Economic Risk and Decision Analysis for Oil and Gas Industry CE81.9008

School of Engineering and Technology
Asian Institute of Technology

January Semester

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Utility Functional Forms

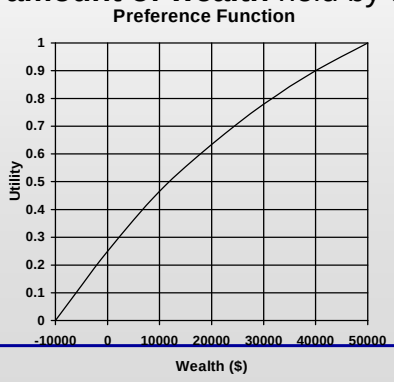
Utility Functional Forms

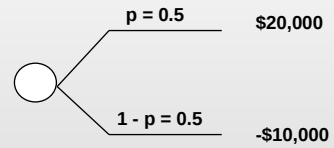
- Utility functions might be specified in terms of a **graph** or **utility curve.**
- Alternatively, **utility functions** may be expressed in terms of a mathematical form.
- Three general categories of risk aversion and their mathematical form:
  - Decreasing Risk Aversion (Log) $u(x) = log\ (x + c)$
  - Increasing Risk Aversion (Power) $u(x) = x^c$

  **Constant Risk Aversion (Exponential) $u(x) = -e^{-cx}$

Constant Risk Aversion: Exponential Function

- Condition which implies that the risk premium is the same for gambles that are identical except for adding the same constant to each payoff.
- The **risk premium *does not*** depend on the **initial amount of wealth** held by the decision maker.

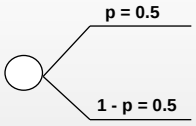




where,

Expected Value	= $5,000
Expected Utility	= 0.32
CEQ	= $2,800
Risk Premium	= $2,200

- Now consider again the case when we add a constant to each of the payoffs in the lottery. . .



	(A)	(B)	(C)	(D)
	$20,000	$30,000	$40,000	$50,000
	-$10,000	$0	$10,000	$20,000
Expected Value:	$5,000	$15,000	$25,000	$35,000
Expected Utility:	0.32	0.52	0.68	0.82
Certainty Equivalent:	$2,800	$12,800	$22,800	$32,800
Risk Premium:	***$2,200***	***$2,200***	***$2,200***	***$2,200***

- If we know the DM's CEQ of only one lottery, we can easily determine the CEQ of any other lottery over the range.
- It is reasonable to use the **exponential utility function** as an ***approximation in modeling*** preferences and risk attitudes.

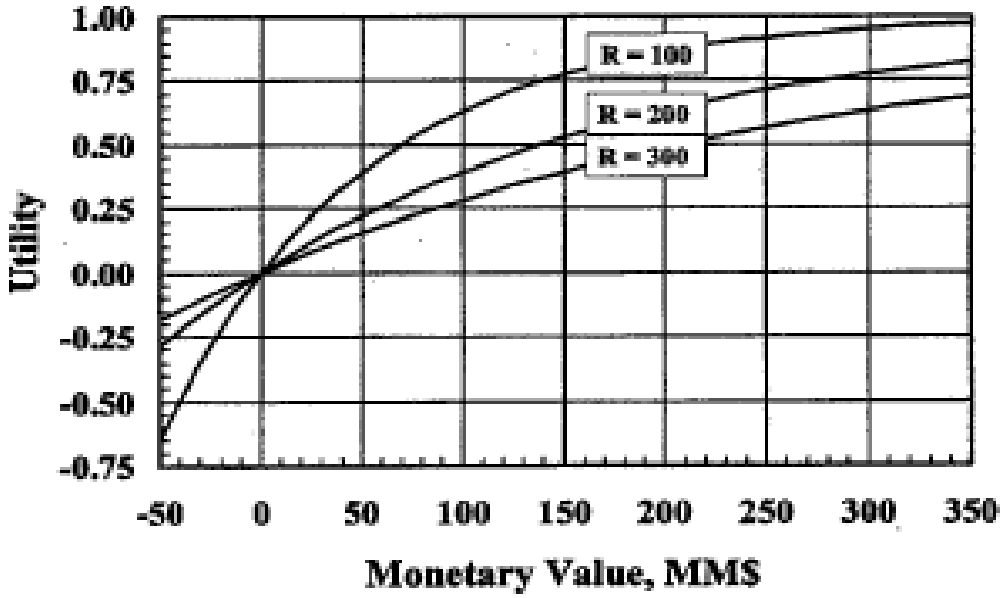
Exponential Utility Function

- The **exponential utility** has only ***one*** *adjustable numerical parameter*, and there are straightforward ways to discover the most appropriate value of this parameter for an individual or company.
- General form $$U(x) = a + be^{-cx}$$
- Special case $$U(x) = 1 - e^{-x/R}$$

where **R** is an adjustable parameter called **risk tolerance** or **RT > 0**

- **Smaller values of R** imply **risk aversion**
- **Curve becomes flat** for **larger values of R**

Exponential Utility Function

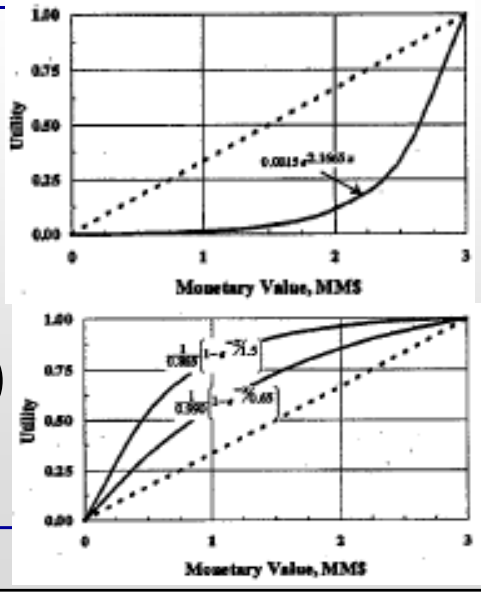


Exponential Utility Function

- Other special cases

$$U(x) = ae^{bx}$$

$$U(x) = \frac{1}{a}\left(1 - e^{-x/R}\right)$$



Other Utility Functions

- Logarithmic

$$U(x) = a\log(b+x)+c$$

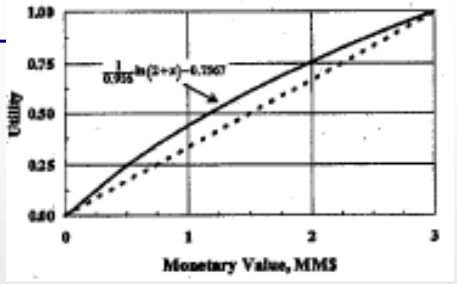
$$U(x) = \ln\left(1+\frac{x}{R}\right)$$

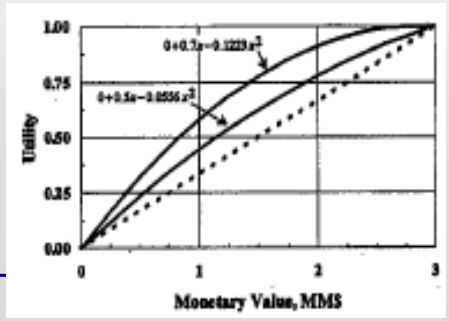
- Quadratic

$$U(x) = a + bx - cx^2$$

- Linear plus exponential

$$U(x) = ax - be^{-x/R}$$





Other Utility Functions

- Power

$$U(x) = a + bx^c$$

- Hyperbolic Tangent

$$U(x) = 1 - \tanh\left(\frac{x}{R}\right)$$

CE from Utility Function

- CE is inverse of any equation representing specified utility function
- For special case of exponential function

$$CE = -R \ln\left[1 - U(x)\right]$$

- For logarithmic function

$$CE = anti\log\left(\frac{U(x) - c}{a}\right) - b$$

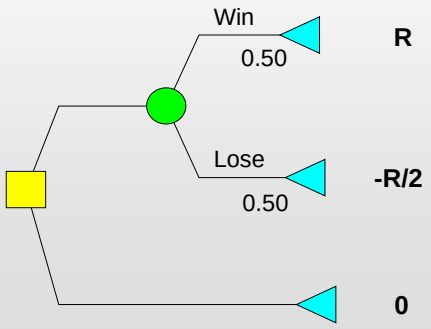
Exponential Utility -- continued

- **Risk tolerance** measures how much risk the decision maker will tolerate.
- To assess a person's exponential utility function, we need only to **assess the value of *RT***.
- A couple tips for doing this are:
  - **The first tip** is that the **risk tolerance** is approximately equal to that dollar amount *RT* such that the decision made is indifferent between the following two options:
    - Option 1: Obtain no payoff at all.
    - Option 2: Obtain a payoff of *RT* dollars or a loss of *RT*/2 dollars, depending on the flip of a fair coin.

