

Financial Risk Management Ideas applicable to Problems in Risk and Resilience

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Western
Science

My goal for today

- To share my thoughts about what quantitative finance is, what its main “high level” ideas are, and how what we do in quant finance relates to disaster management

Fundamental Quantitative Finance

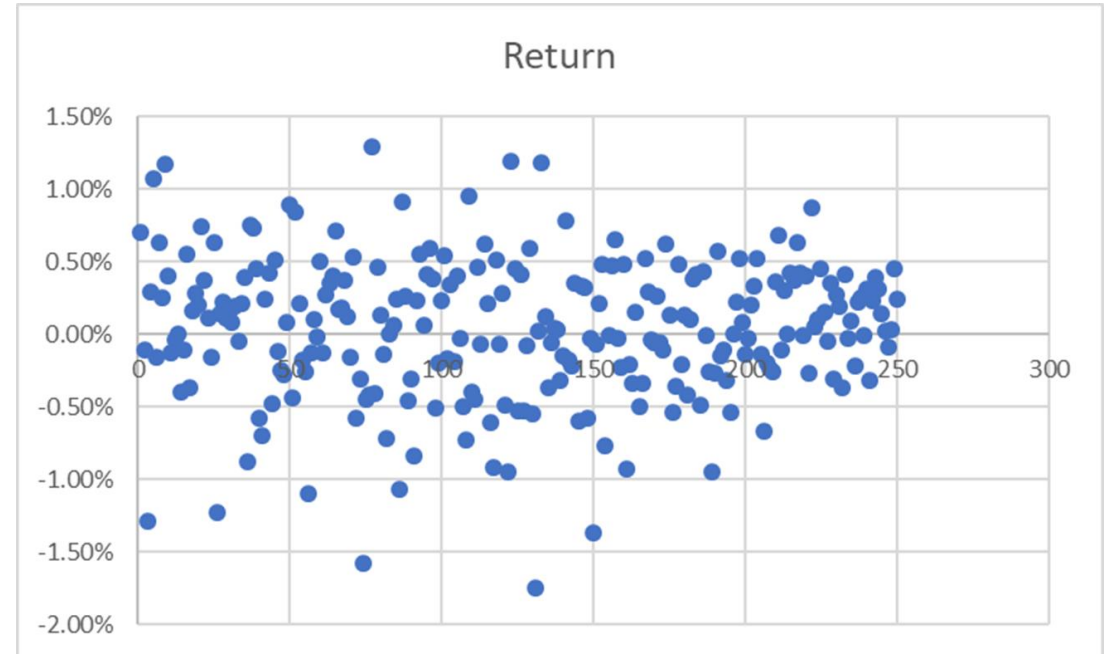
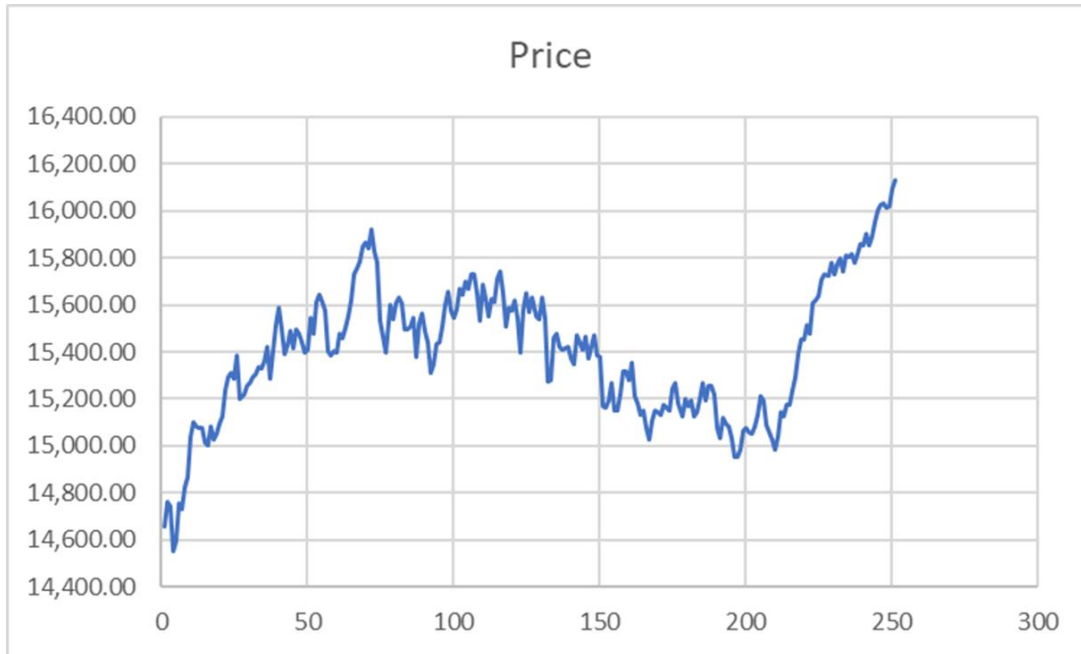
Fundamental Dogma

