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A World of Risk – And a Road Map to Understand It

"The 4 Quadrants"

Risk Management Background Note

06/2010-5714

This background note was written by Claudia Zeisberger, Affiliate Professor of Decision Sciences at INSEAD, and David Munro, Director at Volatility Research & Trading, and is based on public talks, literature, blogs and publications by various authors dealing with the classification of risks in Taleb's Four Quadrants.

To progress, mankind must take risk. By reaching just beyond our capacity, we build new businesses, solve seemingly insurmountable problems, and come up with astounding inventions.

> *"Only those who will risk going too far can possibly find out how far one can go."*
>
> T.S. Eliot

But we often do an abysmal job of weighing the cost vs. the benefit of a risk. Large or indeterminate risks are frequently assumed for negligible gains if the risk is perceived as "unlikely". Tiny risks with the potential to yield significant gains are sometimes avoided just because the risks are so visible.

> *"I don't think much about risk. I just do what I want to do. If you gotta go, you gotta go."*
>
> Lillian Carter

A Methodology to Classify Risk

Attempting to classify, rank and understand the different types of risk we face in our businesses, investments and in day to day life is not easy. Degrees of magnitude are difficult to sort if outcomes are non-linear, subject to crowd valuation and part of complex systems. We need a broad framework to understand risk, and a roadmap to guide us when we get lost.

It is safe to assume that all our MBA students will face risk management responsibilities at one point in their career. Every decision involving growth and the pursuit of a better life (for yourself or others) involves risk. The broad framework of risk offered below, with four major classifications, will not only help with case studies in class, but will also offer guidance for future risk management challenges.

Of course the mere act of classifying risks, while necessary, is not sufficient. Methodologies or tools are needed to reduce or eliminate unwanted risk and, perhaps more importantly, to embrace those risks with attractive risk-reward characteristics.

The Four Quadrants

The idea of classifying risk by distribution of observations (normal or fat-tailed) and our ability to understand the interconnectedness of the risk (simplicity or complexity) was suggested by Nassim Taleb. The classification concept is excellent, but we feel it has not been well developed. The main take-away is to "stay away from the fourth quadrant" where statistics and models fail. This paper is intended as a guide for assigning risks to quadrants and for risk managing them optimally.

Earlier four-quadrant risk literature classifies risk by significance of impact and likelihood of occurrence, which is useless since we frequently understand neither in advance.

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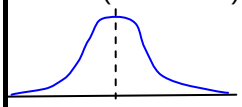
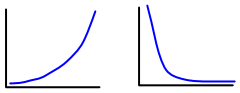
QUADRANT 1

Predictable Gaussian World (Simplicity and Normal Distribution)

Distribution	Payoff: Simple (win/lose)	Payoff: Complex (almost anything)
Normal (Bell Curve) 	**Coin toss; Height** **Q1**	Q3
Fat-Tailed or Indeterminate 	Q2	Q4

A Gaussian world is safe (no big surprises) and events and observations are normally distributed.

There are two categories of observations in the first quadrant:

1. Binary
   a. Outcomes are of the yes/no, black/red, heads/tails variety.
   b. In a heads/tails coin toss, a sufficient number of tosses (let's say 1,000) will lead to a normal distribution – the classic bell-shaped curve.
   c. No single outcome can dramatically change the mean.

2. Small Range
   a. The distance from the minimum possible reading to the maximum possible reading is small.
   b. Measure the height of enough MBA students (let's say 1,000) and you will end up with a relatively small range and a normal distribution.
   c. No single outcome can dramatically change the mean. Add the tallest MBA student in the world (213cm?) to the 1,000 student average of 178 cm, and the average increases to just 178.03 cm. No drama.
   d. While height, weight and commuting time conform to this "no single reading can significantly change the average" concept, the wealth of individuals does not. The average net worth of a Mexican is $13,000. Take 1,000 Mexicans, add the $53 billion net worth Carlos Slim to the group, and the average net worth of the 1,001 sample jumps to $52.96 million. The distribution of wealth of individuals is not normal and therefore this data series does not belong in Q1. (Wealth tends to follow a power distribution).