Assessing Risk Tolerance

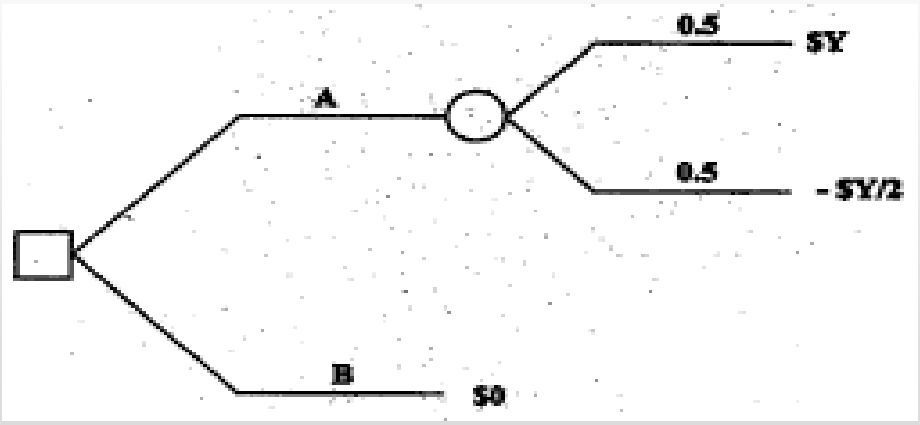
- To assess a person's exponential utility function, we need only to assess **the value of *RT***.

The **Risk Tolerance** is dollar amount *R* that makes the investor ***indifferent*** between the two winning the sum and losing half the sum



Risk Tolerance

- **Risk averse** willing to accept gamble only for **small value of Y**
- **Risk seeker** willing to accept gamble for **much larger values of Y**



Example Application of Utility Function

- We can model Aggie Oil Company's risk preference by the equation $1-e^{-x/R}$, with R = 100
- We want to calculate EU, CE, and risk premium for each project in table that follows
- On the basis of parameter values, we want to select optimal project

Project Alternatives

Project A		Project B	
Probability	**NPV (M$)**	**Probability**	**NPV (M$)**
0.80	80	0.80	30
0.20	-40	0.20	-5
EMV	56		23
Std. Dev.	48		14

Calculated Utilities and Expected Utilities

Project A			Project B		
Probability	NPV,M$	Utility, $1-e^{-x/100}$	Probability	NPV,M$	Utility, $1-e^{-x/100}$
0.8	80	0.5507	0.8	30	0.2592
0.2	-40	-0.4918	0.2	-5	-0.0513
EMV,EU	56	0.3422		23	0.1971

Choose project A – largest EU

Certainty Equivalents

$$CE_A = -R\ln(1-EU_A) = -100\ln(1-0.3422)$$
$$= \$41.88M$$
$$CE_B = -R\ln(1-EU_B) = -100\ln(1-0.1971)$$
$$= \$21.95M$$

Risk Premiums

$$RP_A = EMV_A - CE_A = 56 - 41.88 = \$14.12M$$

$$RP_B = EMV_B - CE_B = 23 - 21.95 = \$1.05M$$

Approximation to Certainty Equivalent

- When project's outcome approximately normally distributed,

$$CE \approx EMV - \frac{0.5s^2}{R}$$

where s^2 is variance, R risk tolerance

Application of Approximation

- For previous example,

$$s^2 = 0.80x80^2 + 0.20x(-40)^2 - 56^2 = 2{,}304$$

$$CE_A \approx 56 - \frac{0.5x2{,}304}{100} = 44.48 vs. 41.88$$

Risk Aversion

- Risk Aversion, *RA*, defined as

$$RA = -\frac{U'(x)}{U''(x)}$$

where

- *U'(x)* is first derivative of *U(x)*
- *U"(x)* is second derivative of *U(x)*

Risk Aversion for Special Cases

- Exponential of form
  $RA = R$
  $U(x) = 1 - e^{-x/R}$
- Exponential of form
  $RA = R$
  $U(x) = \frac{1}{R}\left(1 - e^{-Rx}\right)$
- Logarithmic of form
  $RA = \frac{1}{(b+x)}$
  $U(x) = a\log(b+x) + c$
- Quadratic of form
  $RA = \frac{2c}{b+2cx}$
  $U(x) = a + bx - cx^2$

Analysis of Risk Aversion

- When risk aversion remains **constant** as **payoff increases** (exponential utility function), **calculated RP** remains **constant**
- When risk aversion **decreases** as **payoff increases** (logarithmic, quadratic utility functions), **calculated RP decreases**

Expected Utility Decision Criteria

- First **calculate EMV** for all alternatives
  - Alternative with **largest EMV** selected if decision maker is **risk neutral**
- If decision maker is **affected by risk** (risk averse or risk seeker), determine whether decision is **sensitive to risk attitude**
  - If **sensitive to risk attitude**, include in model
  - Determine **utility function** and replace **monetary payoffs** in decision tree or table by **utility values**
  - Select alternative with **largest EU** or **expected CE**

Spreadsheet Applications
Fitting the Utility Curve

- Best general method: use **SOLVER in Excel** to **determine equation** that best fits utility curve
- Better than arbitrarily choosing exponential equation as much literature advocates
- For example utility function generated earlier (by “interview”), we fit the data with each of the common utility functions
- Quadratic equation proves to have best fit (smallest sum of squares of errors)
- Procedure using SOLVER outlined on pages 270-272 of Mian

Finding Certainty Equivalent

Alternatives

- Can **estimate from equation**

$$CE \approx EMV - \frac{0.5s^2}{R}$$

- Can **calculate from inverse of utility equation** reflecting decision maker's preference
- Inverse may involve iterative solution when inverse not easily derived
  - Goal Seek option of Excel can find inverse
  - Mechanics illustrated on pp. 273-274 of Mian

Critical Risk Tolerance

- **Critical risk tolerance** is risk tolerance at which EU of two alternatives under consideration are equal
- We can use critical risk tolerance for **sensitivity analysis**
  - If our **risk tolerance > critical value**, we should choose riskier project
  - If our **risk tolerance < critical value**, we should choose less risky project

Critical Risk Tolerance

- To determine critical risk tolerance, we use computer to find R-value that will make EU of two projects equal
- SOLVER or GOAL SEEK can be used
- Text illustrates use of SOLVER on pp. 275-276

PrecisionTree and Utility Functions

- PrecisionTree can solve decision problems based on CE and EU theory
- Program has built-in exponential $(1-e^{-x/R})$ and logarithmic $[\ln(1+x/R)]$ functions
  - User can add user-defined utility functions with VBA
- Application illustrated on pp. 276-279 of text

Exponential Utility -- continued

- The **second tip** is for finding *R* is based on **empirical evidence**
- Some companies reportedly will take 25% of total annual exploration budget as **risk tolerance**
- Empirical research showed that the larger the size of E&P firms, the larger the corporate RT value

Risk Tolerance & Financial Measures

- **Howard (1988**) suggest that the firm's **RT** or **(1/c)** can be closely related to **financial measures** such as sales, net income and equity.
- Cursory study of oil and chemicals industry:

Risk Tolerance/Sales	0.064
Risk Tolerance/Net Income	1.240
Risk Tolerance/Equity	0.157

Measure	Ratio	Annual Report	Risk Tolerance	RAL (*c*)
Net Sales	0.064	$3,500 MM	$224 MM	0.005
Net Income	1,240	$130 MM	$161 MM	0.006
Equity	0.157	$1,700MM	$267 MM	0.004

Howard's Rule

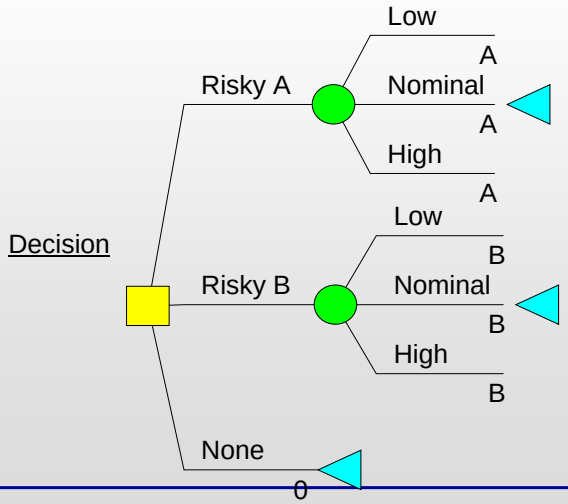
- Howard found that *RT* was approximately:
  - 6.4% of net sales
  - 12.4% of net income
  - 15.7% of equity for a firm.
- These percentages are just guidelines.
- They do indicate that **larger companies** have **larger values of *RT***.

