University of California, Berkeley

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An Introduction to Corporate Finance, and Applications to Regulated Industries

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The “wordsoup” of finance

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
  - Adding in Two Complications:
    - **R**isk
    - **C**apital **S**tructure (Debt & Equity)
  - DCF and CAPM approaches to imputing returns

C. Regulatory Risk
  - Qua Volatility
  - Qua Insurance
  - Qua Truncation
  - Commitment, Predictability & Flexibility

D. Real Options (Time permitting)

Motivation

- What *is* corporate finance?
  - Understanding how financial claims & cash flows from a business (a) are valued; and (b) affect behavior.
  - Most (but not all) of our conversation today will be about (a)
- How is (a) different than accounting?
  - Forward-looking (or at least it's supposed to be)
  - Cash flows most critical (not accruals)
  - Fair Market Value (FMV) predominates.
- Why should regulators / commissioners / staff care?
  - Cost-of-Service / RoR Regulation: Critical for determining reasonable rate of return to attract capital (meet Ave. Econ. Cost)
  - Price/Revenue Cap Regulation: Cap setting / X-adjustment still must be predicated against reasonable rate of return (among other things)
  - Incentive regulation: Profit opportunities should be commensurate with risk to induce optimal continuation / entry

Bluefield Waterworks v. Public Service Comm'n, 262 U.S. 679 (1923).

- *"A public utility is entitled to such rates as will permit it to earn a return on the value of the property which it employs for the convenience of the public equal to that generally being made at the same time and in the same general part of the country on investments in other business undertakings which are attended by corresponding risks and uncertainties, but it has no constitutional right to such profits as are realized or anticipated in highly profitable enterprises or speculative ventures."*

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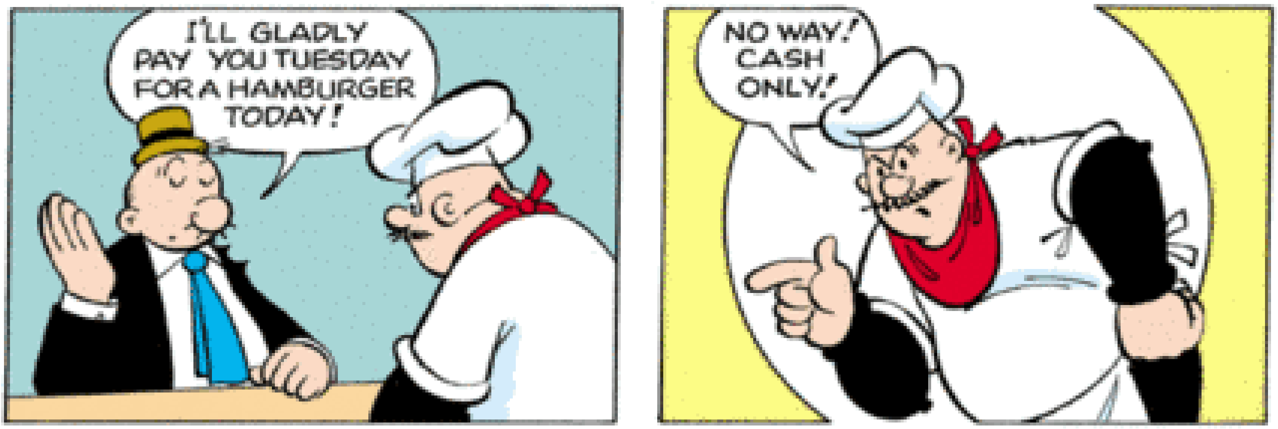

Finance for Dummies (and comic strip readers)

- 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 treasury bill 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

– Alternatively denoted as 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):

$$r_{0,1} = \frac{P_1 - P_0}{P_0} = \frac{P_1}{P_0} - 1$$

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

$$r_{0,t} = \frac{P_t - P_0}{P_0} = \frac{P_t}{P_0} - 1$$

Simple Example

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

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

$$= 50\%$$

An Aside on Jargon: Basis Points

- 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?
  - Often very small % differences make for very big $ differences
  - Makes them sound smart (Don’t discount this one.)
  - 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: (Get ready for a few formulas)

- 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:

$$F = P \times \left(1 + r_{0,1}\right)$$

  - Discounting: The investment P necessary today at rate *r* to generate F dollars in the future will be equal to:

$$P = \frac{F}{(1 + r_{0,1})}$$

Compounding Over Multiple Periods

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

$$F_{20} = \underbrace{\underbrace{\underbrace{P_0 \times (1 + r_{0,1})}_{F_1} \times (1 + r_{1,2})}_{F_2} \times \ldots \times (1 + r_{19,20})}_{F_{20}}$$

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

$$\begin{aligned} F_{20} &= P_0 \times \underbrace{(1 + r) \times (1 + r) \times \ldots \times (1 + r)}_{\text{20 times}} \\ &= P_0 \times (1 + r)^{20} \end{aligned}$$

Compounding & Discounting when return is expected to remain constant

- Compounding (from last slide):

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

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

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

- Discounting a “stream” of cash flows:

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

Using time discounting to value a project: Example

- 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 operating 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 rate of:

  a) 5.0%?

  b) 10.0%?

  c) 15.0%?

Table of NPVs for Running Example

		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**

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

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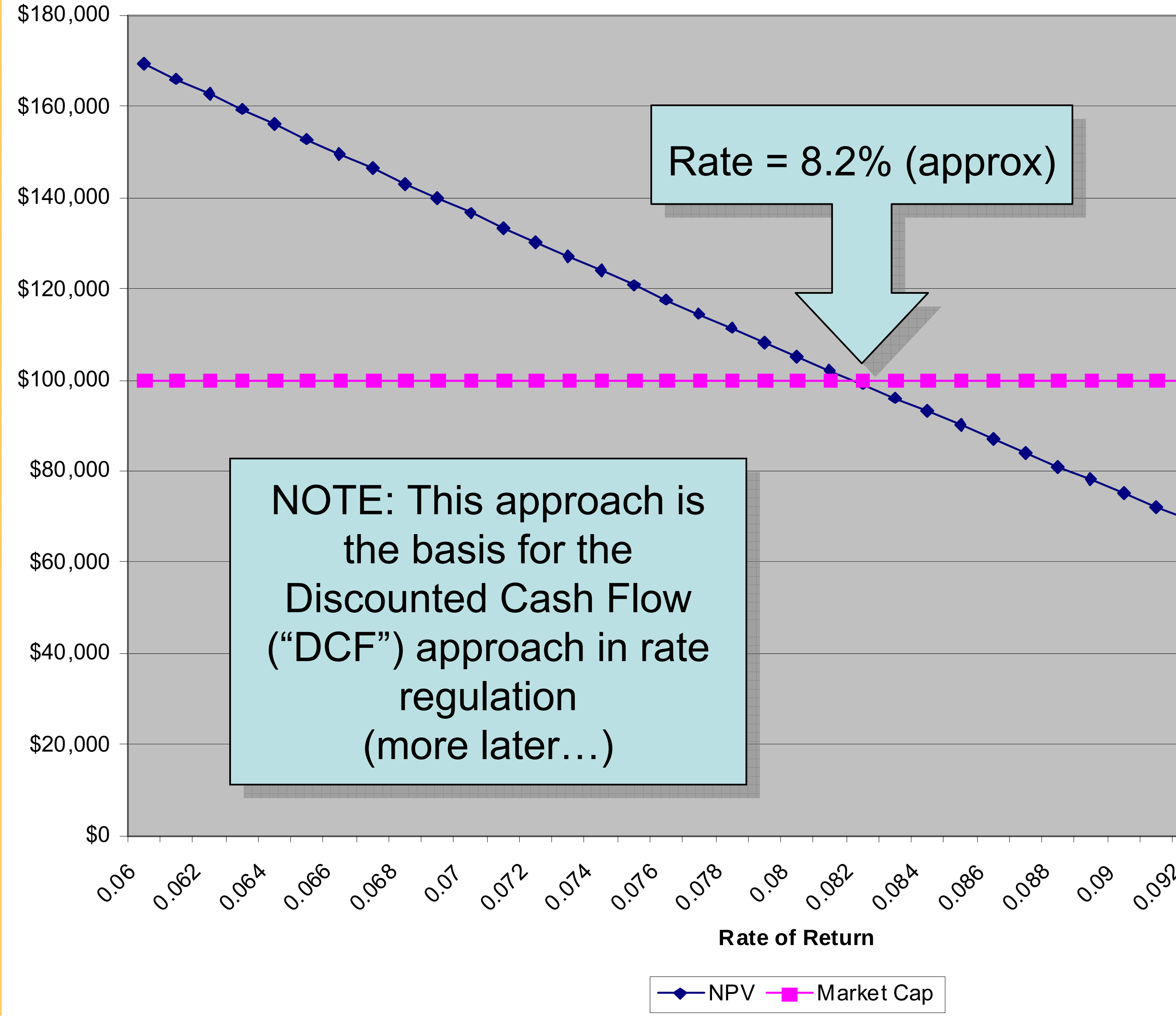
Running Example (continued)

