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An Introduction to Corporate Finance, and Applications to Regulated Industries

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Outline

A. Motivation
- What *is* corporate finance?
- How is it different than accounting?
- Why would / should a regulator care?

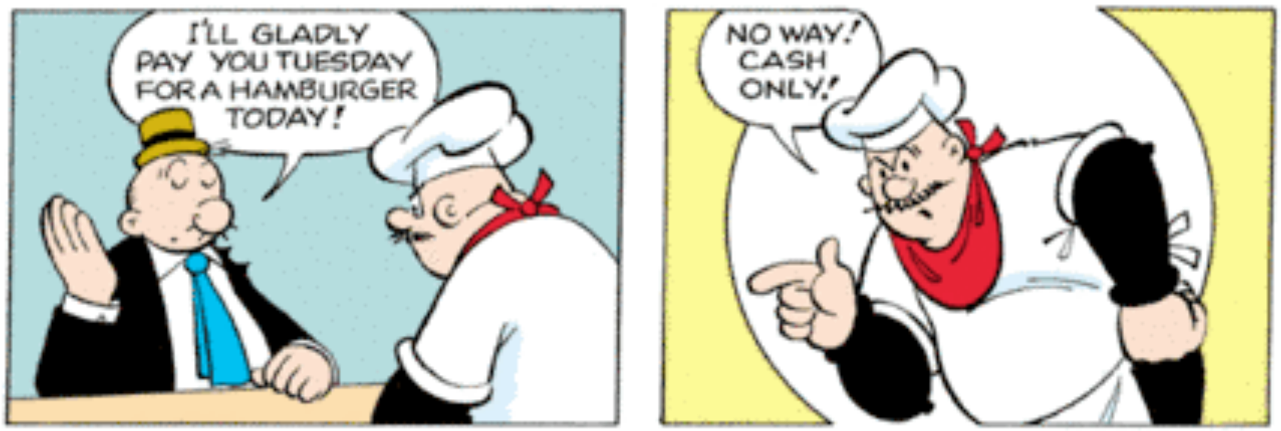
B. Nuts & Bolts of Valuation
- Valuing **T**ime
- Valuing **R**isk

C. Regulatory Risk
- Qua Volatility
- Qua Insurance
- Qua Truncation
- Commitment and Predictability

D. Real Options

Motivation

- What *is* corporate finance?
  - Understanding how financial claims & cash flows (a) are valued; and (b) affect behavior
  - Most of our conversation today will be about (a)
- How is (a) different than accounting?
  - Forward-looking
  - Cares most critically about actual cash flows
  - FMVs matter
- Why should a regulator care?
  - RoR Regulation: Critical for determining reasonable rate of return
  - Price Cap Regulation: Setting cap still predicated against equilibrium rate of return
  - Incentive regulation: Rent extraction should be commensurate with risk to induce optimal entry



My First Finance Lesson

B. Nuts and Bolts of Corporate Finance
1. Valuation Time

- Basic Idea:
  - Cash flows (costs & revenues) that occur early in time carry greater weight with financial decision makers than those that occur later in time
  - Why? The ability to use cash flows for some other purpose during the interim period is valuable
    - E.g., alternative investments during delay period
- What's worth more – a right to receive $1000 today or the right to receive $1000 in a year?
  - The former: $1000 received today can (for example) be invested in a federally guaranteed CD that pays back the invested amount *plus interest* in a year; it will thus be worth more than $1000 at that time.

Some (unavoidable) Notation

t = time (today is frequently denoted as "t=0")

T = terminal or "end" period (sometime in future)

C_t = cash flow at time t

– Sometimes denoted with F_t or P_t (depending on use)

r = "rate of return" from two periods of time

Most financial economists speak the language of returns

– One Period Return (between t=0 and t=1):

– Multi-period Return (between t=0 and future date t)

Simple Example of Returns

- If you invest $10 today, and are promised to be paid back $15 in 10 years, what is the 10-year rate of return?

$$r_{0,10} = \frac{\$15 - \$10}{\$10} = 0.5$$

$$= 50\%$$

A Vernacular Aside: Tips on BiPS

- BPS (“BiPS”) = “BASIS POINTS”
  – 1 Basis point = (Difference in percentage rates) x 100
- Many finance experts express difference in terms through BPS rather than percentages. Why?
  – Makes them sound smart (Don’t discount this one.)
  – Often very small % differences make for very big $ differences
  – Nomenclature may help avoid ambiguity…
- Compare 15% and 20%.
  – Is 20% is 5% more than 15%?
  – Or is it 33.3% more than 15%?
  – Basis points help avoid that ambiguity
    - 20% is 500 BPS more than 15%.

Key Point

Discounting and Compounding: Two sides of the same coin

- Functional Descriptions:
  - Compounding: How much will $X invested today be worth in T years?
  - Discounting: How much is a future payment of $X realized in T years worth today?
- The Baseline Formula(s)
  - Compounding: For a one-period investment of *P* dollars at rate *r*, its future value *F* will be equal to:
  - Discounting: The investment P necessary today at rate *r* to generate F dollars in the future will be equal to:

$$P = \frac{F}{(1+r)}$$

Compounding Over Multiple Periods

- Compound interest over many (e.g., 20) Periods

- In most contexts (though not all), the rate of return is expected to remain constant over time at "*r*". In this case, future value becomes:

Compounding & Discounting when return is expected to remain constant

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- Compounding:

$$F_t = P_0 \times (1+r)^t$$

- Discounting to "Net Present Value" (for each future cash payment):

$$\underline{F_t} = P_0 \times (1+r)^t$$

- Discounting a "stream" of cash flows:

$$P_0 = NPV = F_0 + \frac{F_1}{(1+r)^1} + \frac{F_2}{(1+r)^2} + \ldots + \frac{F_T}{(1+r)^T}$$

Example (to be revisited many times)

- Suppose a utility company could build a new plant for $1 million today. After one year, the plant will be operational, but not at full capacity, and will generate net sales revenues of $200K. In the remaining 4 years of its useful life, it will generate $300K in net annual revenues, at full capacity. It has zero salvage value at the end of 5 years..
- Should the company invest in the new plant now? Assume that the company discounts payoffs at the risk-free rate:

a) 5.0%?

b) 10.0%?

c) 15.0%?

Table of NPVs for Running Example

$$P_0 = \frac{F_t}{(1+r)^t} = \frac{\$300,000}{(1+0.05)^3}$$

		Discount Rate		
		5.00%	[illegible]	[illegible]0%
Year	Cash Flow	*Sum Up…*		
0	-$1,000,000	-$1,000,000	-$1,000,000	-$1,000,000
1	$200,000	$190,476	$181,818	$173,913
2	$300,000	$272,109	$247,934	$226,843
3	$300,000	$259,151	$225,394	$197,255
4	$300,000	$246,811	$204,904	$171,526
5	$300,000	$235,058	$186,276	$149,153
NPV		**$203,605**	**$46,327**	**-$81,310**