Everyone likes a Gaussian world – normally distributed and safe – where predictions without errors are easy. Such perfect environments are every risk manager's dream.

Risks are binary or cover a small range of possibilities, and are not life-threatening. Only probability is important – not magnitude.

Much scientific and academic research is based on a Gaussian Quadrant 1 environment (Black-Sholes pricing model) due to the high degree of predictability.

Examples of Q1 Risks:

Binary

- Roulette: Red/black
- Coin toss: Heads/tails
- Digital Options: Win/lose
- Mortality: Life/death
- Elections: Win/lose

Small range

- Height or weight of people
- Commuting time (subway uncertainty in the absence of terrorist threats)
- Length of a movie
- Daily temperature range in Singapore
- Longevity
- Automobile insurance claims

Q1 Checklist:

- One additional extreme reading cannot change the average significantly.
- No leverage exists.
- Out of 1,000 coin tosses, you can be extremely wrong many times (guessing tails or heads come up) and not be devastated.
- The payoff is "Simple"
- The distribution is "Normal"

Risk Management Tools:

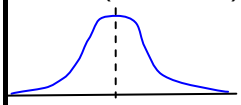
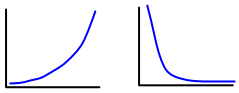
"At-Risk"-type (VaR) risk management models are perfect for such risks since probabilities derived from historical data work well. There are no "outliers" or surprises.

Or

Fire your risk managers if you only play in Quadrant 1; you won't need them.

QUADRANT 2

Risk Models CAN Work – Simple Payoffs with Fat or Indeterminate Tails

	Payoff	
Distribution	**Simple (win/lose)**	**Complex (almost anything)**
Normal (Bell Curve) 	Q1	Q3
Fat-Tailed or Indeterminate 	**Coconuts** **Q2**	Q4

As with Q1, the payoff is simple. The anticipated outcome either happens, or it doesn't. The difference with Q2 is that we don't understand the distribution very well – numerous tame observations can be followed by one observation with a dramatic and potentially devastating impact. And we don't know when that dramatic event will take place.

We don't usually recognize the presence of Q2 risks at first glance, though if we think about it for a second, the risk becomes apparent and we can define it. We can easily understand and estimate the possible outcomes of a potential tail event.

We just can't predict HOW FAT the tail will be nor WHEN it will occur. If "size matters" and "timing is everything", then we have a problem in Q2. The good news is that Q2 risks are manageable.

To compare Q2 to Q1, let's look at two fruit trees:

	Apple Tree (Q1)	Coconut Tree (Q2)
Number of fruits that can potentially fall	Several hundred to thousands	10
Ability to predict when they will fall	High – many per day when ripe	No idea. When you least expect it
Weight of fruit	150 gm	2,000 gm
Height of fruit on tree	3m	25m
Impact if one hits you on the head	Surprise	Concussion or death
Risk management	Wear a hat, but really not necessary	Don't sit under the coconut tree. Place a strong wire skirt around the tree trunk (high up) to catch falling coconuts
Simple or complex system	Simple – an apple either falls or it doesn't	Simple – a coconut either falls or it doesn't
Normal or fat-tailed or indeterminate distribution	Normal – one apple won't hurt you	Fat–tailed or indeterminate – just one can kill you

Examples of Q2 Risks

- Coconut uncertainty
- Most linear financial products (without leverage)
- Wealth destruction from house burning down
- Shark attack (discovery channel!)
- Falling airplane parts
- Tsunami
- Nine eleven
- Oil spills (BP in April 2010)
- Ponzi schemes (Madoff)
- Subway uncertainty (for cities where terrorism is a threat)

