Politecnico di Torino
27 October 2004

Fundamental Concepts of Valuation

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Introduction: What is a Successful IT Project?

The oft-quoted headline [by the Standish Group] is that only 28% of IT projects actually succeed fully: 49% are "challenged" and 23% fail. Of course this kind of statistic rests very heavily on the definition of success, and it's significant that the Standish [Group] defines success as "on-time, on-budget and with most of the expected features."

Like most of the agile community I question this. To me a project that is late and over-budget is a failure of the estimate. A project can be late, way over budget and yet still a big success - as Windows 95 was for Microsoft.

Project success is more about whether the software delivers value that's greater than the cost of the resources put into it - but that's very tricky to measure.

- Martin Fowler

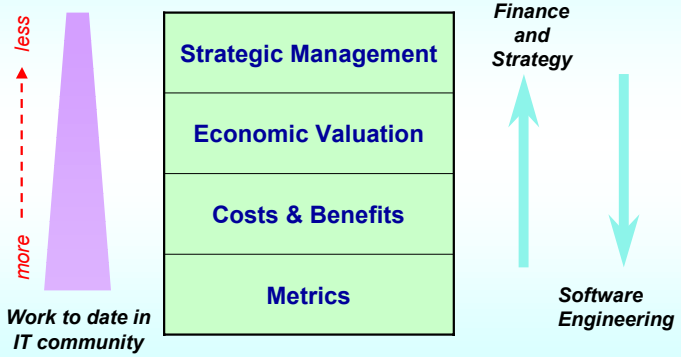
*Determining whether an investment delivers more value than it costs involves **VALUATION***

What is Valuation?

- The object of investment is to to find assets that are worth more than they cost
  - *The bigger-fool theory*: it doesn't matter what it's worth, as long as somebody else will pay a higher price
  - *The fair-value theory*: people will only pay what it's worth
- **Valuation is the process of estimating how much an asset is worth**
- Valuation encompasses many considerations
  - *how* the value of an asset is determined
  - *why* the asset has a certain value, and not a higher or lower one
  - how to *compare* asset values, as a basis for investment decision making

In economic terms, how much is this asset worth?

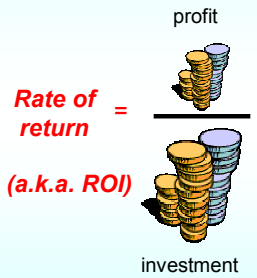
What do IT Professionals Know Today?



Present Value Concepts

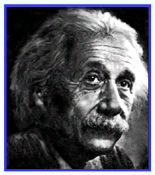
Rate of Return

- You have some money to invest. You want the best **rate of return**
  - rate of return = profit divided by investment
- Example: You buy a house for 100 thousand dollars and sell it again in a year for 120 thousand dollars
  - Your rate of return is 20/100 = 20%
- Example: You put your 100 thousand dollars in the bank. After a year it's worth 105 thousand dollars.
  - Your rate of return is 5/100 = 5%
  - Your bank account earned **interest**



All About Interest

- **Interest** is one of the most fundamental concepts in finance
  - you pay interest on loans
  - the bank pays you interest on your account
- **Simple interest** – paid one time only
  - $X_1 = X_0 * (1 + r)$
- **Compound interest** – paid at intervals
  - **Albert Einstein** once said that "compound interest is the greatest mathematical discovery of all time"
- Einstein's "Rule of 72"
  - How long will it take for my money to double?
  - Divide 72 by the interest rate
  - Example 72/12 = 6 years to double at 12% interest compounded annually



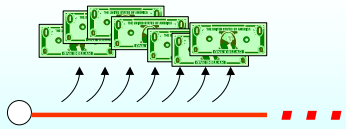
Albert Einstein

Continuously Compounded Interest

- **Continuous compounding**
  - the limit as compounding intervals go to zero
  - often assumed in financial analysis (e.g. when income is spread out over the year)

$$X_1 = X_0 e^{rt}$$

Continuously compounded interest



Investment

Interest compounded continually as time passes

Converting Rates of Return

- The first example we looked at was an **annual** rate of return
  - In one year, we earned 5%
- What does that correspond to for a different time period?
  - If I earn 7% in half a year and you earn 1% in two weeks, which of us has done better?
  - If I earn 15% in a year, how much in a month?
- In finance, we often have to convert rates
  - "aligning" them to the same units of measure

$r_1 = 5\%$
$N_1 = 8$ months
$r_2 = ???$
$N_2 = 12$ months

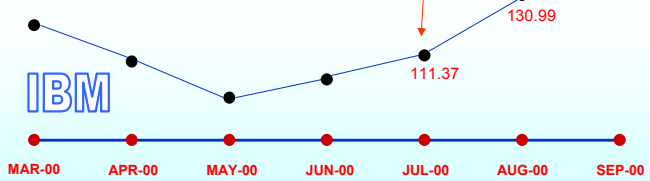
$$r_2 = (1 + r_1)^{N_2 / N_1} - 1$$

The Rate of Return of a Stock

Same basic ROI formula applies for calculating stock rates of return

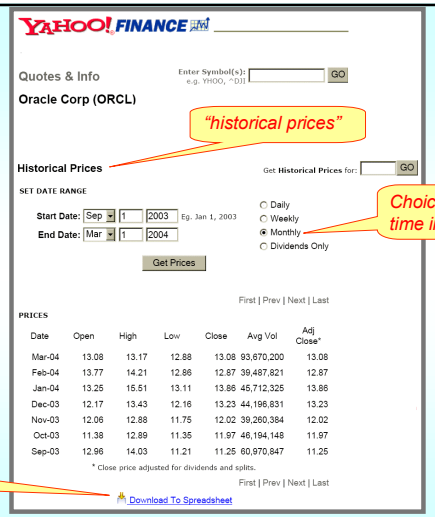
$$r = \frac{P_{final} - P_{start}}{P_{start}}$$

$$17.6\% \Rightarrow \frac{130.99 - 111.37}{111.37}$$



Obtaining Market Data

There are several sources of historical market data. One free source (so far) is Yahoo!Finance



Download to spreadsheet

Comparing Investments

- Valuation does not only concern the value of a **single** investment (e.g. its rate of return)
- Valuation especially concerns **comparison** of **multiple** investment possibilities
- Different investments can have many different characteristics
  - How can we be sure we do not "compare apples with oranges?"

How can we compare investments with different characteristics?

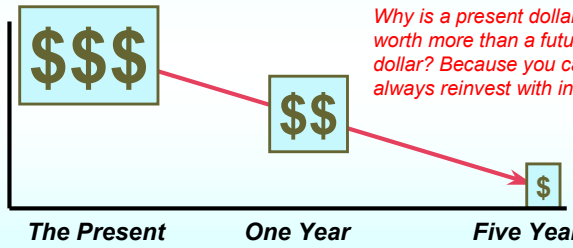
Payoffs at Different Times

- Suppose you bought a house today for 100 thousand dollars
  - One friend offers to pay you 120 thousand tomorrow
  - Another friend offers 120 thousand next year
  - Which would you take? Why?
- Suppose yet another friend offered 125 thousand next year
  - Would you take it? It's more than 120, but is it enough?
- This is the problem of **investments that pay off at different points in time**
  - How do we **compare** such investments?

now *next year*

The Time Value of Money

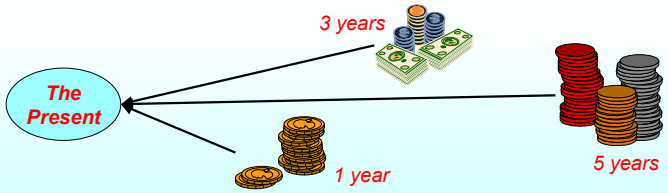
- "Time is money."
- "A dollar received today is worth more than a dollar received tomorrow."



Why is a present dollar worth more than a future dollar? Because you can always reinvest with interest!