- 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%?
- Suppose the utility invests in the above project, and the project is its only activity. Suppose that the utility is publicly traded, has no debt, and pays all its net revenues out as dividends each year. Its 100,000 shares are currently trading for $1 each. At what rate of return do investors appear to discount the utility's market value?

Rate of return that justifies price ("yield")



r	NPV	Mkt Cap
0.06	$169,370	$100,000
0.061	$166,028	$100,000
0.062	$162,701	$100,000
0.063	$159,389	$100,000
0.064	$156,091	$100,000
0.065	$152,807	$100,000
0.066	$149,538	$100,000
0.067	$146,283	$100,000
0.068	$143,041	$100,000
0.069	$139,814	$100,000
0.07	$136,601	$100,000
0.071	$133,402	$100,000
0.072	$130,217	$100,000
0.073	$127,045	$100,000
0.074	$123,887	$100,000
0.075	$120,742	$100,000
0.076	$117,611	$100,000
0.077	$114,494	$100,000
0.078	$111,389	$100,000
0.079	$108,298	$100,000
0.08	$105,220	$100,000
0.081	$102,156	$100,000
0.082	$99,104	$100,000
0.083	$96,065	$100,000
0.084	$93,040	$100,000
0.085	$90,027	$100,000
0.086	$87,027	$100,000
0.087	$84,039	$100,000
0.088	$81,064	$100,000
0.089	$78,102	$100,000
0.09	$75,152	$100,000

Discounting when rate of return (r) is constant and cash flows (F) have consistent pattern

- *Constant stream* of cash flows (annuity of \$F / period):

$$NPV = \frac{F}{(1+r)^1} + \frac{F}{(1+r)^2} + \ldots + \frac{F}{(1+r)^T} = \frac{F}{r} \times \left(1 - \frac{1}{(1+r)^T}\right)$$

- Note: as *T* grows arbitrarily large (perpetuity of \$F/period):

$$NPV = \frac{F}{r}$$

- *Constantly growing stream* of cash flows (at rate *g*)

$$NPV = \frac{F}{(1+r)^1} + \frac{F(1+g)^1}{(1+r)^2} + \ldots + \frac{F(1+g)^{T-1}}{(1+r)^T} = \frac{F}{r-g} \times \left(1 - \frac{(1+g)^T}{(1+r)^T}\right)$$

- As T grows arbitrarily large (<u>and</u> assuming g<r):

$$NPV = \frac{F}{r-g}$$

Commonly used in DCF valuation analyses (Gordon Div. Growth Model); see below.

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Rules of Thumb from Time Valuation

Key Point

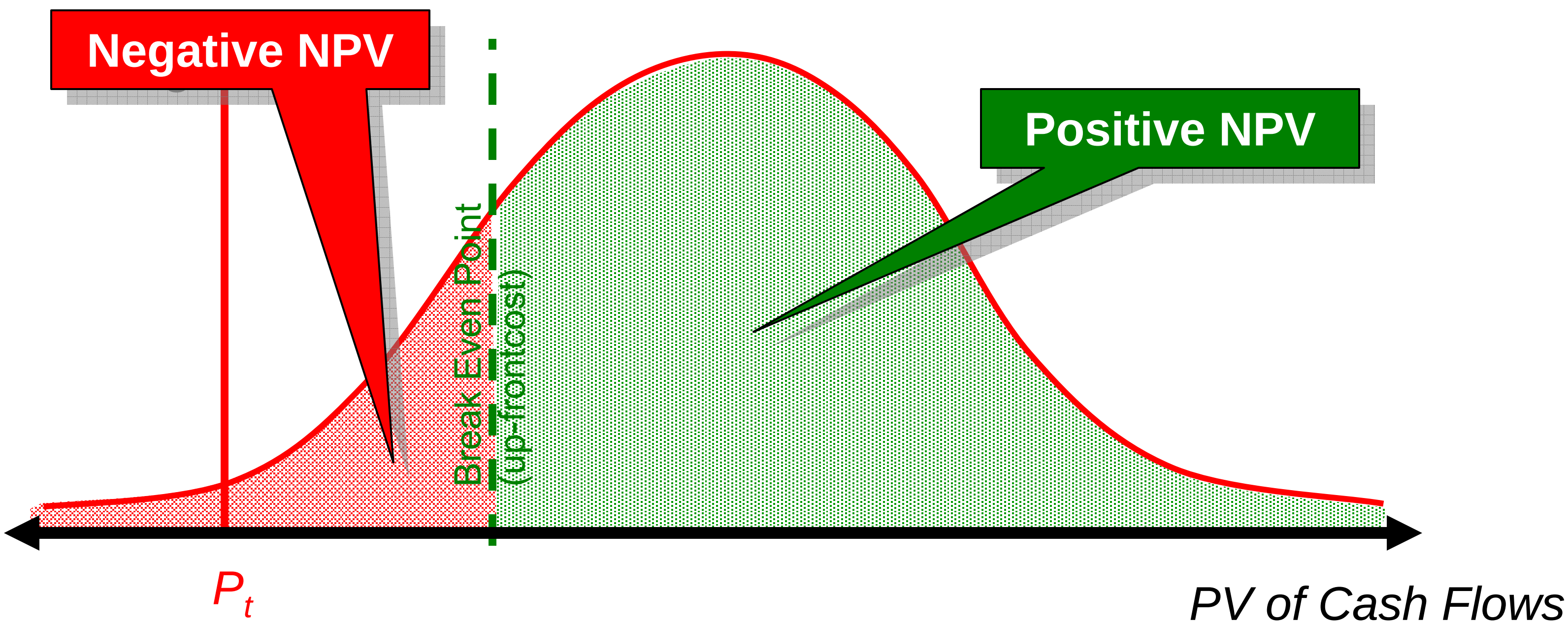
- Most investors / financial decision makers will make an investment only when the Net Present Value (NPV) of the project is positive.
- Holding all else constant, the NPV of a “typical” investment’s cash flow pattern ***increases*** when…
  1. …up-front costs <u>decrease</u>
  2. …the size of follow-on benefits <u>increases</u>
  3. …the period over which follow-on benefits accrue <u>increases</u>
  4. …the rate at which market actors discount 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.