Risk Management Tools

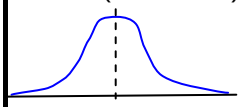
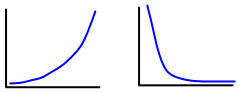
- Know the risks – define them – raise awareness
- Rules-based solutions – plan what to do, if and when
- Reduce, cap, mitigate, avoid or
- Insure risks (but make sure the insurer can pay)

While the payoffs on Q2 are simple (happens/doesn't happen), risk solutions are most often difficult. If the risk solutions are simple (avoidance – don't go outside, don't work in a high rise, don't swim in the ocean) then there is often a significant opportunity cost.

Risk	**Risk Management**	
Coconut uncertainty	Don't sit under the tree	Skirts to catch falling coconuts
Linear financial products	Use a stop loss (weak)	Buy a "crash put" (strong)
House burning down	Install sprinkler system Build a moat	Buy fire insurance
Shark attack	Don't swim in the water	Swim in a fenced/netted area
Falling airplane parts	Don't go outside	Don't live under air routes
Tsunami	When the tide goes way out, head for higher ground or stay in the water significantly offshore	Build your house or resort on a cliff.
Nine eleven	Don't work in high-rises. Don't teach flying students who don't want to land.	Equip everyone above the 30th floor with a quick-release parachute.
Oil spills	Engineering building codes	Alternative energy sources
Ponzi schemes	Basic due diligence	If something is "too good to be true", it probably isn't true.
Subway uncertainty (where terrorism threat possible)	Don't take the subway	Increase surveillance

QUADRANT 3

Complexity & Normal Distributions – Think Engineering

Distribution	Payoff: Simple (win/lose)	Payoff: Complex (almost anything)
Normal (Bell Curve) 	Q1	Moon Landing **Q3**
Fat-Tailed or Indeterminate 	Q2	Q4

Quadrant 3 deals primarily with physical laws where normal distributions exist. The outcome can be predicted with a high degree of certainty. No leverage is involved. The consequences of being wrong are extreme, yet the likelihood of error is small. Errors are most often human, not physical (exceeding O-ring temperature guidelines in the Space Shuttle Challenger, pilots attempting to land in bad weather instead of diverting to a safer airport), so risk management involves hiring smart engineers, rational operators and making systems resilient.

Examples of Q3 Risks

Physics

In Quadrant 3, numerous independent parts work together to form a complex interdependent whole. The independent parts are usually mechanical in nature and conform well to traditional statistical methods.

Biology and Social Systems ARE NOT in Q3

Distributions can stray far from the bell-shaped "normal" where biological or social systems are concerned. The spread of SARS can be limited to Hong Kong one day, and then spread throughout Canada the next day after one infected Hong Kong carrier hops on a plane to Toronto. The growth of Facebook connections looks much more exponential than normal. When a YouTube video goes "viral" power distributions are at work.

Q3 Auto Example

An automobile is made up of thousands of independent parts (nuts, bolts, hoses, wires) that form many independent systems (electrical, engine, fuel, cooling, drive train, and brakes) that interact to make a complex car. Each of the independent systems has simple statistical properties that can be replicated (mass produced) with tiny margins of error. The result is thousands of complex vehicles where the expected performance can be forecast with precision. The performance distribution is normal, yet the system is complex.

Q3 Lunar Exploration Example

The first human landing on the moon – clearly a complex undertaking – involved the interaction of gravity, orbits, earth spin, pressure, oxygen, electrical, mechanical, propulsion engineering and numerous other parts and systems. Computing power was laughable by today's standards. Yet the landing was precise and without incident. The lunar landing was a truly complex task where the expected result fell within a very small range of possibilities.

Risk Management Tools - Resilience and the Many R's

Q3 risks can only be managed by introducing sufficient redundancy and buffers into a complex system.