Example
Incorporating Attitudes Toward Risk

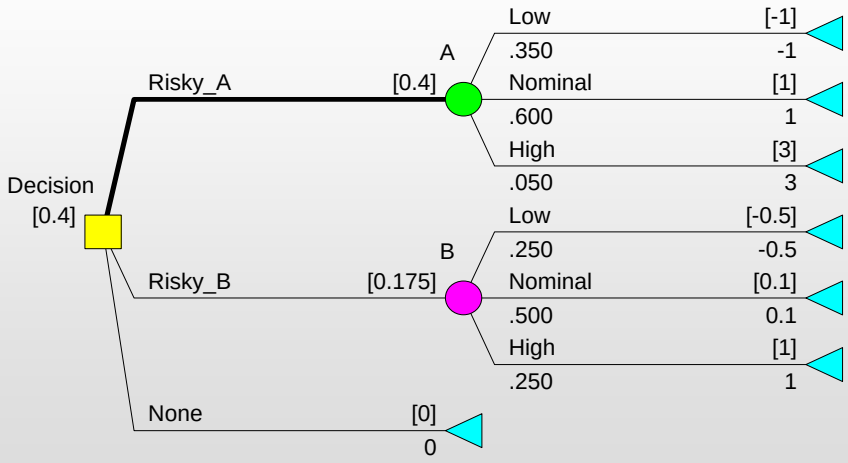
Background Information

- **Petroleum Venture** is a company with **net sales of $30 million.**
- The company currently must **decide whether to enter one of two risky ventures** or **do nothing**.
- The possible outcomes of the **less risky venture** are a $0.5 million loss, a $0.1 million gain, and a $1 million gain.
- The probabilities of these outcomes are 0.25, 0.50, and 0.25.
- The possible outcomes of the **more risky venture** are a $1 million loss, a $1 million gain, and a $3 million gain.
- The probabilities of these outcomes are 035, 0.60, and 0.05.
- If Petroleum Venture can enter at most **one of the two** risky ventures, **what should they do?**

Petroleum Ventures



Petroleum Ventures – Expected Value

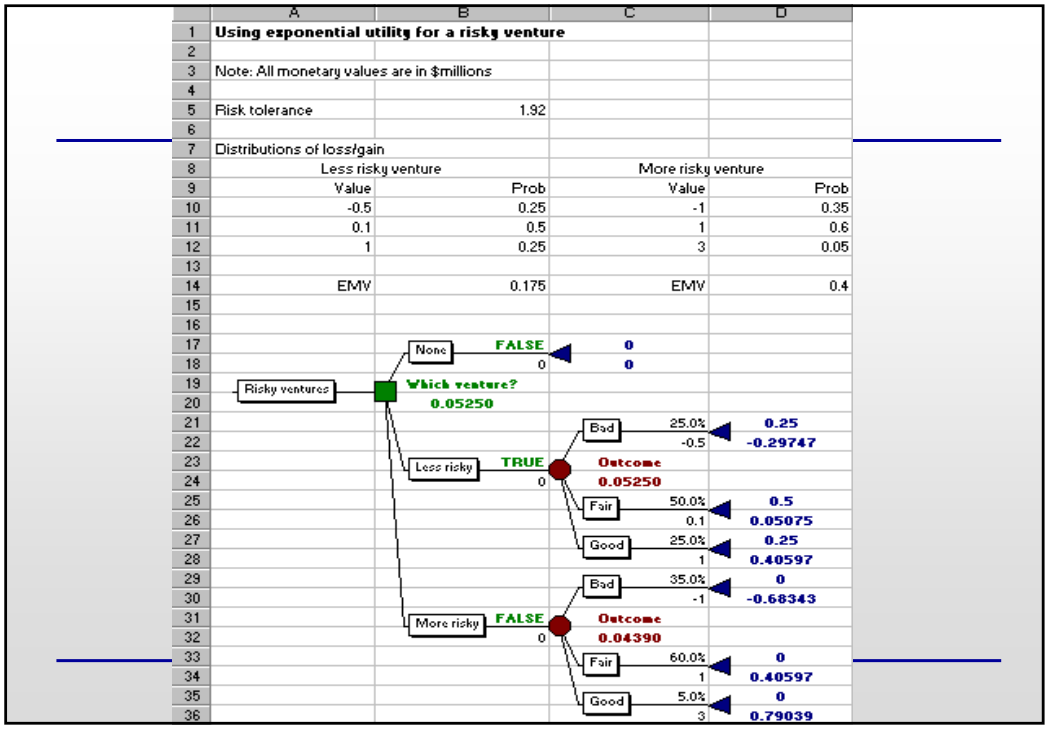


Solution

- The **EMV** of the project is **0.4M** and the solution indicates that the **Risky Project A** should be undertaken.
- We will now **assume Petroleum Ventures is risk averse** and has an **exponential utility function**.
- Based on Howard's guidelines, we will assume that the company's **risk tolerance** is 6.4% of its net sales, or **$1.92 million.**

Utility Functions

- Using the **exponential utility formulas** we can find **the utility** of any monetary outcome.
- We then input **the exponential utility function with risk tolerance 1.92.**
  - The gain for doing nothing is **$0** and its utility is **0**.
  - For example, the utility of a **$1 million loss** is -0.683.



Interpretation

- The optimal solution now indicates that **for this level of risk tolerance,** the **less risky** venture **Risky Project B** is now preferred
- From an **EMV** point of view, the **more risky** venture is definitely best.
- However, Petroleum Ventures is sufficiently risk averse, and the monetary values are sufficiently large compared to the size of the firm, that the company is **willing to sacrifice the EMV to reduce its risk.**

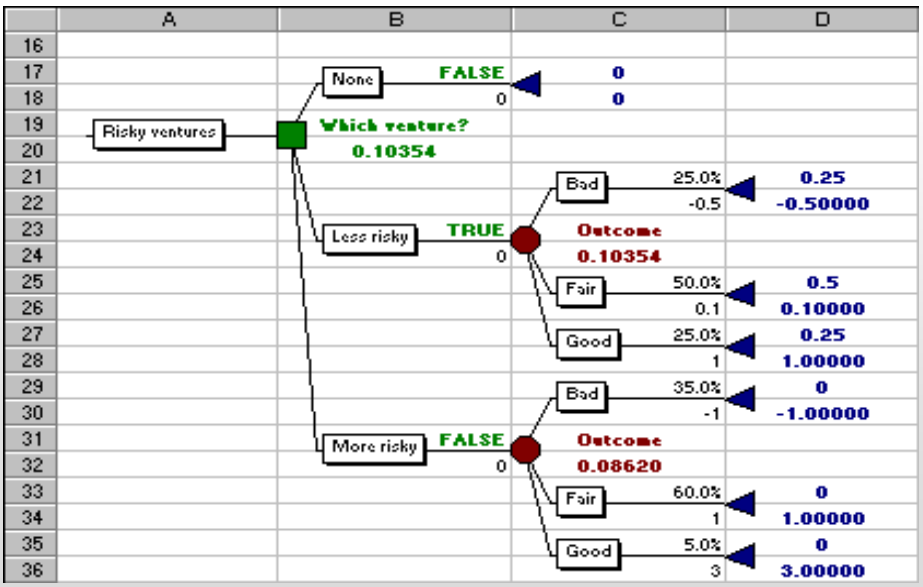
Interpretation

- How **sensitive** is the optimal decision to the key parameter, the risk tolerance?
- We can answer this by **changing the risk tolerance** and watching how the decision tree changes.
  - When the **risk tolerance increases to approximately $2.075 million** the company is more risk tolerant.
  - When the **risk tolerance decreases** the "do nothing" decision becomes optimal.
- Thus we can see that **the optimal decision** depends heavily on the attitudes toward risk of **Petroleum Ventures top management.**

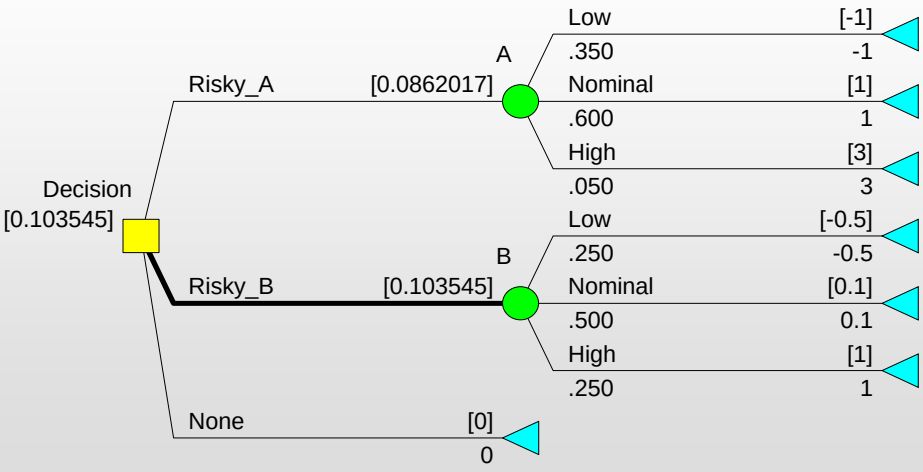
Certainty Equivalents

- Now suppose Petroleum Ventures only had two options, enter the **less risky venture** or **receive a certain dollar amount *x*** and avoid the gamble altogether.
  - If it enters the **risky venture**, its **expected utility** is **0.0525**, calculated previously.
  - If it receives ***x* dollars for certain**, its **expected utility** is approximately **$0.104 million**.
- This value is called the **certainty equivalent** of the risky venture.