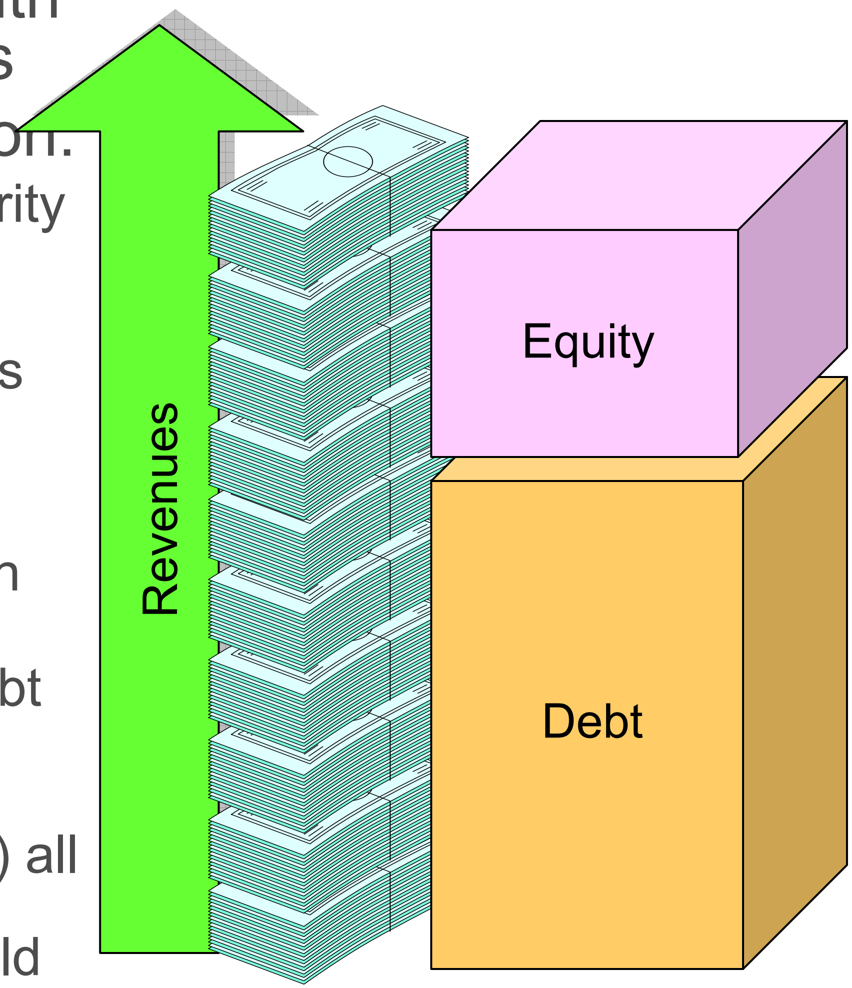
Complication #1: RISK

- Challenge:
  - Prior 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**



Complication #2: CAPITAL STRUCTURE

- Many utilities have multiple classes of investors, each with different claims on cash flows
- Conventional/simple distinction:
  - Debt/Bonds: "Fixed" claim; priority (first dibs) on revenues
  - Equity/Stock: "Residual" claim; back seat on claims to revenues
- Consequences of capital structure (+ risk) for finance:
  - For a given pattern of risky cash flows, debt is safer than equity.
  - Expected/required return on debt (ROD) is lower than expected return on equity (ROE)
  - ROD, ROE, and Δ=(ROE-ROD) all tend to increase in leverage (though total cost of capital could go up or down)



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Adjusting valuation analysis to account for the risky environments

- The Good News:
  - Most of the rules of thumb about time discounting / compounding still hold
  - In fact, all of the FV / PV expressions above still apply, in very much the same forms before…
- The Bad News:
  - Applying of these formulas can be a bit more complex, in at least three ways. We now must focus on:
    - *Expected* cash flows (e.g., cash flows "on average");
    - *Risk-Adjusted Expected* rates of return;
    - *Combining Expected Returns Different Classes of Investors* (e.g., ROD & ROE) using the "WACC"

The Good News: Adjusting valuation formulas

Certain Payoffs	Risky Payoffs
Compounding	Compounding
$F_t = P_0 \times (1+r)^t$	$E(F_t) = P_0 \times (1+E(R))^t$
Discounting	Discounting
$P_0 = \dfrac{F_t}{(1+r)^t}$	$P_0 = \dfrac{E(F_t)}{(1+E(R))^t}$

Identical adjustments for all the other NPV formulas outlined above (e.g., annuities, perpetuities, growing annuities/perpetuities)

Multiple rates of return & Weighted Average Cost of Capital (WACC)

- *Financial economists tend to equate WACC with best measure of reasonable RoR (min for attracting investors)*
- WACC = "Weighted" average of ROE and ROD, where weights correspond to the relative fair market value of utility's debt & equity to total value (D & E, respectively):

$$WACC = \left(\frac{D}{D+E}\right) \times ROD + \left(\frac{E}{D+E}\right) \times ROE$$

- For taxable utilities, the version you'll usually see is a bit more complicated, and is adjusted to account for the tax advantages of debt. If utility has marginal tax rate *T*…

$$WACC = \left(\frac{D}{D+E}\right) \times ROD \times (1-T) + \left(\frac{E}{D+E}\right) \times ROE$$

Reason for Tax Adjustment: Utility gets to "claw back" T% of its debt interest paid as a tax deduction

Estimating WACC requires an estimating expected returns of capital claims (ROE; ROD)

- Investors don't know what their actual realized return will be on their investment.
- Instead, they forecast an *expected return:*
  - Effectively, what return they expect to receive on average from holding the investment across periods
  - They then can use those expected returns to discount future cash flow payments.
- 2 dominant ways to estimate expected ROE/ROD:
  - Discounted Cash Flow (DCF) approach
  - Capital Asset Pricing Model (CAPM) approach
  - Often valuation experts use both approaches

The DCF method for estimating ROE; ROD

- For ROD:
  - Conventional approach: use the yield on the utility's current debt obligations
    - Ideally, this entails using the yield on the utility's publicly traded bonds (or as close a comparable measure as possible).
  - [While standard, this convention is injects imprecision, particularly for highly leveraged firms – more later].
- For ROE:
  - DCF method useful principally for utilities stocks that pay regular dividends…
  - …and whose future pattern of dividends can itself be projected on average
  - Idea: NPV of a stock = to PV of its future stream of dividend payments

Illustrative Example: DCF Method

- A public utility is financed by both debt and equity, and faces a marginal tax rate of 20%.
  - It has 1,000 “zero-coupon” bonds outstanding, which matures in 3 years, and each of which has a face value of $1,000. The current market price of each bond is $850 (and thus total market value of debt is $850,000).
  - It also has 10,000 shares of stock and regularly pays dividends. Next year, it is expected to pay a $2 dividend, and its dividends are expected to grow 3% / for the foreseeable future going forward. The utility’s current stock price is $30 (and thus total market value of equity is $300,000).
- What is the firm’s expected return on debt (ROD)?
- What is its expected return on equity (ROE)?
- What is the company’s WACC?