The Concept of Present Value

- There is only one way to **compare** investments that pay off at different times
  - calculate what they are all worth at *one particular point in time*
  - which point in time?
  - "there is no time like the present!"
- **Present Value (PV)**
  - the value of a future return as though it were received today



The Discount Rate

- How do you calculate the present value of a future return?
- We have seen that moving forward from present to future, your investment "grows" with its rate of return
- Now turn it around: moving *backwards* from future to present, your investment "shrinks" with the rate of return
- When you move "back in time", it is called the **discount rate**
  - You "discount future values back to the present"

Present ⟷ **Future**

$X_0 (1+r) \longrightarrow X_1$

rate of return

$X_0 \longleftarrow X_1 / (1+r)$

discount rate

Present and Future Cash Flows

- In finance the revenues received from an investment are called **cash flows**
- They are represented in tabular form according to chosen time periods
  - for example, years
- All years in the life of the investment
  - Usually there is an original investment C_0, represented as a negative number
  - The others are C_1, … C_n
  - Sometimes a "continuing value" is estimated beyond the horizon
- Investments are compared only on the basis of their **discounted cash flows**

C0	-5000
C1	2000
C2	3000
C3	6000

An initial investment of $5000, followed by three years of positive cash flows

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Net Present Value

- How can we use Discounted Cash Flow to evaluate investments?
- We have seen that we can calculate the Present Value of all cash flows of an investment by discounting back to the present at the discount rate *r*
- We have seen that we can represent the cost of an investment by an initial cash flow C_0
- What we really want to know is whether the value we get is greater than the cost!
- We want to know the **Net Present Value**
- Rule: ***accept if NPV > 0***

value *cost*

$$NPV = PV - C_0$$

NPV > 0?

This question is simply asking whether the investment is worth more than it costs!

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Basic DCF Formula

- Rule: accept the investment if NPV > 0

cash flows in subsequent periods (months, years, ...)

$$NPV = C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + \ldots$$

First cash flow usually interpreted as the initial investment (= negative number)

discount rate

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Origins of Present Value

- Present value concepts come from the heritage of pricing financial instruments such as bonds (e.g. Savings Bonds)
- An **annuity** pays a fixed sum each year for a specified number of years
  - for example equal-payment house mortgage or credit on equal installments
- A **bond** is simply a long-term debt
  - Provides a fixed set of cash payoffs
  - Are sold by many companies to raise cash
  - They are also sold by the government
  - There is a competitive market for bonds

A house mortgage can be a form of annuity

Bonds are sold by many companies

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Buying a Treasury Bond

- Suppose you buy a Treasury bond that "matures in five years with a coupon rate of 6 percent and face value of $1000"
  - this is a medium-term bond
- Translation into cash flows:
  - five annual interest payments of 6% of $1000 = $60 per year
  - final payment of $1000
- What is the Present Value of this bond?
  - The Present Value is what the bond is worth in today's dollars
  - Even more importantly, it is the price you should have to pay for the bond
  - If you have to pay more than that, you are losing money!

Year	Cash Flow
1	60
2	60
3	60
4	60
5	1060

Cash flows on our bond

Calculating the Present Value of a Bond

- To determine the **Present Value** of our bond, we need to find out the rate of return provided by the competition
  - suppose that similar medium-term bonds average a 6.9% return
  - This becomes its **discount rate**, representing the rate we are giving up by buying this particular bond
- The **Net Present Value** NPV is the PV minus the price paid
  - if you pay less than PV, then NPV > 0 and you have paid a good price!

$$PV = \frac{60}{1.069} + \frac{60}{1.069^2} + \frac{60}{1.069^3} + \frac{60}{1.069^4} + \frac{1060}{1.069^5} = \$963$$

Any financial calculator has this function built-in

The Opportunity Cost of Money

There is always a risk-free alternative to a risky investment

- Suppose that one bank offered you an interest rate of 3% on your bank account, and another offered 5%. Which would you take?
  - Obviously, the 5% investment. It offers a higher rate of return under the same circumstances
- Suppose that your bank offered you an interest rate of 3% on your bank account, and a friend offered to you to invest instead in his new software company where he thought the rate of return would be 5%. Which would you take?
  - What is the problem?
  - RISK!

Choosing a risky alternative to a safe investment has an "opportunity cost"

The Risk-Free Rate of Return

- What is exactly a "risk-free investment"?
  - Its earnings are guaranteed
- But there is no truly safe investment
  - Stocks? (Enron)
  - Bonds? (Parmalat)
  - Banks? (Savings & Loans in America)
- The best we can do is a loan to the government
  - If that goes wrong (Argentina?) it's not your only problem…
- Long-term obligations on the capital markets
  - E.g. ten-year Treasury Bonds
- Short-term obligations on the money market
  - E.g. 3-month treasury bills (T-Bills)

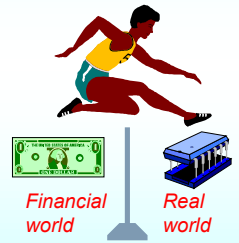
A 3-month T-bill is considered by many to have a "risk-free" rate of return

The Risk-Free Rate of Return in Italy?

- Just as in America, the Italian government is in the business of borrowing money from its citizens
- *Titoli di stato*
- One obvious counterpart used in Italy is the BTP
- The ten-year BTP is often used

From Financial to Real-World Investments

- Up to now we have only considered financial investments
  - Treasury Bills, corporate bonds, bank accounts, stocks
- How do we evaluate real-world investments?
  - Projects, factories, manpower
- *The same discounted cash flow techniques are used!*
  - There is always an alternative financial investment to any real-world investment
  - the "alternative rate of return" of the financial investment is a **hurdle rate** that must be overcome to convince the investor to take the real-world project



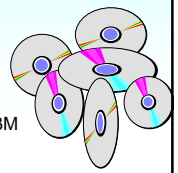
The Fed and Hurdle Rates

- The stock and bond markets are always affected by the actions of the Federal Reserve Bank with respect to interest rates
- What is the link between interest rates and the stock market?
  - Hurdle rates!
  - Interest rates affect the hurdle rate for investments in real-world companies (through stocks)

Alan Greenspan, Chairman of the Federal Reserve Bank

DCF Example for a Real-World Project

- Mother company subcontracts to build multimedia repository for CD-ROM production.
  - Initial investment of $100K for repository construction
  - One-year phase of staffing and launching production for $3M
  - Sells third year's production to mother company for $3.5M
  - Discount rate of 5%



$$\mathrm{NPV} = C_0 + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} = (-0.1) + \frac{-3.0}{1.05} + \frac{3.5}{1.05^2} = 0.217$$

Opportunity cost of not investing in financial instruments

NPV > 0

Financial Versus Real World Investments

- There are three major differences between financial investments and real world ("equity") investments

1. A bond carries a legal obligation to pay some specified amount of cash in the future
   - Neither equity stocks nor real-world projects carry that kind of guarantee – you may or may not receive the money
2. Bonds typically have a specified lifetime ("term")
   - Companies generally have an indefinite lifetime
   - Projects may also have indefinite periods in which the benefits are expected to be felt
3. The "opportunity cost of capital" or discount rate is generally more difficult to estimate for equity or project investments than for financial investments

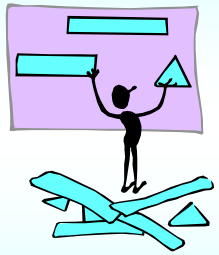
Key Concepts

- We have transferred the theory of present value from the financial world (bonds, etc.) to the real world (projects)
- The transfer from financial to real isn't easy
  - Cash flows must be estimated
  - Project lifetimes must be estimated
  - Discount rates must be estimated
- **Present value** is the most fundamental concept in all valuation,
- The concept of **discount rates** is essential in managing a business
  - It provides a way to compare an investment with competing investments

Treatment of Risk in Valuation

The Traditional IT View of Risk

- Software engineers have an intuitive view of risk that is related more to project management, even to sociology or psychology, than to finance
  - "What can go wrong in my project?"
  - "Implement the riskiest components first"
- From the financial point of view, risk has a much more precise, well-defined meaning
  - Not surprisingly, it is one of the most important topics in finance



The traditional IT view of risk tends to be related to project management issues

What is a Good Model of Risk?

- What should a good model for risk be able to do?
  - **Provide a universal measure of risk.** The measure must apply to all investments, whether financial, or real-world projects, or buying real estate, since they all compete for investment money.
  - **Distinguish which kinds of risk are rewarded.** It is well-known that not all kinds of risk are rewarded for investments. The model should say which are rewarded and why.
  - **Standardize risk measures, to allow analysis and comparison.** An investor should be able to compare the riskiness of an investment relative to other candidates.
  - **Relate the measure of risk to an expected return.** It is not enough to say that "more risk should yield more return." A specific estimate must be provided.
  - **Function in the real world.** Over the long term, the model should predict the relationship between risk and return correctly.

What Can Happen?

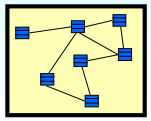
- **Risk**: "more things *can* happen than *will* happen."
- If you can enumerate all of the possible scenarios and their probabilities of happening, you have described the project's risk
- We know how to calculate the **average** of a set of numbers
  - Sum(n_i) / N
- The **expected value** of a set of numbers is an average, but weighted by the probability of each number occurring
  - Sum (n_i * p_i) / N
- So the **expected return** is the probability-weighted average of returns

$Scenario_1$	$Probability_1$
$Scenario_2$	$Probability_2$
$Scenario_3$	$Probability_3$
etc.	