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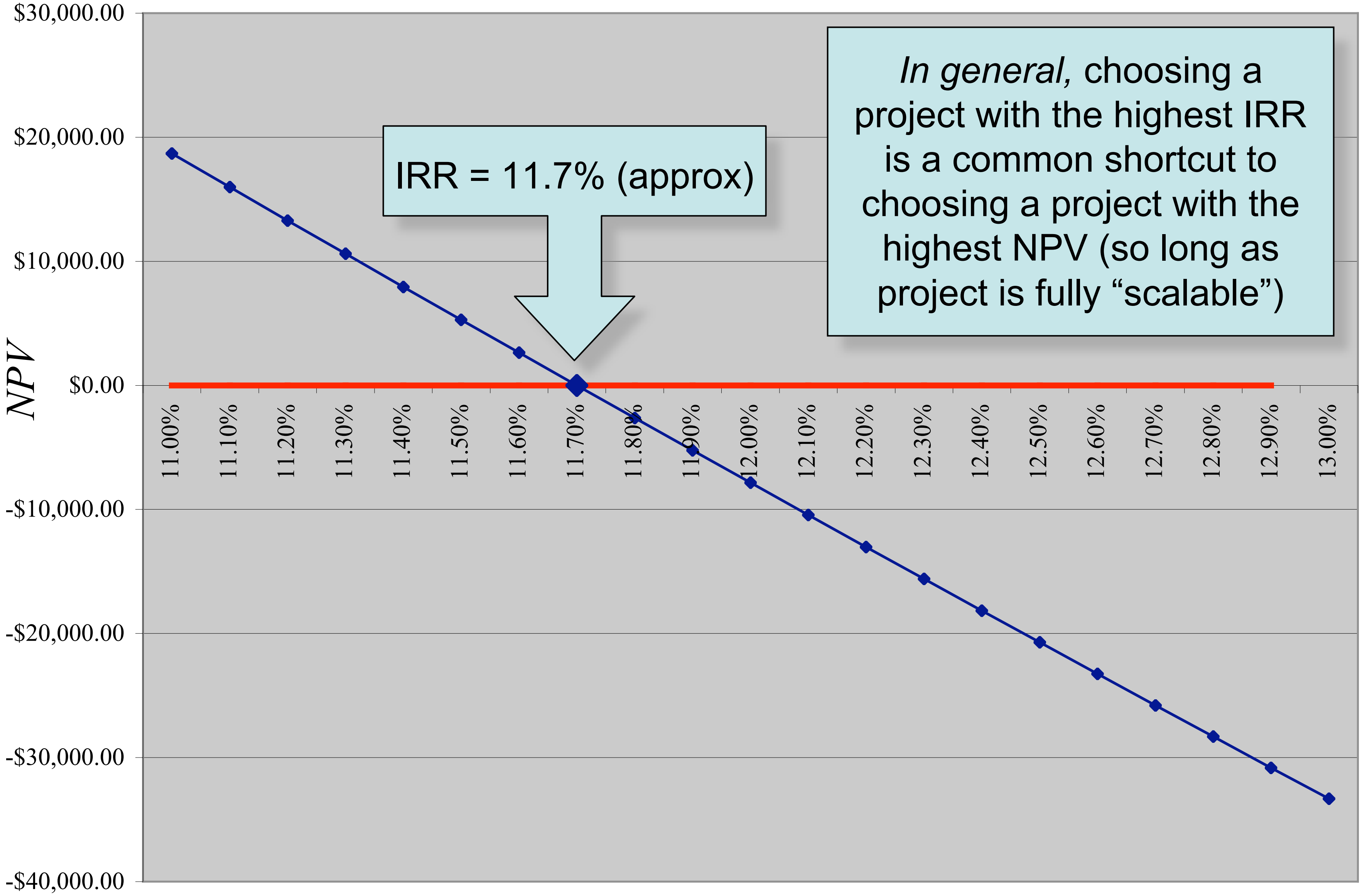
Running Example (continued)

- Suppose a utility company could build a new plant for $1 million today. After one year, the plant will be operational, but not at full capacity, and will generate net sales revenues of $200K. In the remaining 4 years of its useful life, it will generate $300K in net annual revenues, at full capacity. It has zero salvage value at the end of 5 years.
- Should the company invest in the new plant now? Assume that the company discounts payoffs at the risk-free rate:
  a) 5.0%?
  b) 10.0%?
  c) 15.0%?
- What rate would make the company just indifferent between investing and not investing in the plant?
  – "Internal Rate of Return"

Internal Rate of Return



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Rules of Thumb from Time Valuation

Key Point

- Most financial decision makers make investment choices using the Net Present Value (NPV) rule – i.e., invest only in project(s) that yield a positive NPV
- Holding all else constant, the NPV of a “typical” investment’s cash flow pattern ***increases*** when…
  1. …up-front costs <u>decline</u>
  2. …the size of downstream benefits <u>increases</u>
  3. …the period over which downstream benefits accrue <u>lengthens</u>
  4. …the rate at which one discounts the future <u>decreases</u>

Economic factors / policies that bring about (1) – (4) tend to increase investment.

And, vice versa, things that reverse (1) – (4) tend to discourage investment.

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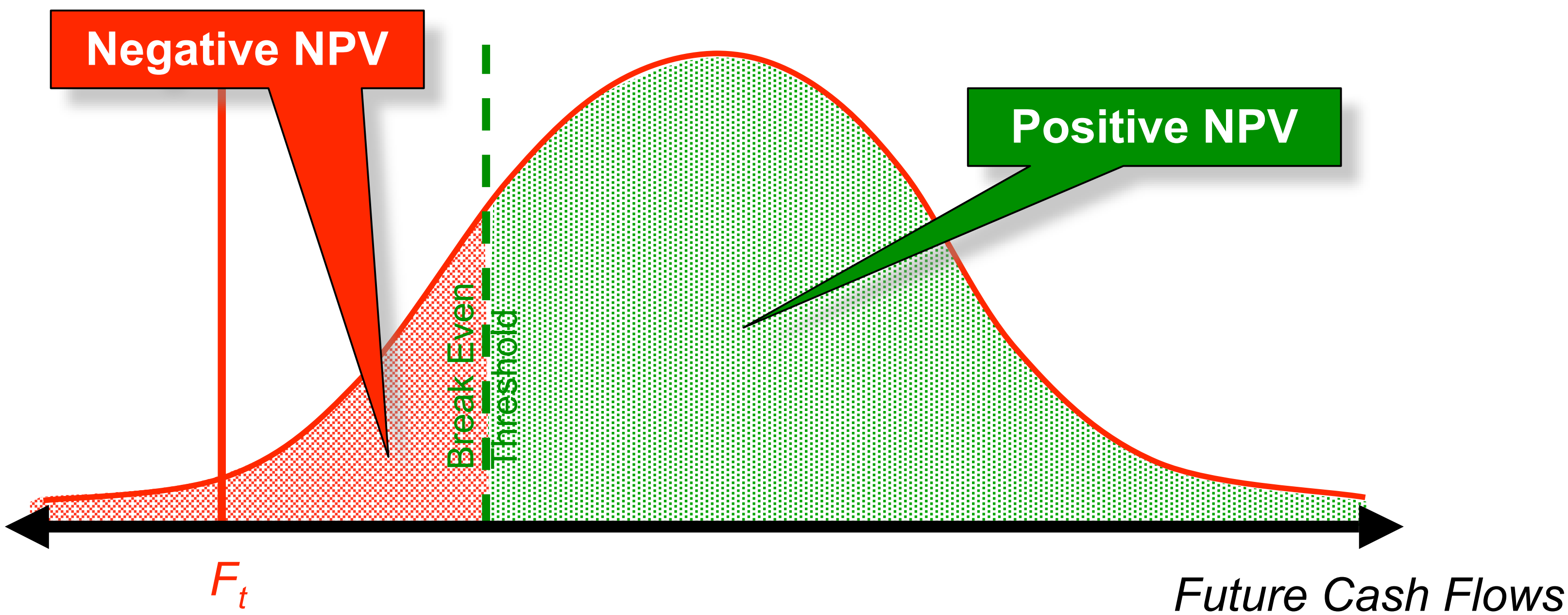
2. Valuing Risk

- Challenge:
  - Previous discussion: future cash flows were **certain**; key was to find projects yielding positive NPV (above break even threshold)
  - Most realistic economic settings, however, are risky ones (particularly in businesses) – cash flows are **probabilistic**



Adjusting the NPV rule to account for the risky environments

- <u>The Good News</u>:
  - Most of the rules of thumb about time discounting still hold
  - In fact, the FV / PV expressions above still apply, in very much the same forms before

- <u>The Bad News</u>:
  - The ingredients of these formulae (i.e., the F_t's and the r's) become a bit more complex:
    - In a world of risk, we must now focus on
      - <u>*Expected*</u> cash flows (e.g., "on average"); and
      - <u>*Risk Adjusted Expected*</u> rates of return;

Adjusting compounding / discounting formulae to account for risk

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<u>Certain Payoffs</u>

- Compounding

$$F_t = P_0 \times \left(1 + r_f\right)^t$$

- Discounting

$$P_0 = \frac{F_t}{\left(1 + r_f\right)^t}$$

<u>Risky Payoffs</u>

- Compounding

$$E(F_t) = P_0 \times \left(1 + E(R_A)\right)^t$$

- Discounting

$$P_0 = \frac{E(F_t)}{\left(1 + E(R_A)\right)^t}$$

Adjusting expectations for risk: Example

- <u>Project A</u>: Invest \$10 now, and in one year you receive \$11 (with certainty)

  Return = (11-10)/10 = 10%

- <u>Project B</u>: Invest \$10 now & in 1 year you receive

  i. \$14 with probability ½

  ii. \$8 with probability ½

  Expected Future Cash Flow = ½ x \$14 + ½ x \$8 = \$11

  Expected Return = ½ x (14-10)/10 + ½ x (8-10)/10 = 10%

- *Q: Where would you rather put your money?*
  - *Likely Project A: Expected return with risk usually must exceed that of a safe investment (government bonds) for someone to hold it*
    - *By how much? Keep listening…*

