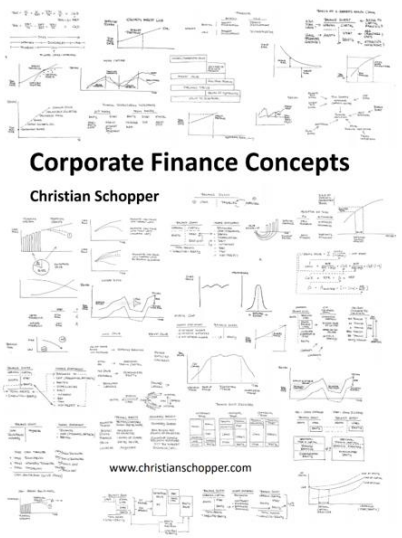
Risk Primer

incl. An Adaptation of Thoughts by Ashwath Damodaran

2016

For more concepts click on:



What is Risk?

Old and New Risk Mindset?

A Very Short History of Risk

- For much of **human history**, **risk and survival** have gone hand in hand
  - Prehistoric humans lived short and brutal lives, as the search for **food** and **shelter** exposed them to physical danger from preying animals and poor weather
  - Even as more established communities developed in Sumeria, Babylon and Greece, other risks (such as **war** and **disease**) continued to ravage humanity

- The advent of **shipping** created a new forum for risk taking for the adventurous
  - The **Vikings** embarked in superbly constructed ships from Scandinavia for Britain, Ireland and even across the Atlantic to the Americas in search of **new lands to plunder** – the risk-return trade off of their age
  - The **spice trade** that flourished as early as 350 BC, but expanded and became the basis for empires in the middle of the last millennium provides a good example
  - Traders in **London**, **Lisbon** and **Amsterdam**, with the backing of the crown, would invest in ships and supplies that would embark on the long journey

- In the last couple of centuries, the advent of financial instruments and markets on the one hand and the **growth of the leisure business** on the other has allowed us to **separate physical from economic risk**
  - A person who **buys options** on technology stocks can be exposed to significant economic risk without any potential for physical risk, …
  - … whereas a person who spends the weekend **bungee jumping** is exposed to significant physical risk with no economic payoff. While there remain significant physical risks in the universe, this book is about economic risks and their consequences

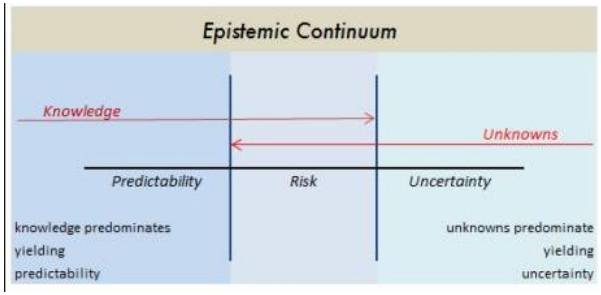
Defining Risk

In 1921, Frank Knight summarized the **difference between risk and uncertainty** thus:

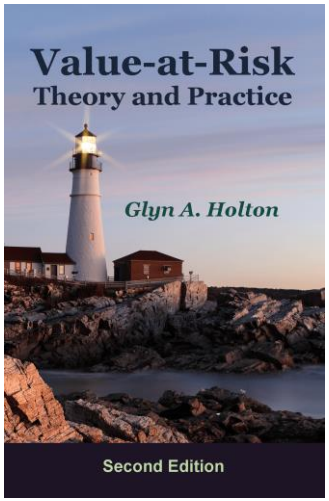
- "… **Uncertainty** must be taken in a sense radically **distinct from** the familiar notion of **Risk**, from which it has never been properly separated …

- … The essential fact is that "**risk**" means in some cases a **quantity** susceptible of **measurement**, …
- … while **at other times** it is something distinctly **not** of this character …
- … and there are far-reaching and crucial differences in the **bearings** of the phenomena depending on which of the two is really present and operating …

- … It will appear that a **measurable uncertainty**, or "risk" proper, as we shall use the term, is so far different from an un-measurable one that it **is not in effect an uncertainty** at all"



Defining Risk (cont´d)



The emphasis on whether uncertainty is subjective or objective seems to us misplaced

- It is true that **measurable risk** is **easier to insure** …
- … **but we do care about all uncertainty**, whether measurable or not

- Holton (2004) argues that there are **two ingredients** that are **needed for risk** to exist:
  1. **Uncertainty about the** potential **outcomes** from an experiment and
  2. The **outcomes have to matter** in terms of providing utility

- **Risk is incorporated into so many different disciplines** from insurance to engineering to portfolio theory that it should come as no surprise that it is **defined in different ways by each one**

Defining Risk (cont´d)

Risk versus Probability

- Some definitions focus only on the probability of an event occurring, …
- … more comprehensive definitions incorporate both (i) the **probability of the event occurring** and (ii) the **consequences** of the event

Risk versus Threat

- A threat is a **low probability event with very large negative consequences**, where analysts **may be unable to assess the probability**
- A risk, on the other hand, is defined to be a **higher probability** event, where there is enough information to **make assessments** of both the **probability and** the **consequences**

All outcomes versus negative outcomes

- **Some definitions** tend to focus **only** on the **downside** scenarios, …
- … whereas **others** are more expansive and **consider all variability** as risk
- The engineering definition of risk is defined as the product of (i) the probability of an event occurring, that is viewed as undesirable, and (ii) an assessment of the expected harm from the event occurring

Defining Risk (cont´d)

- Risk in finance is defined in terms of **variability of actual returns** on an investment **around an expected return**, even when those returns represent positive outcomes

- The Chinese symbol for risk best captures this duality

危險

- This Chinese symbol for risk is a **combination of danger** (crisis) **and opportunity**, representing the downside and the upside of risk
  - This is the definition of risk that captures perfectly both the essence of risk and the problems with focusing purely on risk reduction and hedging
  - Any approach that focuses on minimizing risk exposure (or danger) will also reduce the potential for opportunity

Dealing with Risk

The link between risk and reward that has motivated much of risk taking through history

Risk and Reward

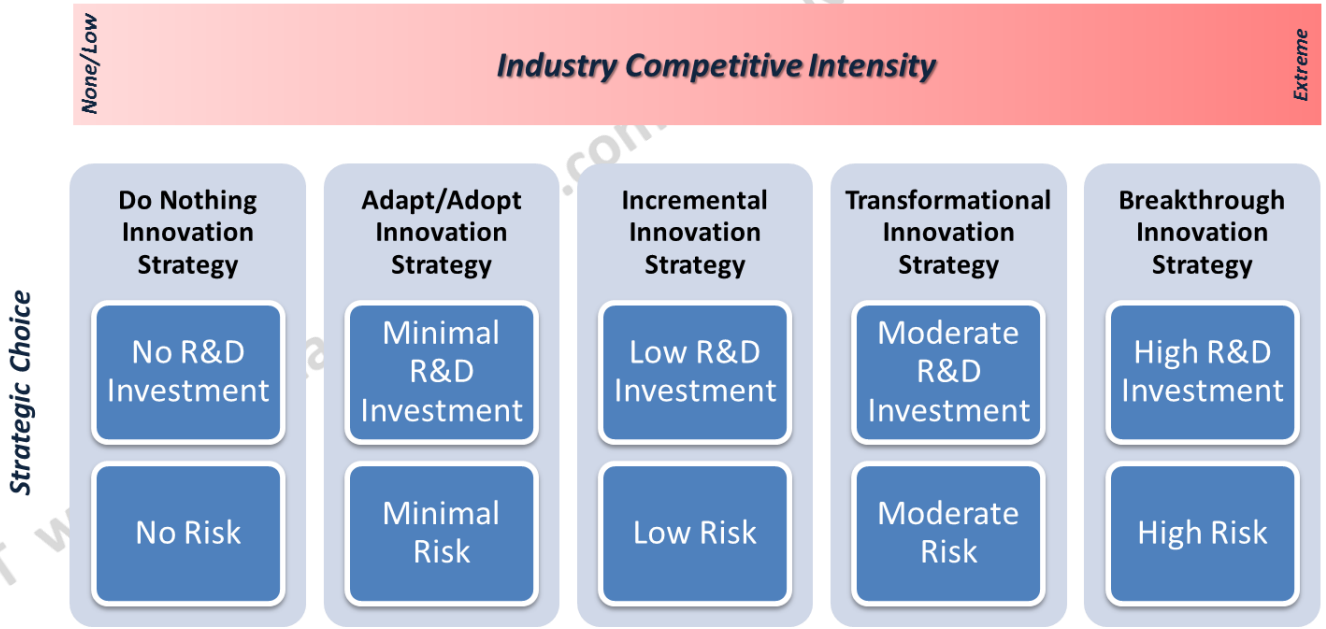
- "… there is **no free lunch**"
- Those who desire **large rewards** have to be willing to expose themselves to **considerable risk**
- The link between risk and return is **most visible when making investment choices**
  - Stocks are riskier than bonds, but generate higher returns over long periods. …

Risk and Innovation

- Many of our most durable and valuable inventions have come from a desire to either **remove risk or expose** ourselves **to it**
  - Consider again the example of the **spice trade**: The risks at sea and from hostile forces created a need for more seaworthy crafts and powerful weapons, innovations designed to exploit risk …
  - … at the same time, the first full-fledged examples of insurance and risk pooling showed up at about the same time in history

Dealing with Risk

Risk and Innovation (cont´d)



Risk Management

The Conventional View and its Limitations

- Many risk management offerings are really **risk reduction or hedging** products, with little or **no attention paid to exploiting risk**
  - In finance, especially, our definition of risk has been narrowed more and more over time to the point where we define risk statistically and think off it often as a negative when it comes to assessing value

1. The bulk of **risk management products are risk hedging products**, be they **insurance**, **derivatives** or **swaps**
   - Since these products generate substantial revenues for those offering them, it should come as no surprise that they become the centerpieces for the risk management story
2. **Human nature to remember losses** (the downside of risk) more **than profits** (the upside of risk)
3. The **separation of management from ownership** in most publicly traded firms creates a **potential conflict of interest** between what is good for the business (and it stockholders) and for the mangers
   - Managers decide how much and how to hedge risk, that risks that owners would never want hedged in the first place …

A More Expansive View of Risk Management

- Risk management **has to be more than risk hedging**
  - Businesses that are in a constant defense when it comes to risk are in no position to find risks that they are suited to take …

Why Do We Care About Risk?

The Duality of Risk

- In a world where people sky dive and bungee jump for pleasure, and gambling is a multi-billion dollar business, …
- … it is clear that human beings collectively are **sometimes attracted to risk** and that some are more susceptible to its attraction than others

- At the same time, though, there is **evidence that human beings try to avoid risk in both physical and financial pursuits**

I am Rich but am I Happy? Utility and Wealth

- While we can talk intuitively about risk and how human beings react to it, …
- … economists have used utility functions to capture how we react to at least economic risk

The St. Petersburg Paradox and Expected Utility: The Bernoulli Contribution

- I will **flip a coin** once and will pay you **a dollar** if the coin came up **tails** on the first flip …
- … and you will **double your winnings if** the coin came up **tails again**
- … whereby the experiment will **stop if** it came up **heads**
- **How much would you be willing to pay** to partake in this gamble?

I am Rich but am I Happy? Utility and Wealth (cont´d)

St. Petersburg Paradox

Number of Tails Before First Head	Probability	Payoff	Probability x Payoff
0	$(1/2)^1 = 1/2$	$2^0 = \$1$	\$0.50
1	$(1/2)^2 = 1/4$	\$2	\$0.50
2	$(1/2)^3 = 1/8$	\$4	\$0.50
3	$(1/2)^4 = 1/16$	\$8	\$0.50
4	$(1/2)^5 = 1/32$	\$16	\$0.50
n	$(1/2)^{n+1}$	$\$2^n$	\$0.50
Total $n \to \infty$	1.00		∞

Expected payoff infinity... Pretty good! Hmm. Really??