These scenarios capture the project's risk

How to Capture the Overall Risk Picture?

- We have seen that enumerating all of the possible outcomes (e.g. returns) together with their probabilities, we entirely characterize the risk of an investment
- But that is rarely practical – we need some general way of capturing the overall picture
  - As an analogy: in the UML, the class diagram succinctly captures *all* structural scenarios that could happen, and the object diagrams show scenarios that do happen
  - What is the equivalent of a class diagram for capturing overall risk?

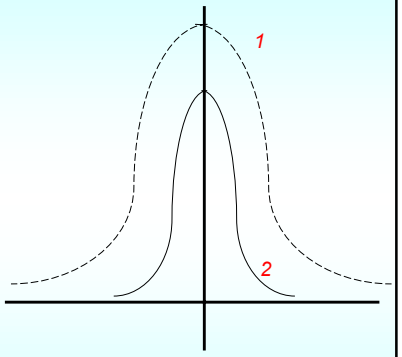


Class diagrams capture the overall architectural picture

How to capture the overall risk picture?

Measuring Risk with Variance

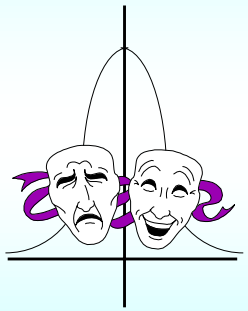
- If you associate risk with "uncertainty of returns", then the **variance** is a good way to measure risk
  - It captures the **spread** of possible outcomes
  - a kind of "class diagram" of risk: all possible outcomes and their probabilities
- A stock with no variance in returns has a *guaranteed* return
- Variance is also used as a synonym for volatility



Stock 1 has a higher expected value, but also a higher variance

Is Variance a Reasonable Way to Measure Risk?

- Variance includes both upside and downside dispersion around the expected return
  - Some have pointed out that risk is only the possibility of a *bad* outcome
  - *Good* outcomes, like higher than expected returns, are surely not considered to be risks?
- True: we tend to think of the downside component as the real risk
  - But as long as the distribution is symmetrical, variance is still a good measure of risk
  - Although *individual* stocks don't necessarily have symmetrical distributions of returns, well-diversified portfolios of stocks tend to have them



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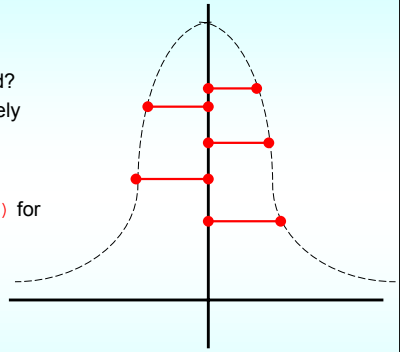
Calculating Variance

- How is variance calculated?
- Fortunately it is a completely straightforward calculation supported by all statistical tools
- Excel has a function `var()` for calculating variance



$$\frac{1}{N-1}\sum_{i=1}^{N}(actual-mean)^2$$

Variance is the expected squared deviation from the expected return

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Are We Finished?

- We have defined a universal measure of risk: the **variability of returns in an investment**
- This measure can be used on all kinds of investments, from financial to real projects.
- But we haven't answered some important questions yet:
  - Are there **different kinds of risk** that should be rewarded in different ways?
  - How *much* should the reward be for accepting those risks?

Are all risks created equal? Should they all be compensated in the same way?

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The Different Kinds of Risks

- In order to understand what the different kinds of risks are, we need to move away from individual investments toward **portfolios** of investments
- The birth of all modern study of how risk works in capital markets can be traced to the work of Harry Markowitz in creating **modern portfolio theory**
- He studied more rigorously than anyone before the composition of portfolios and their effect on **diversification** and risk
- The beginnings of understanding:
  - the **different kinds of risk**
  - the relationship between **risk and reward**

Harry Markowitz
Nobel Prize 1990

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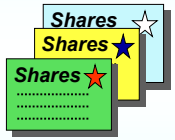
The Risk of a Portfolio?

- We have defined our universal measure of risk: the variance of returns of an investment
- Suppose we have a **portfolio** of more than one investment
  - What is its overall expected return?
  - What is its overall risk – that is, its variance?
- The expected return of this portfolio is just the *average* of all expected returns
- Is its variance also just the *average* of all individual variances?
  - The answer: almost never! It is generally *less* – due to **diversification**



What is the variance (risk) of a portfolio?

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The Effects of Diversification

- Suppose you invest equal amounts in a winery and a mushroom factory
  - A rainy year produces great mushrooms (+30% return) but bad wine (-10% return)
  - The mushroom harvest is bad in a year without much rain (-10% return) but the wine is outstanding (+30% return)
- What is the return on this portfolio?
  - Rainy years: 20%
  - Sunny years: 20%
- You have completely eliminated all risk

Mushrooms need lots of rain

A dry year produces great wine

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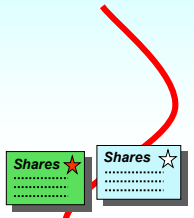
Formalizing Diversification: Covariance

- We can begin to formalize the study of how diversification works with the concept of **covariance** of stocks
  - Gives an idea of how much stocks tend to "move together"
- Note how similar the calculation is to the variance calculation
  - In fact, you can see that variance is just a special case of covariance
  - "Covariance with itself"



How much they move together

$$\frac{1}{N-1}\sum_{i=1}^{N}(actual_1 - mean_1)\times(actual_2 - mean_2)$$

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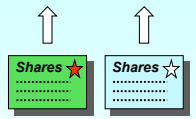
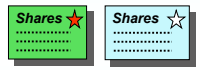
The Correlation Coefficient

- The **correlation coefficient ρ** is derived from the covariance, and provides a perfect illustration of the effects of covariance:
  - if it is positive, stocks tend to move together
  - if zero, the stocks move independently of each other
  - if negative, they tend to move in opposite directions (very rare!)
- When stocks are not perfectly correlated, they tend "cancel each other out" and reduce variance

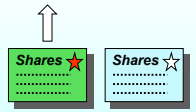
0< ρ < 1



ρ = 0



-1<ρ < 0



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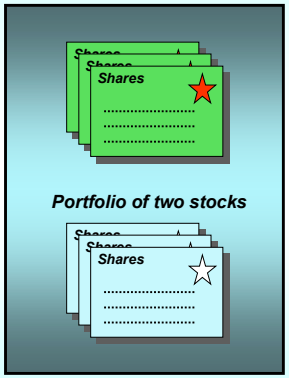
A Portfolio of Two Stocks

- Consider a portfolio of two stocks only, composed as follows:
  - x_1 percent of the first stock
  - x_2 percent second stock
- Each stock has its own standard deviation of returns
  - σ_1 for the first stock
  - σ_2 for the first stock
- Then the portfolio variance is:

$$x_1^2\sigma_1^2 + x_2^2\sigma_2^2 + 2(x_1x_2\rho_{12}\sigma_1\sigma_2)$$

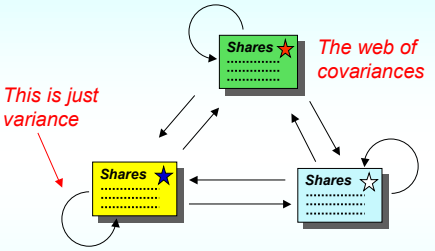
covariance



The General Calculation of Portfolio Variance

- The general calculation of the variance of a portfolio is actually quite simple: it is just the weighted average of all covariances
  - Each covariance is weighted by the proportion of each stock in the portfolio

This is just variance

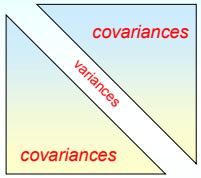


The web of covariances

$$\sum_{i=1}^{N}\sum_{j=1}^{N} x_i x_j \mathrm{COVAR}(i,j)$$

The Variance of Very Large Portfolios

- What happens when a portfolio contains many stocks – for example the entire S&P500?
- Suppose we have equal proportions of N stocks in the portfolios
- Then the covariances totally dominate the variances
- The general formula reduces to the following:



Portfolio variance = 1/N * Average Variance + (1 – 1/N) * Average Covariance

The portfolio variance converges to the average covariance.

The individual variances become insignificant.

How to explain this?