How financial economists think about risk

- Random Variable (or, "RV")
  - An observable outcome (price; return; annual rainfall; the Rockies' Team ERA) that is not yet known, but may take on a number of different values, each associated with a probability.
  - Example: Random Variable "X" = Outcome of a toss of a fair die
    - RV's Outcomes: X = {1, 2, 3, 4, 5, 6}
    - Associated Probabilities: P = {1/6, 1/6, 1/6, 1/6, 1/6, 1/6}
- *Expected Value* of a RV (sometimes called "mean"):
  - The summed outcomes of a R.V., weighted by their probabilities

$$E(X) = \frac{1}{6}(1) + \frac{1}{6}(2) + \frac{1}{6}(3) + \frac{1}{6}(4) + \frac{1}{6}(5) + \frac{1}{6}(6) = 3\tfrac{1}{2}$$

- *Variance* of a RV (often denoted *var(X)*, or σ^2):
  - Expected value of the **squared** "**mean-adjusted**" **outcome** the RV

$$Var(X) = \frac{1}{6}(1-3.5)^2 + \frac{1}{6}(2-3.5)^2 + \frac{1}{6}(3-3.5)^2 + \frac{1}{6}(4-3.5)^2 + \frac{1}{6}(5-3.5)^2 + \frac{1}{6}(6-3.5)^2 = 2\tfrac{11}{12}$$

  - *Std Deviation* = Sq. Root of Variance (often denoted SD(X) or σ)

$$SD(X) = \sqrt{2\tfrac{11}{12}} = 1.708$$

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Measuring Co-movement

- Sometimes, one needs to keep track of how two RVs (call them X and Y) move relative to one another.
- E.g.:

  X = outcome obtained by rolling one fair “red” die

  Y = the *total* outcome obtained on the *same roll* of the red die, *plus* that obtained on the role of a second fair “black” die.

  - All outcomes described as a pair: e.g., {X,Y}={6,12}

- A common measure that statisticians use to describe two RVs’ co-movement is *covariance*
  - Covariance = Expected value of the **product** of each random variable’s **mean-adjusted outcomes**.
  - Covariance can be positive, negative, and zero; captures extent of linear relationship between variables
  - Often denoted: *cov(X,Y)*

Computing covariance in running dice example
(Recall: X = red die; Y = sum of both dice)

Probabilities of each pairing

Y \ X	1	2	3	4	5	6
2	1/36	0	0	0	0	0
3	1/36	1/36	0	0	0	0
4	1/36	1/36	1/36	0	0	0
5	1/36	1/36	1/36	1/36	0	0
6	1/36	1/36	1/36	1/36	1/36	0
7	1/36	1/36	1/36	1/36	1/36	1/36
8	0	1/36	1/36	1/36	1/36	1/36
9	0	0	1/36	1/36	1/36	1/36
10	0	0	0	1/36	1/36	1/36
11	0	0	0	0	1/36	1/36
12	0	0	0	0	0	1/36

Product of Mean-Adjusted Values

Y \ X	1	2	3	4	5	6
2	12 1/2	7 1/2	2 1/2	-2 1/2	-7 1/2	-12 1/2
3	10	6	2	-2	-6	-10
4	7 1/2	4 [illegible]	1 1/2	-1 1/2	-4 1/2	-7 1/2
5	5	3	1	-1	-3	-5
6	2 1/2	1 1/2	1/2	- 1/2	-1 1/2	-2 1/2
7	0	0	0	0	0	0
8	-2 1/2	-1 1/2	1/2	1/2	1 1/2	2 1/2
9	-5	-3	[illegible]	1	3	5
10	-7 1/2	-4 1/2	[illegible]	1 1/2	4 1/2	7 1/2
11	-10	-6	[illegible]	2	6	10
12	-12 1/2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

= (3 – 7) x (2 – 3½)

Mean of Y= 7
Mean of X= 3 1/2
Var of Y = 5 5/6
Var of X = 2 11/12

= (1/36) x (6)

(Pair Probability) x (Product of Mean Adjusted Values)

Y \ X	1	2	3	4	5	6
2	25/72	0	0	0	0	0
3	5/18	1/6	0	0	0	0
4	5/24	1/8	1/24	0	0	0
5	5/36	1/12	1/36	- 1/36	0	0
6	5/72	1/24	1/72	- 1/72	- 1/24	0
7	0	0	0	0	0	0
8	0	- 1/24	- 1/72	1/72	1/24	5/72
9	0	0	- 1/36	1/36	1/12	5/36
10	0	0	0	1/24	1/8	5/24
11	0	0	0	0	1/6	5/18
12	0	0	0	0	0	25/72

Add up all cells in this final table to find covariance:

Cov(X,Y) = 2 11/12

Capital Asset Pricing Model

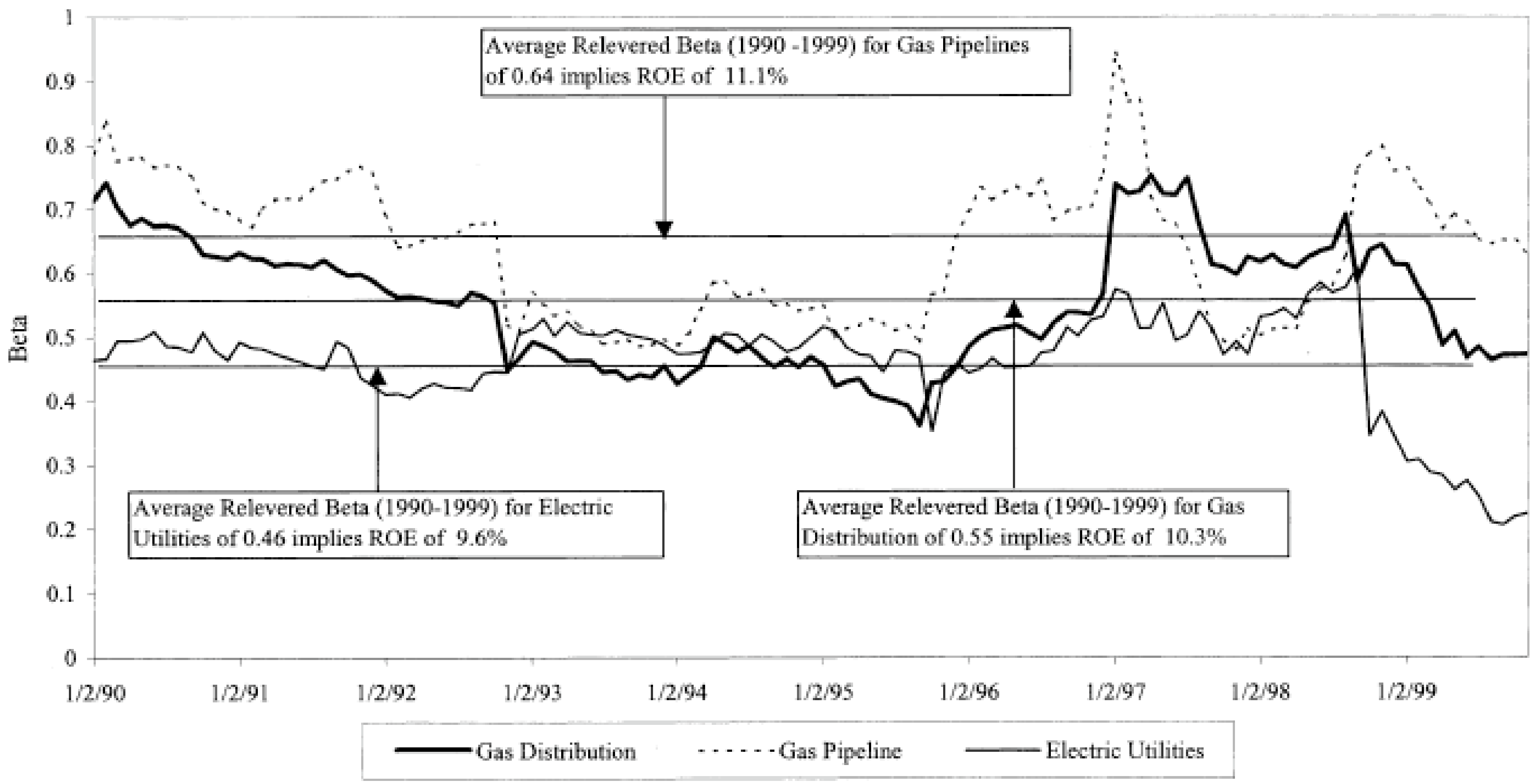
- An important contribution in finance theory (Markowitz; Tobin; Sharpe) that helps adjust an investment/asset's required rate of return $E(R_A)$
  - Assumptions: Investors care only about mean and variance in returns; no transaction costs; no restrictions on short selling
- Ingredients:
  1. Risk free rate on "safe" asset: r_f
  2. Expected Rate of Return on the "Market": $E(R_{Market})$;
     - Market = extremely broad portfolio of investments, weighted by their market value (such as Wilshire 5000)
  3. An investment's "β" = an expression of its risk relative to overall market risk:

$$\beta = \frac{\mathrm{cov}(R_A, R_{Market})}{\mathrm{var}(R_{Market})}$$

Some personality traits of β

- Although β could take on any value in theory (+ or -), in most practical applications, an investment's β will be between zero and three.
  - By definition, a risk free investment has a $\beta = 0$
  - By definition, a highly diversified market portfolio has a $\beta = 1$
- Relatively safe companies tend to have $\beta < 1$, while relatively risky companies tend to have $\beta > 1$.
  - Utilities are often cited as a good example of "low β" stocks
    - Why? Part of the answer to this puzzle comes from the Alexander et al reading for later this afternoon
  - Note: Even companies with highly variable returns may have low β s: Variance is uncorrelated with market risk
    - Systematic versus Diversifiable Risk
- Combinations of investments:
  - A portfolio of a set of investments has β equal to the (value weighted) average across those investments