I am Rich but am I Happy? Utility and Wealth (cont´d)

The St. Petersburg Paradox and Expected Utility: The Bernoulli Contribution (cont´d)

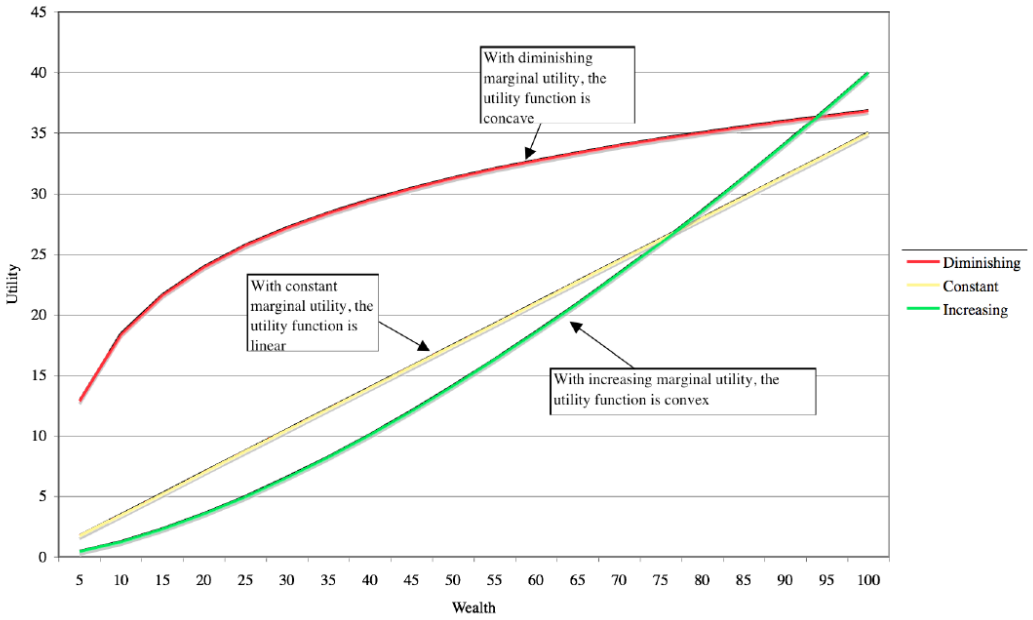
- This gamble, called the St. Petersburg Paradox, has an **expected value of infinity** but **most of us would pay only a few dollars** to play this game

- Bernoulli: "… the **value** of an item **must not be based upon its price**, **but** rather on the **utility** it yields
  - The **price** of the item is dependent only on the thing itself and is **equal for everyone**;
  - the **utility**, however, is **dependent on the particular circumstances** of the person making the estimate …

1. The **value** attached to this gamble would **vary across individuals**, …
   - … with **some** individuals willing to **pay more than others**, …
   - … with the **difference** a **function of their risk aversion**
2. The **utility from gaining** an additional dollar would **decrease with wealth** …
   - … "**one thousand ducats is more significant to a pauper than to a rich man** though both gain the same amount".

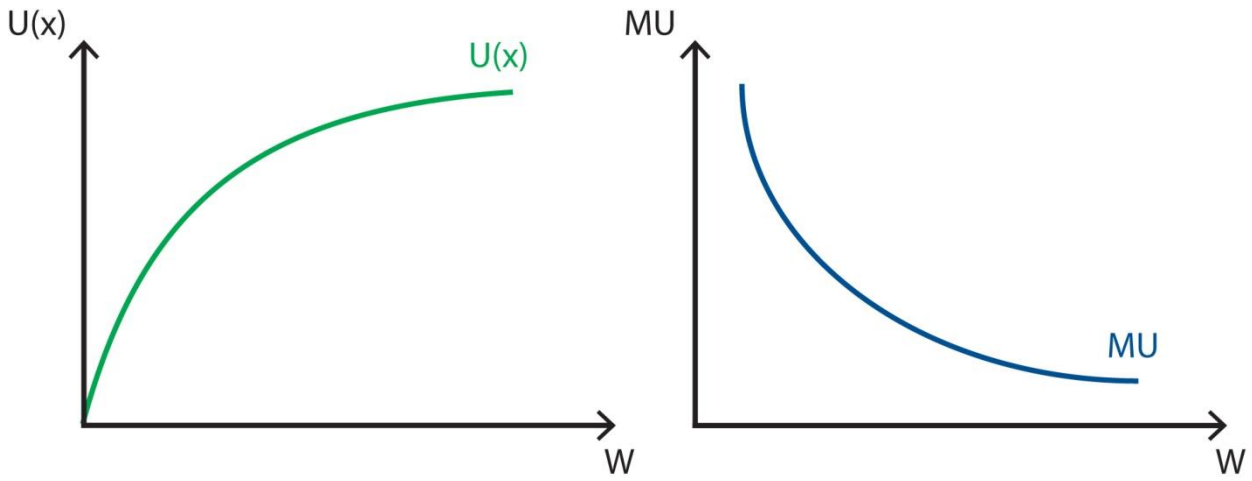
I am Rich but am I Happy? Utility and Wealth (cont´d)

The St. Petersburg Paradox and Expected Utility: The Bernoulli Contribution (cont´d)



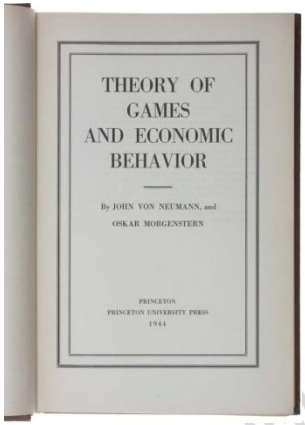
- If we accept the notion of diminishing marginal utility of wealth, it follows that **a person's utility will decrease more with a loss of $ 1 in wealth than it would increase with a gain of $ 1**

I am Rich but am I Happy? Utility and Wealth (cont´d)



I am Rich but am I Happy? Utility and Wealth (cont´d)

- **By extending the discussion from whether an individual should accept a gamble or not to how he or she should choose between different gambles, von Neumann and Morgenstern laid the foundations for modern portfolio theory and risk management**



Mathematics meets Economics: Von Neumann and Morgenstern

- Von Neumann and Morgenstern shifted the discussion of utility **from outcomes to probabilities**
  - What it would take an individual to partake a specific gamble, if presented with multiple gambles?

1. **Comparability** or Completeness: Alternative gambles or choices are comparable and individuals able to specify their preferences for each one

2. **Transitivity**: An individual prefers A to B and B to C, and therefore prefers A to C

3. **Independence**: The outcomes in each lottery or gamble are independent of each other
   - Essentially, we are assuming that the preference between two lotteries will be unaffected, if they are combined in the same way with a third lottery

4. **Measurability**: The probability of different outcomes within each gamble is measurable with a probability

5. **Ranking**: If an individual ranks outcomes B and C between A and D, the probabilities that would yield gambles on which he would be indifferent (between B and A&D and C and A&D) have to be consistent with the rankings

I am Rich but am I Happy? Utility and Wealth (cont´d)

Expected-Utility Axioms

(Von Neumann & Morgenstern,1947)

- Connectedness
  x>=y or y>=x
- Transitivity
  If x>=y and y>=z, then x>=z
- Substitution Axiom or Sure-thing principle
  If x>=y, then (x,p,z) >= (y,p,z) for all p and z

- If you "buy into" all axioms, then you will choose X over Y
  - if and only if EU(X) > EU(Y),

$$\text{where } EU(X) = \text{Sum}_{\text{over all } i}\{u(x_i)\,p(x_i)\}$$
$$\text{and } EU(Y) = \text{Sum}_{\text{over all } i}\{u(y_i)\,p(y_i)\}$$

- Choice 1: large apple vs. orange
- Choice 2: orange vs. small apple
- Choice 3: large apple vs. small apple

I am Rich but am I Happy? Utility and Wealth (cont´d)

- **… when a trader at a hedge fund puts the fund's money at risk in an investment where the potential payoffs clearly do not justify the price paid, he is gambling, as is a firm that invests money into an emerging market project with sub-par cash flows**

The Gambling Exception?

- Gambling, whether on long shots on the horse track or card tables at the casinos, **cannot be** easily **reconciled with** a world of **risk averse individuals**, such as those described by Bernoulli

1. A subset of "strange" **human beings gamble** and cannot be considered rational

2. An individual may be **risk averse over some segments** of wealth, become **risk loving over other** and revert back to being risk averse again

3. Gambling cannot be compared to other wealth seeking behavior because individuals **enjoy gambling for its own sake** and that they are willing to accept the loss in wealth for the excitement that comes from rolling the dice

4. **Behavioral quirks** that seem to be systematic**?**
   - **Individuals seem to routinely over estimate their own skills** and the probabilities of success when playing risky games …

I am Rich but am I Happy? Utility and Wealth (cont´d)

- **It may follow that there can be no unified theory of risk management, since how we deal with risk will depend upon how large we perceive the impact of the risk to be**

Small versus Large Gambles

- You are offered a choice between getting **$ 10 with certainty** …
- … or a gamble, where you will make **$21 with 50% probability** and nothing the rest of the time;
  - The expected value of the gamble is $10.50
- Which one would you pick?

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  - The expected value of the gamble is $10,500
- Which one would you pick?

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- With conventional expected utility theory - where investors are risk averse and the utility function is concave - you would **reject the first gamble**, and you **should reject the second one as well**

- **But**: **Large companies may choose not to hedge risks that smaller companies protect themselves** against, and …
- … the same business may hedge against risks with large potential impact while letting smaller risks pass through to their investors

Measuring Risk Aversion

- If we accept **Bernoulli's proposition** that it is **utility** that **matters** and not wealth per se, and we add the **reality** that **no two human beings are alike**, …
- … it follows that **risk aversion can vary widely across individuals**

Certainty Equivalents

- A **risk-neutral individual** will be willing to **accept a fair bet**

- **The price that an individual is willing to pay for a bet where there is uncertainty and an expected value is called** the certainty equivalent value

- Many **experiments in risk aversion** have been based upon making subjects **choose between risky gambles and guaranteed outcomes**, …
- … and using the choices to measure how their risk aversion

- **Most risk hedging products** - such as insurance and derivatives - **offer** their users a **certain cost** (the insurance premium, the price of the derivative) in exchange **for** an **uncertain cost** (the expected cost of a natural disaster or movement in exchange rates) and that a **significant subset of investors choose the certain equivalent**

Measuring Risk Aversion (cont´d)

Risk Aversion Coefficients

- Economists want more precision in risk measures to develop models for dealing with risk
  - Risk aversion coefficients represent natural extensions of the utility function