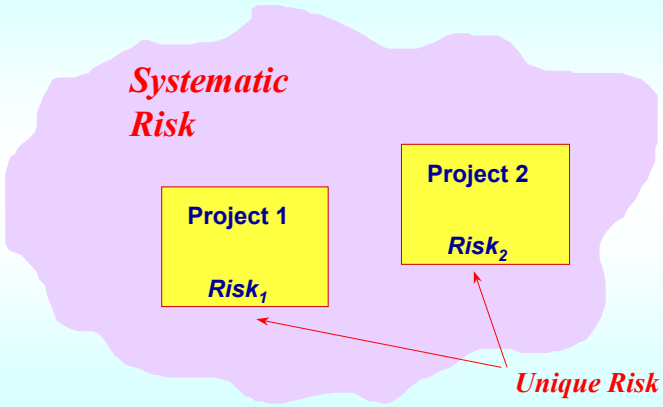
Systematic vs. Unique Risk

- We don't work in a vacuum – we participate in a market
- We are affected by systematic, macro-economic risks that permeate the system
  - Treasury interest rates
  - The overall state of the economy
  - Outside events like war or epidemic diseases
- We take our own **unique risks** in our projects or companies
- But we are all subject to risk inherent to our economic system - that is, **systematic risk**

unique risk affects only you

systematic risk affects everybody

Systematic versus Project Risk



Two kinds of risk

Unique risk (unsystematic)

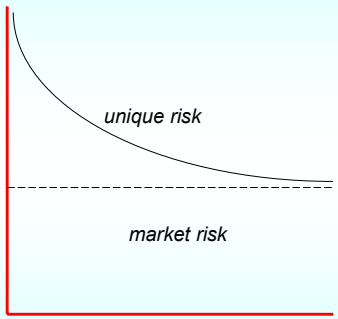
- Bill Gates might take early retirement from Microsoft
- Adobe's new product might fail
- A competitor of Oracle might develop a new database technology
- A domain analysis might fail to identify a generic architecture

- inflation might increase
- the budget deficit might increase
- T-Bill interest rates might rise
- A war may break out in the Middle East

Market risk (systematic)

Unique Risk versus Market Risk

- Unique risk affects only the individual company or project
  - **technical risk** is an important type of unique risk. It is the kind of risk that software engineers are most aware of
- Market risk affects all companies and projects
  - "The rising tide lifts all boats"
  - It is "bedrock" risk
  - it cannot be "**diversified**" away



Are We Finished Now?

- We have made good progress now
  - We have defined a universal measure of risk – the variance of returns of an investment
  - We have also identified two different types of risk – unique risk, which is the variance of individual returns, and systematic risk, which arises from the covariances in a portfolio
- But we still haven't answered some questions:
  - Which kinds of risk should be rewarded, and which not?
  - How much should the reward be?
  - Does the model basically work in practice?

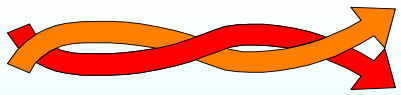
Risk and Reward

- Now let us examine the question of **risk versus reward**
- Taking a risk should be rewarded. Agreed.
- But how much?
- The question is harder than it seems at first sight
  - should you get no extra reward? (too little?)
  - exponential reward? (too much?)
- Economists searched for decades for a concrete answer to this question

The Capital Asset Pricing Model

- The *Capital Asset Pricing Model* (CAPM) is the most used model of risk and return
- **Nobel Prize 1990** for William Sharpe

William Sharp
Nobel Prize 1990



"When the Market sneezes, how bad a cold does the company/project get?"

Beta and Market Sensitivity

- We have seen that diversification can eliminate the unique risk in a portfolio
  - this is done by reducing the overall variance in the portfolio
- But we have also seen that some variance nearly always remains
  - Where does it come from?
- *The risk of a well-diversified portfolio depends on the market risk of the securities included in the portfolio*
- Thus we need a measure of **market risk**
  - this is known as **beta**, the sensitivity of an individual security to market movements

The Market

β

Individual company

Estimating Beta

Company return

One way to estimate beta is to look at how a stock's price has responded in the past to market movements

β = ...

***Beta** is the slope of the "best-fit" regression line through the points*

***Alpha** is the Y-intercept – the part of the returns that is independent of the market*

Market return

from January 19xx to December 20xx

***R-Square** is the portion of total risk that is systematic (market) risk*

Here we plot monthly rates of return of a company against market rates of return for the same months

Some Beta Scenarios

What are Alpha, Beta, and R-Square in these scenarios?

The stock earns fixed returns

The stock earns double the market return

Alpha? Beta? R-Square?

The stock returns are the opposite of the market returns

The stock and market returns are independent of each other

Some IT Company Betas

Company	Beta
Amazon.com	2.228
Sun Microsystems	2.677
Lucent	2.863
SAP	2.549
Peoplesoft	2.414
Computer Associates	2.309

Source: Yahoo!Finance

Betas of some IT companies in April 2004

Notice how high they are!

Some Italian Company Betas

Company	Beta
FIAT	1.25
Tiscali	2.41
Telecom Italia	1.21
ENEL	0.92
AISoftw@re	1.30
e.Biscom SpA	1.92

Source: Yahoo!Finance

Betas of some Italian companies in October 2004

The Contribution of the CAPM

- The CAPM was developed in the mid-1960s by William Sharpe, John Lintner, and Jack Traynor
- The Capital Asset Pricing Model answered the questions about risk and return in some concrete ways
- Q: *Which kinds of risk should be rewarded and which not?*
  - A: Investors do *not* expect to be rewarded for unique risk
  - A: Investors *do* expect to be rewarded for systematic/market risk
- Q: *How much should the reward be?*
  - A: The reward should be directly related to **beta**
- It works (more or less) in practice
  - The correlation between risk and reward over the past decades has been reasonably close to that predicted by the CAPM
- Above all, the CAPM has become the standard for all research and practice in the area of risk and return

Relating Beta to Discount Rates

- The beauty of the Capital Asset Pricing Model lies partly in its simplicity
- In the CAPM, beta is the single factor that reflects market risk
- In the CAPM, the amount of return expected by investors is **linearly** related to beta
- Summary: one factor, linear relationship
  - that is one of the reasons for the popularity of the CAPM

$$EX = r_f + ß(r_m - r_f)$$

Market risk premium

Relating Beta to Expected Return

Stock	Beta	Expected Return
AT&T	0.65	10.7%
Bristol-Myers Squibb	0.95	13.1%
Coca-Cola	0.98	13.3%
Compaq	1.13	14.5%
Exxon	0.73	11.3%
General Electric	1.29	15.8%
McDonald's	0.95	13.1%
Microsoft	1.26	15.6%
Reebok	0.87	12.5%
Xerox	1.05	13.9%

Betas in July 1998 from a variety of industries, from telecom to consumer goods

What about Project Betas?

- Project betas are often classified differently according to different levels of systematic risk
  - The key is to understand that this risk is from the point of view of the *outside* investor, who may know nothing about individual characteristics of the project
- Even today there is no "scientific" and proven approach to determining the beta of a project. There are some general rules of thumb
  - Look for factors in the project's revenues that make them "move with the market" – for example, cyclical companies depend on the overall health of the economy
  - Higher fixed costs tend to magnify betas – all other things being equal for two projects, the one with higher fixed costs will have a higher beta

Company ß

???

Project ß

Project Discount Rates and Classification

- Often, a company uses a single company-wide (or perhaps division-wide) RADR for "normal" projects.
  - This "normal" RADR is then adjusted upward or downward for projects of higher or lower (systematic) risk.
  - Alternatively, some companies attempt a **classification** of projects according to riskiness with associated discount rates, as below

Project type	Discount Rate
Pioneer technology	**30%**
New product introduction	**20%**
Existing business	**15% (the "normal" rate)**
Proven technology	**10%**

Key Concepts

- Total risk = private risk + systematic risk
- Once again we see the central importance of the **discount rate**
  - **It represents the opportunity cost of money**
  - **It captures the effect of systematic risk**
  - **It represents the return that an investor requires for making an investment at a certain level of systematic risk**

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Economic Valuation Techniques in Practice

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All that ROI Jargon

- It's fine to talk about Net Present Value and Discounted Cash Flow
  - But is that what people talk about in the real world?
- In the real world, people seem to talk about other things
  - **Return on Investment**
  - **Payback**
- What is the relationship between all these terms anyway?
  - What do they *really* mean?
- Let's at least be sure we know what we're talking about

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Jargon in the Software Literature

Examples taken from the literature on the economics of reusable software component development

- **Payback**
  - Software Productivity Consortium, "Reuse Adoption Guidebook," Report SPC-92051-CMC, Version 01.00.03 (Nov. 1992)
- **Internal Rate of Return**
  - IBM, "A Reuse Metrics and Return on Investment Model," *Proceedings 2nd. Int. Workshop on Software Reusability*, 1991
- **Profitability Index**
  - NATO, "Standard for Management of a Reusable Software Component Library," August 1991
- … and of course, **ROI**, *everywhere* in the literature

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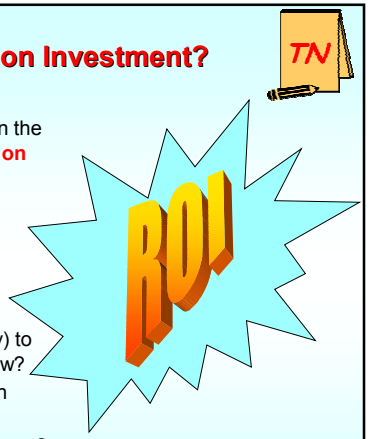
What is Return on Investment?