Example continued…

Return on Debt

(Convention: Yield)

$$P_0 = \frac{E(F_t)}{(1+E(R))^t}$$

$$\$850 = \frac{\$1000}{(1+ROD)^3}$$

$$ROD = 5.5667\%$$

Return on Equity

(Gordon Growth Model)

$$P_0 = \frac{E(F)}{E(R)-E(g)}$$

$$\$30 = \frac{\$2}{E(R)-0.03}$$

$$ROE = 9.6667\%$$

WACC

$$WACC = \left(\frac{D}{D+E}\right) \times (ROD) \times (1-T) + \left(\frac{E}{D+E}\right) \times (ROE)$$

$$= \left(\frac{850K}{850K+300K}\right) \times (5.567\%) \times (1-0.2) + \left(\frac{300K}{850K+300K}\right) \times (9.667\%)$$

$$= 5.8136\%$$

Caveats/problems with the DCF method

- Single company, or average across peer companies?
  - Problem of multi-division firms and holding companies
  - Appropriate peers?
- Single period, or average over multiple periods?
  - Which periods?
- Appropriateness of DCF approach
  - Difficult to apply to firms not using dividends to deliver SH value
- Projection of dividends growth extremely speculative
  - Historical patterns? Ad hoc approach? Sustainable?
- Yield/ROD fudge factor bad for heavily leveraged firms
  - Tends to bias ROD upwards => higher rates.
- Leans (too?) heavily on perfect pricing efficiency of securities market for a single company

The Capital Asset Pricing Model

- An alternative method for estimating required returns taken from finance theory (Markowitz; Tobin; Sharpe)
- Usually used as alternative to estimating ROE
  - But can be used for both ROD and ROE
- Assumptions
  1. Investors care only about mean and variance in returns; no transaction costs; no restrictions on short selling
  2. Risk free rate on "safe" asset: r_f
  3. Expected Rate of Return on the Market: $E(R_{Market})$;
     - "Market" = extremely broad portfolio of investments, weighted by their market value (such as S&P 500 or Wilshire 5000)

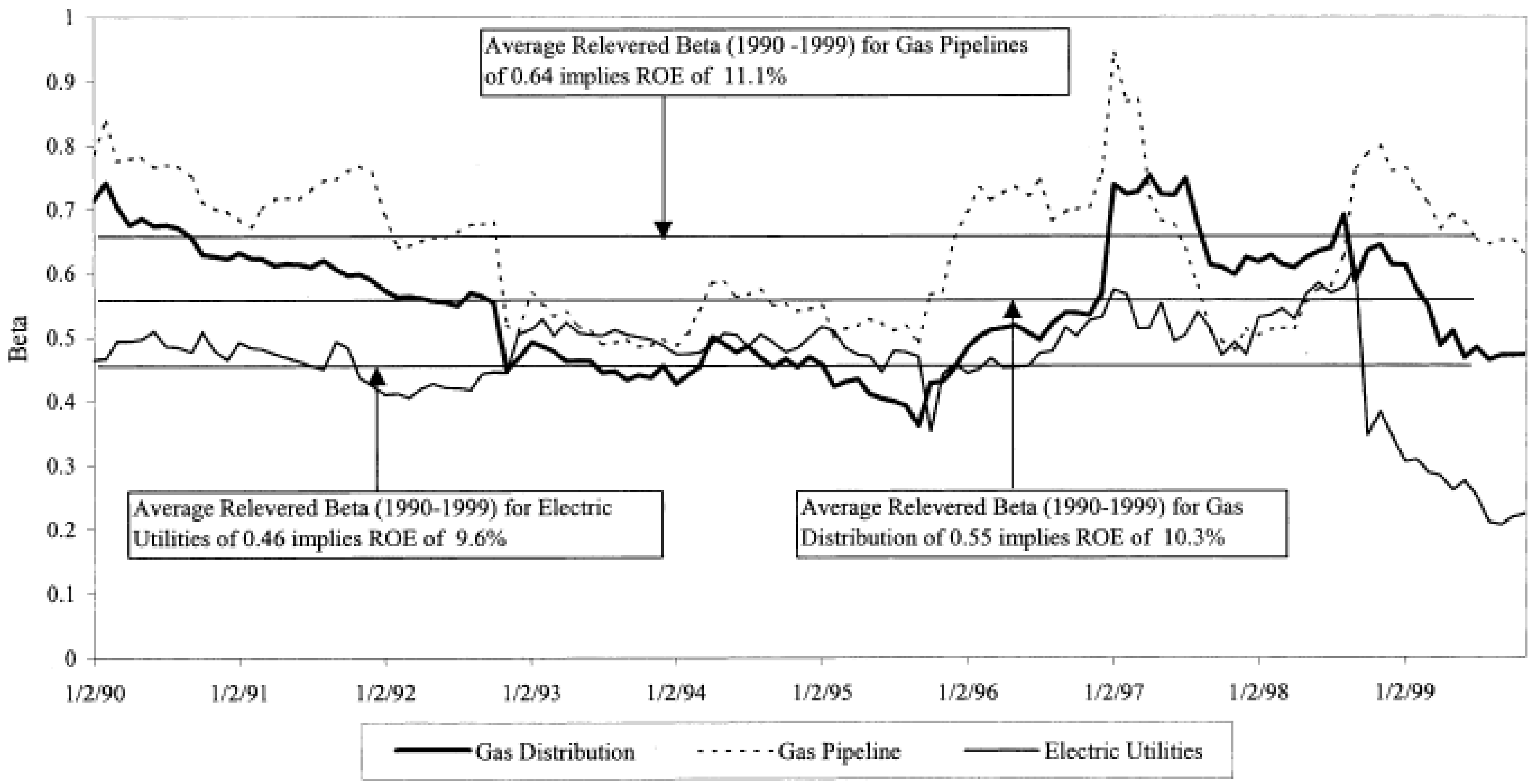
Financial asset's risk summarized by "β" = the risk of asset relative to market risk (a.k.a., "undiversifiable" risk):

$$\beta = \frac{\operatorname{cov}(R_{Asset}, R_{Market})}{\operatorname{var}(R_{Market})}$$

Core characteristics of β

- While β could take on any value in theory (+ or -), in most practical applications, an investment's β will be positive (and almost always between 0 and 3).
  - By definition, a risk free asset (e.g., T-bill) has a β = 0
  - By definition, the market portfolio has a β = 1
- Relatively safe companies/assets tend to have β < 1, while relatively risky ones tend to have β > 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 today
  - Note: Even companies with highly variable returns may have low βs: Variance can be 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

Select Historic Utility Equity βs (by sector)



Source: Cragg et al (2001)