Selected Historic Utilities βs



Source: Cragg et al (2001)

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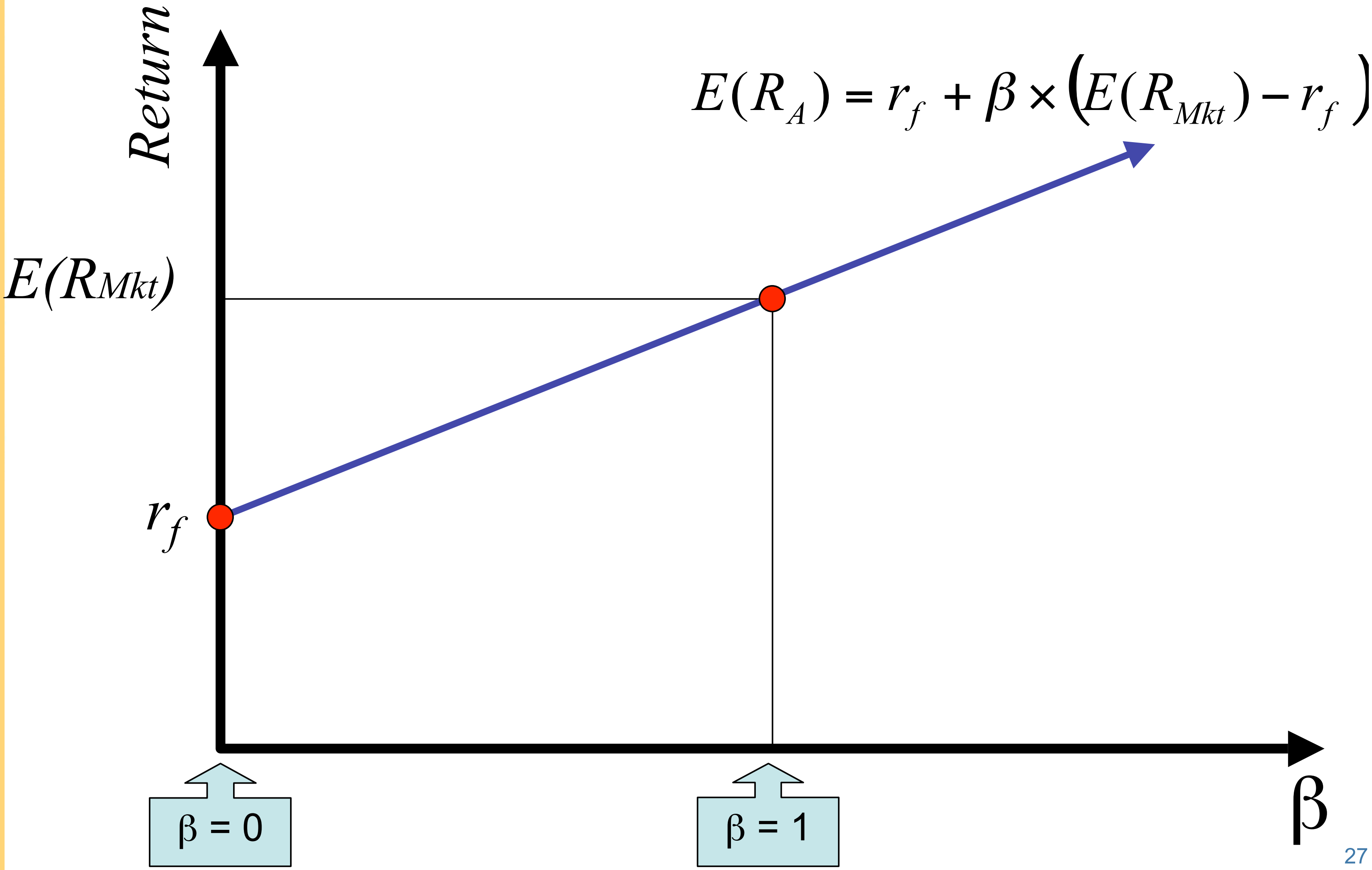
The Securities Market Line and an Asset's Expected Rate of Return



Running Example…

- Go back to utility's plant investment example (w/ small modification):
  - Year 0 cash flows: -$1 million
  - Year 1 expected cash flows: $ 200k
  - Year 2-5 expected cash flows: $ 300k per year
- Suppose plant is comparable to those already operated by the utility. The utility is wholly financed by equity, and has β = 0.7. The risk free rate is 5% and the expected return of the market is 12%. What is the risk-adjusted NPV? Should the company build the plant?
- Risk adjusted return:

$$E(R_A) = r_f + \beta \times \left(E(R_{Mkt}) - r_f\right)$$
$$= .05 + 0.7 \times \left(0.12 - 0.5\right)$$
$$= 9.9\%$$

  - At this adjusted rate of discount, the NPV of the project is +$49,155.44
  - Equivalently, recall that IRR of project is 11.7%, and thus the project yields is less than its required rate of return.

- THEREFORE: utility **will** undertake the investment

A few important caveats

- How do we know the risk free rate?
  - Usually widely available data; thick markets (e.g., t-bill rate; LIBOR)
  - Key issue: applicable term (time horizon; useful life)
- How do we know the market's expected rate of return?
  - The truth? We sort of don't! Many simply project historical market premia forward (discounted slightly for various reasons)
  - Sometimes consensus forecasts among economists/analysts
- How do we compute the company's β?
  - Estimated by historical data (if publicly traded), using regression
    - Many services (e.g., Yahoo Finance) publish this information
  - Problem: Data is unreliable / time variant
    - Pool industry / international data (but don't assume β=1!)
  - Problem: What if company is privately held?
    - Must pool industry/int'l data (if known)
  - Problem: What if project is not typical of firm's other projects?
    - Firm β not be appropriate; other firms with similar projects?

Alternatives to the CAPM

- CAPM does not predict perfectly
  – Premia for small firms, high market to book firms, recent winners
  – CAPM's assumptions may be too special
- Some have attempted to generalize / abandon CAPM in the last two decades:
  – APT & multi-"factor" models (Fama & French 1993; Carhart 1997)
    - Seems to explain better, but still very ad hoc
  – Gordon Dividend Growth Model
    - Even more ad hoc and backward looking
  – CAPM model is still used by far the most frequently used approach (warts and all)

Weighted Average Cost of Capital

- Unlike our example, many companies are financed with both debt and equity
- Debt tends to be less risky than equity (why?)
  - Thus debt βs are lower than those on stocks
- Thus, when a company takes on a new project, and finances it with a mixture of debt and equity…
  - …it is appropriate to formulate risk-adjusted rates of return in a way that similarly combines the costs of capital on both debt and equity
- WACC = The average of the E(R)s generated with debt and equity βs, weighted by the relative value of debt and equity in company's financing
  - Often with tax adjustments that we'll ignore (for now)

$$WACC = \left(\frac{D}{D+E}\right) \times E(R_{Debt}) + \left(\frac{E}{D+E}\right) \times E(R_{Eq})$$

Utilizing WACC in Running Example…

- Recall:
  - Year 0 cash flows: -$1 million
  - Year 1 expected cash flows: $ 200k
  - Year 2-5 expected cash flows: $ 300k per year
- The utility is 60% financed by stock, and 40% financed by debt. The firm's equity β is equal to 0.7, and its debt β is equal to 0.4. The risk free rate is 5% and the expected return of the market is 12%. Assuming that the company finances the new plant in the same ratios (and ignoring tax effects), what is the company's WACC for the project, and what is the NPV?

$$E(R_{Eq}) = r_f + \beta_{Eq} \times \left(E(R_{Mkt}) - r_f\right) = .05 + 0.7 \times \left(0.12 - 0.5\right) = 9.9\%$$

$$E(R_{Debt}) = r_f + \beta_{Debt} \times \left(E(R_{Mkt}) - r_f\right) = .05 + 0.4 \times \left(0.12 - 0.5\right) = 7.8\%$$

$$WACC = (0.6) \times (9.9\%) + (0.4) \times (7.8\%) = 9.06\%$$

  - Using WACC, the NPV of the project is +$73,388.37

- THEREFORE: utility **will** undertake the investment

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Aside: WACC with taxes

- If debt is tax preferred relative to equity (e.g., interest on debt may be fully deducted), then company gets some tax relief with debt financing.
- Tax-adjusted WACC: If τ denotes the company's tax rate, then WACC is given by:

$$WACC = (1-\tau)\times\left(\frac{D}{D+E}\right)\times E(R_{Debt}) + \left(\frac{E}{D+E}\right)\times E(R_{Eq})$$

- Note that this is lower than the pre-tax WACC.
  - Given that this is the rate used by the financier at the firm, it is probably the appropriate one to use
  - But many regulators use pre-tax WACC (to the great pleasure of regulated entities coming before them!)