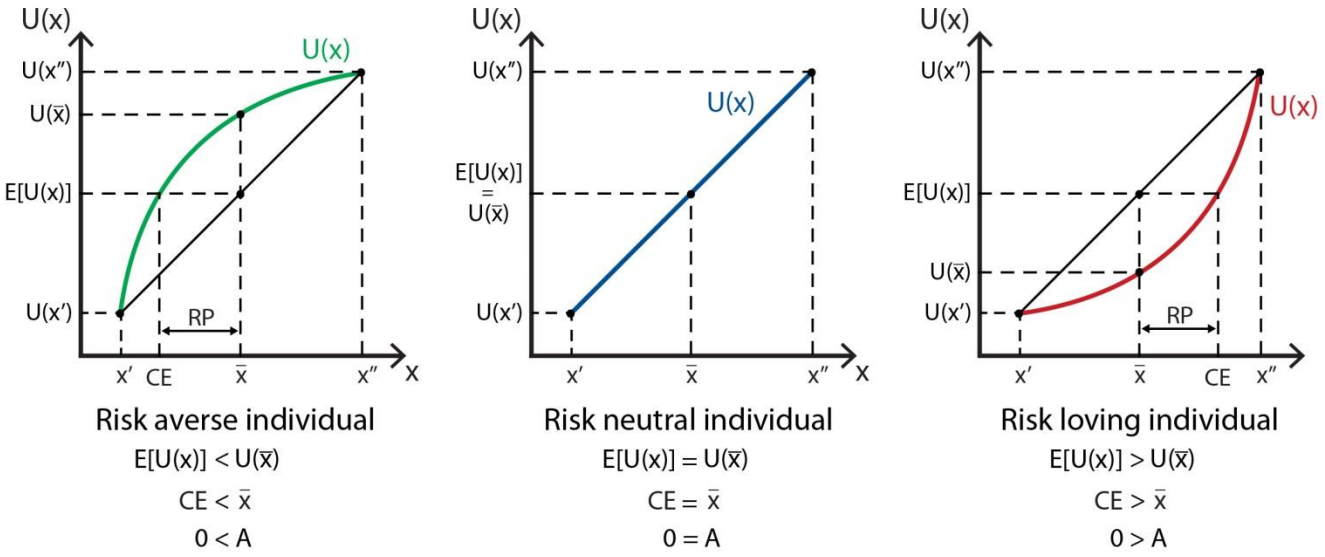
- The risk aversion coefficient measures **how much utility we gain (or lose) as we add (or subtract) from our wealth**

- Pratt and Arrow proposed to look at the second derivative of the utility function
  - This measures how the change in utility (as wealth changes) itself changes as a function of wealth level, and divide it by the first derivative to arrive at a risk aversion coefficient
  - This number will be **positive for risk-averse investors** and **increase with the degree of risk aversion**

$$\text{Arrow-Pratt Absolute Risk Aversion} = - U''(W)/U'(W)$$

  - The advantage of this formulation is that it can be compared across different individuals with different utility functions to draw conclusions about differences in risk aversion across people

Measuring Risk Aversion (cont´d)



Certainty Equivalent $CE \rightarrow U(CE) = E[U(x)]$

Risk Premium RP

Measuring Risk Aversion (cont´d)

Other Views on Risk Aversion

- In the last few decades, there have been some attempts by researchers, who have been unconvinced by conventional utility theory …
- … or have been under whelmed by the empirical support for it, to come up with alternative ways of explaining risk aversion

The Allais Paradox

- **P1**: $ 100 with certainty
- **P2**: $0 with 1% chance, $100 with 89% chance, $500 with 10% chance
- Most individuals, given a choice, picked P1 over P2, which is consistent with risk aversion.
- **Q1**: $0 with 89% chance and $100 with 11% chance
- **Q2**: $0 with 90% chance and $500 with 10% chance
- **Mathematically**, it can be shown that an individual who picks P1 over P2 should pick Q1 over Q2 as well
- **In reality** Allais noted that most individuals switched, picking **Q2 over Q1**

- Allais also noted what he called **the common ratio effect**
- Given a choice between a 25% probability of making $ 8,000 and a 20% probability of making $ 10,000, Allais noted that most individuals chose the latter, in direct contradiction of the dictums of expected utility theory

- Both of the propositions presented by Allais suggest that the **independence axiom** on which expected utility theory is built **may be flawed**

Measuring Risk Aversion (cont´d)

Other Views on Risk Aversion (cont´d)

Expected Utility Responses

- Loomes and Sugden **relaxed** the **transitivity axiom** in the conventional expected utility framework to develop what they called regret theory
- Premise that individuals compare the outcomes they obtain within a given gamble …
- … and are disappointed when the outcome diverges unfavorably from what they might have had
- Thus, **large differences between (i) what you get from a chosen action and (ii) what you could have received from an alternate action give rise to disproportionately large regrets**
- The net **effect** is that you can **observe actions** that are **inconsistent with** conventional expected **utility theory**

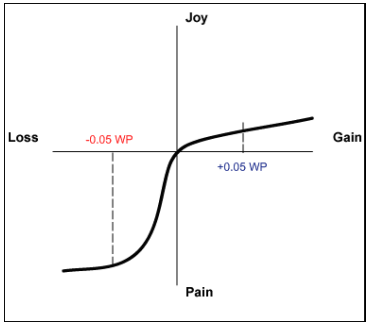
- Meaning
  - Emotional reaction to having made an error of judgment.
  - Investors avoid selling stocks that have gone down in order to avoid the regret of having made a bad investment and the embarrassment of reporting the loss.
  - They find it easier to follow the crowd and buy a popular stock : if it subsequently goes down ,it can be rationalized as everyone else owned it.

Measuring Risk Aversion (cont´d)

Prospect Theory

– Psychologists defined a prospect theory based on some well observed **deviations from rationality**

1. **Framing**: Decisions often seem to be affected by how choices are framed, rather than the choices themselves
   - We **buy more of a product when it is sold at 20% off a list price** of $2.50 than when it sold for a list price of $2.00
2. **Nonlinear preferences**: If an individual prefers A to B, B to C, and then C to A, the standard preference theory (transitivity) is violated
3. **Risk aversion** and risk seeking: Individuals often simultaneously exhibit risk aversion in some of their actions while seeking out risk in others
4. **Source**: The mechanism through which information is delivered may matter, even if the product or service is identical
   - People will pay more for a good, based upon how it is packaged
5. **Loss Aversion**: Individuals seem to fell more pain from losses than from equivalent gains



Consequences of Views on Risk

Investment Choices

- Asset Allocation
- Asset Selection
- Performance Evaluation

Corporate Finance

- Investment Decisions
- Financing Decisions
- Dividend Decisions

What Do We Think About Risk?

Experimental Findings

Extent of Risk Aversion

1. There seems to be clear evidence that human beings collectively are **risk averse** and that they get **more so as the stakes become larger**
2. There is also evidence of **significant differences** in risk aversion **across individuals**, with some showing no signs of risk aversion and some even seeking out risk

Differences across different gambles/settings

- Lotteries versus Auctions
  - Subjects who were only **slightly risk averse** or even risk neutral **in lottery** choices became much **more risk averse in bargaining games** and in interactive auctions
  - Interpersonal dynamics may play a role in determining risk aversion
- Institutional setup
  - The same set of subjects went from being **risk-loving in domestic auctions** to **risk averse in foreign auctions**
- Information effects
  - Can risk aversion be affected by providing more information about possible outcomes in an experiment?
  - There is a tendency of human beings to be **more sensitive to losses** than equivalent gains and to become more so **as** they **evaluate outcomes more frequently**

Experimental Findings (cont´d)

Risk Aversion Differences across sub-groups

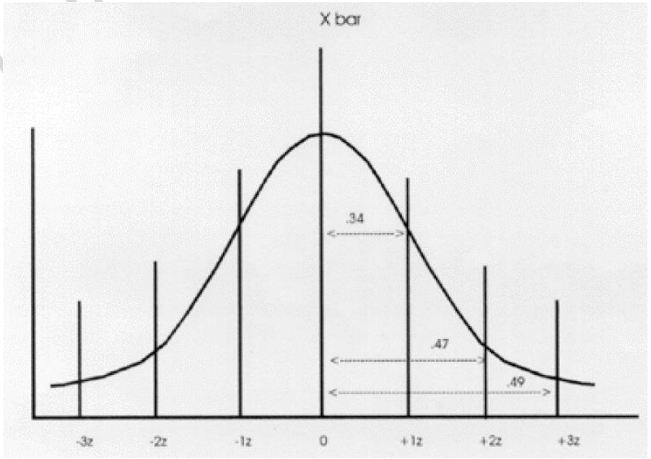
- Male versus Female
  - There seems to be some evidence that women, in general, are more risk averse than men, …
  - … though the extent of the difference and the reasons for differences are still debated
- Naïve versus Experienced
  - Does experience with an asset class make one more or less risk averse?
  - In experiments “naïve” were more risk averse than the experts
- Young versus Old
  - Risk aversion increases as we age
- Racial and Cultural Differences
  - Human beings have a lot more in common when it comes to risk aversion than they have as differences
  - Found no race-based differences in risk aversion

How Do We Measure Risk?

Estimating Probabilities: First Step to Quantifying Risk

From Pascal´s Triangle to the Normal Distribution …

1
1 1
1 2 1
1 3 3 1
1 4 6 4 1
1 5 10 10 5 1
1 6 15 20 15 6 1
… … … … … … …



Estimating Probabilities: First Step to Quantifying Risk (cont´d)

The Insurance View of Risk

- Since insurers are **concerned** primarily **about losses** (and covering those losses), insurance measures of risk are almost always focused on the **downside**
- Thus, a company that insures merchant ships will **measure risk in** terms of the **likelihood** of ships and cargo being damaged and the **loss** that **accrues** from the damage
- The potential for **upside** that exists has little or **no relevance** to the insurer since he does not share in it

Financial Assets and the Advent of Statistical Risk Measures

- There was little access to information and few ways of processing even that **limited information** in the 18th & 19th centuries
  - One way was to treat entire groups of investments as sharing the same risk level
  - The other was to categorize investments based upon how much information was available
- By the early 20th century, services were already starting to **collect** return and price **data** on individual securities
- in 1934, **Ben Graham** argued **against** measures of **risk based upon past prices** (such as **volatility**), whereby **price declines** can be **temporary** and not reflective of a company's true value

The Markowitz Revolution

Efficient Portfolios

- Create a process by which investors could generate **optimally diversified portfolios**, i.e., portfolios that would **maximize returns for any given level of risk** (or minimize risk for any given level of return)

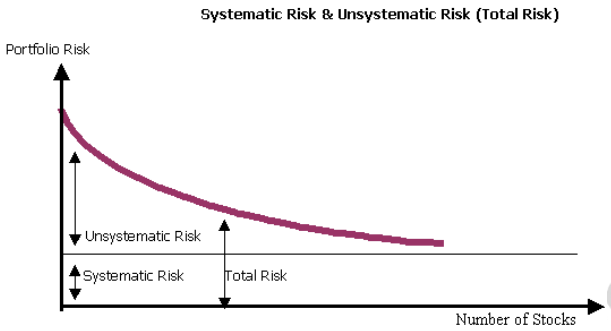
The Mean-Variance Framework

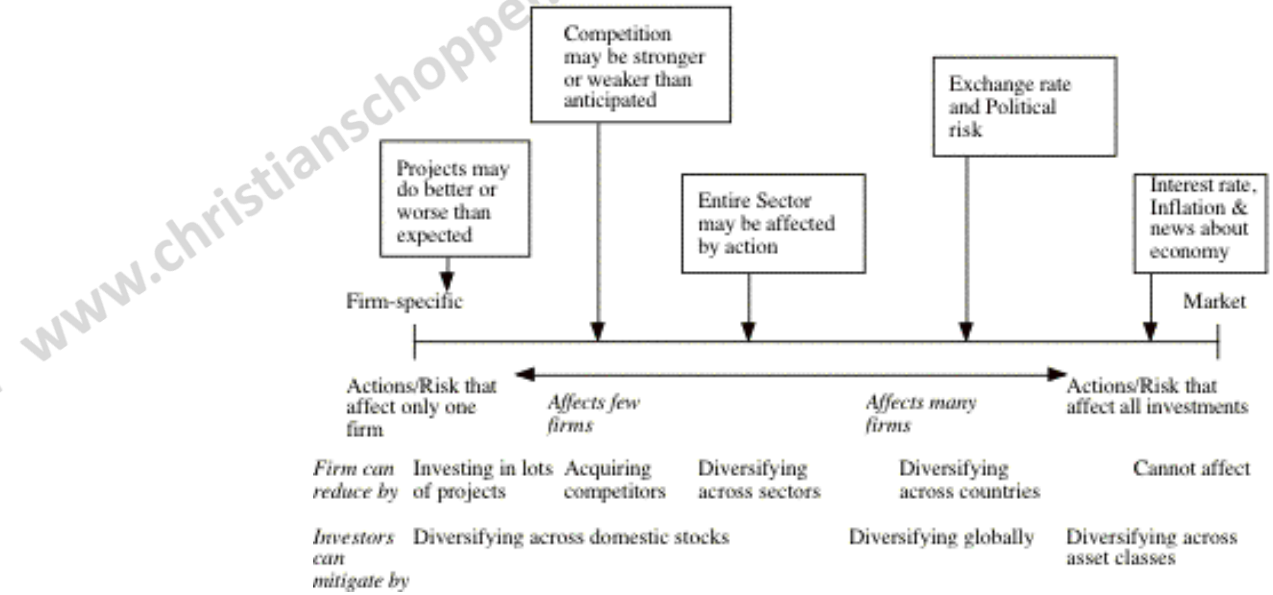
- Investor choices limited to two dimensions: The **"good" dimension** is captured in the expected return on an investment and the **"bad" dimension** is the variance or volatility in that return