The role of resilience in integrated risk management has gained much traction in recent years. As Walter Ammann noted in his presentation to the 2009 Global Risk Forum in Davos:

- "Resilient systems reduce the probability of failure, the consequences of failure and the time needed for recovery.
- Resilience reflects a concern for improving the capacity of physical and human systems to respond to and recover from extreme events.
- Resilience is both inherent strength and the ability to be flexible and adaptive after environmental shocks and disruptive events."

The building blocks of a resilient system, referred to in various research papers as the 3, 4 or 5R's, are;

- Redundancy
- Reliability
- Robustness
- Resourcefulness
- Rapid response
- Regulation

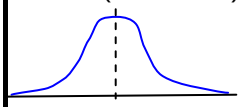
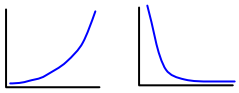
Questions We Need to Ask:

Why are Quadrant 3 tails thin? Is it because we are truly playing in the land of normal distributions, or is there simply insufficient historical data or laboratory research to form a statistically significant distribution? Many distributions appear normal until the fat tail hits.

Are Q3 risks so safe that sound models, rational operators and resilient systems are sufficient to remove the risk of extreme events, or do we suffer from the illusion of control?

QUADRANT 4

Risk Models Don't Apply – Complex Systems &Fat or Indeterminate Tails

Distribution	Payoff: Simple (win/lose)	Payoff: Complex (almost anything)
Normal (Bell Curve) 	Q1	Q3
Fat-Tailed or Indeterminate 	Q2	Leveraged Finance **Q4**

- Q4 extreme risk events are infrequent, yet their impact is massive (same characteristics as our Q2 coconut). In fact, their infrequency often lulls us into a false sense of security and overconfidence in our ability to avoid catastrophe.
- The complexity and interconnectedness in Q4 is enormous, yet risks are often invisible or ignored.
- Leverage – often excessive – is usually present in Q4.
- Our ability to forecast the timing and magnitude of Q4 risk events is poor – approaching the impossible. The world is just too complex and too interconnected to figure out how a Q4 risk will materialize. So we mistakenly try to forecast harder, with more inputs and better models.
- Risk models don't work in Q4.
- Since risk models don't work, the modelers try to tweak and calibrate models to make them work better. (We have a tendency to make small incremental changes – iterations – in our attempt to find solutions instead of completely discarding bad models and starting afresh with a clean slate).
- Modelers try to modify and adapt risk measures that work in Q1 (VaR) to account for leverage, unpredictability and fat tails (expected loss), but they just introduce the illusion of control. We think we can model and risk manage fat-tailed Q4 risks, but we can't.
- Nassim Taleb refers to Q4 as "Extremistan".
- The social impact of a Q4 fat-tail event is enormous (people lose jobs, houses, retirement funds, have heart attacks, get arrested and spend time in jail, governments fail, new laws and regulations are introduced).

Examples of Q4 Risks

- Lehman – leveraged and interconnected financial system risks leading to a systemic meltdown. No one knew that Lehman was a party to so many trades. Without government

action (printing money) almost all banks and investment dealers in the US (and many in parts of Europe) would have gone bankrupt and anarchy would have prevailed. A clear Q4 risk.

- AIG – agreed to insure credit risks that exceeded their capital by more than 10 times. The risk was simple (a debtor either defaults or it doesn't), yet the conditions leading to defaults were unpredictable. Complexity and leverage – definitely Q4.
- Bubonic plague, SARS – any virus spread by air or contact. Fast, modern transportation allows viruses to spread more rapidly than ever before. Traditional statistics of mean and standard deviation cannot help us when the spread of viruses reaches the logarithmic or power distribution phase. Vaccines or isolation help where models fail.
- Economic systems are Q4 phenomena.
- Leveraged financial products. If you bought a Greek government bond at par with 10 time's leverage, and the bond's price drops (yields rise) by 10% within one month, your investment has gone to zero.
- Short gamma (short, short-dated options).
- Complex or "structured financial products". Even the issuers often fail to understand the complexities of their products.
- Lloyds of London names. High net worth individuals wrote insurance policies for centuries and generated a substantial and steady income. When the US courts ruled in favor of asbestos-related injuries, which Lloyds names had insured in what are now regarded as badly-worded policies, names were "called" and many went bankrupt. A better-worded contract that capped claims would have placed Lloyds' names in Q2.
- The internet – not all Q4 risks are bad. Many of the most influential inventions and innovations are Q4 surprises. Complex, interconnected systems, significant leverage and major impact. (think: the hand phone, fax machine, computer)