Decision Tree with Certainty Equivalents



Petroleum Ventures - CE



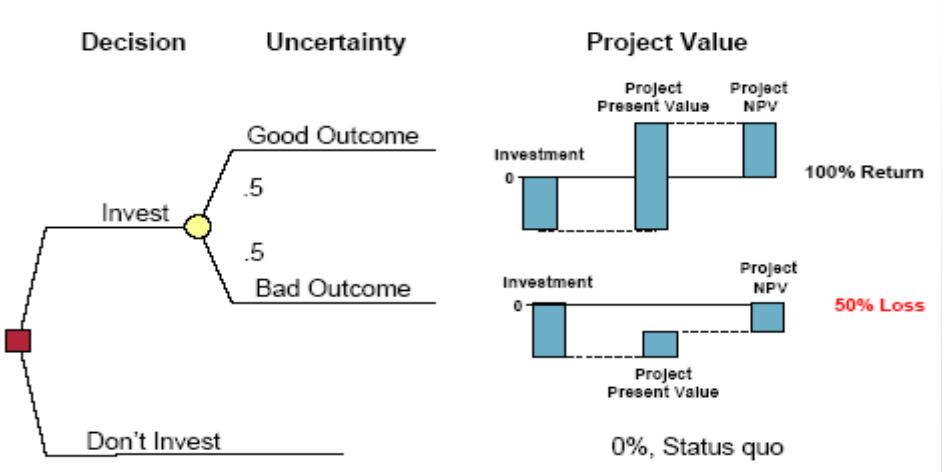
Empirical Evidences from Risk Tolerance Assessment

Example on Corporate Risk Tolerance Assessment

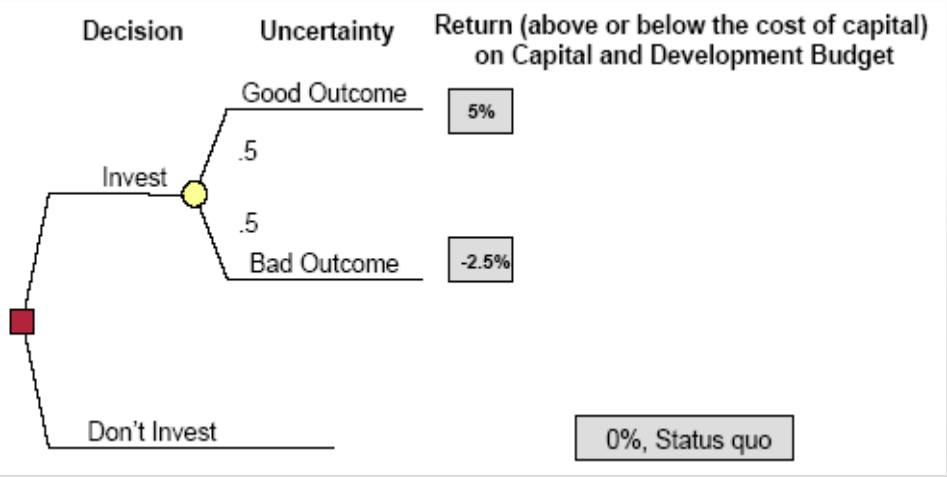
Investment Specifics

- Your business unit represents about 1/5 of the revenue and shareholder value (SHV) of the company.
- Your yearly capital and development budget is 10% of your revenue (or 2% of the corporation's SHV)
- You have a new investment opportunity that has a 50-50 chance of success.
  - You are confident that your staff has studied it in depth and have characterized the risk well—the assessments are neither optimistic nor pessimistic.

Form of questions



Risk Attitude Assessment



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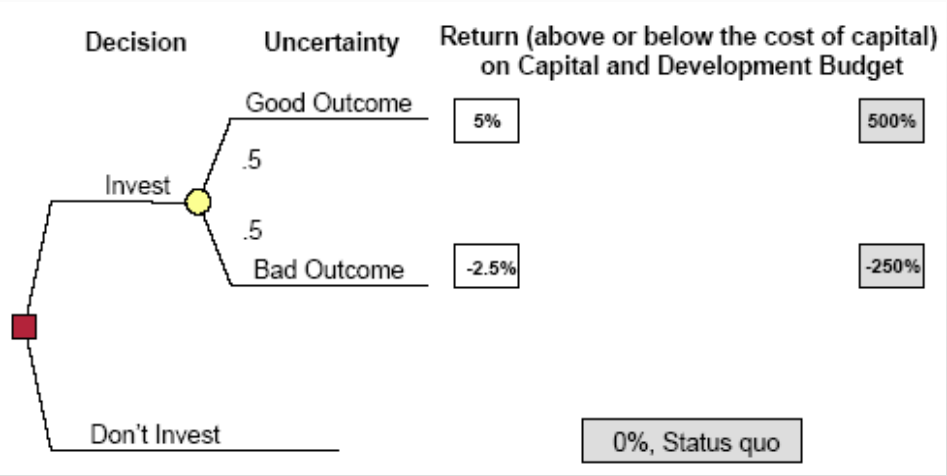

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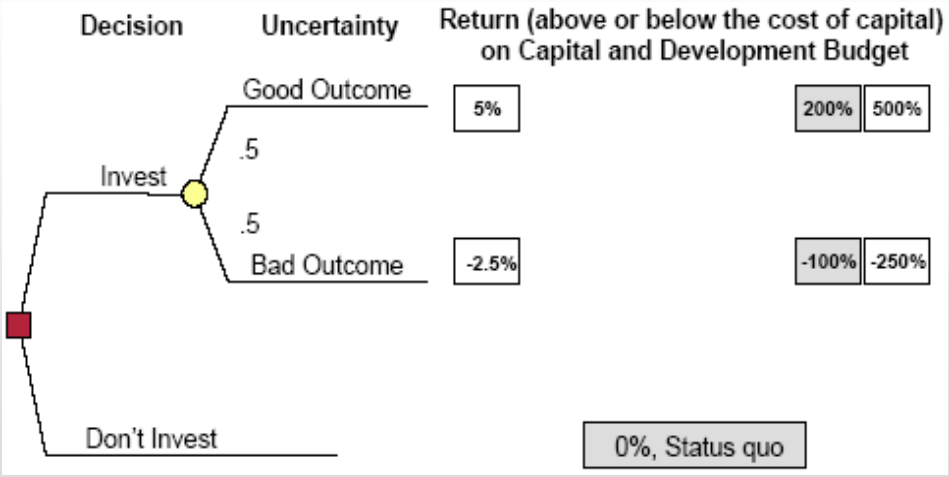

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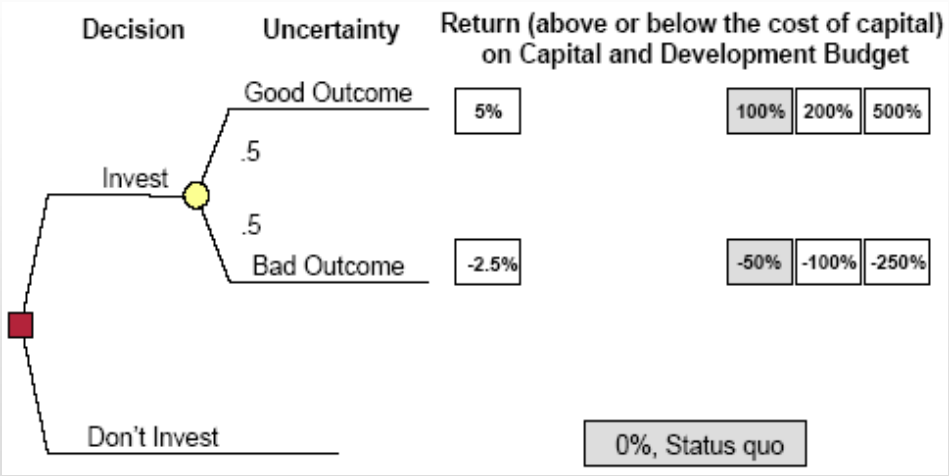