- You can't predict anything
- But you can characterize form of uncertainty.
- Deck of cards

Fundamental Ideas

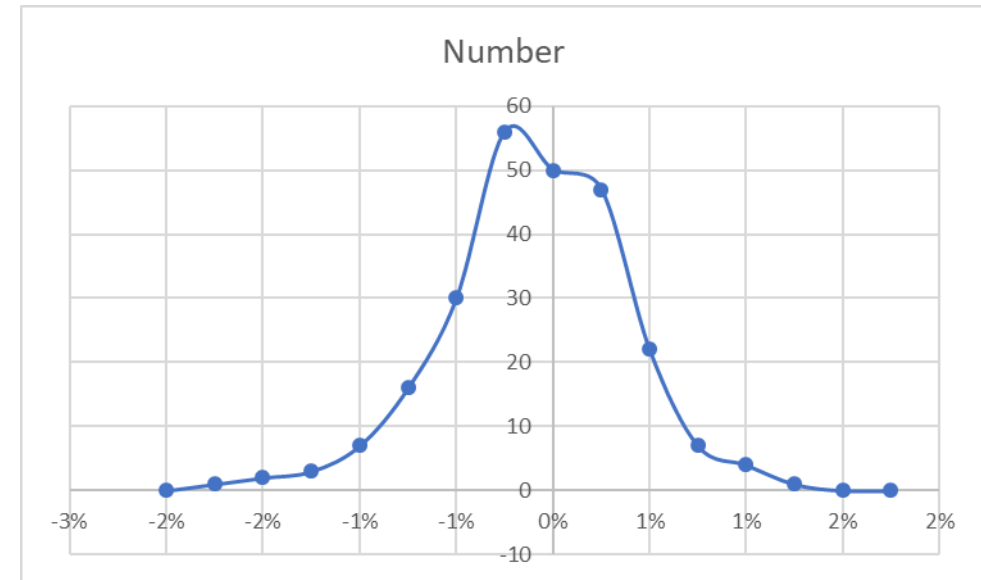
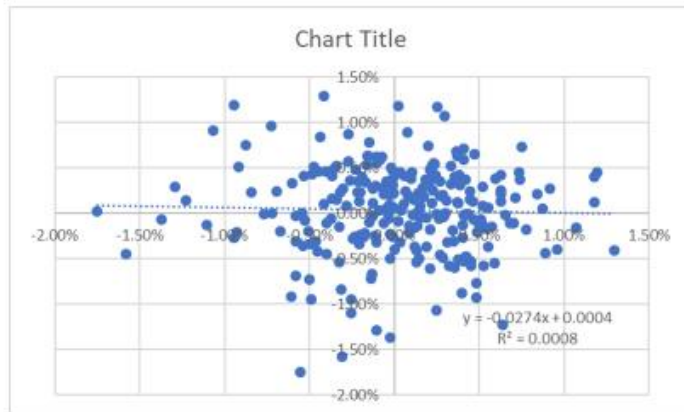
- 1. You can change risk/return properties by diversifying
- 2. You can change risk/return properties by hedging
- 3. You can change risk/return properties using leverage
- 4. Options have value, and this value is intimately connected with their optimal exercise.

Stock prices



Unpredictable yet following a random law

Simple Predictive Analytics



Idea 1a: Diversification: Stock Markets

Bet	If Heads	If Tails
1	\$6	-\$4
2	\$6	-\$4
3	\$6	-\$4
4	\$6	-\$4

Outcome	Payoff	Probability
4H 0T	\$24	1/16
3H 1T	\$14	1/4
2H 2T	\$4	3/8
1H 3T	-\$6	1/4
0H 4T	-\$16	1/16

Idea 1b: Diversification (Insurance)

Individual investment

Event	Probability	Payoff
No claim	99%	\$15
Claim	1%	-\$985

Aggregate 100 independent like left

# of claims	Probability	Payoff
0	36.60%	\$1500
1	36.97%	\$500
2	18.49%	-\$500
3	6.10%	-\$1500
4	1.49%	-\$2500
5 or more	0.34%	-\$3500 or worse

Idea 2: Hedging

- On Friday Nov 1 Royal Bank closed at \$106.45 per share.
- On Friday Nov 1 you could trade a put which allows but does not require its owner to sell Royal Bank for \$105 per share, on Dec 20, at \$0.97 by \$1.03
- If you pay \$107.48 to buy a share of RY and also buy a Dec 20 strike \$105 put the package will be worth at least \$105 on Dec 20 and possibly much more.
- This is hedging a long position in a share with a long position in an option.