Implications for Risk Assessment

- The **argument for diversification** becomes irrefutable
- In general, the **risk of an asset** can be **measured by** the **risk it adds** on to the portfolio that it becomes part of and in particular**, by how much it increases** the **variance of the portfolio** to which it is added
- The **other parameters** of an investment, such as the potential for large payoffs and the likelihood of price jumps, become **irrelevant once** they have been **factored into** the **variance** computation

The Markowitz Revolution (cont´d)





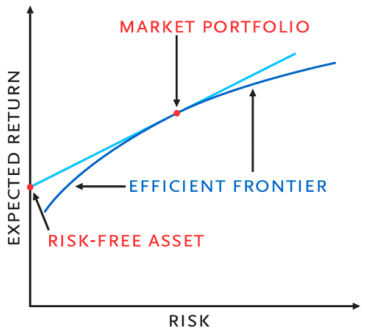
The Capital Asset Pricing Model (CAPM)

- Sharpe and Linter **added a riskless asset** to the mix and concluded that there existed a superior alternative to investors at every risk level, created by combining the riskless asset with one specific portfolio on the efficient frontier

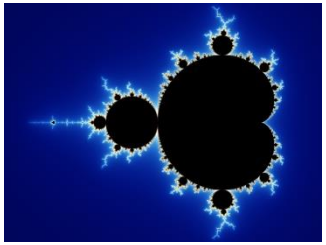
- In **addition**, the model assumed that all investors shared a **single period time horizon** and that they could **borrow** and invest **at the risk-free rate**

- The risk of an individual asset becomes the risk added on to the market portfolio and can be measured statistically as follows

$$\text{Risk of an asset} = \frac{\text{Covariance of asset with the market portfolio}}{\text{Variance of the mar: ket portfolio}} = \text{Asset Beta}$$



Mean Variance Challenged

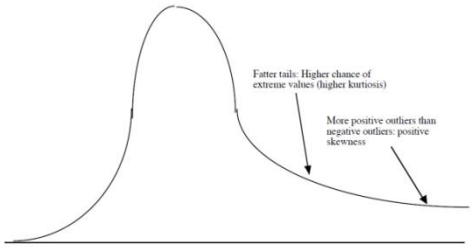


Fat Tails and Power Law Distributions

- Benoit **Mandelbrot**, a mathematician who also did pioneering work on the behavior of stock prices, was one of those who took issue with the use of normal and lognormal distributions
- In practical terms, the power law proponents argue that using measures such as **volatility** (and its derivatives such as beta) **under-estimate the risk** of large movements

Asymmetric Distributions

- **Intuitively**, it should be **downside** risk **that concerns** us and not upside risk
- In other words, it is not investments that go up significantly that create heartburn and unease but investments that go down significantly



Data Power: Arbitrage Pricing and Multi-Factor Models

Arbitrage Pricing Model

$$R_i = \alpha_i + \gamma_{i1}F_1 + \gamma_{i2}F_2 + \ldots + \gamma_{ij}F_j + \ldots + \gamma_{in} + \varepsilon_i$$

where R_i = return on stock i

α_i is the expected return on stock I if all factors have a value of zero.

F_j is the value of jth factor which influences the return on stock I

γ_{ij} is the sensitivity of stock I's return to the jth factor

ε_i is a random error term

- **Replaces** the **single market risk factor in the CAPM** (captured by the market portfolio) with **multiple market risk factors**, …
- … and the single market beta in the CAPM (which measures risk added by an individual asset to the market portfolio) with multiple factor betas (measuring an asset's exposure to each of the individual market risk factors)
- More importantly, the arbitrage pricing model does **not make** restrictive **assumptions about investor utility** functions **or** the **return distributions** of assets
- The **tradeoff**, though, is that the arbitrage pricing model does **depend** heavily **on historical price data**

Multi-factor and Proxy Models

- While arbitrage pricing models restrict themselves to historical price data, multifactor models expand the data used to **include macro-economic data,** in some versions and **even firm-specific data** (such as market capitalization and pricing ratios) in others

Data Power: Arbitrage Pricing and Multi-Factor Models (cont´d)

DEFINITION OF 'ARBITRAGE PRICING THEORY - APT'

An asset pricing model based on the idea that an asset's returns can be predicted using the relationship between that same asset and many common risk factors. Created in 1976 by Stephen Ross, this theory predicts a relationship between the returns of a portfolio and the returns of a single asset through a linear combination of many independent macro-economic variables.

DEFINITION OF 'MULTI-FACTOR MODEL'

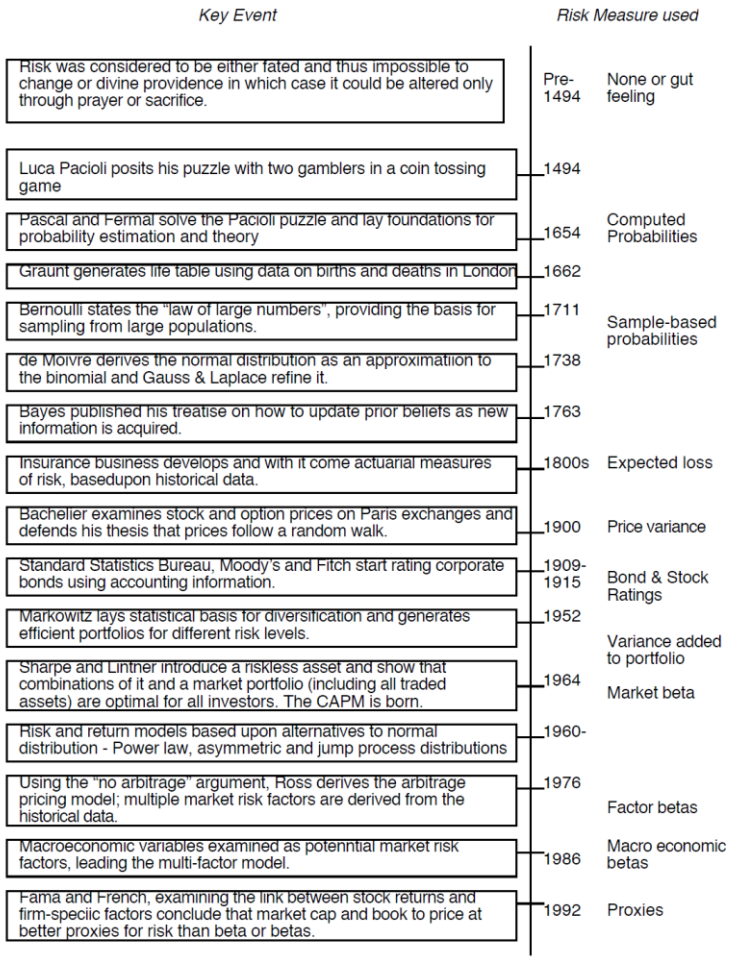
A financial model that employs multiple factors in its computations to explain market phenomena and/or equilibrium asset prices. The multi-factor model can be used to explain either an individual security or a portfolio of securities. It will do this by comparing two or more factors to analyze relationships between variables and the security's resulting performance.

Factors are compared using the following formula:

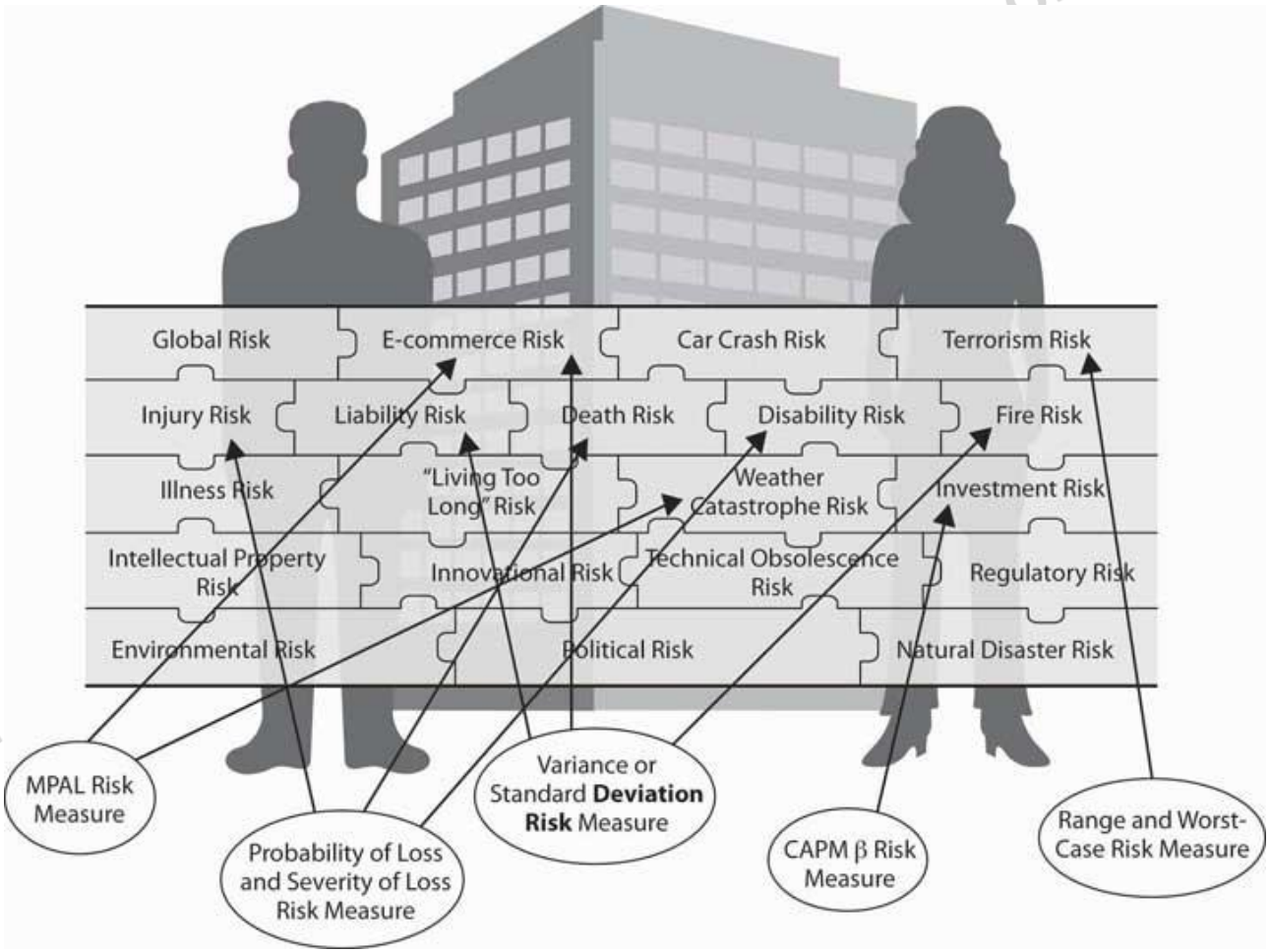
$$Ri = ai + \beta i(m)\, Rm + \beta i(1)F1 + \beta i(2)F2 + \ldots + \beta i(N)FN + ei$$