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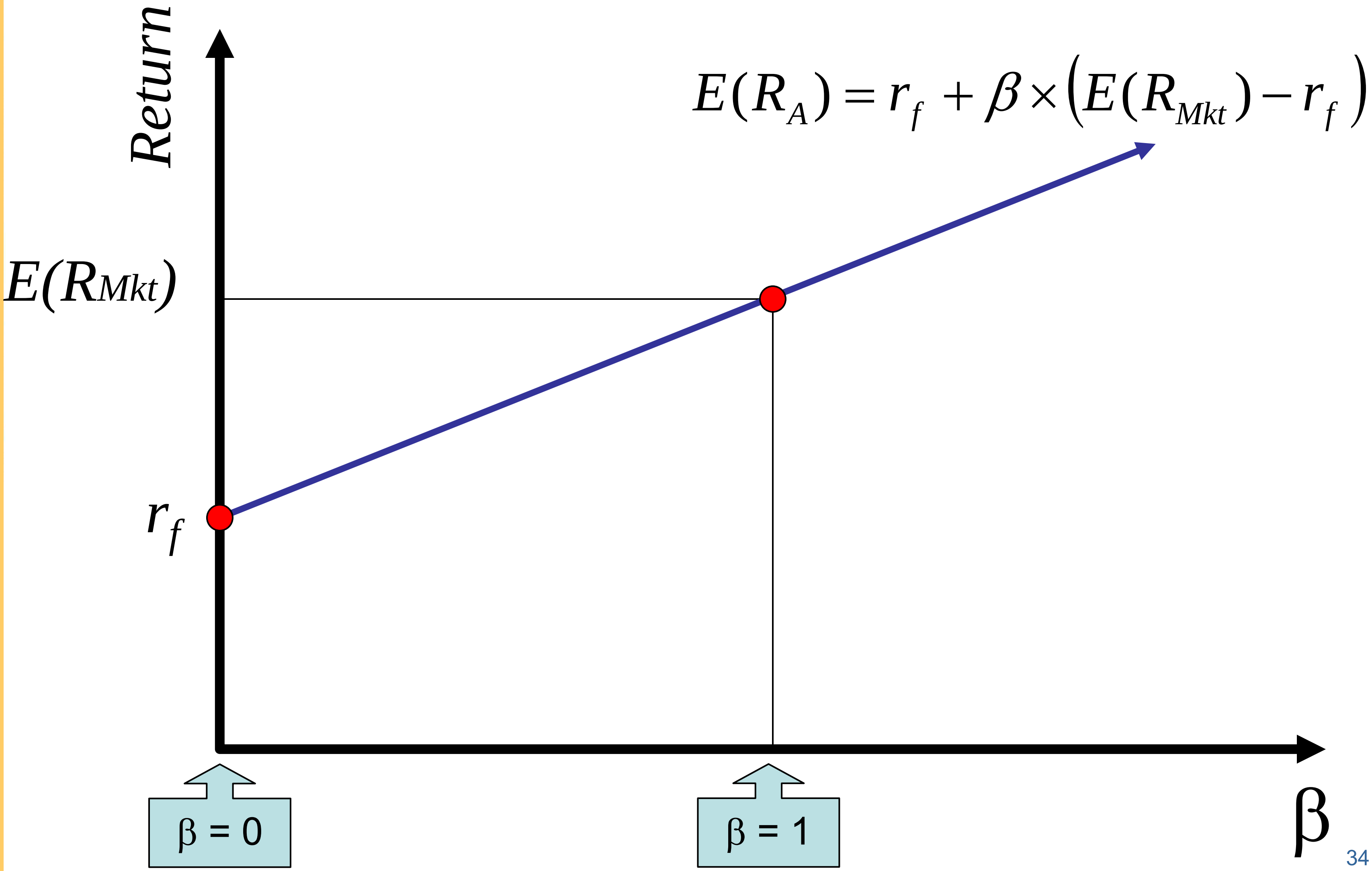
Using β to estimate expected return: The CAPM Securities Market Line



Example…

- Return to previous example, and add following facts:
  - Utility's estimated equity β = 0.7
  - Utility's estimated debt β = 0.1
  - Rate on T-bills = 5%
  - Expected return on market portfolio is 12%
- Use CAPM to re-estimate the utility's ROD; ROE & WACC.
- ROD & ROE:

$$ROD = r_f + \beta_{Debt} \times \left(E(R_{Mkt}) - r_f\right) = .05 + 0.1 \times (0.12 - 0.5) = 5.7\%$$

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

- WACC:

$$WACC = \left(\frac{D}{D+E}\right) \times (ROD) \times (1-T) + \left(\frac{E}{D+E}\right) \times (ROE)$$

$$= \left(\frac{850K}{850K + 300K}\right) \times (5.7\%) \times (1-0.2) + \left(\frac{300K}{850K + 300K}\right) \times (9.9\%)$$

$$= 5.953\%$$

Important caveats/problems with CAPM

- What's the risk free rate?
  - Usually widely available data; thick markets (e.g., t-bill rate; LIBOR)
  - Key issue: applicable term/maturity (time horizon; useful life)
- What's the market's expected rate of return?
  - Extremely hard to know with precision.
  - Often assumed to be historical market returns projected forward, augmented with analyst forecasts and prediction markets
- 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 utility is division of larger firm / holding company?
    - Firm β inappropriate; other more monolithic peers better?

Generalizations/Alternatives to the CAPM

- CAPM does not predict perfectly
  – Premia for small firms, high market to book firms, “momentum” trading
  – CAPM’s assumptions may be too special
- Some have attempted to generalize / augment CAPM in the last two decades:
  – APT & multi-“factor” models (Fama & French 1993; Carhart 1997)
    - Seems to explain better; a little *ad hoc*
  – Adjustments / controls for peer companies
- CAPM is still by far the most widely accepted approach for asset pricing (warts and all)

Rules of Thumb from Risk Valuation

Key Point

- 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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Kicking the tires of DCF/CAPM
7 Questions you can (should) pursue

1. Leverage and effects on appropriate ROE / ROD?
2. Does expert offer a single estimate or range for β; DCF?
3. Utility's Track Record: Permitted versus Realized ROE?
4. Dueling Experts: Split Baby or Final Offer ("Baseball") Arbitration?
   - Cede v. Technicolor, Inc., (Del. Ch. 10/19/1990) (appraisal action)
5. Basis for choosing comparable companies?
   - Different regulatory regimes, industries, leverage, holding co's?
6. Is there a <u>real</u> basis for post-analysis "adjustments" or is it merely *ad hoc* fudging?
7. Does cost of capital estimate attempt to adjust for regulatory risk unnecessarily?
   - Why not already incorporated into of utilities' DCFs / βs?
   - Do sophisticated regulators (e.g., IRLE veterans) have to adjust?

3. Regulatory Risk

- Regulated companies ≠ non-profits.
  - Just like other for-profit firms, they 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. The multiple faces of regulatory risk

- RR as a type of insurance
- RR as a type of volatility
- RR as a type of return truncation
- Balancing commitment & flexibility

Regulation as Insurance/Reduced Volatility

- Textbook Rate of Return regulation = guaranteed return; perfect insurance against cost fluctuations
  - Perfect ROR reg. => reasonable rate = T-bill rate
  - Never true in practice (regulatory lag; private information/gaming; incentives; other types of RR)
- Nevertheless, estimated βs for RoR regulated firms historically lower than for price cap firms
  - Incentives / investment tradeoff
  - Evidence is perhaps weaker than one might think
- Here, anticipated regulatory safety nets may subsidize inefficient or excess investment

Alexander et al (1996)

	Electricity		Gas		Combined gas and electricity		Water		Telecoms	
Country	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.

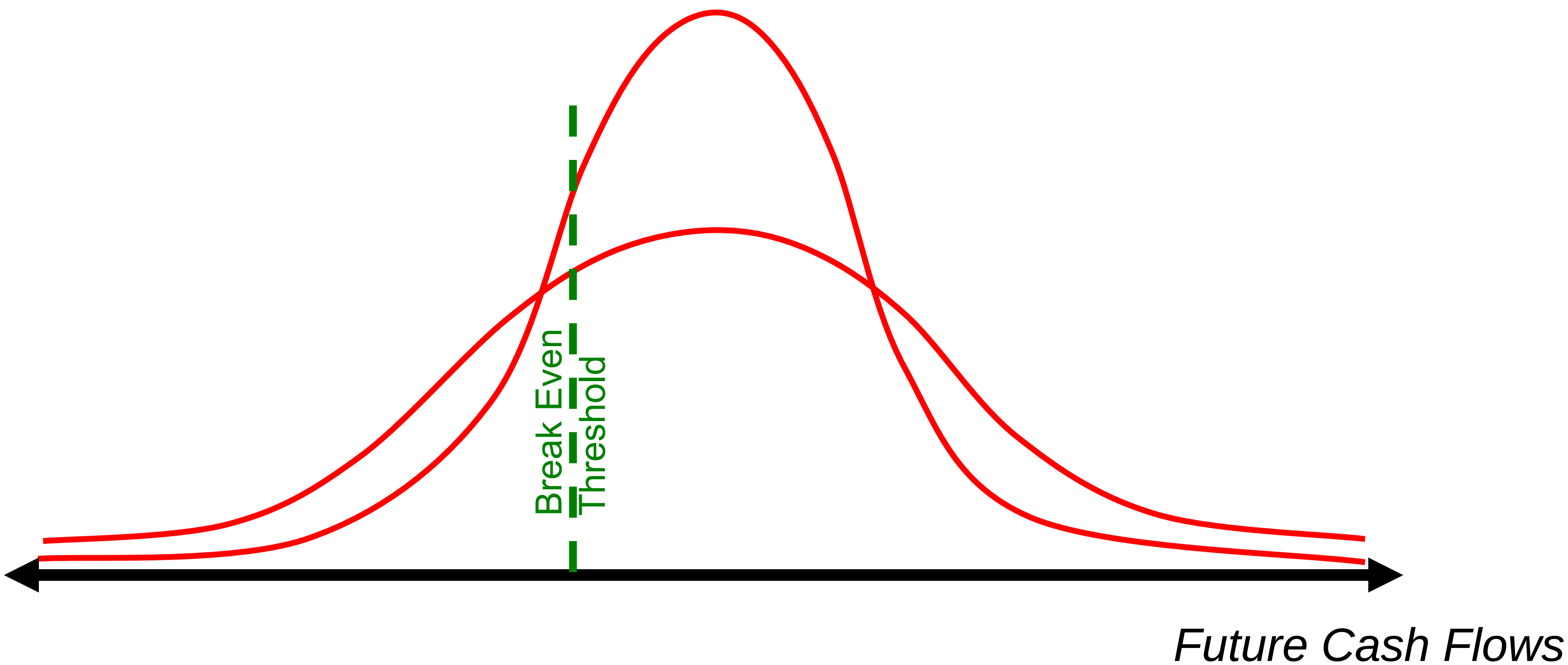
Source: Oxford Economic Research Associates, "Regulatory Structure and Risk: An International Comparison" (London, 1996).