- The Number 1 favorite term in the software community: **Return on Investment**
- But what does it *mean*?
  - "Lots of money"
  - "Lots of growth"
  - "Lots of quality"
  - "Lots of good things"
- What is its relationship (if any) to NPV and discounted cash flow?
- Is "high ROI" better than "high NPV"?
- Is it the same thing? Is it different?

ROI is a Profitability Ratio

- Back to basics: ROI is a **profitability ratio**
  - Ratio of profits to costs
- There are many variations
  - Return on equity
  - Return on assets
- The most fundamental expression of the profitability ratio is the **rate of return**
  - **The final value B ("benefits") minus the original investment C ("Costs")**
  - **Divided by Costs**

$$\frac{B - C}{C}$$

Achieved versus Required: The Missing Link?

- Suppose you invest $100 and after a year are given $107
  - You have achieved an ROI of 7%
  - Is that good?
  - Is that bad?
- The answer: *we don't know*
- The ROI formula only calculates the *achieved* ROI
- In isolation, it makes no statement about the *required* ROI
  - That is the main problem with ROI as a single measure

Achieved = ROI

Required = ???

The Missing Link is the Discount Rate

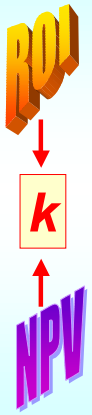
- NPV makes a statement about the **required ROI** in the form of the **discount rate *k***
- Reconsider our example with ROI = 7%
- Suppose k = 3%
  - Then NPV = $107/1.03 - $100 = $3.88
  - Positive NPV
- Suppose k = 10%
  - Then NPV = $107/1.10 - $100 = -$2.73
  - Negative NPV
- What happens when ROI is exactly **equal** to k?

Achieved = ROI

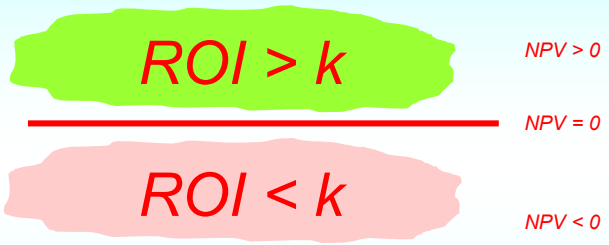
Required = ***k***

ROI is the Discount Rate That Makes NPV = 0

- If ROI = *k*
  - NPV = $107/1.07 - $100 = 0
- Let's check that more formally by setting NPV = 0 and seeing what we get:
  - `0 = NPV = Benefits/(1+k) - Costs`
  - `Costs = Benefits/(1+k)`
  - `1+k = Benefits/Costs`
  - `k = Benefits/Costs - 1`
  - `k = (Benefits - Costs) / Costs`
- That is exactly the definition of ROI!
- So the relationship between ROI and NPV is:
  - **ROI is the discount rate that makes NPV = 0**



The Discount Rate Links ROI to NPV



NPV > 0

NPV = 0

NPV < 0

$$0 = \text{NPV} = C_0 + \frac{B}{1+\text{ROI}}$$

But Does ROI Work for Multiple Periods?

- We have now understood the relationship between ROI and NPV
  - But our analysis only covered ROI for one period
  - What happens in **multiple periods**?

Period	*0*	*1*	*2*
Benefits	0	$300	$500
Costs	$400	$200	$100

Simple typical three-period case, with original investment followed by increasing benefits and decreasing costs

First Try at Extending ROI for Multiple Periods

- It seems reasonable to simply try to preserve the same formula for ROI
- Just add up all the costs and benefits and use them in the formula for ROI

Period	*0*	*1*	*2*	*Totals*
Benefits	0	$300	$500	**$800**
Costs	$400	$200	$100	**$700**

$$\text{ROI} = \frac{\$800 - \$700}{\$700} = 14\%$$

Looks good!

But This Can't Be Right

- But what about this scenario: we switch the benefits in the last two periods
  - Higher benefits come earlier
  - But this has exactly the same ROI

Same ROI as before?

Period	0	1	2	Totals
Benefits	0	$500	$300	$800
Costs	$400	$200	$100	$700

THIS CAN'T BE RIGHT!!!

Needed: a Time-Sensitive ROI Calculation

Clearly we must find a way to take our basic ROI formula …

$$0 = \text{NPV} = C_0 + \frac{B}{1+\text{ROI}}$$

… and make it sensitive to the order in which benefits occur. That is, we have to account for the time value of money somehow.

What about just extending the basic formula in a "discounting" style …

$$0 = \text{NPV} = C_0 + \frac{B_1}{1+\text{ROI}} + \frac{B_2}{(1+\text{ROI})^2} + \ldots$$

… where B_t are the net benefits in each period? Would that work?

Testing the Time-Sensitive ROI Formula

First let's try the new formula on the original project:

Period	0	1	2	Totals
Benefits	0	$300	$500	$800
Costs	$400	$200	$100	$700

$$0 = \text{NPV} = -\$400 + \frac{\$300-\$200}{1+\text{ROI}} + \frac{\$500-\$100}{(1+\text{ROI})^2} \Rightarrow \text{ROI} = 13\%$$

Now try the formula on the other version of the project:

Period	0	1	2	Totals
Benefits	0	$500	$300	$800
Costs	$400	$200	$100	$700

$$0 = \text{NPV} = -\$400 + \frac{\$500-\$200}{1+\text{ROI}} + \frac{\$300-\$100}{(1+\text{ROI})^2} \Rightarrow \text{ROI} = 18\%$$

The Internal Rate of Return

- Our new time-sensitive version of the ROI formula "works"
  - It correctly calculates a higher ROI when larger cash flows arrive earlier
- This formula for multi-period ROI calculation is known as the **Internal Rate of Return** (**IRR**)
- But it has the same problem as normal ROI
  - It makes no statement about the *required* rate of return
  - That's why it is called the "internal" rate of return – it makes no reference to any external rate
  - Same relationship to NPV as the single period version of the formula: it is the discount rate that makes NPV = 0

IRR

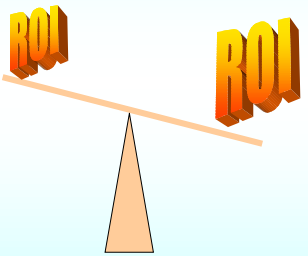
There is no closed formula for calculating IRR

Using ROI in Practice to Evaluate Investments

- Now we can answer a question such as this: "My project earns 15% ROI. Is that good?"
  - Our answer: "We don't know."
- Hopefully you are convinced by now that using ROI to evaluate an investment only makes sense when compared to the required rate of return – that is the discount rate.
- There are two other situations in which we often see people using the ROI formula:
- **"Fixed project, variable budget"** – comparing two projects at different costs, or different ways of doing the same project
- **"Fixed budget, variable projects"** – comparing different ways to spend your money
- Does ROI make sense in these situations?

Fixed Project, Variable Budget

- "This project has a higher ROI than the other one. Let's take it."
- Often we are talking about different ways of doing the same project
  - Use .NET or Enterprise Java?
  - Sell as one-time development or as a long-term service subscription?
  - Use a COTS database or hand-code?
- Is higher ROI always better?