Where:
Ri is the returns of security i
Rm is the market return
F(1,2,3...N) is each of the factors used
β is the beta with respect to each factor including the market (m)
e is the error term
a is the intercept

The Evolution of Risk Measures



Risk Measures and the Company



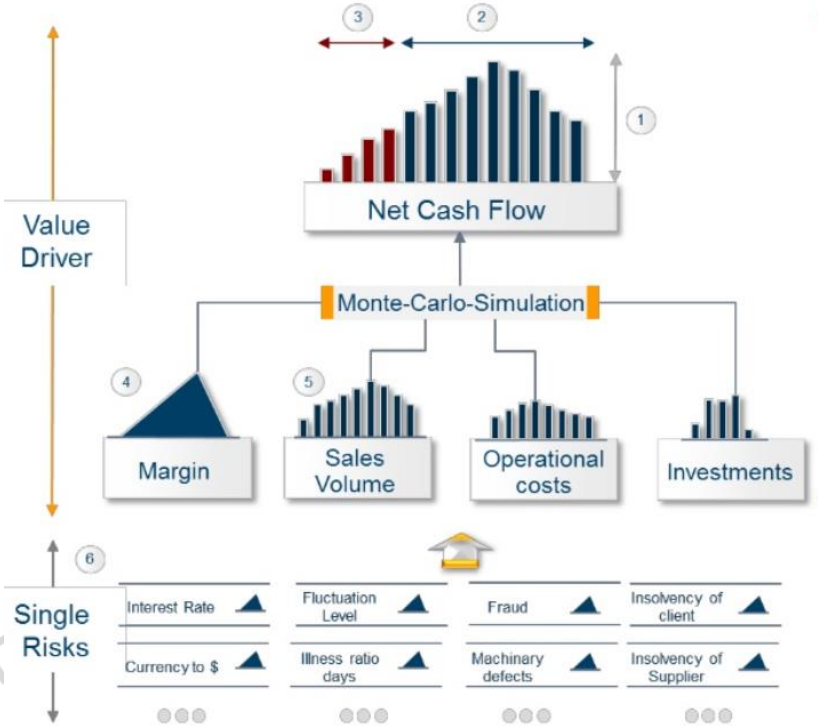
Risk Adjusted Value

Risk Adjusted Value

Conceptionally, **incorporate** the effect of **risk into estimates of asset value**

1. Estimate a **risk-adjusted discount rate**, relying on a risk and return model which measures risk and converts it into a risk premium
2. Discount **uncertain expected cash flows** to reflect the uncertainty
3. (**??**) **Further discount** the estimated value of an asset **for** those **risks** that are believed to have **not** been **incorporated** into the discount rate or the cash flows
4. **Use the market pricing of assets of similar risk** to estimate the value for a risky asset
   - The difficulty of finding assets that have similar risk exposure leads to approximate solutions such as using other companies in the same business as the company being valued

Risk Adjusted Value Driver Model



- The result of the Monte-Carlo-Simulations are **distributions** and **statistcial measures** like expectation values. This complex visualization of results enables Analysts to generate **additional insights**
  1. (1) Next to the expected value, the distribution also explains the **probability** of different scenarios. Each of the single bars in the distribution can be viewed as one **consistent what-if-scenario**
  2. (2) The width of one distribution visualizes the **degree of uncertainty** and therefore can direct **management attention** to areas with high relevance
  3. (3) **Alternative statistical measures like Value@Risk can be added into the visualization**

- The final KPI-Distribution is calculated by aggregating the value driver and risks
  1. (4) For driver / risks with low estimated deviation **simple estimation techniques** can be used (e. g. Triangle-Estimations)
  2. (5) For driver/risks with high uncertainty a **deeper** (e. g. history-based) **Analysis** of the risk might be adequate
  3. (6) For **complex risiks,** statistical estimations like e. g. regression analysis or fitting proxies might be useful

Types and Adjustments of Risks

Type of Risk	*Examples*	*Risk adjustment in valuation*
Continuous market risk where buying protection against consequences is difficult or impossible to do	Interest rate risk, inflation risk, exposure to economic cyclicality	Adjust discount rate for risk
Discontinuous market risk, with small likelihood of occurrence but large economic consequences	Political risk, Risk of expropriation, Terrorism risk	If insurance markets exist, include cost of insurance as operating expense and adjust cash flows. If not, adjust the discount rate.
Market risk that is contingent on a specific occurrence	Commodity price risk	Estimate cost of option required to hedge against risk, include as operating expense and adjust cash flows.
Firm specific risks	Estimation risk, Competitive risk,	If investors in the firm are diversified, no risk
	Technology risk	adjustment needed. If investors not diversified, follow the same rules used for market risk.

Probabilistic Approaches

Scenario Analysis

- Best Case/ Worse Case
- Multiple Scenario Analysis

Steps in Scenario Analysis

1. Determination of which **factors** the scenarios will be built around
2. Determining the **number of scenarios** to analyze for each factor
3. Estimation of **asset cash flows under each scenario**
4. Assignment of **probabilities** to each scenario

Issues

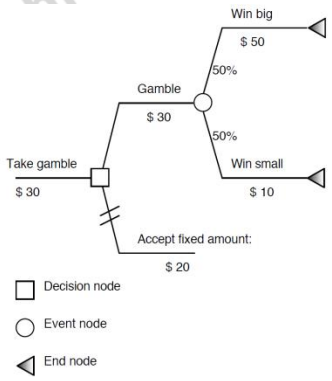
- **Garbage** in, garbage out
- Continuous risk
  - When the **outcomes** can take on any of a **very large number** of potential values or the risk is continuous, it becomes more difficult to set up scenarios
- **Double counting** of risk

Decision Trees

- In some projects and assets, **risk is** not only discrete but is **sequential**

Steps in Decision Tree Analysis

1. Divide analysis into **risk phases**
2. In each phase, **estimate** the **probabilities** of the outcomes
3. Define **decision points**
4. Compute cash flows/value at end nodes
5. F**olding back** the tree



Use in Decision Making

- **Dynamic response** to risk
  - … by linking actions and choices to outcomes of uncertain events
- **Value of information**
- Risk Management
  - Since decision trees provide a **picture of how cash flows unfold over time**, they are useful in deciding what risks should be protected against and the benefits of doing so

Issues

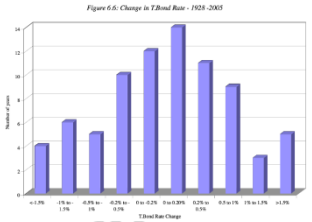
- As with scenario analysis, decision trees generally look at risk in terms of **discrete outcomes**
- Faced with estimation questions to which there may be no easy answers

Simulations

- A way of **examining the consequences of continuous risk**

Steps in Simulation

1. Determine **"probabilistic" variables**
2. Define **probability distributions** for these variables



3. Check for **correlation** across variables
4. Run the **simulation**
   - Number of probabilistic inputs
   - Characteristics of probability distributions
   - Range of outcomes

Use in decision making

- Better input estimation
- It yields a **distribution for expected value** rather than a point estimate

Issues

- **Garbage** in, garbage out
- Real **data** may not fit distributions
- Non-stationary distributions
- **Changing correlation** across inputs

Comparing the Approaches

Selective versus Full Risk Analysis

- In the **best-case/worst-case** scenario analysis, we look at **only three scenarios**
- With **decision trees and simulations**, we attempt to consider **all possible outcomes**
  - Put in terms of probability, the sum of the probabilities of the scenarios we examine in scenario analysis can be less than one, whereas the sum of the probabilities of outcomes in decision trees and simulations has to equal one

Type of Risk

- **Scenario analysis** and **decision trees** are generally built around **discrete outcomes** in risky events whereas simulations are better suited for **continuous risks**
- Focusing on just scenario analysis and decision trees, the latter are better suited for **sequential risks**

Correlation across Risks

Discrete/Continuous	*Correlated/Independent*	*Sequential/Concurrent*	*Risk Approach*
Discrete	Independent	Sequential	Decision Tree
Discrete	Correlated	Concurrent	Scenario Analysis
Continuous	Either	Either	Simulations

Comparing the Approaches (cont´d)

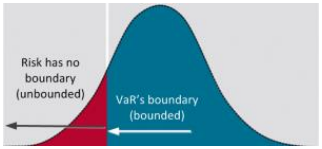
- In the most **extreme** form of **scenario analysis**, you look at the value in the **best case and worst case scenarios** and **contrast** them **with** the **expected value**
  - In its more general form, you estimate the value under a small number of likely scenarios, ranging from optimistic to pessimistic

- **Decision trees** are designed for **sequential** and **discrete** risks, where the risk in an investment is considered into **phases** and the risk in each phase is captured in the possible outcomes and the probabilities that they will occur
  - A decision tree provides a complete assessment of risk and can be used to determine the optimal courses of action at each phase and an expected value for an asset today

- **Simulations** provide the most complete assessments of risk since they are based upon **probability distributions for each input** (rather than a single expected value or just discrete outcomes)
  - The **output** from a simulation takes the form of an **expected value across simulations and a distribution for the simulated values**

Value at Risk

What is Value at Risk



- **What is the most I can lose** on this investment?
- In its most general form, the Value at Risk measures the potential loss in value of a risky asset

Key aspects

1. Estimate the **probability of the loss**, with a **confidence interval**
   - Define the probability distributions of individual risks, the correlation across these risks and the effect of such risks on value
2. Focus in VaR is clearly on **downside risk** and potential losses
   - Its use in banks reflects their fear of a liquidity crisis, where a low-probability catastrophic occurrence creates a loss that wipes out the capital and creates a client exodus
3. There are three **key elements** of VaR
   - Specified **level of loss in value**
   - A fixed **time** period over which risk is assessed and
   - A **confidence interval**
4. While the VaR at investment banks is specified in terms of market risks – interest rate changes, equity market volatility and economic growth – there is no reason why the risks cannot be defined more broadly or narrowly

Value at Risk - Conclusion

- Value at Risk has developed as a risk assessment tool at banks and other financial service firms in the last decade
  - Its usage in these firms has been driven by the failure of the risk tracking systems used until the early 1990s to detect dangerous risk taking on the part of traders and it offered a key benefit: a measure of capital at risk under extreme conditions in trading portfolios that could be updated on a regular basis

- While the notion of Value at Risk is simple, there are **three ways in which Value at Risk can be measured**