Punch-line?

More recent evidence is much weaker. Implications?

Regulation as a source of added volatility

- Unpredictability of regulation (even in RoR regimes) can enhance volatility utility's returns
- Can lead to lower expected cash flows and/or higher βs, with a higher required rate of return



Effects of Regulation as Added Volatility: Return to Running Example…

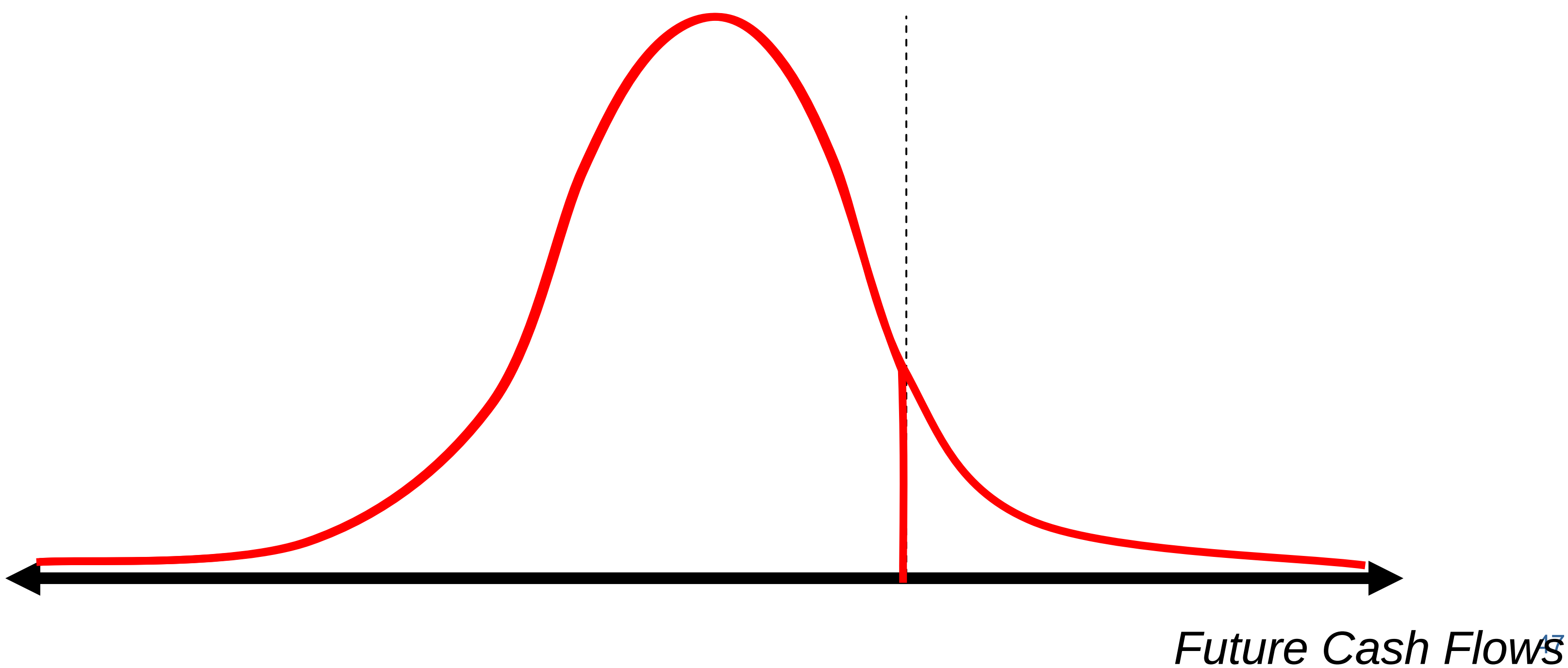
- Recall:
  - Risk Free Rate = 5%; Exp. Market Return = 12%; Tax Rate = 20%
- Regulator is subject to political pressures tied to economy. In each year, there is a 10% chance that the economy is in a recession, in which case, the regulator will force utility to reduce rates. There is also a 10% chance that the economy will be booming, and the regulator will allow an increase in rates. The added risk change causes the equity β of the firm to increase to 1.1, and debt b to increase to 0.5. How does this affect ROD,ROE, WACC?
  - ROD: 8.5 % (from 5.7%)
  - ROE: 12.7% (from 9.9%)
  - WACC: 8.34 % (from 5.13%)
- Hurdle rates for projects go up – investment goes down.

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 (see above)

RR as truncation

- Regulator cannot commit to refrain from interventions when returns are high
  - E.g., reg. adjustment / X-factor; Schumpeterian entry
- Consequences: Reduces expected returns, and mildly decreases (upside) risk



How to deal with these issues?

- Most commonly proposed way to address:
  - Regulatory Commitment
- But commitment depends on numerous factors
  - Sufficient information to “get it right” ex ante
  - Legal/constitutional constraints (binding successors)
  - Value of flexibility to adapt to changing conditions
  - Regulatory structure that is self-correcting
    - Potential advantage of RoR regulation?
  - Political Cycles
    - Possibly easier to strike deals right after electoral cycle

3. Valuing Options

- Motivation:
  - The logic of NPV 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

