency requires that analysis be conducted either in constant dollars or in terms of nominal values. This may require converting some nominal values to real values, or vice versa.

http://www.whitehouse.gov/omb/circulars/a094/a094.html

Choice of DR Critical

- DR indicates if any investment is minimally acceptable
- Ranking of investments changes with DR which are:
  - less capital intensive
  - shorter lives (example: VW vs. Mercedes)
- Choice of DR very political. Low rates favored by
  - project enthusiasts ; believers in government control
- DR difficult to define accurately!

Part 2 : A Common Practical Method

Weighted Average Cost of Capital

(WACC)

How do Companies Estimate Cost of Money?

- Companies unlikely to apply an "opportunity cost of capital" approach as outlined previously
  - Unlikely to have an exhaustive list of opportunities
  - Their returns may be difficult to identify unambigously
- They need an alternative approach. This is to estimate their historic, comparable returns.
- Note: The focus – as throughout course – is on the evaluation of Designs of Engineering Projects
  - Emphasis different from Finance, which stresses the use of public or market data enterprises with similar products
  - Data on Engineering Projects typically closely guarded corporate secrets, not publically available

… Frequently by some version of WACC

- Weighted Average Cost of Capital (WACC) is a common starting point.
- WACC is based on
  - average cost of money – an aggregate measure,
  - estimated returns expected by investors, NOW
- BUT, limitations on use as Discount Rate
  - May represent a minimum rate
  - Does not reflect Opportunity Cost
  - Does not account for UNCERTAINTY of project

Issues to Address Now

- How do companies raise money?
- What do investors expect?
- Mechanics of Calculations for WACC
- Uses and Mis-uses of WACC
- Treatment of uncertainty elsewhere

How do Companies Raise Money?

- Debt -- they borrow money
  - General bank loans and bond issues
  - Company uses immediate proceeds, and repays over time with interest
- Equity -- they sell shares in the company
  - Company uses proceeds
  - Shareholders gain ownership in the company
  - Shareholders expect future earnings and growth
  - Note: Most trades of stock occur in "secondary market", company gets money only once

What do Investors Expect?

- **Holders of Debt and Equity expect to make money**
  - **Explicit for Debt: Equals interest rate**
  - **Implicit for Equity: Investors anticipate combination of growth and earnings, realized as dividends or higher stock prices**
- **To Company, these expectations represent cost of money**
  - **Either repay loan with interest**
  - **Or give up part of future earnings and stock growth**

What Affects Cost of Money?

- **Confidence in Company**
  - **Either interest company pays to borrow**
  - **Or value of Shares in company**
- **Factors that Affect Confidence**
  - **Start-up vs. Well-established company**
  - **Risky vs. Safe Industries or Regions of World**
  - **Weak vs. Strong company (financially or strategically)**
  - **Other?**

Calculating WACC (1)

- **Basic Idea: Average Expected Return**
- **First-order formula:**
  - **WACC = R for equity (Equity %) + R on Bonds (Bond %)**
- **Return on Equity difficult to estimate**
  - **Estimate future growth and earnings, based on track record (if any) and prospects**
  - **Examine historical returns for similar companies in similar situations**
- **More sophisticated formulas take into account local tax issues, not relevant to current presentation of principle**

Simple Example: Start-up Company

- **Hypothetical case**
  - **First money raising effort**
  - **No outstanding debts**
- **Equity:**
  - **Will sell $10 million worth of shares; estimated return = 25%**
- **Debt:**
  - **Will issue $5 million in debt, will pay 10% interest a year**
  - **Note: Bonds cheaper than stock -- WHY?**
- **Total money raised = debt + equity = $15 million**
- **WACC = ?**

  = 25% (2/3) + 10% (1/3) = 20 %

Calculating WACC (2)

- For Established Companies
  - Procedure similar in concept,
  - more difficult to do because of variety of securities
- Estimated debt and equity returns estimated from current MARKET prices of securities (this is major difference from previous case)
  - A $1000 bond paying 10% on face value may, for example, be selling at $1200 so that its actual return = (10%) 1000/1200 = 8.33%
  - Total value of Equity = "market capitalization" = (share price)(number of shares outstanding)l

Calculating WACC (3)

$WACC = r_{equity} (E/V) + r_{debt} (D/V)$

D, E = current market value of debt and equity

V = D + E = sum of debt and equity value

r_{debt} = current rate of borrowing

r_{equity} = current expected rate of return on stock

- Again, return on equity includes earnings and growth

Simple Example: Established Company

- Company has a proven record
- Current market value of its securities
  - Debt = 50 million; Annual payments = 4 million
  - Stock = 100 million; expected return = 20%
- WACC = Equity R (Equity %) + Bond R (Bond %)
  = ???
  = 20% (2/3) + 8% (1/3) = 16%
- Represents Current Average:
  - Investor expectations (if stock safer => lower return)
  - Cost of capital company could expect

Potential Use and Mis-Use of WACC as DR

- Uses as a Metric
  - Performance: cost of money over time
  - Comparison: within and between companies in industry
- Use as a reasonable discount rate
  - if project is an average investment for company
  - example: the 32,000th McDonald store (no. as of 2009)
- Often, WACC is an inappropriate discount rate
  - Many projects not average (some more risky than others)
  - WACC is cost of money, not necessarily opportunity cost

WACC Summary

- WACC is an average cost of raising money; proportional average of investor expectations
- Useful metric for some activities
- A starting point for project analyses
- HOWEVER, use WACC as DR with caution
  - Is investment "typical" for the organization?
  - If not, WACC is probably not applicable

Part 3 – Including Uncertainty

Capital Asset Pricing Model

(CAPM)

CAPM Concept

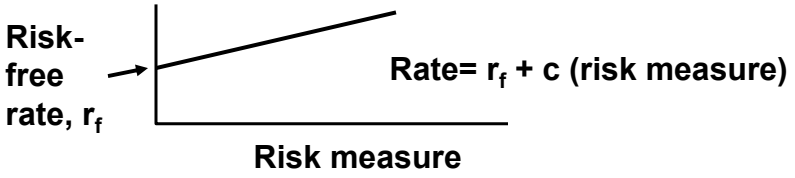
- CAPM adjusts discount rate for risk.
- Basic idea: Investors demand more reward if an Investment is more Uncertain
- For equal return, prefer more certain project
- More Uncertainty => more return
- Relationship between Uncertainty ("Risk") and return to be derived from market

CAPM Model Illustrated

- "Risk-Return" relationship generally linear

$$\text{Rate} = r_{free} + c\,(\text{risk measure})$$

Where r_{free}, "risk-free" rate is taken to be safest return, often taken to be US Treasury debt



Summary for today

- Choice of DR rate not obvious
- Principle is clear
- … but application not easy
  - Difficult to calculate precisely
  - Easy to manipulate
  - Motivation to manipulate great
- WACC is a common approximation
  - But not fully satisfactory
- CAPM is a way to recognize uncertainty