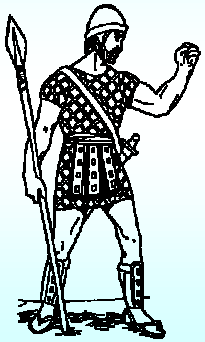
David and Goliath

Two alternative approaches for doing the same project

Project David – "do it on the cheap," smaller investment, modest cash flows

Period	0	1	2
Goliath	-500	400	800
David	-100	150	350

Project Goliath – "do it on a grand scale," more ambitious, larger investment and larger projected cash flows



Comparing David and Goliath

Project David has a much higher ROI (calculated as Internal Rate of Return) than Project Goliath

Period	0	1	2	ROI (IRR)	NPV at 10%
Goliath	-500	400	800	73%	$525
David	-100	150	350	177%	$326

But Project David has a far lower NPV – in simple terms, it is worth less

Analysis: ROI is Insensitive to Scale

- We just saw that ROI can give contradictory answers to NPV when comparing projects
  - Project David has a higher ROI
  - But it has a lower NPV
- This is typical of the ROI measure: it is **insensitive to scale**
  - $10 profit on a $100 investment has a lower ROI than $2 profit on a $10 investment – but it makes you richer
- ROI tends to lead to the selection of **smaller projects**, requiring less investment, over larger projects
  - *Even when they are worth less*

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The Tortoise and the Hare

Project Hare – sprints out of the gate, receives all of its cash flows and finishes after only two periods.

Period	*0*	*1*	*2*	*3*	*etc.*
Hare	-500	400	800	0	0
Tortoise	-500	150	150	150	*indefinitely*

Project Tortoise – Moves slowly but surely. Starts with the same upfront investment and generates much smaller cash flows, indefinitely into the future.

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Comparing the Tortoise and the Hare

*Project Hare has a much **higher ROI** (calculated as Internal Rate of Return) and **faster payback** than Project Tortoise*

Period	*0*	*1*	*2*	*ROI (IRR)*	*NPV at 10%*
Hare	-500	400	800	73%	$525
Tortoise	-500	150	*etc.*	30%	$1000

But Project Hare has a far lower NPV – in simple terms, it is worth less

By the way: how are the IRR and NPV of Project Tortoise calculated?

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Using ROI for Comparing Investments

The ROI (IRR) measure tends to favor **small projects**

and **fast payback**

over **larger projects**

and **longer payback times**

… even when they are worth less

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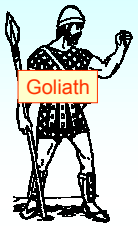
Fixed Budget, Variable Projects

- We have seen that ROI often leads people to choose smaller projects with fast payback
  - But is that really the only reason they choose those projects?
- NPV is easy to use when you have an unlimited budget
  - Just take all projects with positive NPV
- But is that realistic?
  - In public companies, in fact it's not so unrealistic
  - But in most companies, public or private, people feel under pressure from a **limited budget**

How realistic is an unlimited budget?

A Set of Four Projects



Four projects, in various sizes

Project	CF0	CF1	CF2
Goliath	-500	400	800
Goliath Jr.	-400	300	500
David Sr.	-200	200	300
David	-100	150	350

Which ones should we take?

NPV of the Four Projects

Project	CF0	CF1	CF2	NPV at 10%
Goliath	-500	400	800	+525
Goliath Jr.	-400	300	500	+286
David Sr.	-200	200	300	+230
David	-100	150	350	+326
Totals	-1200	1050	1950	+1366

All have positive NPV

Total investment

Total NPV

*Since all of the projects have positive NPV, it would be ideal to take **all** of them, with a total investment of 1200 and total NPV of 1366*

Limited Budget

But what if you only have 700 to invest?

Project	CF0	CF1	CF2	NPV at 10%
Goliath	-500	400	800	+525
Goliath Jr.	-400	300	500	+286
David Sr.	-200	200	300	+230
David	-100	150	350	+326
Totals	-1200	1050	1950	+1366

Goliath + Goliath Jr. = 900

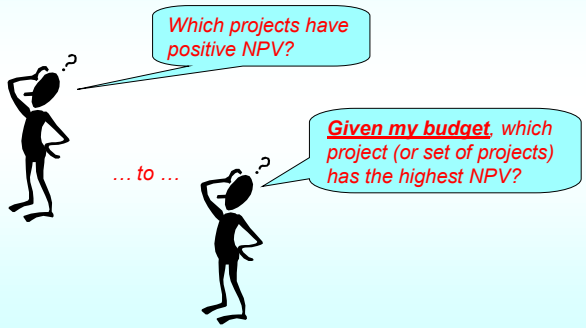
Goliath + David Sr. + David Jr. = 800

…

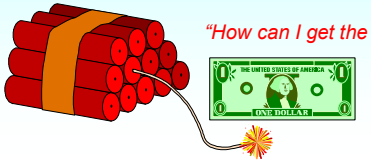
Isn't there some systematic way to decide which projects to take?

NPV on a Budget: Ranking Projects

When money for investment is limited, the question changes from …



The Biggest Bang for the Buck



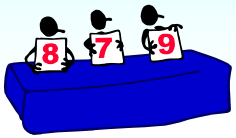
"How can I get the biggest bang for my buck?"

What package of projects will maximize NPV for the amount of money I have to spend?

This involves RANKING projects

Ranking Projects

- "Getting the biggest bang for the buck" involves **ranking projects**
- We have already seen that ROI is unreliable for ranking projects
  - ✧ Doesn't capture the discount rate
- The profitability measure that comes closest is the **profitability index**
  - ✧ Ratio of NPV to investment cost
- Variation: **benefit/cost ratio**
  - ✧ Ratio of PV to investment cost
- **Calculates NPV per unit of investment**



ranking projects

$$\frac{\text{NPV}}{\text{Unit of Investment}}$$

The Profitability Index

The Profitability Index tells us which projects are most profitable

Project	CF0	CF1	CF2	NPV at 10%	Profitability Index
Goliath	-500	400	800	+525	1.05
Goliath Jr.	-400	300	500	+286	0.71
David Sr.	-200	200	300	+230	1.15
David	-100	150	350	+326	3.26
Totals	-1200	1050	1950	+1366	

David *is the most profitable project*

Followed by **David Sr.**

Followed by **Goliath**

Followed by **Goliath Jr.**

Using the Profitability Index to Select Projects

Rule: take the most profitable projects until the budget of 700 is exhausted

Project	CF0	CF1	CF2	NPV at 10%	Profitability Index
Goliath	-500	400	800	+525	1.05
Goliath Jr.	-400	300	500	+286	0.71
David Sr.	-200	200	300	+230	1.15
David	-100	150	350	+326	3.26
Totals	-1200	1050	1950	+1366	

Select **David** *first, leaving 600 more to invest*

Then **David Sr.** *leaving 400 more to invest*

Skip **Goliath** *because it would put us over budget*

Take **Goliath Jr.** *which exhausts the budget exactly*

The Profitability Index Rule Doesn't Always Work

There is a problem: the chosen package doesn't have the highest NPV

Project	CF0	CF1	CF2	NPV at 10%	Profitability Index
Goliath	-500	400	800	+525	1.05
Goliath Jr.	-400	300	500	+286	0.71
David Sr.	-200	200	300	+230	1.15
David	-100	150	350	+326	3.26
Totals	-1200	1050	1950	+1366	

David + **David Sr.** + **Goliath Jr.** has NPV = 326 + 230 + 286 = **841**

David + **Goliath** has NPV = 326 + 525 = **851**

The second package even requires less investment!

Analysis: Profitability Index Has ROI's Problems

- Unfortunately, the profitability index is unreliable for ranking and selecting projects
- It shares the common problems of all **profitability ratios**
  - For example, the problem of **scale**
- Is the profitability index useless?
  - No, it can communicate useful information about profitability
  - It can help in relatively simple scenarios
- But it is not a general solution to **NPV on a budget**

$$\frac{B}{C} > \frac{B}{C} ?$$

*The problem of **scale** with profitability ratios*

A General Solution to NPV on a Budget

- There is a general solution to ranking projects on a budget: it is called **linear programming**
- Linear programming has a fascinating history
  - Developed (independently) by Kantorovich & Koopmans (Nobel Prize 1975)
  - First practical algorithm in 1949 by Dantzig
  - The first polynomial time solution by Khachian was hand-carried to Berkeley from the Soviet Union in 1979
  - Another, even more efficient solution discovered by Karmarkar in 1984
- LP seeks to maximize one parameter ("NPV of the selected projects") under a set of constraints ("don't go over budget")

Tjalling Koopmans

Nobel 1975

Leonid Kantorovich

The Excel facility for linear programming is called `Solver`

Organizing a Linear Programming Problem

Linear programming can be simple or confusing, depending on how you organize yourself