Key Point

Rules of Thumb from Risk Valuation

- Financial decision makers make risky investment choices according the NPV rule *adjusted for risk.*
- Holding all else constant, the risk-adjusted NPV of a typical investment's cash flow pattern ***increases*** when…

1. …up-front costs <u>decline</u>
2. …the *expected* size of downstream benefits <u>increases</u>
3. …the period over which downstream benefits accrue <u>lengthens</u>
4. …the risk free rate of return <u>decreases</u>
5. …the expected market rate of return <u>decreases</u>
6. …the company's market β <u>decreases</u>

Economic factors / policies that bring about (1) – (6) tend to catalyze investment.

And, vice versa, things that reverse (1) – (6) tend to decrease investment.

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3. Regulatory Risk

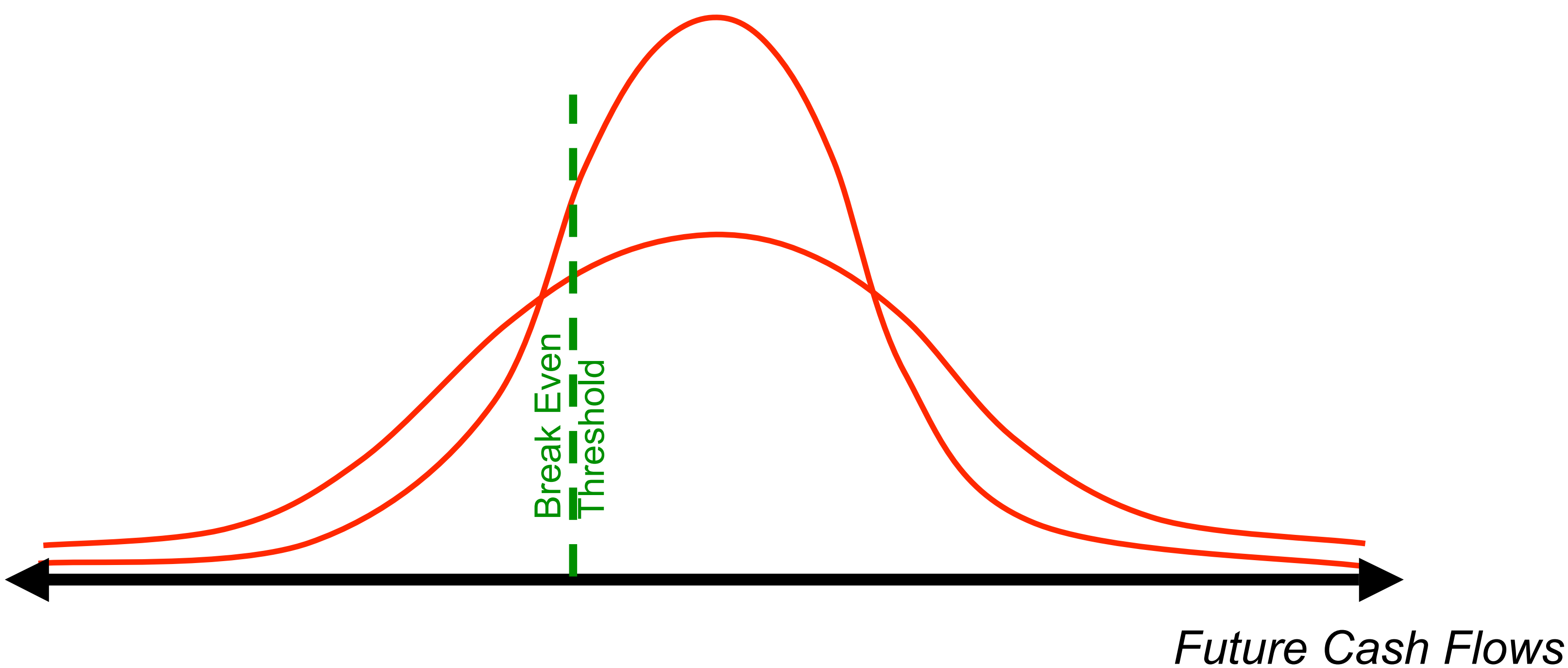
- Regulated companies ≠ non-profits.
  - Just like other for-profit firms, they will tend (and indeed are legally required) to make decisions that are in their investors' long-term financial interests
  - Thus, such companies still make investment / operational decisions that are predicated on maximizing risk-adjusted present value to investors
- The Big Difference: Regulatory Risk
  - In addition to market conditions, costs, rate fluctuations, etc, the regulator's actions (and future anticipated actions) bear on the nature, timing, magnitude, and sustainability of future cash flows
  - Moreover, and somewhat troublingly, cash flow patterns of the regulated company can bear on the regulator's actions…
    - …which can in turn affect the company's cash flow patterns…
    - …which can in turn affect the regulator's actions…
    - …etc…

C. Multiple faces of regulatory risk

- RR as a type of volatility
- RR as a type of insurance
- RR as a type of return truncation
- Regulator’s ability to commit

Regulation as a source of added volatility

- Unpredictability of regulation can enhance volatility of a regulated entity's returns
- Can lead to lower expected cash flows and/or higher βs, with a higher required rate of return



Running Example…

- Recall:
  - Year 0 cash flows: -$1 million
  - Year 1 exp cash flows: $ 200k; Year 2-5 exp cash flows: $ 300k per year
  - Risk Free Rate = 5%; Expected Market Return = 12%
- Assume the utility is wholly financed by equity. In each year the plant is operational, there is a 10% chance that the economy is in a recession, in which case, the regulator will force utility to reduce rates and thereby reduce cash flows by $50K a year. There is also a 10% chance that the economy will be booming, and the regulatory will allow an increase in rates that enhances cash flow by $60K per year. The added risk change causes the β of the firm to increase to 1.1. What is the project's NPV?

$$E(R_{Eq}) = r_f + \beta_{Eq} \times \left(E(R_{Mkt}) - r_f\right)$$
$$= .05 + 1.1 \times \left(0.12 - 0.5\right) = 12.7\%$$

- Interestingly, expected Cash flows actually go up slightly:
  - Year 1: (8/10) x ($200k) + (1/10) x ($150k) + (1/10) x ($260k)=$201K
  - Years 3-5: $301k each year
- But the NPV of the project becomes negative, and is -$22,248.93

Note…

- Sometimes regulatory risk harbors cataclysmic forms of volatility
  - E.g., in many industries, doing business requires one to be in good standing among regulatory authority
  - Ability to revoke / suspend licenses has significant implications
    - Arthur Andersen (“Big 5” accounting firm)
    - ITT
    - GE Medical Systems
- However, regulatory risk may also serve to moderate risks

Regulatory Risk as Insurance

- E.g., It is well known that Rate of Return regulation can act as a form of insurance:
  - By risk borne by company's investors
- Estimated betas for RoR regulated firms generally thought to be lower than for price cap firms
  - Incentives versus investment tradeoff?
  - Perhaps, but depends on where rate / caps set
- Here, anticipated regulatory safety nets may subsidize inefficient or excess investment

Alexander et al (1996)

Country	Electricity		Gas		Combined gas and electricity		Water		Telecoms	
	Regulation	Beta	Regulation	Beta	Regulation	Beta	Regulation	Beta	Regulation	Beta
Canada	—	—	—	—	ROR	0.25	—	—	ROR	0.31
Japan	ROR	0.43	—	—	—	—	—	—	ROR	0.62
Sweden	—	—	—	—	—	—	—	—	Price cap	0.50
United Kingdom	—	—	Price cap	0.84	—	—	Price cap	0.67	Price cap	0.87
United States	ROR	0.30	ROR	0.20	ROR	0.25	ROR	0.29	Price cap (AT&T)	0.72
									ROR (others)	0.52

— Not available or not applicable.