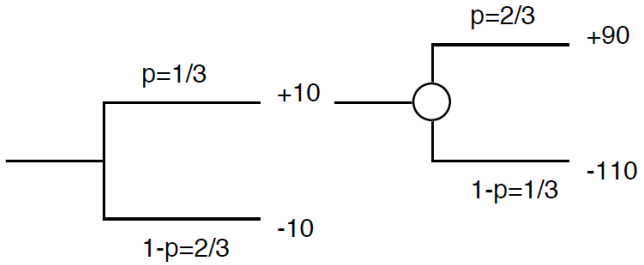
1. We assume that the returns generated by **exposure to multiple market risks** are **normally distributed**
   - Use a variance-covariance matrix of all standardized instruments representing various market risks to estimate the standard deviation in portfolio returns and compute the Value at Risk from this standard deviation
2. **Run a portfolio through historical data** – a historical simulation – and **estimate** the **probability that** the **losses exceed specified values**
3. **Assume return distributions for each** of the **individual market risks and run Monte Carlo** simulations to arrive at the Value at Risk

- The Variance-covariance approach is simple to implement but the normality assumption can be tough to sustain,…
- … historical simulations assume that the past time periods used are representative of the future …
- … and Monte Carlo simulations are time and computation intensive

Real Options

The Essence of Real Options

- In essence, the value of real options stems from the fact that when investing in risky assets, we can **learn from** observing **what happens** in the real world **and adapting** our **behavior** to increase our potential upside from the investment and to decrease the possible downside



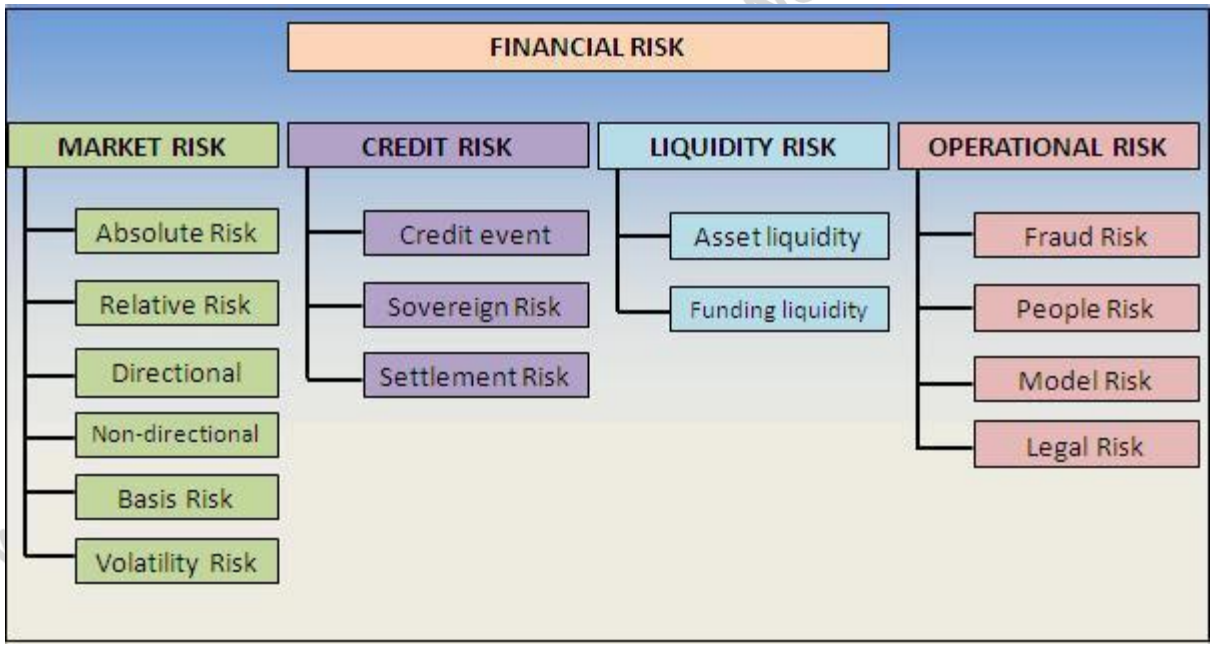
Three **potential actions**

- Option to move on
- Option to abandon
- Option to delay or wait

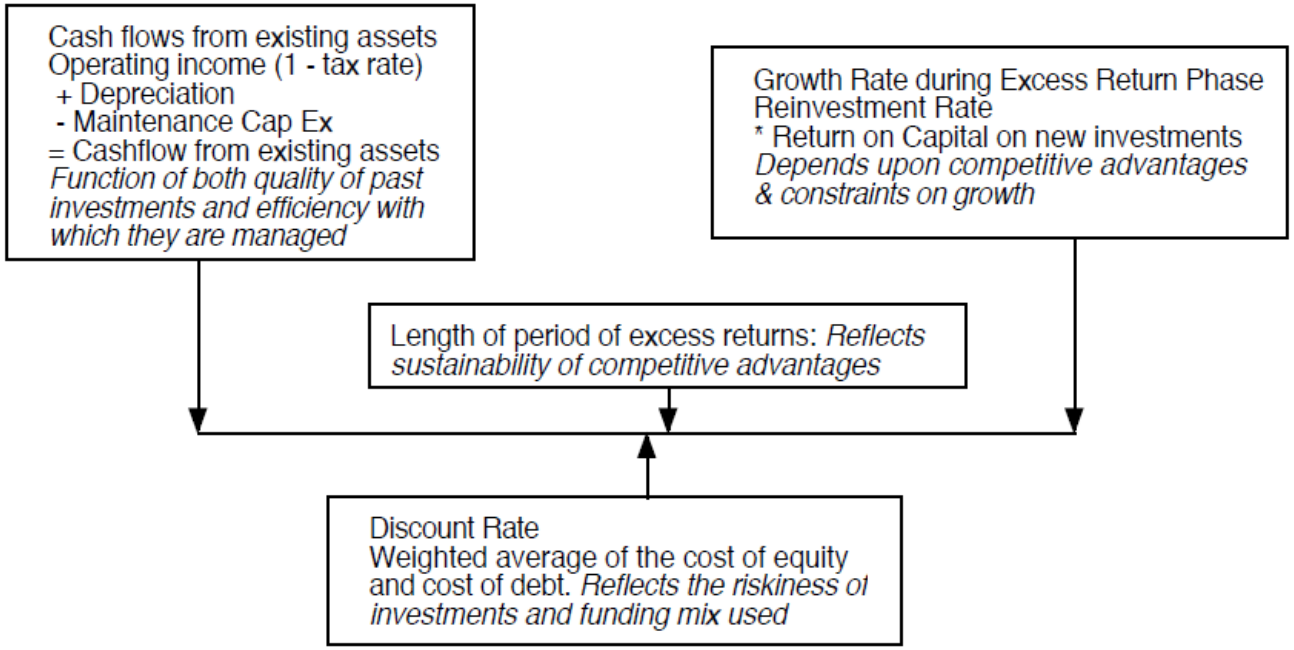
- The **value of learning is greatest**, though, especially **when** the owner and only the owner has access to that learning and can act on it: The **condition of "exclusivity**"

Risk Management – The Big Picture

Financial Risk



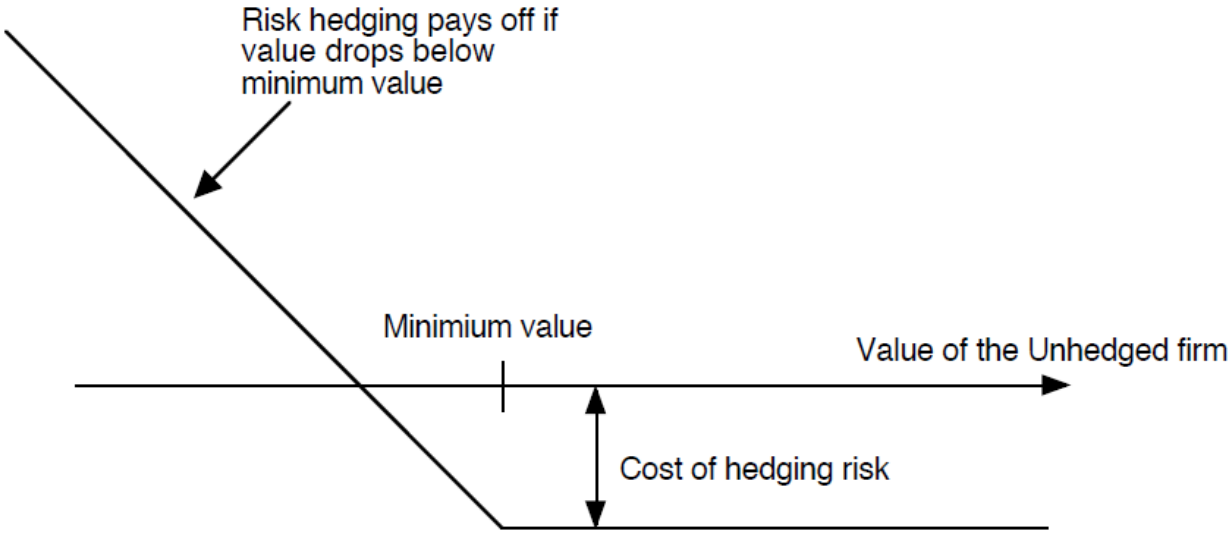
Determinants of Value



Risk Hedging, Risk Management and Value

Valuation Component	*Effect of Risk Hedging*	*Effect of Risk Management*
Costs of equity and capital	Reduce cost of equity for private and closely held firms. Reduce cost of debt for heavily levered firms with significant distress risk	May increase costs of equity and capital, if a firm increases its exposure to risks where it feels it has a differential advantage.
Cash flow to the Firm	Cost of risk hedging will reduce earnings. Smoothing out earnings may reduce taxes paid over time.	More effective risk management may increase operating margins and increase cash flows.
Expected Growth rate during high growth period	Reducing risk exposure may make managers more comfortable taking risky (and good) investments. Increase in reinvestment rate will increase growth.	Exploiting opportunities created by risk will allow the firm to earn a higher return on capital on its new investments.
Length of high growth period	No effect	Strategic risk management can be a long-term competitive advantage and increase length of growth period.

Payoff Diagram for Risk Hedging



Payoff to Risk Hedging

Marginal investor is	*Risk being reduced is*	*Market risk protection exists*	*Firm is highly leveraged*	*Effect on cash flows*	*Effect on growth*	*Effect on discount rate*	*Effect on value*
Diversified	Firm specific risk	Yes	No	Negative (Cost of risk reduction)	None	None	Negative
Diversified	Firm specific risk	No	Yes	Negative	None	May reduce (lower cost of debt and capital)	Neutral to negative
Diversified	Market risk	Yes	No	Negative	None	Reduce	Neutral to negative
Diversified	Market risk	No	Yes	Negative	None	Reduce	Neutral to positive
Not diversified	Firm specific risk	Yes	No	Negative		Reduce	Neutral
Not diversified	Firm specific risk	No	Yes	Negative	Positive	Reduce	Neutral to positive
Not diversified	Market risk	Yes	No	Negative	None	Reduce	Neutral to positive
Not diversified	Market risk	No	Yes	Negative	Positive	Reduce	Positive

When does Risk Management Pay Off?