	A	B	C	D	E	F
1	Selected	Project	CF0	CF1	CF2	NPV
2	1	Goliath	-500	400	800	525
3	1	Goliath Jr.	-400	300	500	286
4	1	David Sr.	-200	200	300	230
5	1	David	-100	150	350	326
6		Totals	-1200	1050	1950	1366

Create a **Selected** *column*

These techniques make using LP simpler

Give **Names** *to key areas such as the initial investment and the NPV of the project*

Setting up the Parameters for LP Constraints

	A	B	C	D	E	F
1	Selected	Project	CF0	CF1	CF2	NPV
2	1	Goliath	-500	400	800	525
3	1	Goliath Jr.	-400	300	500	286
4	1	David Sr.	-200	200	300	230
5	1	David	-100	150	350	326
6		Totals	-1200	1050	1950	1366
7						
8	Budget	700				
9	Cost	1200				
10	Value	1366				

Given

`=SUMPRODUCT(-CF0, Selected)`

`=SUMPRODUCT(NPV, Selected)`

The **SUMPRODUCT()** *function is an elegant way to calculate "the value of this parameter for the selected projects"*

Setting up the Linear Programming

Solver Parameters

Set Target Cell: `Value` **Solve**

Equal to: Max

By Changing Cells:

`Selected`

Subject to the Constraints:

```
Costs <= Budget
Selected = binary
```

Note how much easier it is to read using defined **Names**

Linear Programming Solution

	A	B	C	D	E	F
1	Selected	Project	CF0	CF1	CF2	NPV
2	1	Goliath	-500	400	800	525
3	0	Goliath Jr.	-400	300	500	286
4	0	David Sr.	-200	200	300	230
5	1	David	-100	150	350	326
6		Totals	-1200	1050	1950	1366
7						
8	Budget	700				
9	Cost	600				
10	Value	850				

selected projects

Cost is within budget

NPV is maximized

Selecting Partial Projects

Suppose you relax the constraint that entire projects must be selected?

	A	B	C	D	E	F
1	Selected	Project	CF0	CF1	CF2	NPV
2	0.8	Goliath	-500	400	800	525
3	0	Goliath Jr.	-400	300	500	286
4	1	David Sr.	-200	200	300	230
5	1	David	-100	150	350	326
6		Totals	-1200	1050	1950	1366
7						
8	Budget	700				
9	Cost	700				
10	Value	975				

partial project

Three projects are selected (one partial), using the entire budget, and with a higher NPV

Realistic? Sometimes yes, sometimes no

The Entrepreneur's Planning Game

"Here, have another glass," said Bill, pulling the wine bottle out of the cooler and wiping it off. "It's hard to find a good white in Italy, and *Terre dei Tufi* from San Gimignano is one of the more interesting."

"That's not true," said Greg. "You should take a closer look at what's coming out of Friuli." He picked up the sheet of paper they had been writing on. "But no thanks, we have to wrap up this year's planning session."

Greg and Bill, the proud owners of a small software outsourcing firm with 15 employees, were planning the year's activities.

"Look here," said Bill. "We have a great set of projects we could work on, each of them with good prospects – I already worked it out, they all have positive NPV. But we only have a budget of $500K this year, we can't do all of them."

"Right," said Greg, "and in any case we wouldn't have enough manpower to do all of them."

How can Bill and Greg maximize NPV under these constraints?

Project Selection Under Multiple Constraints

- With a small number of projects and simple constraints, sophisticated approaches for project ranking may not be needed
- The real usefulness of linear programming becomes apparent with
  - a larger set of projects
  - multiple constraints
- A typical set of constraints might include **budget** and **manpower**

Budget and manpower constraints

LP with Budget and Manpower Constraints

	A	B	C	D	E
		Project	Persons	Cost	NPV
		A	3	100	135
3		B	2	60	90
4		C	4	90	130
5		D	2	50	70
6		E	5	200	270
7		F	3	110	150
8		G	4	90	100
9		H	6	250	350
10		I	3	60	100
11		J	2	55	80
12		Totals	34	1065	1475
13					
14	Budget	500			
15	Personnel	15			

10 projects

NPV>0

Budget and personnel constraints

Setting up Parameters for Multiple Constraints

	A	B	C	D	E
1	Selected	Project	Persons	Cost	NPV
2	1	A	3	100	135
3	1	B	2	60	90
4	1	C	4	90	130
5	1	D	2	50	70
6	1	E	5	200	270
7	1	F	3	110	150
8	1	G	4	90	100
9	1	H	6	250	350
10	1	I	3	60	100
11	1	J	2	55	80
12		Totals	34	1065	1475
13					
14	Budget	500			
15	Personnel	15			
16					
17	Costs	1065			
18	Manpower	34			
19	Value	1475			

=SUMPRODUCT(Cost, Selected)

=SUMPRODUCT(Persons, Selected)

=SUMPRODUCT(NPV, Selected)

Setting up the Linear Programming

Solver Parameters

Set Target Cell: Value

Solve

Equal to: Max

By Changing Cells:

Selected

Subject to the Constraints:

Costs <= Budget
Manpower <= Personnel
Selected = binary

The only change is the addition of another constraint

LP Solution for Two Constraints

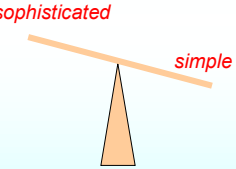
The real advantage of setting up an LP solution is apparent when you begin varying the number of personnel and the amount of the budget as inputs, making a sensitivity analysis of different combinations

	A	B	C	D	E
1	Selected	Project	Persons	Cost	NPV
2	0	A	3	100	135
3	1	B	2	60	90
4	0	C	4	90	130
5	0	D	2	50	70
6	0	E	5	200	270
7	1	F	3	110	150
8	0	G	4	90	100
9	1	H	6	250	350
10	1	I	3	60	100
11	0	J	2	55	80
12		Totals	34	1065	1475
13					
14	Budget	500			
15	Personnel	15			
16					
17	Costs	480			
18	Manpower	14			
19	Value	690			

Budget and personnel constraints respected

The Limits of Linear Programming

- This kind of sophisticated analysis can be taken too far, of course
- Simplicity is also important in project management
  - A lightweight decision-making process is also more transparent
- Yet it is equally important to understand the limits of the simplistic ranking techniques
  - Understanding the more rigorous approaches helps us in balancing the simple against the sophisticated



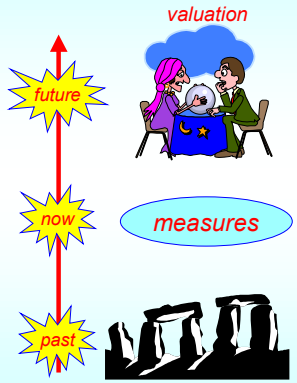
Some Conclusions on All That ROI Jargon

- ROI, IRR, PI, payback…
- Does the discussion in this section mean that all that ROI jargon is useless?
- Certainly not:
  - ROI does tell you the *achieved* return – but don't forget that it makes no statement about the *required* rate of return
  - Payback is a good way to communicate something about the value of an investment in a more informal way
- But it is important to remember that only net present value techniques have these important characteristics:
  - Give an unambiguous go/no go signal
  - Can handle projects of different scales and different durations
  - Incorporate comparison of achieved return against required return
  - Offer a clear indication of economic profitability

Measurement

Valuation – Measurement - Accounting

- Valuation is all about the **future**
  - An estimate of the present value of all future cash flows
- Accounting is all about the **past**
  - What cash flows actually happened?
- Measures are all about the "**present**"
  - Consider them as a bridge between past (accounting) and future (valuation)
  - Trying to answer the question **"What is happening and where are we going?"**



Measuring Progress

- In operations, we need to confront the problem of **measuring progress**
  - What is the right way to measure whether progress is being made?
- Measures are also important for rewarding and encouraging **performance**
  - **Incentives** make sure that managers and employees are rewarded appropriately when they add value

"You can't reward value added unless you can measure it"

⇩

"You get what you reward"

⇩

"You reward what you measure"

⇩

"You get what you measure"

⇩

"Make sure you are measuring the right thing"

- Brealey & Myers

Key Performance Indicators

- One popular way of approaching measurement is known as **Key Performance Indicators (KPI)**
  - Also sometimes called Key Success Indicators
- The approach is popular also because it is very general – it doesn't restrict the type of organization using KPI
- Some examples of organizations that might use the KPI approach:
  - Corporation
  - University
  - Government agency
  - Non-governmental organization


governmental


non-governmental


businesses


schools

Key Performance Indicators are Measurements

- Key Performance Indicators are **quantifiable measurements** that reflect the critical success factors of an organization
- They will vary with the nature and goals of an organization
  - A **business** may have as one of its Key Performance Indicators the percentage of its income that comes from return customers
  - A **school** may focus its KPIs on graduation rates of its students
  - A **Customer Service Department** may have as one of its Key Performance Indicators the percentage of customer calls answered in the first minute.
  - A **social service organization** might measure the number of clients assisted during the year.