Go back to original 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

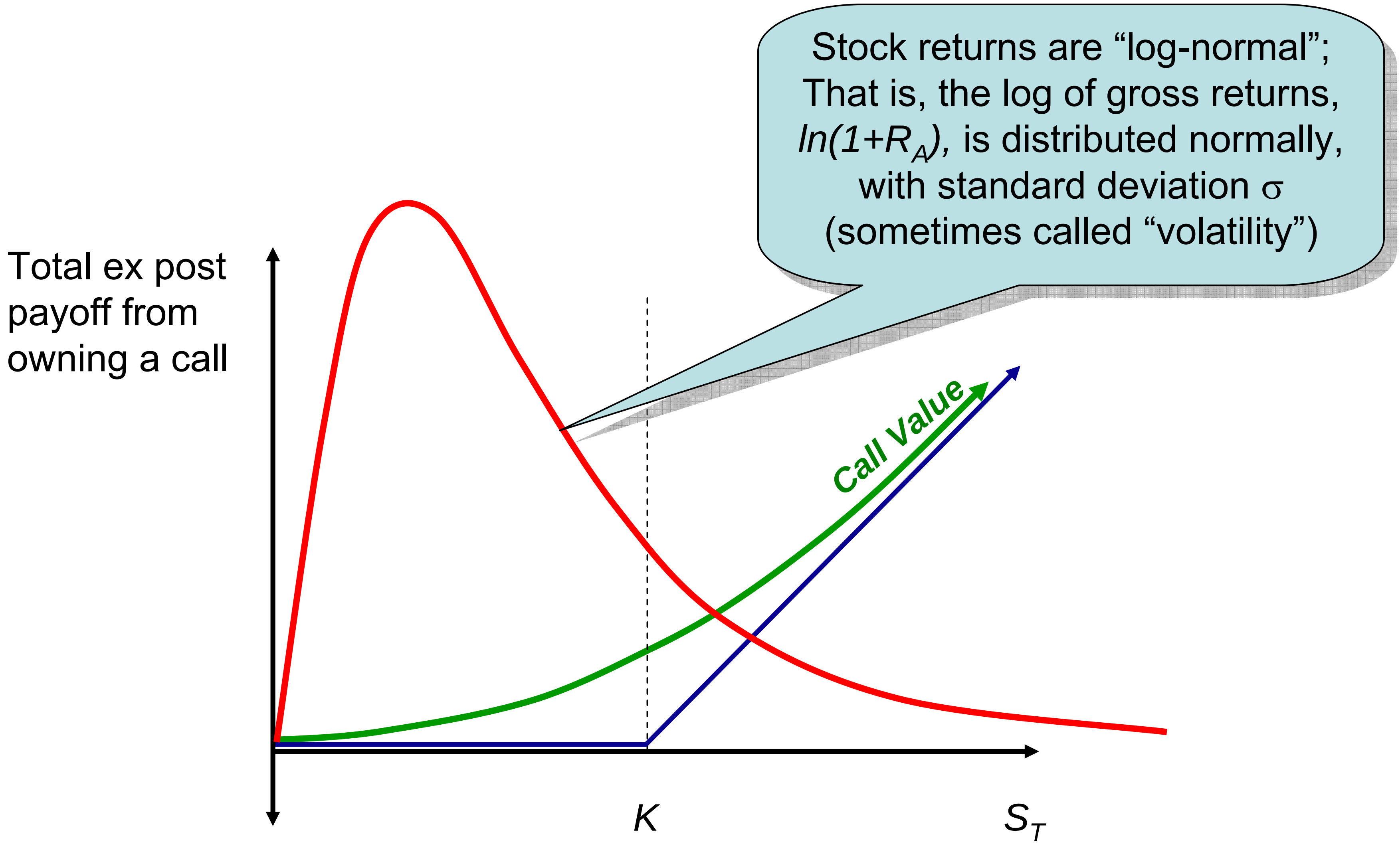
How does one value more complex real options?

- 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)

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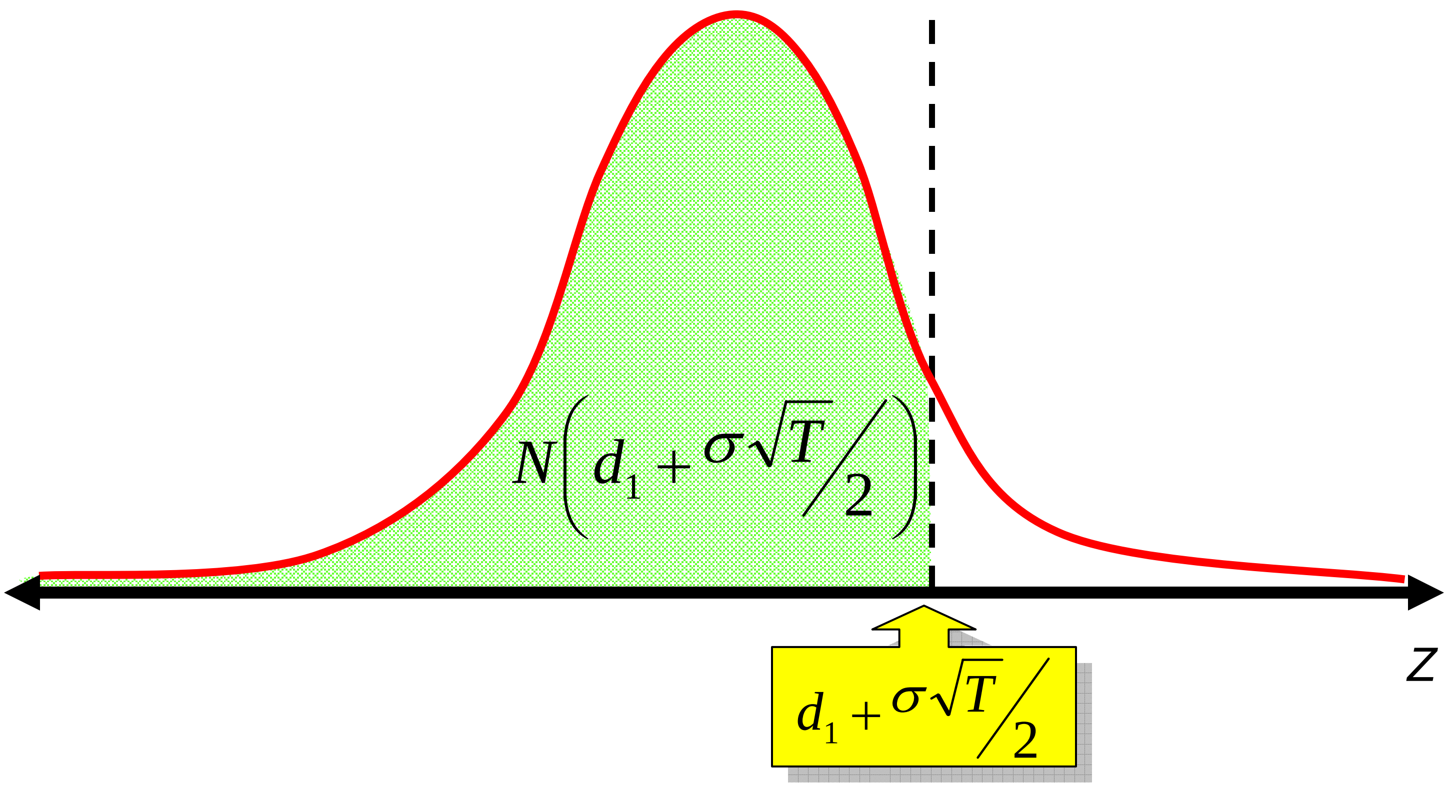
Normal Distribution

- 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

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- 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