Risk Management Tools – Are There Solutions to Q4 Risks?

It is important to accept the fact that we cannot manage or model the risks in Q4. We must get out of Q4!

- Reduce the impact of relationships and complexities we do not understand.
- Chop the tails:
  - Limit the downside contractually
  - Buy "crash puts"
  - Change the risk profile to that of Q2 or Q3.
- Many banks, hedge funds, businesses and individuals have gone to zero (or less) by a misguided belief in their ability to model Q4 risks.
- Do NOT rely on statistics or models.

- Employ the resilience guidelines discussed in Q3 – build in redundancies. (Humans have two kidneys but only need one), make your business robust (some parts of the business do well in an economic downturn), become resourceful and act quickly.
- Reduce leverage.

A Simple Q4 Housing Scenario

Identical houses are offered for sale in the same neighborhood for $1 million each.

Conservative Joe from Q2 has been saving all his life and pays cash for his $1million house. He has bad memories of the 1993 Toronto real estate market when prices collapsed by 60%. Joe buys his house with 100% equity.

Aggressive Fabio from Q4 has no cash, applies for and receives a $1million mortgage from the local bank. Fabio has just finished reading a best-selling book on "How to Profit from the Coming Real Estate Boom with No Money Down" (foreword written by Donald Trump). This is a small town, and the bank has 10 depositors who have each placed their $100k retirement savings on deposit. Deposit insurance has not been invented. Fabio buys his house with 100% debt.

Housing prices collapse by 60%.

Q2 Joe is not happy, but his life doesn't change. He still lives in his house. No drama.

The bank repossesses Q4 Fabio's house, and tries to sell it at auction in a falling market. The 10 bank depositors get wind of this, all try to withdraw their cash simultaneously and create a run on the bank. The bank has insufficient cash and declares bankruptcy. The depositors lose 60% of their retirement savings and will have to work longer, retire later and live in a depressing trailer park. Fabio buys a nice house for $300k at a forced auction.

Who wins and who loses in Q4?

The depositors thought they were being conservative by placing their money with a bank, but they took on leveraged and interconnected complex risk that was difficult to map. They had limited upside potential (the interest paid on their deposits), while their downside was the loss of all their savings. (If deposit insurance had been invented, the taxpayer would have borne the loss instead of depositors).

Fabio thought he was being aggressive, but he really just purchased a simple call option on a house with tremendous appreciation potential for free. He had positive asymmetric risk – no downside and unlimited upside.

Over the course of history, many of the largest personal fortunes have been made by leveraged long real estate portfolios. And many of the most spectacular bank failures have been a result of mortgage lending. Both play in Q4.

Summary

A risk is either **simple** – a coconut falls and hits you on the head, or it doesn't – or **complex** – AIG insures a credit risk, and then another, and then hundreds of billions more, which all go bad and destroy all US investment banks within a week and compel the government to spend trillions of taxpayers' money that they don't have, which threatens social systems, which gives people heart attacks, which starts congressional hearings, which destroys careers, which lands people in jail – well, we assume you get the picture.

And a risk is ether **normally distributed** – casinos rely on this Gaussian world – or **fat-tailed** where a small Mediterranean country with clear waters, sunny skies, sandy beaches, a long history, delicious olive oil, wine and an excessive sovereign debt can potentially destroy the official currency of 16 nations.