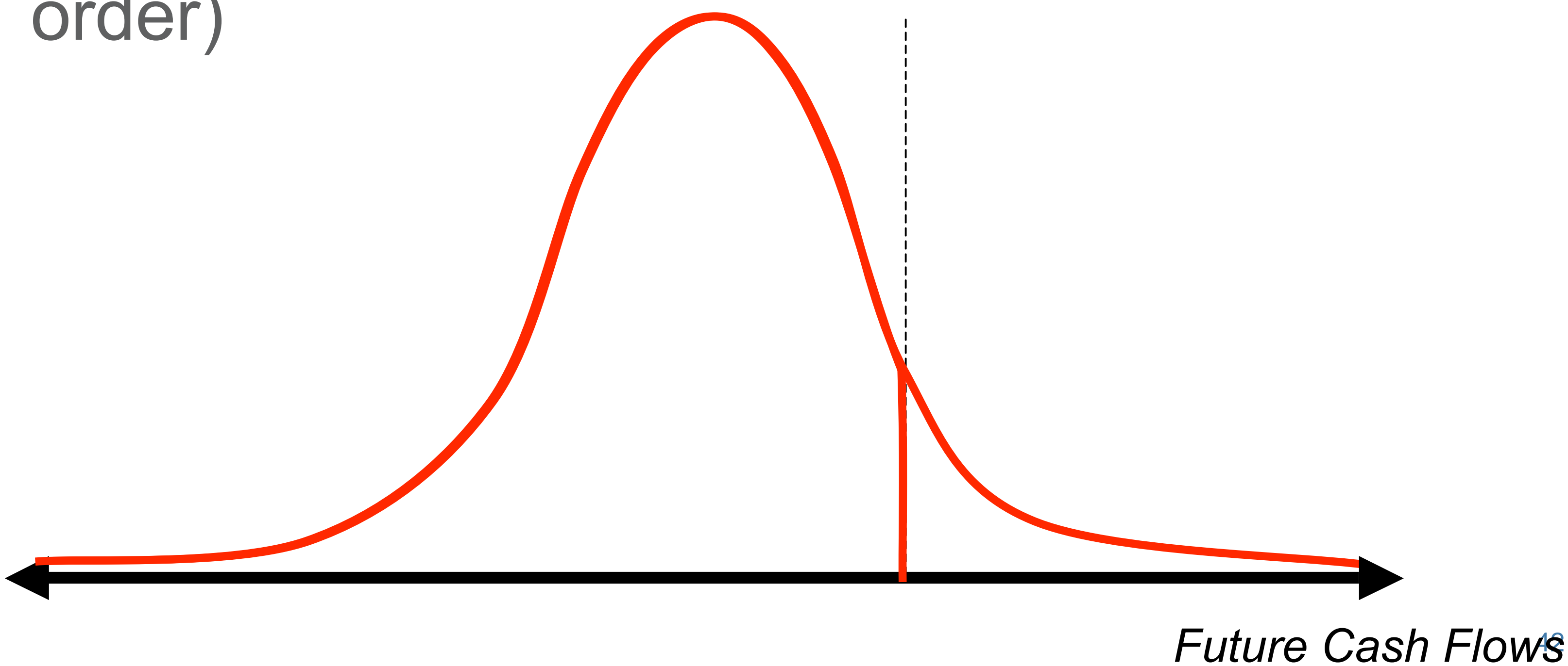
Note: The betas are asset betas that control for differences in debt-equity ratios between firms. ROR is rate-of-return regulation.

Source: Oxford Economic Research Associates, "Regulatory Structure and Risk: An International Comparison" (London, 1996).

Normative Lesson Here?

RR as truncation

- Incentive regulation: Regulator cannot commit to refrain from intervening when returns are high
- Consequences: Reduces expected returns (though also decreases systematic risk – 2nd order)



How to deal with these issues?

- Most commonly proposed way to address:
  - Regulatory Commitment
- But ability to commit may depend on numerous factors
  - Sufficient information to “get it right” ex ante
  - Value of flexibility to adapt to changing conditions
  - Regulatory structure that is self-correcting
    - Potential advantage of RoR regulation?
  - Political Cycles
    - Much easier to strike deals right after electoral cycle

3. Valuing Options

- Motivation:
  - The NPV rule has thus far served us well;
  - But it sometimes happens that even relatively attractive projects with positive NPV (underinvestment in technology in established generation networks)
  - This lack of interest sometimes leaves people scratching their heads. Unobservable risk? Irrationality? Gamesmanship?
  - Perhaps: However, it may also be because the potential investor is not only deciding *whether* to invest, but is also deciding about *when* to make the decision
- Real Option:
  - The existence of an ability to alter strategies / decisions in order adapt to new information, in order to make more profitable decisions or avoid losses

Some Types of Real Options

Option	Description	Examples
Wait/Defer	To wait before taking an action until more is known; regulatory action plays out, or timing is expected to be more favorable	When to introduce a new product, or replace an existing piece of equipment
Rescale	To increase/decrease scale of an operation after learning about demand/profitability	Adding or subtracting to a service offering, or adding memory to a computer
Abandon	To discontinue an operation and liquidate the assets	Discontinuation of a research project, or product/service line
Stage Investment	To commit investment in stages giving rise to a series of valuations and abandonment options	Staging of research and development projects or financial commitments to a new venture
Switch inputs or outputs	To alter the mix of inputs or outputs of a production process in response to market prices	The output mix of telephony/internet/cable/cell services
Grow	To expand the scope of activities to capitalize on new perceived opportunities	Extension of brand names to new products or marketing through existing distribution channels

Running Example…

- Recall:
  - Year 0 cash flows: -$1 million
  - Year 1 expected cash flows: $ 200k
  - Years 2-5 cash flows: $ 300K per year
- Assume further:
  - Utility faces a WACC of 10% (assume it remains constant even after regulatory change). The (1 year) risk free rate is 5%.
  - There is a 20% chance that the new plant will face stricter environmental mandates (regulator will decide at beginning of Year 1)
    - If so, cash flows reduced by $50K in each operational year
- Under the NPV rule, is investment worthwhile?
  - Expected Cash Flows:
    - Year 1: $200K – (0.2)x($50K) = $190K
    - Years 2-5: $300K - (0.2)x($50K) = $290K
  - NPV, discounting at WACC of 10%, is = $8,419; (IRR = 10.31%)
  - **THEREFORE:** according to NPV rule utility **SHOULD** invest
- BUT WILL IT? Could company do better by delaying decision a year?
  - Delay receipt of payoff stream by a year (-)
  - Delay costs of investment (+)
  - Discover relevant information about whether investment valuable (++++)

YES

Preserving option to wait: $26,878

Learning about real options while at Aspen: Priceless

INVEST NOW:
NPV = $8,419

t=0

t=1

WAIT A YEAR:

0.8

NO ADDITIONAL REGULATION
NPV = $46,326

0.2

ADDITIONAL REGULATION
NPV = - $143,212
CHOOSE NOT TO INVEST, ENSURING PAYOFF OF $0

Expected value (as of next year):
(0.8)x$46,326+(0.2)x0 = $37,061

NPV = $37,061/1.05
=$35,297

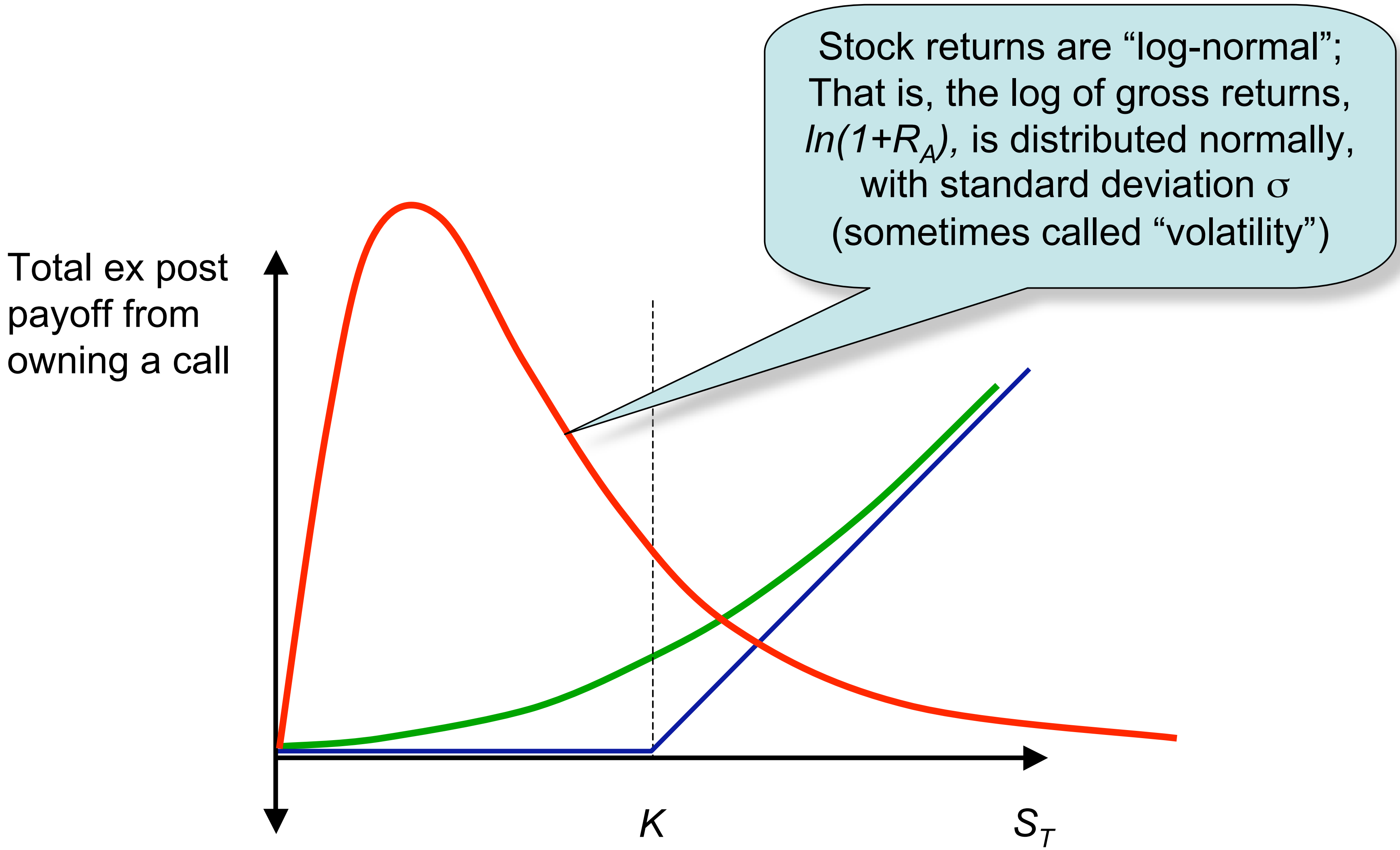
How does one value more complex real options?

- The example used a "decision tree" approach to analyze option. Possible b/c the problem was very simple
  - Binary outcomes; known probabilities
- In more complex environments, these simple approaches may not work
  - E.g., more/continuous outcomes, changing risk over time
  - Here, many have attempted to use techniques developed for valuing financial options in order to value real options
    - Black-Scholes valuation
    - Binomial/trinomial "lattice" approaches
  - Both are predicated on the existence / use of a set of investments that perfectly "track" the value of the option
    - …but are themselves easy to value
- Such approaches do not strictly apply to real options (but many people still use them to get rough assessments)

Fundamental Assumptions of Black-Scholes

- The underlying asset does not pay dividends before expiration of the option;
- *Both the option and the stock can be continuously traded in a frictionless market at zero cost;*
- *There are no restrictions on short selling of any asset (including borrowing and lending at the risk free rate);*
- The risk free rate of interest (r_F) is constant over time, or at least varies in a predictable way
- The underlying stock has returns that are "log-normally" distributed

Fundamental Assumptions of Black-Scholes



The Black-Scholes Option Pricing Formula

- 5 Key Ingredients:
  - S_0 = PV (risk-adjusted) of future cash flows ("stock price")
  - K = Exercise price for option
  - T = Time at which option expires
  - r_f = risk free rate of return
  - σ = volatility of underlying return on S
- These assumptions (and a lot of math) yield:

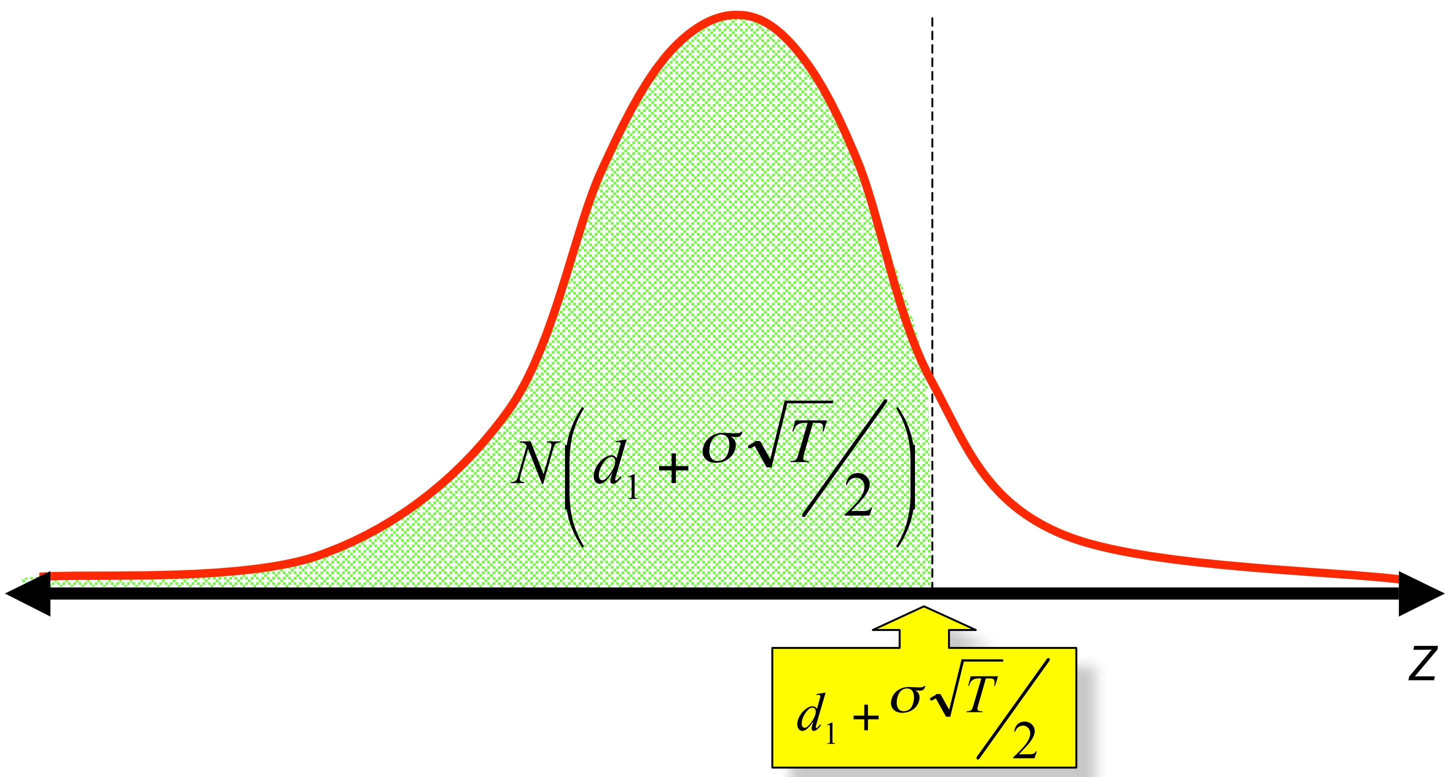
$$Val(Call) = S_0 \times N\left(d_1 + \sigma\sqrt{T}/2\right) + PV(K) \times N\left(d_1 - \sigma\sqrt{T}/2\right)$$

$$d_1 = \frac{\ln(S_0 / PV(K))}{\sigma\sqrt{T}}$$

$N(.)$ = Value of Standard Normal Distrib. (Table/Excel)

Normal Distribution

- N(z) = Area under the standard normal ("bell curve") density at or below prescribed amount
  - => Probability that randomly selected standard normal RV will be less than or equal to Z



Running Example…

- Recall:
  - Year 0 cash flows: -$1 million
  - Utility's WACC = 10%
  - Risk-Adjusted PDV of Expected Revenues if taken today (S_0): $1,046,327
  - The (1 year) risk free rate (r_f): 5%.
- Regulatory Risk:
  - Regulatory risk, resolved in year one, alters could alter the cash flows in a continuous way. In particular, if undertaken a year from now, project's cash flows would be = (S_0)x(1+R), where (1+R) is distributed log-normally with a volatility of 0.2
- Will company choose to invest now or wait?
  - Invest now: NPV = $46,327
  - Wait: We must value a call option on the project