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

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

Step 2: Apply B-S Formula

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

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

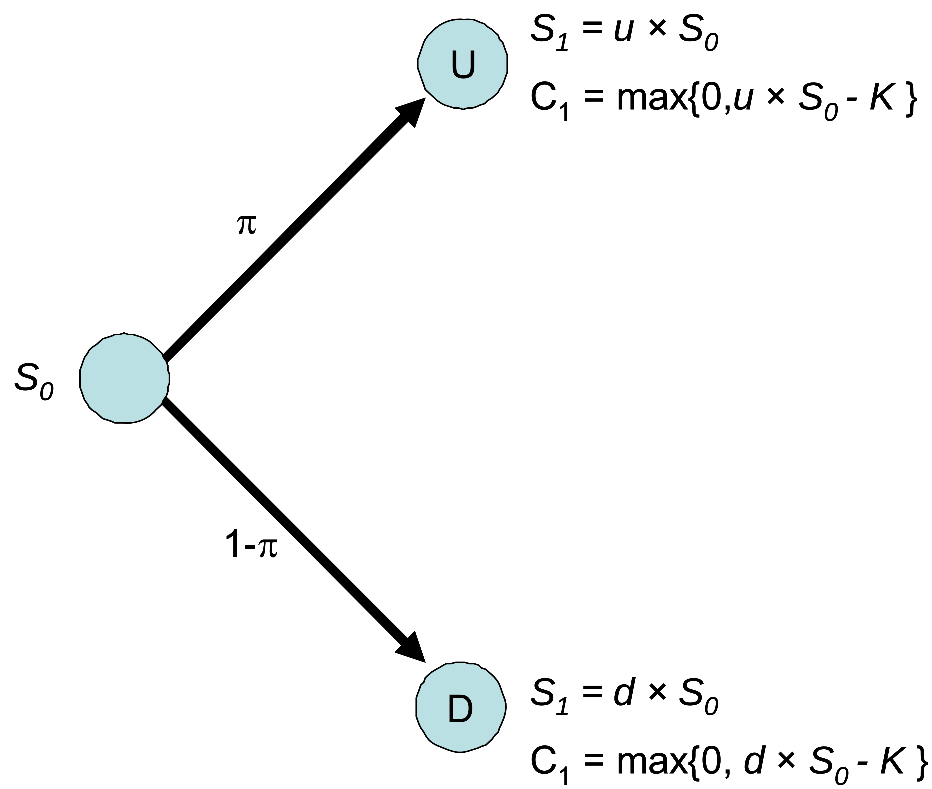
$$= (\$1{,}046{,}327) \times (0.56612691) + \frac{\$1{,}000{,}000}{(1.05)} \times (0.4866467)$$

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

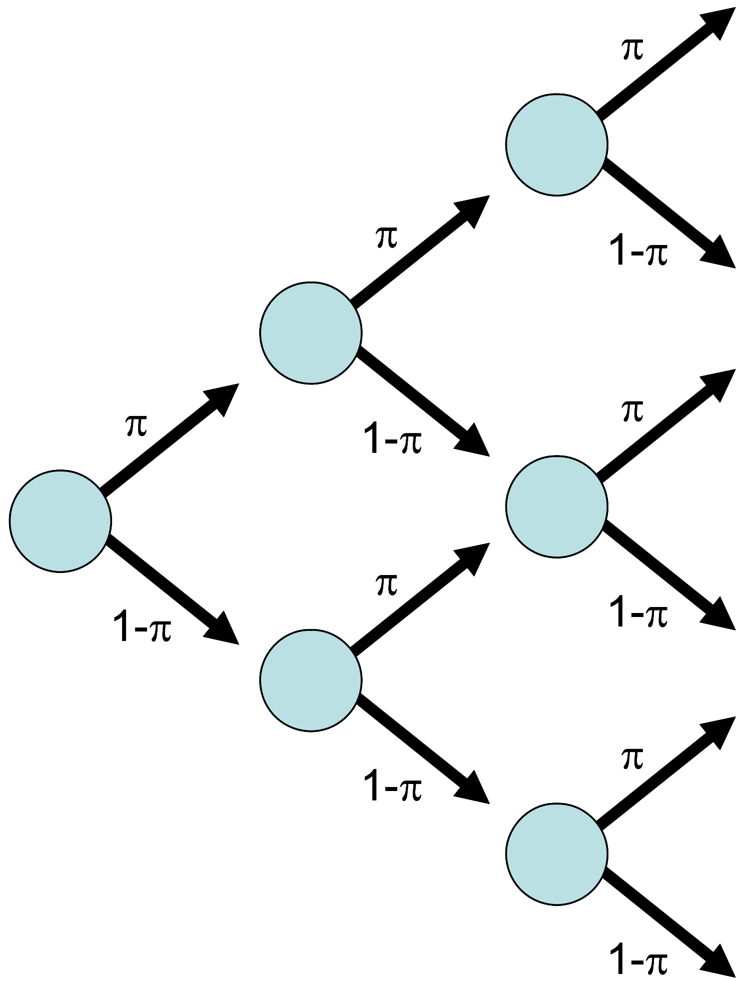
- THEREFORE, the value of the option to wait ($105,580) exceeds the value of investing now ($46,327). If the decision maker uses B-S to value the real option, there will be no immediate investment

Binomial “Lattice” Models

- 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.
- Very simple structure, but can be adapted to complex environments
  - 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

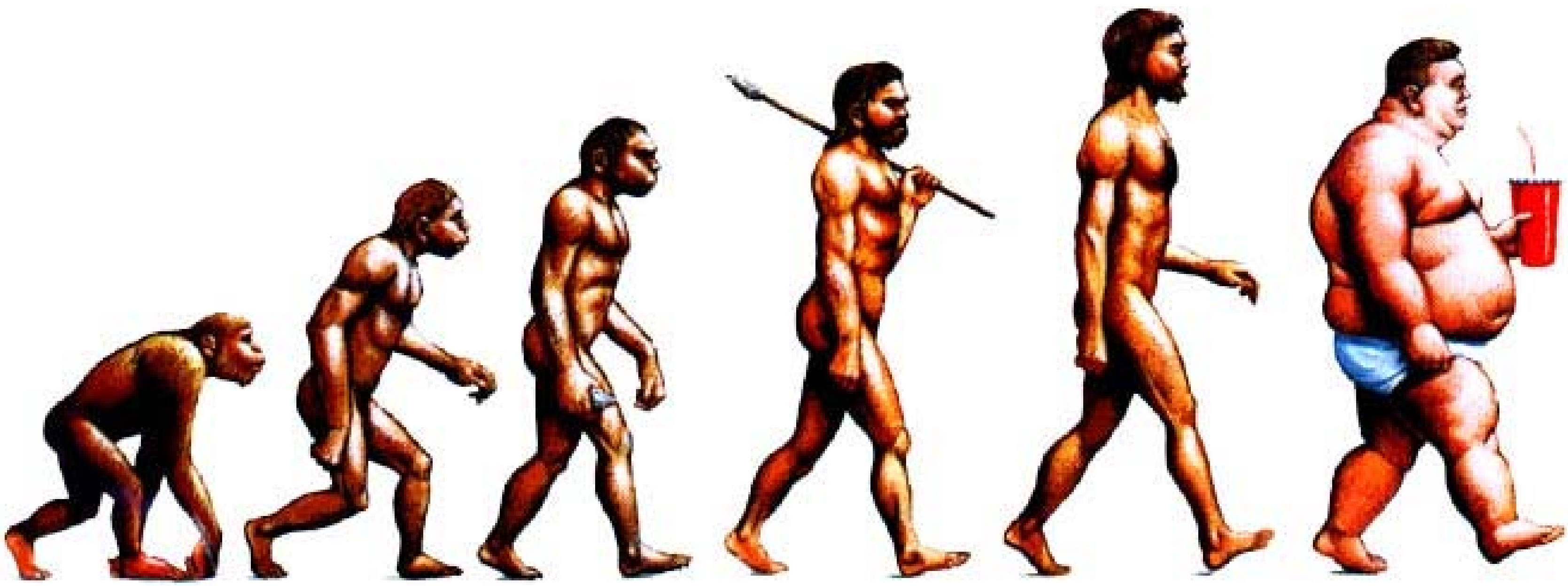
Key Point

- 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 <u>decreases</u>
  2. …the risk free rate of return <u>decreases</u>
  3. …the time horizon for delaying <u>decreases</u>
  4. …the up-front cost of investment <u>decreases</u>
  5. …the timing of the + net revenue stream <u>accelerates</u>

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 of program



The evolving regulatory state