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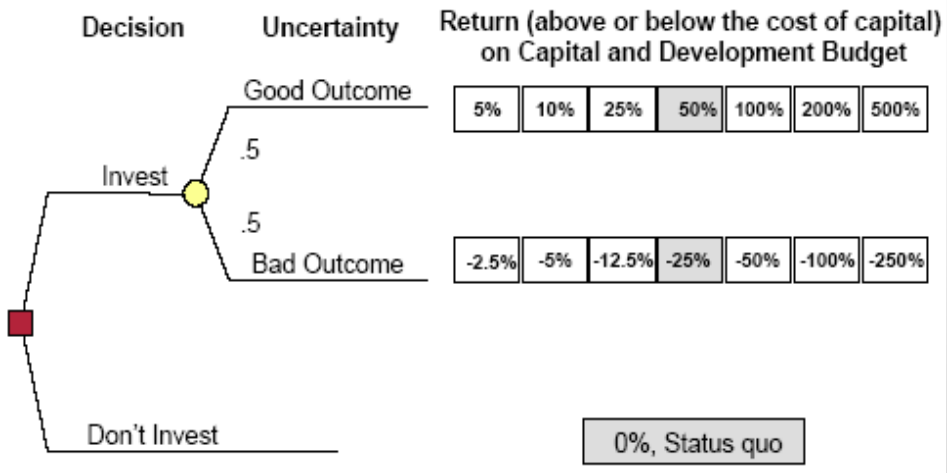
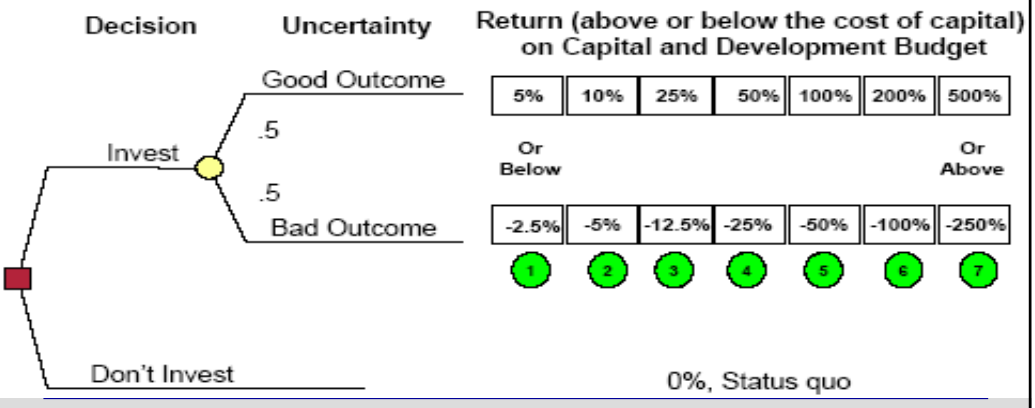


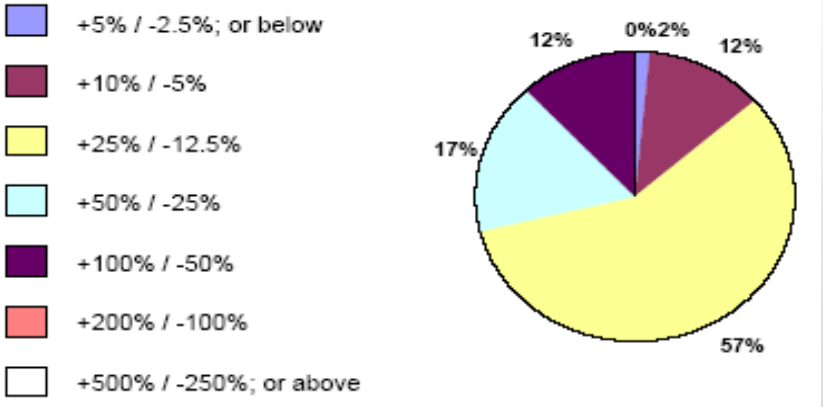
Risk Attitude Assessment

As head of a business unit, what is the highest level of risk at which you would choose to invest?

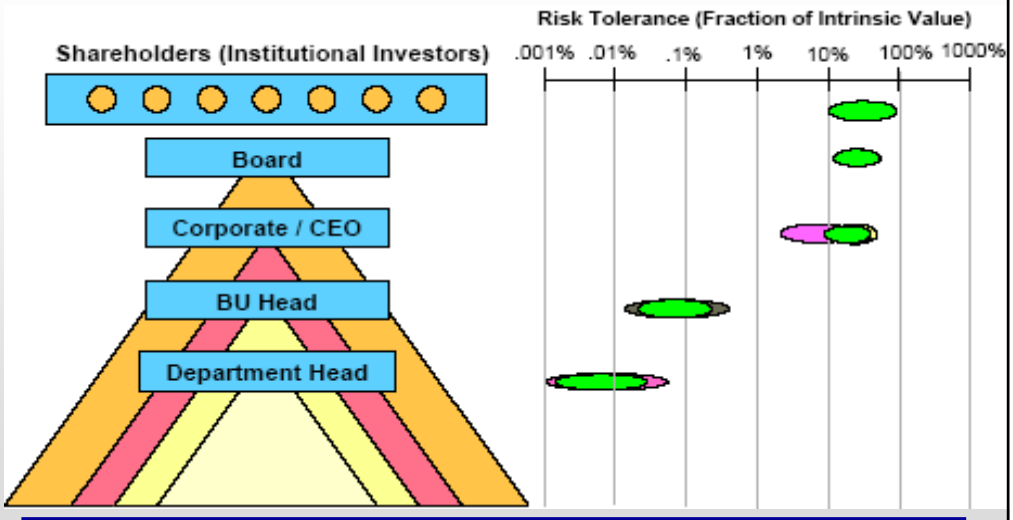


Empirical Evidence from Polling Results

As head of a business unit, what is the highest level of risk at which you would still choose to invest?

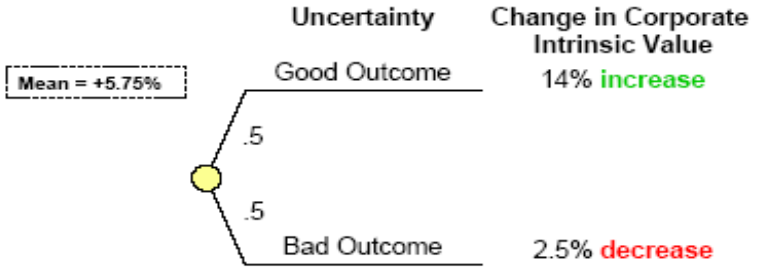


Empirical Evidence:
Risk Tolerance is closely tied to perceived budget constraint



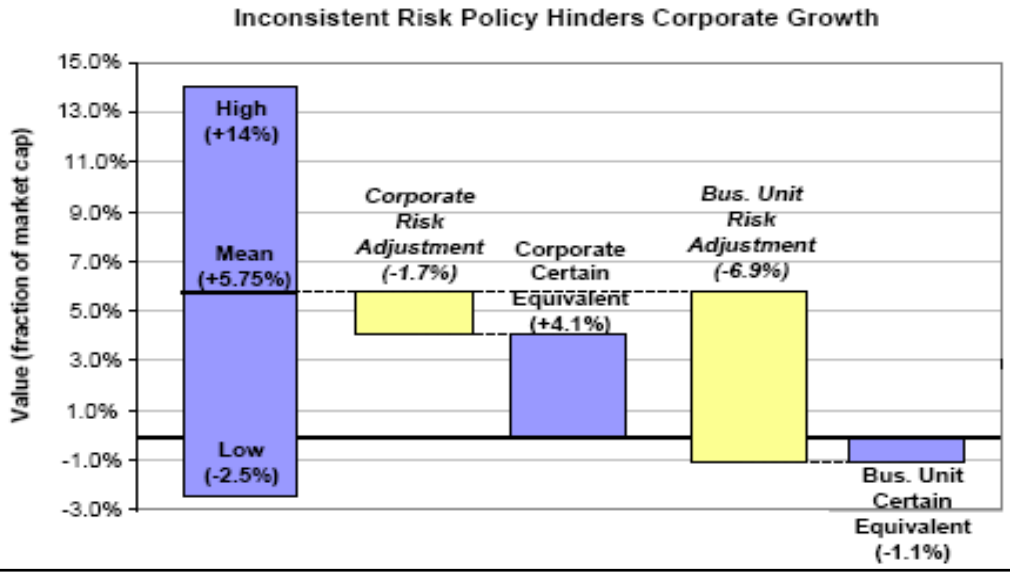
Differing Risk Attitude lead to inconsistent Decision Making

- Assume that **corporate** risk tolerance is equal to **20%** of intrinsic value and that a **business unit's** risk tolerance is **2%** of the corporation's intrinsic value.
- Someone in the business unit has identified the following investment opportunity:



How would the business unit value this opportunity relative to corporate?