- Risk management is an **integral part of doing business**
  - Effective risk management **is more about strategic than financial choices** and will show up in value as higher and more sustainable excess returns

The **benefits** of risk management, though, are likely to be **greatest** in businesses with the following characteristics:

High volatility

- The greater the range of firm specific risks that a firm is exposed to, the greater the potential for risk management
  - After all, it is the uncertainty about the future that is being exploited to advantage

Strong barriers to entry

- Since the payoff to risk management shows up as higher returns, it is likely to **create more value when new entrants can be kept out of the business** either because of infrastructure needs (aerospace, automobiles) and legal constraints such as patents or regulation (pharmaceuticals and financial service firms)

Risk Hedging versus Risk Management

	Risk hedging	*Risk management*
View of risk	Risk is a danger	Risk is a danger and an opportunity.
Objective	To protect against the downside of risk	To exploit the upside created by uncertainty.
Functional emphasis	Financial	Strategic, stretching across all functions.
Process	Product oriented. Primarily focused on the use of derivatives and insurance to hedge against risks.	Process oriented. Identify key risk dimensions and try to develop better ways of handling and taking advantage of these risks than the competition.
Measure of success	Reduce volatility in earnings, cash flows or value.	Higher value
Type of real option	Put option (Insurance against bad outcomes)	Call option (Taking advantage of high volatility to create good outcomes)
Primary Effect on value	Lower discount rate	Higher and more sustainable excess returns.
Likely to make sense for	Closely held and private firms or publicly traded firms with high financial leverage and substantial distress costs.	Firms in volatile businesses with significant potential for excess returns (if successful).

Developing a Risk Management Strategy

1. *Make an **inventory of possible risks***
   - This will include risk that are specific to the firm, risks that affect the entire sector and macroeconomic risks that have an influence on the value

2. *Decide whether to **hedge or not to hedge***
   - Decide which risks it will attempt to hedge and which ones it will allow to flow through to its investors
   - The size of the firm, the type of stockholders that it has and its financial leverage (exposure to distress) will all play a role in making this decision.

3. ***Choose risk hedging products***
   - Market traded (currency and interest rate derivatives, for example), customized solutions (prepared by investment banks to hedge against risk that may be unique to the firm) and some are insurance products

4. ***Determine the risk or risks that you understand better** or deal with better than your competitors*
   - This is the step where the firm moves from risk hedging to risk management and from viewing risk as a threat to risk as a potential opportunity
   - Why would one firm be better at dealing with certain kinds of risk than its competitors?

5. ***Devise strategies to take advantage** of your differential advantage in the long te*rm
   - Firms builds on its competitive edge and lays out what they will do to create the maximum benefit

Risk Management: Profiling and Hedging

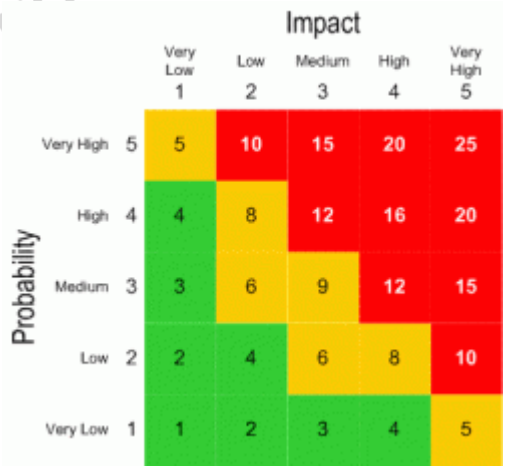
Risk Profile

1. A **listing** of risks

2. **Categorize** the risks
   - Market versus Firm-specific risk
   - Operating versus Financial Risk
   - Continuous Risks versus Event Risk
   - Catastrophic risk versus Smaller risks

3. **Measure** exposure to each risk
   - Earnings versus Value Risk Exposure
   - Measuring Risk Exposure
   - Qualitative approaches
   - Quantitative approaches

4. Risk **analysis**



To Hedge or Not to Hedge?

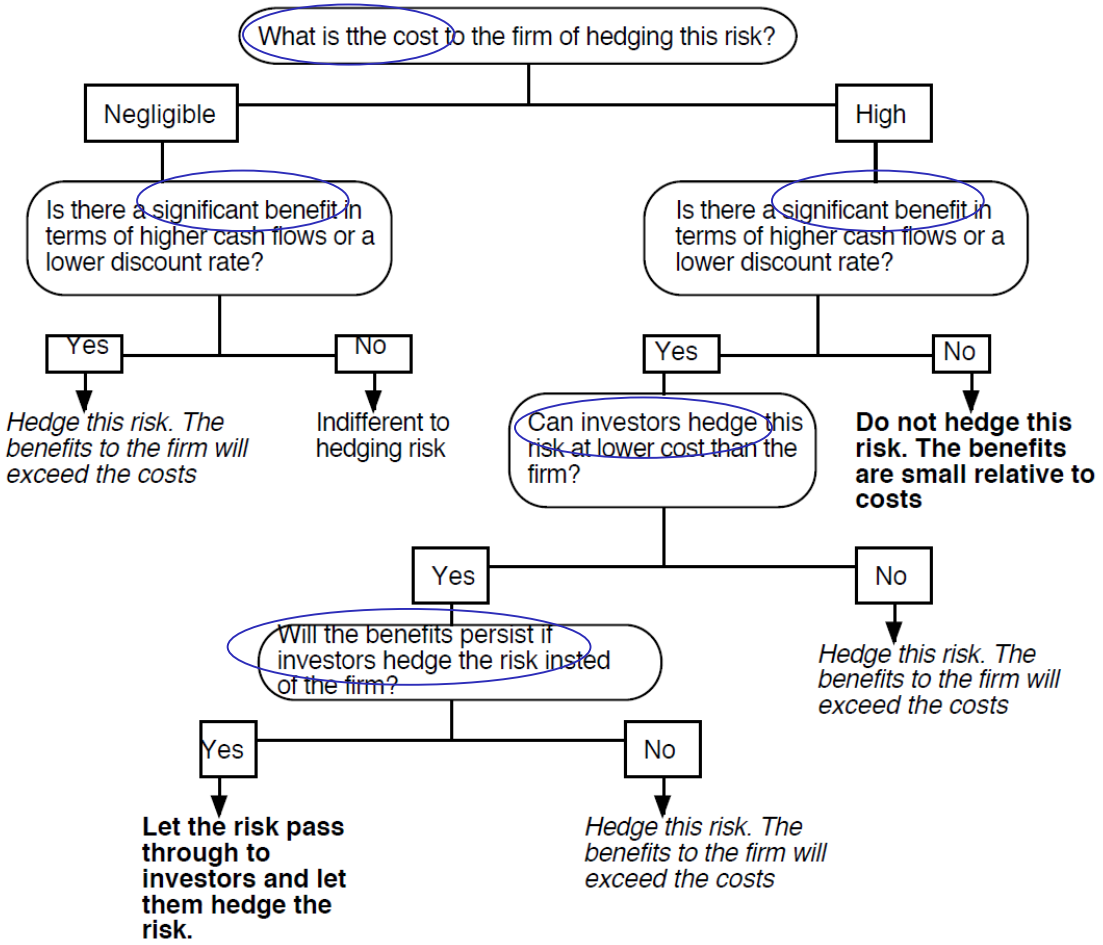
The Costs of Hedging

- Explicit Costs
- Implicit Costs
  - A farmer that buys **futures contracts** to lock in a price for his produce may face no immediate costs (in contrast with the costs of buying put options) but will have to **give up potential profits** if prices move upwards

The Benefits of Hedging

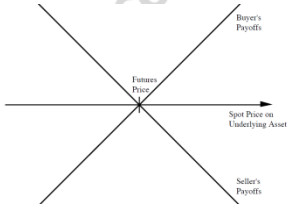
- Tax Benefits
- Better investment decisions
  - Managerial risk aversion
    - May reject investments that add value to the firm because the firm-specific risk exposure is substantial
  - Capital market frictions
    - Firm that has a good investment that it does not have cash on hand to invest in will have to raise capital by either issuing new equity or by borrowing money (issuance with a discount)
- Distress Costs
  - … because of lower cost of capital
- Capital Structure
  - The evidence on whether hedging does increase debt capacity is mixed
- Informational Benefits

To Hedge or not to Hedge?

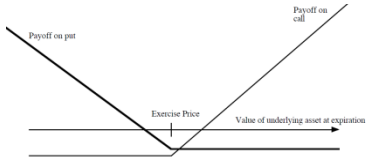


Alternative Techniques for Hedging Risk

- Investment Choices
- Financing Choices
- Insurance
- Derivatives
  - Futures and Forwards