Step 1: Identify Key Variables

- Recall 5 Key Ingredients:

  S_0 = \$1,046,327 (all future revenues except up-front cost)

  K = \$1,000,000 (up-front cost)

  T = 1 Year

  r_f = 0.05

  σ = 0.2

- This implies that

$$d_1 = \frac{\ln(S_0 / PV(K))}{\sigma\sqrt{T}} = \frac{\ln\left(\$1{,}046{,}327 \Big/ \left(\frac{\$1{,}000{,}000}{1.05}\right) \right)}{0.2\sqrt{1}} = 0.066522$$

$$d_1 + \frac{\sigma\sqrt{T}}{2} = 0.166522; \quad d_1 - \frac{\sigma\sqrt{T}}{2} = -0.033478$$

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Step 2: Apply B-S Formula

$$Val(Call) = S_0 \times N\left(d_1 + \sigma\sqrt{T}/2\right) + PV(K) \times N\left(d_1 - \sigma\sqrt{T}/2\right)$$

$$= (\$1{,}046{,}327) \times \mathrm{N}(0.166522) + \frac{\$1{,}000{,}000}{(1.05)} \times \mathrm{N}(-0.033478)$$

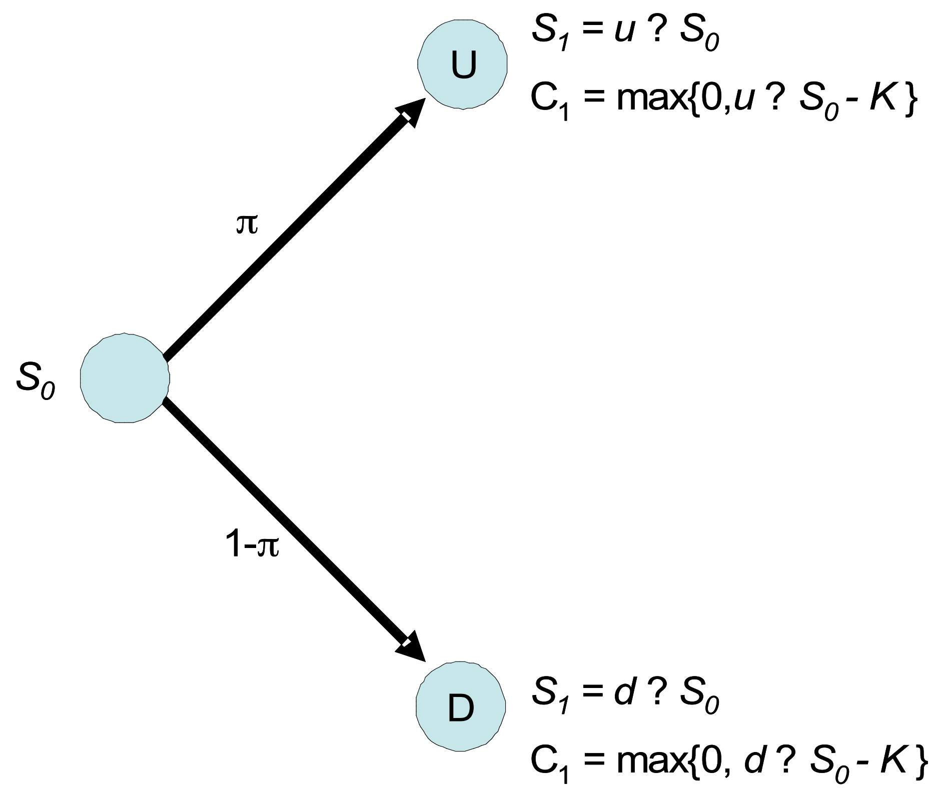
$$= (\$1{,}046{,}327) \times (0.56612691) + \frac{\$1{,}000{,}000}{(1.05)} \times (0.4866467)$$

$$= \$105{,}580$$

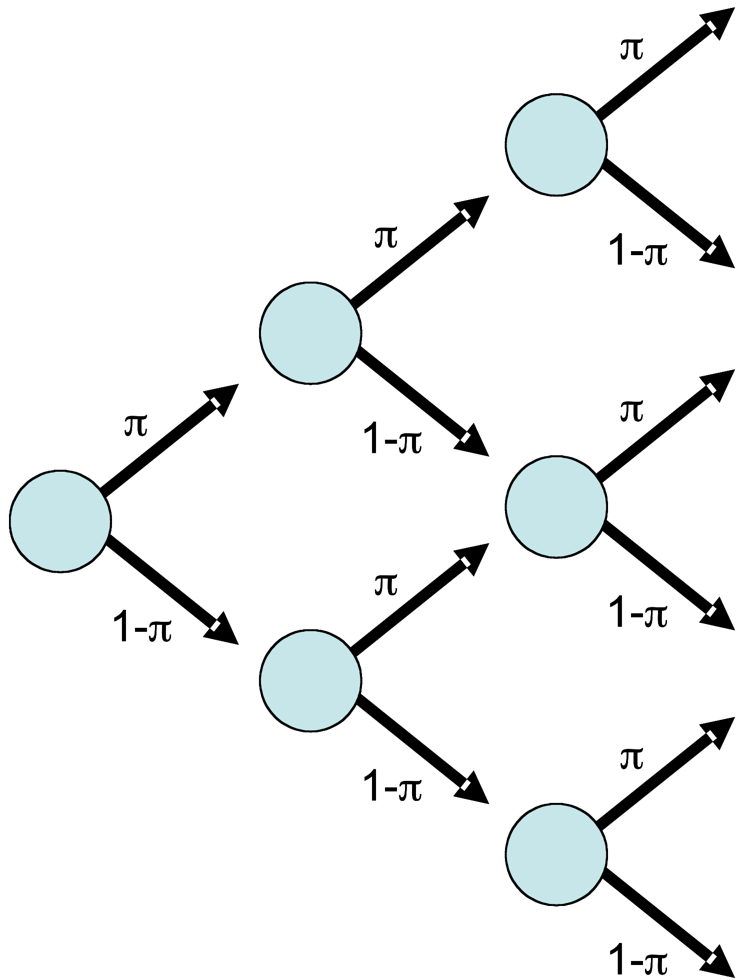
- THEREFORE, the value of the option to wait ($105,580) exceeds the value of investing now ($46,327). If the decision maker uses B-S to value the real option, there will be no immediate investment

Binomial "Lattice" Models

- A decision tree-like structure in which value of asset could experience an "up" return (1+R =*u* > *1*), or a "down return (1+R = *d* < *1*).
- Probabilities of "u" and "d" are given by π and $(1-\pi)$
  - "Risk neutral" probabilities
- Value of call at t=0 is simply equal to probability-weighted value of each call at t=1.
- Thus seems very simple, but
  - Each tree is a simple computation for a computer
  - It's possible to add on many "branches" of the tree and set the computer to work…



Example: Three Periods



$S_1 = u^3 \cdot S_0$
$C_1 = \max\{0, u^3 \cdot S_0 - K\}$

$S_1 = d \cdot u^2 \cdot S_0$
$C_1 = \max\{0, d \cdot u^2 \cdot S_0 - K\}$

$S_1 = d^2 \cdot u \cdot S_0$
$C_1 = \max\{0, d^2 \cdot u \cdot S_0 - K\}$

$S_1 = d^3 \cdot S_0$
$C_1 = \max\{0, d^3 \cdot S_0 - K\}$

A Word of Caution

- Both the Black-Scholes and the binomial approaches depend on two core assumptions that are probably not satisfied in practice for real options:
  - *Both the option and the stock can be continuously traded in a frictionless market at zero cost;*
  - *There are no restrictions on short selling of any asset (including borrowing and lending at the risk free rate);*
- This has led some to question their usefulness in valuing real options
- But there also may be no good practical candidates (e.g., Decision Tree)

Rules of Thumb from Options Valuation

Key Point

- In addition to the rules of thumb from risk-adjusted NPV (see above), the option to delay investment may also have value
- Holding all else constant, investors are more likely to invest now (instead of delaying) when…
  1. …future volatility / uncertainty decreases
  2. …the risk free rate of return decreases
  3. …the time horizon for delaying decreases
  4. …the up-front cost of investment decreases
  5. …the timing of the + net revenue stream accelerates

Economic factors / policies that bring about (1) – (5) tend to catalyze current investment.

And, vice versa, things that reverse (1) – (5) tend to discourage current investment.

End