The business unit would reject this project, even though it would be a positive addition to the corporate portfolio.



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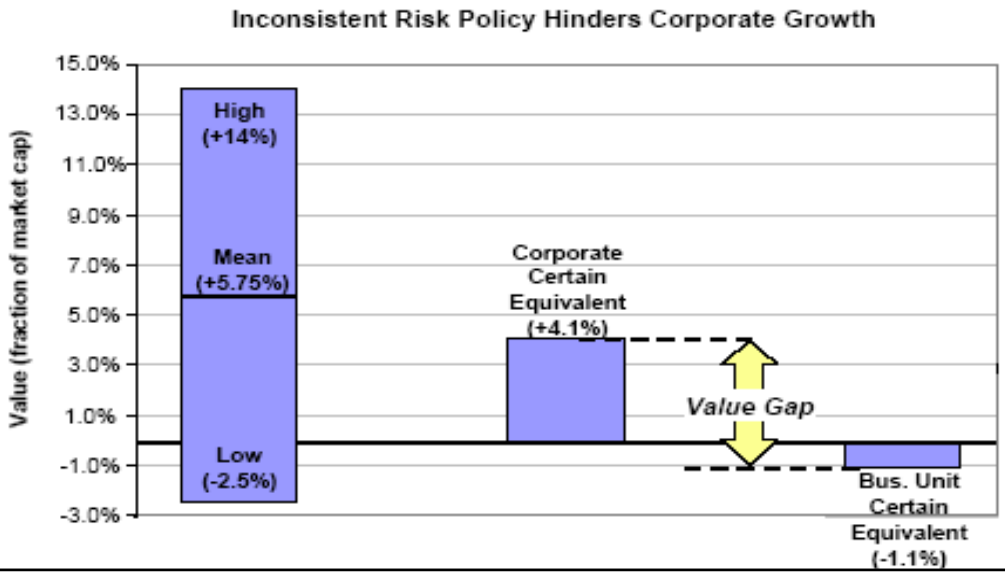
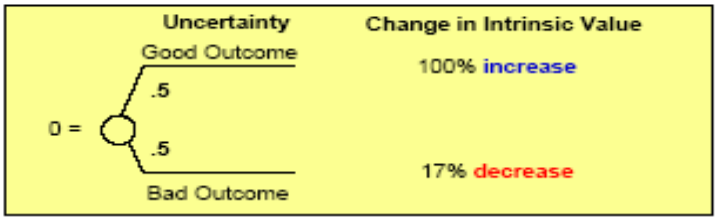
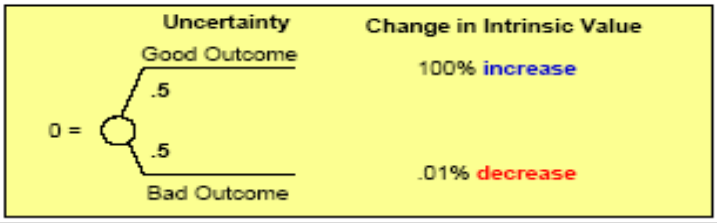


What is the maximum loss that you would be willing to consider to double the organization's value? The answers differ greatly for the different levels of the organization.

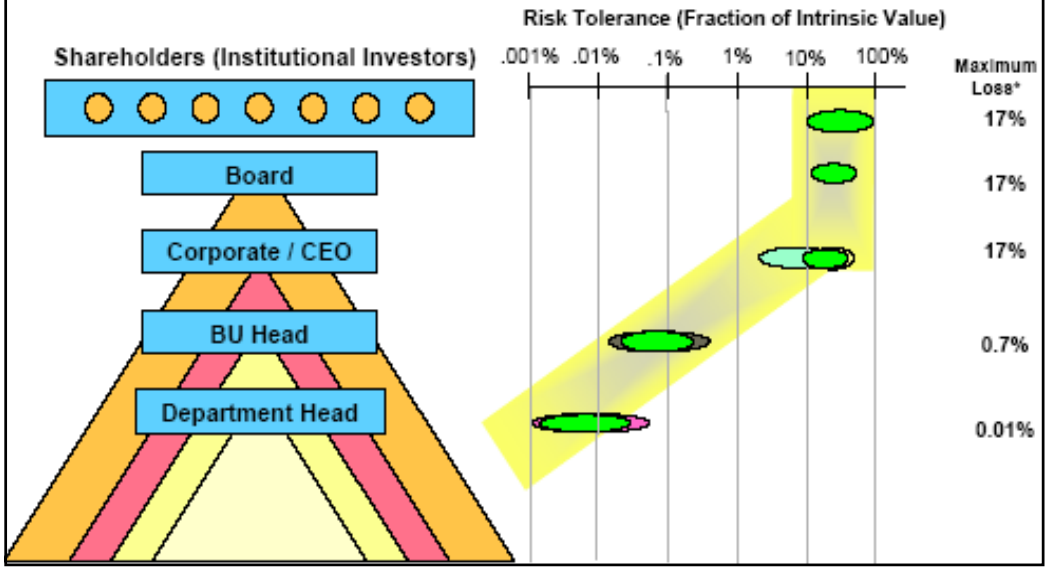
CEO/Board: Risk Tolerance = 25% of Intrinsic Value



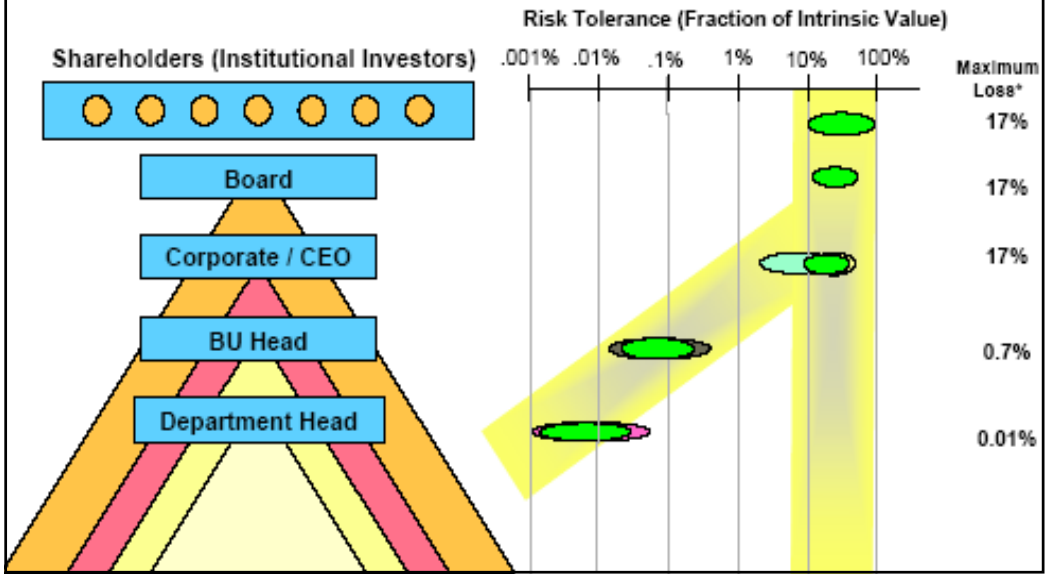
Department Heads: Risk Tolerance = .02% of Intrinsic Value



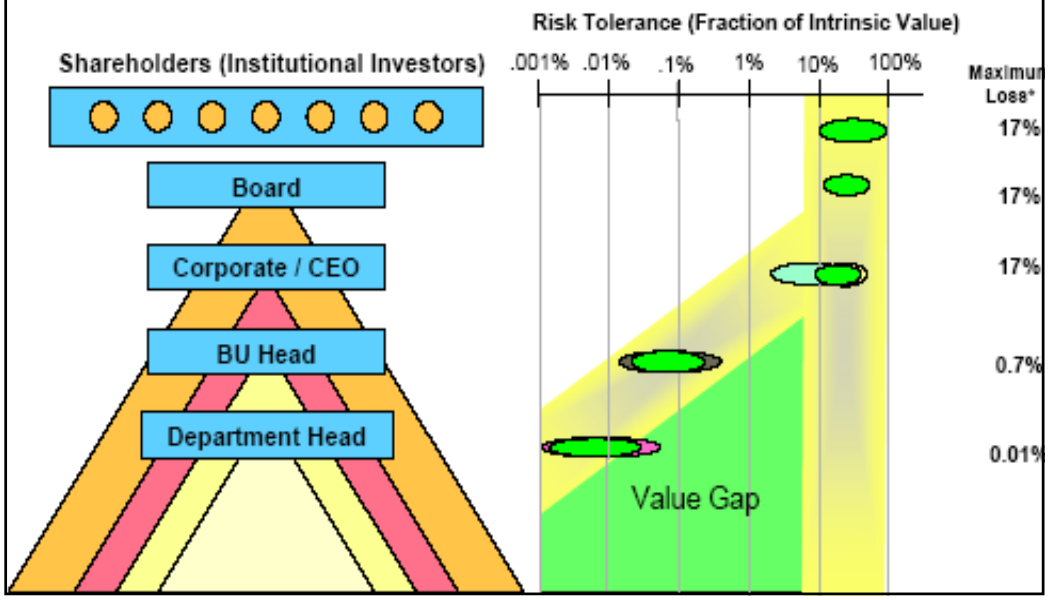
Increasing risk aversion at lower levels of the corporation results in the rejection of value-creating projects.