KPIs Reflect the Organizational Goals

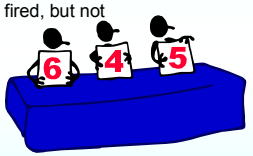
- A business will likely have the organizational goal to "maximize profits"
  - KPIs will probably include income, costs, etc.
  - But "percentage of income contributed to charity" will not be a KPI
- A university doesn't care about profits, so KPIs are different
  - "number of students graduating"
  - "number of jobs found after graduation"
- But what if the university *does* care about profits?
  - For example, private American universities like Yale
  - Then profits become a KPI – remember the goals!
- Governmental agencies may have completely different KPIs
  - "Number of citizens helped at the information center"


businesses


schools

KPIs are Quantifiable

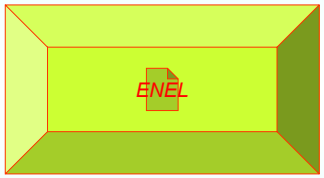
- It must be possible to measure a KPI in a consistent and unambiguous manner
- Good:
  - KPI: "reduce employee turnover"
  - Defined as: employees who resign, who are fired, but not those who retire."
  - What to measure: use employee records
- Bad:
  - KPI: "increase sales"
  - Defined as: "increase in sales volume"
  - What to measure: Total sales in our area
- The second example is imprecise and ambiguous
  - Number of units sold, or Euros earned?
  - What if a customer brings back a purchase?
  - Etc ….



An Example of KPIs from Government

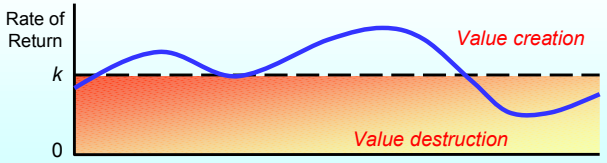
An Example of KPIs from Industry

An Example of KPIs from Utilities



A Key Performance Indicator for Profitability?

- When calculating profits, a company might start with revenues, and then deduct costs (wages, equipment, overhead, taxes)
  - This is measuring **operating profits** (accounting profits)
  - Should these become a Key Performance Indicator?
- But the cost of capital must also be covered
  - Investors also expect a positive return on their investment
  - Depreciation of capital assets is not the same thing
  - Breaking even in accounting terms is really *making a loss* – you are not covering the cost of capital



Economic Profit

- Value Based Management uses a financial measure of profitability known as **Economic Profit**
- Start with the usual definition of ROI as operating profits divided by amount of capital invested
- Then **Economic Profit = capital invested × (ROI – *k*)**
- Equivalently, EP = operating profits – capital invested × *k*
- The expression (capital invested × *k*) is the **capital charge**
- An ROI higher than *k* creates value
- An ROI lower than *k* destroys value

Economic Profit is Aligned with NPV

- It is important that any measure of profitability be aligned with the fundamental Present Value formula
- It can be shown that Present Value can be expressed equivalently either as
  1. A stream of future discounted cash flows
  2. The invested capital plus a stream of future discounted Economic Profits
- For (forward-looking) valuation, it is generally more convenient to use the Present Value formula
- For ongoing project management, period by period, it is generally more convenient to use the Economic Profit formulation, which gives an ongoing signal of value creation or destruction

Company Value = Capital invested plus Economic Profits

Formal Equivalence of DCF and EP

1 *Start with the standard Present Value formula:*

$$\mathrm{PV} = \frac{C_1}{(1+k)} + \frac{C_2}{(1+k)^2} + \frac{C_3}{(1+k)^3} + \ldots = \sum_{t=1}^{\infty} \frac{C_t}{(1+k)^t}$$

2 *Recall that* **EP** *= C – "capital charge" = C – I × k, where I = invested capital*

3 *So we can express the cash flow of period t like this:* $C_t = \mathrm{EP}_t + I \times k$

4 *Now substitute that for the* C_t *in the standard formula:* $\sum_{t=1}^{\infty} \frac{\mathrm{EP}_t + I \times k}{(1+k)^t}$

5 *Now separate terms:* $\sum_{t=1}^{\infty} \frac{\mathrm{EP}_t}{(1+k)^t} + \sum_{t=1}^{\infty} \frac{I \times k}{(1+k)^t}$

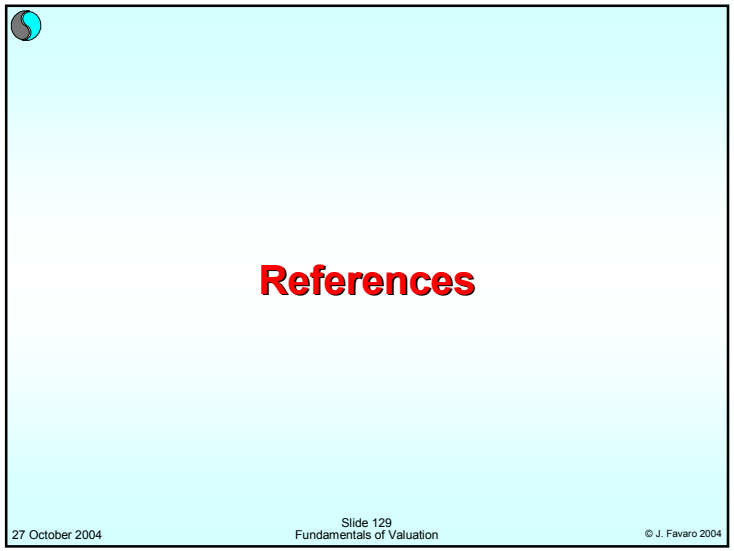
6 *Pull out I:* $\sum_{t=1}^{\infty} \frac{\mathrm{EP}_t}{(1+k)^t} + I \times \sum_{t=1}^{\infty} \frac{k}{(1+k)^t}$

7 *But:* $\sum_{t=1}^{\infty} \frac{k}{(1+k)^t} = 1$

8 *Thus:* $\mathrm{PV} = I + \sum_{t=1}^{\infty} \frac{\mathrm{EP}_t}{(1+k)^t}$

Key Concepts

- Key Performance Indicators are a powerful approach to organizing the measurement of organizational drivers
  - Will be different for different organizations
- **Earning your cost of capital is the bedrock foundation of value based management**
  - **The Economic Profit measure sends a strong signal about whether you are really creating value**
  - **Measuring and rewarding Economic Profit encourages managers to use resources efficiently and not use too much capital**


References
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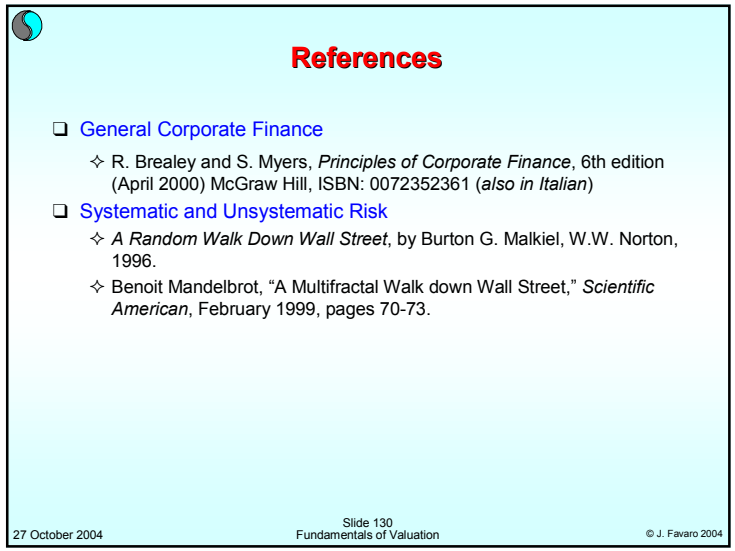
References
General Corporate Finance
R. Brealey and S. Myers, Principles of Corporate Finance, 6th edition (April 2000) McGraw Hill, ISBN: 0072352361 (also in Italian)
Systematic and Unsystematic Risk
A Random Walk Down Wall Street, by Burton G. Malkiel, W.W. Norton, 1996.
Benoit Mandelbrot, "A Multifractal Walk down Wall Street," Scientific American, February 1999, pages 70-73.
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