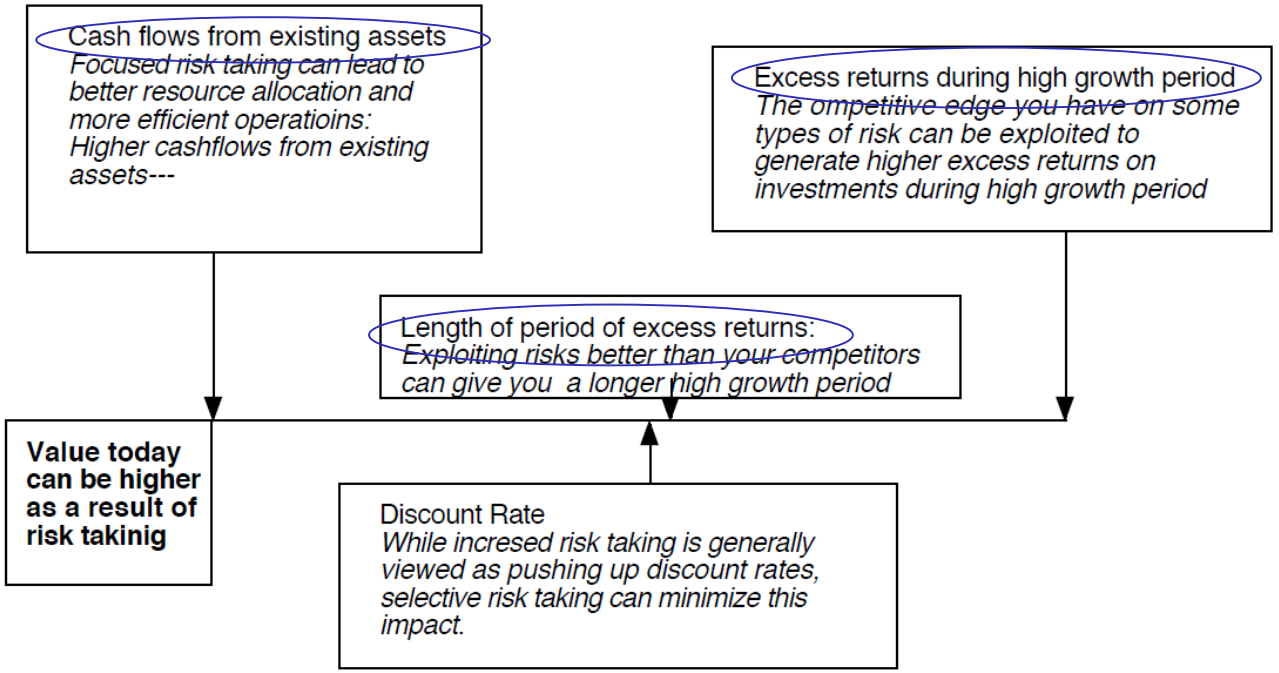
  - Options



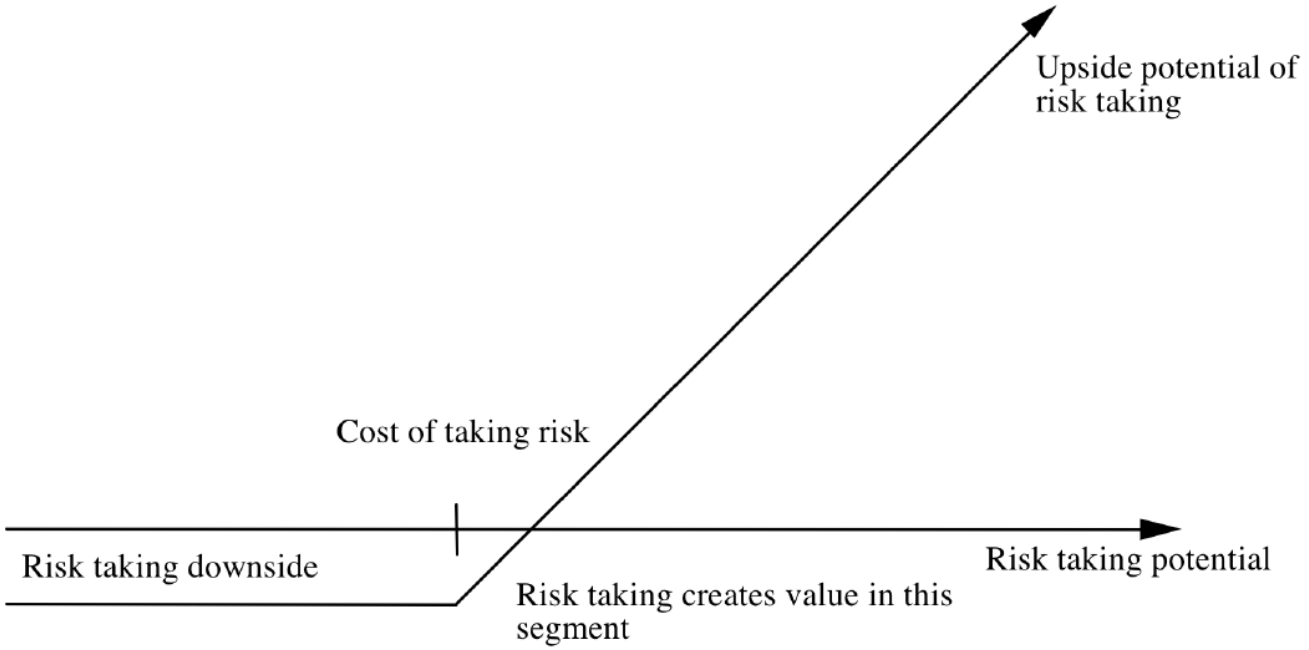
  - Swaps

Strategic Risk Management

Risk Taking and Value



Risk Taking as a Call Option



How to Exploit Risk?

1. Better and **more timely information** about events as they occur
   - … and their consequences, allowing you to tailor a superior response to the situation

2. The **speed** with which you **respond** to the changed circumstances in terms of modifying how and where you do business
   - … by acting faster than your competitors

3. **Past experience** with similar crises in the past and the knowledge of how the market was affected by those crises
   - … enabling to respond better than other firms in the business

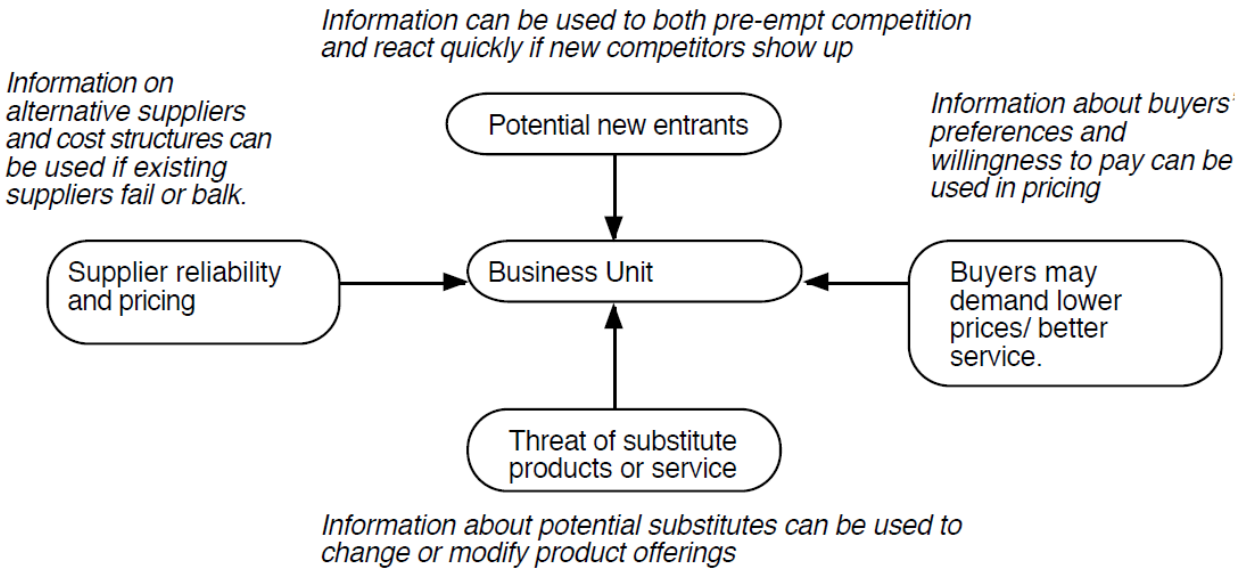
4. **Having resources** – financial and personnel – that allow to ride out the rough periods that follow a crisis better than the rest of the sector

5. The final factor is **financial and operating flexibility**
   - Being able to change your technological base, operations or financial structure in response to a changed environment can provide a firm with a significant advantage in an uncertain environment

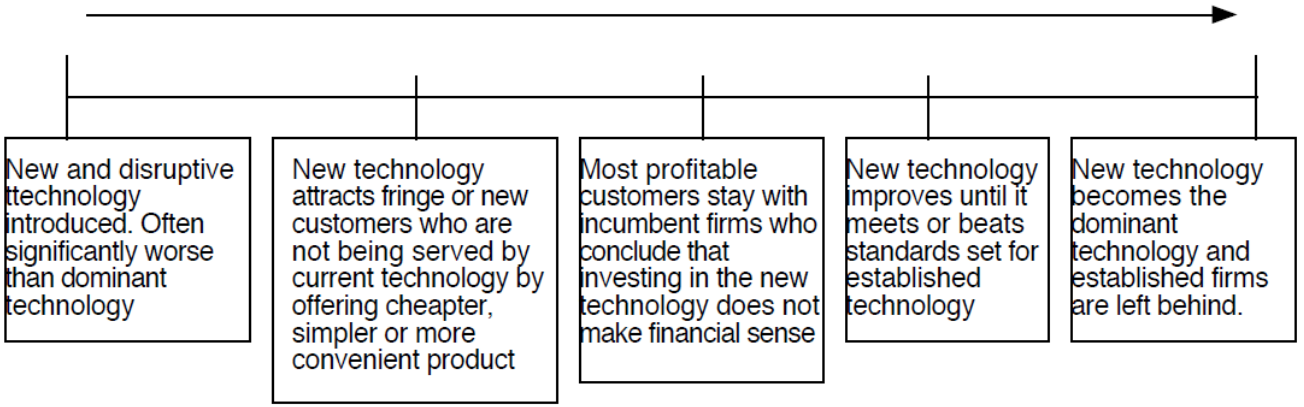
The Key Principles of Risk Management

- **Risk is everywhere**
  - Risk is global
  - Risk cuts across businesses
  - The Emergence of Financial Market Risk
- **Risk is threat and opportunity**
- **We are ambivalent about risks and not always rational about the way we assess or deal with risk**
- **Not all risk is created equal**
  - Small versus Large Risks
  - Symmetric versus Asymmetric risks
  - Short term versus Long term
  - Continuous versus Discontinuous
- **Risk can be measured**
- **Good risk measurement / assessment should lead to better decisions**
- **The key to good risk management is deciding which risks to avoid, which ones to pass through and which ones to exploit**
- **The payoff to better risk management is higher value**
- **Risk management is part of everyone's job**
- **Successful risk taking organizations doe not get there by accident**
  - Alignment of interests
  - Good and timely information
  - Solid analysis
  - Flexibility:
  - People

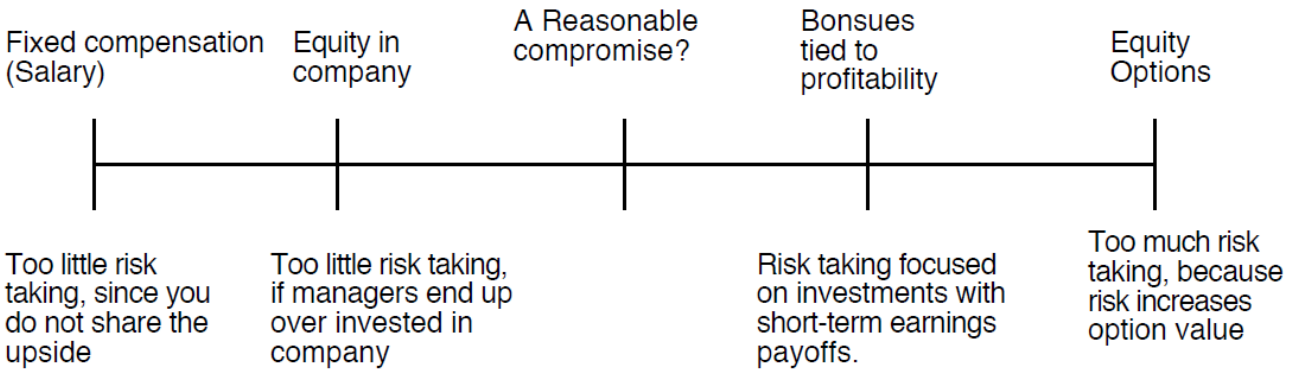
Information Technology and Strategic Risks



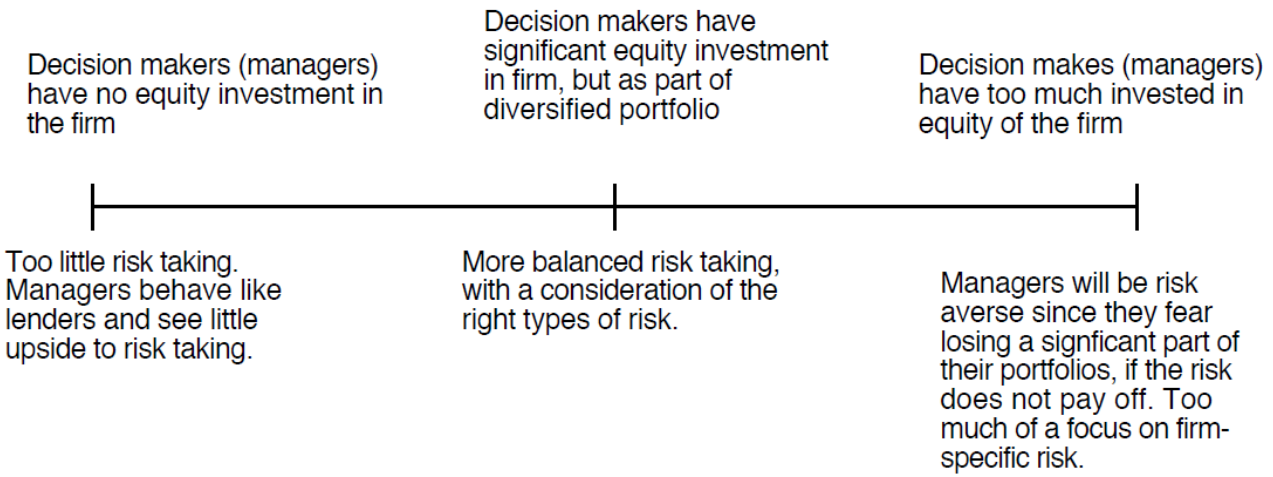
Disruptive Technology



Compensation and Risk Taking



Corporate Governance and Risk Taking



Contact

Christian Schopper
Private: christian.schopper@aon.at
Business: christian.schopper@corpfince.com

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