Corporations need to use a consistent risk policy throughout the organization...



...or, miss significant value-creating opportunities.



An example of a missed opportunity from applying a low risk tolerance:

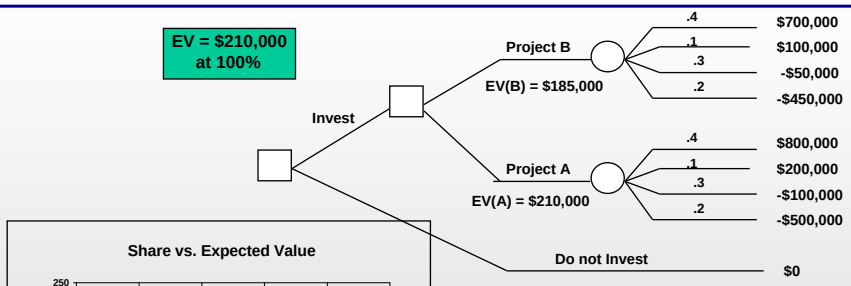
- In '95, Walls, Morahan, and Dyer* worked with Phillips Petroleum to determine the optimal level of investment in exploration projects.
- The eight projects ranged in size from $2.2 million to $18.6 million.
- The expected value for all eight totaled $69 million.
- Based on a $25 million risk tolerance (.23% of Market Value), an amount "management was comfortable with," Phillips reduced participation in five of the projects.
- A risk tolerance on the order of 25% market value would have resulted in nearly 100% participation in all projects.
- Using the risk tolerance of "management" reduced the value of the portfolio by $50 million.

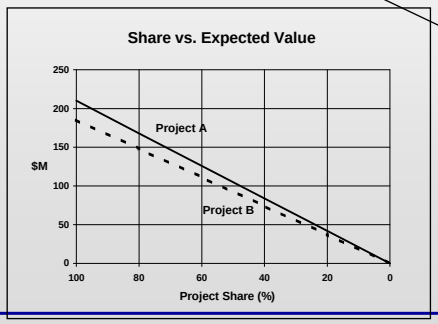
To close the value gap, companies need to take five steps:

1. Appropriately characterize the uncertainty for key decisions.
2. Develop an explicit corporate risk policy.
3. Encourage prudent risk taking by training executives and communicating the corporate risk tolerance.
4. Reward good decisions and not just "results."
5. Challenge all levels of the organization to raise opportunities, even if they seem highly risky. Then evaluate the opportunities with the CE method using the corporate risk tolerance. If the opportunity seems attractive from this CE valuation, but still feels too risky at your level, **hand it up to a higher organizational level!**

Other Applications on Risk Preferences

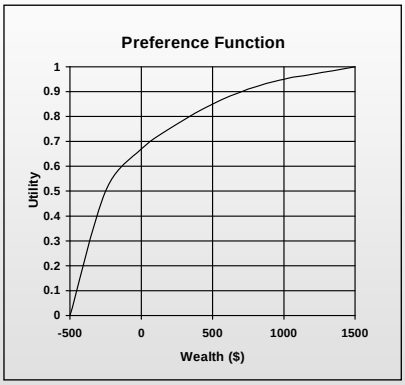
Risk Sharing - An Investment Example



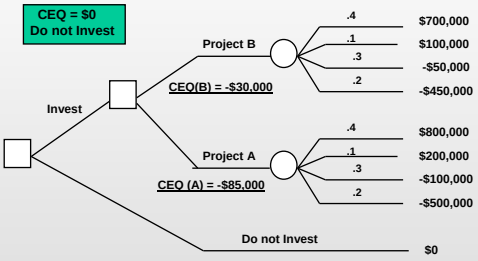


- Risk neutral evaluation indicates a linear relationship between share and expected value of each alternative.
- Project A dominates in all cases.

Now suppose we use the following utility function. . .

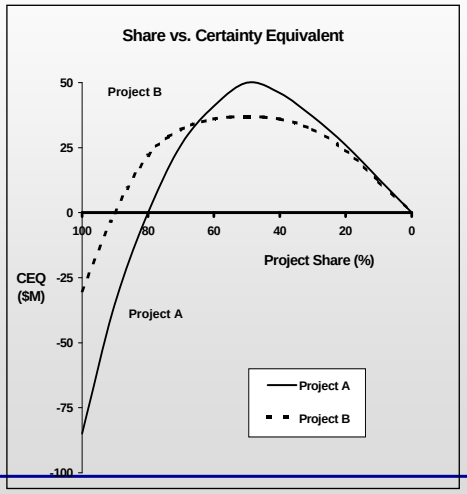


...and analyze our investment problem on the basis of certainty equivalents.



- With **no risk-sharing**, do not take either project, since Project A has a CEQ of -$85,000 and Project B has a CEQ of -$30,000.

Consider the CEQ evaluation at different project shares



- With a **50-50 partnership**, take Project "A" since it has a CEQ of $50,000 and is better than Project "B" at that level of risk-sharing.
- Provides valuable insights concerning firm's **optimal share** in individual, as well as groups of, risky projects.
- Willingness to participate in risky projects can be systematically incorporated into project evaluation.

Measuring Risk Tolerance

- Suppose the firm rejects **Expected Monetary Value** as the basis for making Risky Decisions. What do we do?
- Our goal is to construct a **Preference Scale** that:
  - Encodes the firm's attitude towards financial risk
  - Can be used with probabilities to compute **Certainty Equivalents (CEQ)**
- A number of practical approaches for measuring **Risk Tolerance** are available
  - Industry-specific Questionnaires
  - Analysis of Prior Decisions
  - Industry Empirical Analysis

Utility Function Worksheet

- Make Participation Choices Among a Set of Exploration Prospects as Part of Your Annual Budget Process

Prospect	*Outcome*	*Value*	*Prob.*	*Choice (W.I. Level)*				
1	Success	$75mm	0.50	100%	75%	50%	25%	0%
	Dry Hole	-$30mm	0.50					
2	Success	$45mm	0.15	100%	75%	50%	25%	0%
	Dry Hole	-$3mm	0.85					
3	Success	$22mm	0.30	100%	75%	50%	25%	0%
	Dry Hole	-$4mm	0.70					
4	Success	$16mm	0.80	100%	75%	50%	25%	0%
	Dry Hole	-$9mm	0.20					
5	Success	$16mm	0.20	100%	75%	50%	25%	0%
	Dry Hole	-$1.4mm	0.80					

Example from Real Study

Risk Tolerance Survey

Assume you are presented the following ten exploration prospects as part of your annual budgetary considerations.

Given each prospect's risk characteristics and the option to participate in each venture, *select your participation level recommendation for each prospect*. Make your choices based on your normal annual drilling budget constraints.

Prospect	Outcome	Value ($millions)	Probability	Choice (circle one) Participation Level					
1	Success	45.0	15%	100%	75%	50%	25%	15%	0%
	Failure	-3.0	85%						
2	Success	75.0	50%	100%	75%	50%	25%	15%	0%
	Failure	-30.0	50%						
3	Success	14.5	35%	100%	75%	50%	25%	15%	0%
	Failure	-8.0	65%						
4	Success	16.0	70%	100%	75%	50%	25%	15%	0%
	Failure	-10.0	30%						
5	Success	22.0	25%	100%	75%	50%	25%	15%	0%
	Failure	-5.0	75%						
6	Success	200.0	10%	100%	75%	50%	25%	15%	0%
	Failure	-5.0	90%						
7	Success	60.0	40%	100%	75%	50%	25%	15%	0%
	Failure	-7.0	60%						
8	Success	100.0	20%	100%	75%	50%	25%	15%	0%
	Failure	-9.0	80%						
9	Success	7.5	45%	100%	75%	50%	25%	15%	0%
	Failure	-6.5	55%						
10	Success	150.0	15%	100%	75%	50%	25%	15%	0%
	Failure	-7.0	85%						

Certainty Equivalent Analysis ($MM)

Prospect #2

Probability of Success	0.5
Probability of Failure	0.5
NPV of Success ($MM)	75
NPV of Failure ($MM)	-30
Expected Value ($MM):	22.5000

	PARTICIPATION LEVEL				
RT	100% W.I.	75% W.I.	50% W.I.	25% W.I.	15% W.I.
1000	21.1225	16.1000	10.9065	5.5389	3.3440
500	19.7488	15.3262	10.5613	5.4525	3.3130
300	17.9295	14.2984	10.1030	5.3380	3.2717
200	15.6871	13.0238	9.5323	5.1946	3.2200
100	9.3089	9.3154	7.8435	4.7661	3.0652
75	5.4547	6.9817	6.7471	4.4824	2.9623
50	-1.1186	2.7501	4.6544	3.9218	2.7574
40	-5.0716	-0.0023	3.1921	3.5092	2.6048
30	-10.0981	-3.8037	0.9877	2.8411	2.3531
20	-16.2417	-9.0232	-2.5358	1.5961	1.8631
15	-19.6165	-12.1813	-5.0490	0.4938	1.3963
10	-23.0688	-15.5723	-8.1209	-1.2679	0.5500
5	-26.5343	-19.0343	-11.5344	-4.0604	-1.2441

Result of the Study

No.	Name	Group	Risk Tol. ($ MM)	Stand. Dev. ($MM)	CM	Consistency Rating
1	VP - Africa	A	60	69	1.2	High
2	VP - Planning	A	60	460	7.7	Low
3	VP - Eurasia	A	74	381	5.2	Low
4	VP - Egypt	A	60	53	0.9	High
5	VP - UK	A	35	25	0.7	High
6	VP - Far East	A	68	464	6.9	Low
7	VP - Canada	A	60	73	1.2	High
8	VP - Finance	B	20	31	1.6	Moderate
9	Manager - PAPT	B	64	386	6.1	Low
10	Manager - PAPT	B	28	30	1.1	High
11	Senior VP - Expl.	B	80	456	5.7	Low
12	Manager - Legal	C	15	30	2.0	Moderate
13	Manager - Land	C	10	31	3.1	Moderate
14	Manager - Land	C	40	397	9.9	Low
15	Manager - Technical	C	60	73	1.2	High
16	Manager - Technical	C	53	26	0.5	High
17	Manager - Legal	C	18	25	1.4	High
18	Manager - Geology	C	68	463	6.9	Low
19	Manager - Geology	C	50	391	7.8	Low
20	Manager Geophysics	C	53	26	0.5	High

RT & Analysis of Past Decisions

- Proposition: Analysis of Recent Resource Allocation Decisions Represents Firm's Exhibited Risk Tolerance Level.
- Study:

  Offshore Bid Sale

  Firm: BP Exploration, Inc.

  Prospects: 60 Offshore Drilling Blocks

  Decisions: Bid on 48 Blocks (8 at 100%)

  Note: <u>All Blocks Had Positive Expected NPV's.</u>

- Findings: BP exhibited a risk tolerance (RT) level of between $30-$40 million. Firm maintained "consistent" risk attitude on about 50% of prospect decisions. Suggests firm was either highly inconsistent in its risk preferences or that other considerations influenced the bids.

Risk Tolerance (RT) And Firm Performance

- There Exists an Abundance of Evidence that Firms Behave in a Risk-Averse Manner.
- From a Business Policy Perspective We are Compelled to Ask:
  - ***What is the appropriate risk tolerance level for the firm?***
  - ***What effect, if any, does corporate risk policy have on firm performance?***
- Empirical Setting and Analysis
  - 66 of the Largest U.S. Based Oil & Gas Firms
  - Period of Investigation: 1981-1990
  - Risk Tolerance Model Development includes domestic/foreign budget allocations, leasehold, exploratory and development costs, success rates, reserve additions, etc.

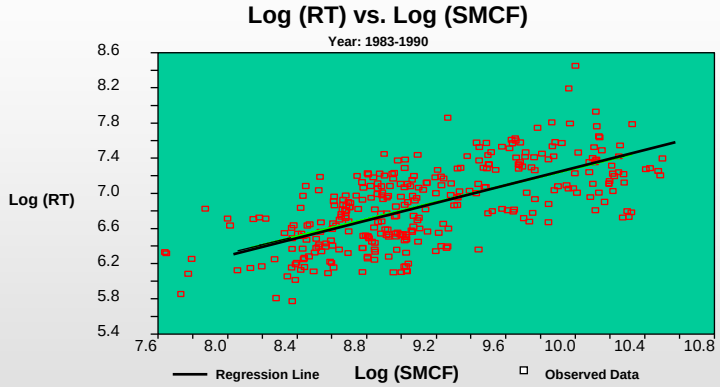
Corporate RT - An Industry Look

CORPORATE RISK TOLERANCE ($MM)

Year	*Phillips*	*Exxon*	*Shell*	*UTP*	*Texaco*
1990	***18.4***	***24.9***	***85.4***	***10.6***	***22..7***
1989	***21.0***	***18.9***	***62.7***	***13.2***	***281.3***
1988	***34.1***	***20.8***	***64.4***	***12.1***	***10.9***
1987	***27.4***	***16.5***	***37.5***	***10.9***	***12.0***
1986	***21.4***	***16.8***	***34.3***	***14.3***	***12.4***
1985	***19.1***	***16.1***	***43.4***	***9.6***	***10.2***
1984	***19.8***	***18.0***	***44.8***	***12.3***	***15.7***

- **Risk Tolerance Measure** Provides Valuable Insight into Risk Propensity of Industry Competition.

Risk Tolerance versus Firm Size



For the entire period 1983-1990, there exists a significant positive relationship between corporate risk tolerance and firm size.

Risk Tolerance - Comparing Firms

- **Risk Tolerance Ratio (RTR)** - A New Approach for Comparing Risk Tolerance Among Firms of Different Size.
- RTR = RTi/RT', where
  - RT_i is the Observed Risk Tolerance for Firm *i* in Period *t* and *RT'* represents the Predicted Risk Tolerance of Firm *i* as a Function of Size.
- RTR Provides Valuable Insight Concerning Competitor's Relative Propensity to Take on Risk.
- **RTR Provides Guidance on Setting and Communicating an Appropriate Risk Policy**.

Risk Tolerance Ratio

	Firm X	Firm Y	Firm Z
SMCF (Size)	*$1000MM*	*$100MM*	*$10MM*
RT' (Predicted)	*$100MM*	*$15MM*	*$2MM*
RTi (Actual)	*$ 50MM*	*$20MM*	*$2MM*
RTR (RTi/RT')	*0.50*	*1.33*	*1.0*

RTR>1.0 (<1.0) Implies a Stronger (Weaker) Propensity to Take on Risk Than Firms of Equivalent Size.

RTR - A Relative Measure of Risk

CORPORATE RISK TOLERANCE RATIO

Year	***Phillips***	***Exxon***	***Shell***	***UTP***	***Texaco***
1990	*1.16*	*0.62*	*3.46*	*1.15*	*0.93*
1989	*1.24*	*0.37*	*2.39*	*1.74*	*7.41*
1988	*2.58*	*0.71*	*3.39*	*1.78*	*0.56*
1987	*2.60*	*0.59*	*2.10*	*1.66*	*0.69*
1986	*2.03*	*0.73*	*2.19*	*2.21*	*0.72*
1985	*1.78*	*0.80*	*2.83*	*1.20*	*0.67*
1984	*1.58*	*0.79*	*2.60*	*1.50*	*0.85*

RTR Measure Points to Firm's Relative Risk Propensity Compared to Industry Competition.

RTR - The Performance Implications

RETURN ON E&P ASSETS

	Risk Tolerance Ratio			
	High (>2.5)	*Moderate (1.5 - 2.5)*	*Average (0.5-1.5)*	*Low (<0.5)*
Mean	*5.0%*	*9.1%*	*5.7%*	*5.3%*
Stand. Dev.	*2.5%*	*6.4%*	*5.0%*	*3.1%*
Conf. Int.	*3.3-6.9*	*8.1-10.7*	*5.6-7.7*	*3.8-7.2*

E&P Firms exhibiting moderate Risk Tolerance demonstrate significantly higher returns than Firms either more or less Risk Tolerant.

Concepts Regarding the Estimation of a Risk Attitude

- Makes explicit a **corporate attitude toward risk** taking
- Can assure a **constant risk attitude** in different divisions/regions of a company
- May allow **comparison**s with the **risk attitudes** of other companies in the same industry
- Can be used to rank prospects, to determine shares, and to select the **"best" portfolio** from efficient ones