Idea 3: Leverage

- TD has a 5 year closed mortgage rate posted of 3.07%.
- To lend you money TD needs to do some work, have some office staff, etc. All to make 3% on its money. Is this how TD is making billions of dollars a quarter? Not exactly.
- TD invests 1 dollar, borrow 9 more from my depositors paying them (next to) nothing, and invest the 10 dollars at 3.07%.
- They now make 30.7% on their invested dollar (less operational costs and defaults).
- This leverage increases risk and also profit and is built right into finance even of the simplest “credit union” kind.

Options and Exercise

- Perpetual put option: Can sell one share of Royal Bank for \$80 any time between now and the heat death of the universe.
- What is value of this?
- It is the present value of the expected value of the cash flows I get if I exercise it optimally
- How should I use the flexibility this option gives me? Should I use it when Royal bank first touches \$80? \$70? \$60??
- Fascinating moving boundary problem for differential equations, or optimal stopping time....
- Insight is that optimal value requires optimal exercise.

Fundamental Risk Management

Fundamental Dogmas

- Your business is a bundle of different risks – you can choose how you invest among them.
- You can't increase return without increasing risk
- You can learn about the future from the past if you are careful.

Fundamental Ideas

- Investments/businesses can be decomposed into risk factors
- Risks assessed with various metrics
- Correlations between risks key
- Reward based on decisions, not outcomes

Finance and natural hazards: modelling

Finance

- Believe can't really predict anything
- Don't even try to understand how individual hazards work
Believe can characterize distribution of outcomes
- Correlation between risk factor outcomes key (and time dependent)

Natural Disasters

- Some prediction possible
- Huge focus on understanding hazards
- Probability of hazards can be quantified
- Understanding multihazard risks key

Finance and natural hazards: system

Finance

- Believe can predict risk of given cost as a function of systemic weights
- Can buy disaster insurance (puts, reinsurance)

Natural Disasters

- Risk of disaster of given cost will depend on precautions taken (e.g. Firesmart, building codes, not building in flood plains)
- Insurance and reinsurance useful ways to recover from financial costs of disasters
- And catastrophe bonds & possibly weather derivatives

Finance and natural hazards: operational

Finance

- If I have 1% of my money in each of 100 stocks and 99 of them make 2% this month, one of them goes bankrupt and loses all its value, I make 0.99% this month and am pretty happy

Disasters

- If one of 100 equal sized remote northern communities is destroyed by fire with complete loss of life and property I am NOT happy at all, even if the other 99 had pretty good years.
- And even if I get a big reinsurance payout

Financial lessons only go so far

- Diversification and Hedging work in finance because making 2 dollars here and losing 1 dollar there is the same as making 1 dollar here and breaking even there.
- When losses are to lives, ecosystems, culturally or socially important sites, etc, we are not indifferent...

However financial ideas are useful in preparing for disasters

- Idea of real options
- Real options studies the way in which a real concern has operational flexibility using mathematical technology similar to that used in financial options.
- For instance if electricity prices fluctuate a great deal, a rechargeable battery may have substantial economic value which can be quantified.
- Quantifying this requires thought about optimal rules (charge when price $< X$, sell into market when price $> Y$)

Using real options to value resilient infrastructure

- If infrastructure can be used multiple ways, one of which is valuable in a disaster, this can be valued.
- For instance the flood control ponds now common in subdivisions may have value as fire protection if appropriate pumps are installed.
- This would require development of (optimal) protocols for their use.
- Paying for upgrades of houses to avoid e.g vinyl siding may have value in a fire setting, if this decreases probability of fire propagation through a neighbourhood.

Need for advances

Modelling advances

- Financial risk management began when people gave up on the idea of prediction entirely and started thinking about characterization.
- This is a hard pill to swallow but had interesting outcomes

Methodological advances

- Financial risk is nearly always just temporal
- Physical risks have strong spatial element.
- How can this be incorporated?

Conclusions

- How financial mathematicians think about financial risk
- Some of this is immediately transferrable to climate/earthquake/fire/flood/etc risk
- And some will never be transferrable
- In the middle perhaps we have some easy ways to build insight and some new ways to think about the value of resilient infrastructure via a real options paradigm.
- I look forward to engaging in discussions around this in the future!

Thank you/questions

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Catastrophe bonds

- These arise from earthquakes and hurricanes
- They are bonds that pay their coupon only if there is no major earthquake or hurricane event during the year. Otherwise they just return the principal but with no interest.
- The reinsurers who issue them use this to hedge their reinsurance book of earthquake (or hurricane) business.
- Two problems here – the standard one of money not helping... the second one being that there is no unambiguous notion of fire risk that investors can believe. The cost of a fire depends on the efforts to quash it. Investors aren't into this. Better mechanism design needed here. Could be a cool research project but I am not sure it is very relevant.

Energy Real Options

- For Hydro Plants (save water or generate power with it)
- For Natural Gas storage (pump gas when it is cheap, withdraw when it is expensive)
- For Oil Tankers (has to do with forward markets).
- For Corn Ethanol
- Share some Corn Ethanol slides now

Pause to bring it back to fire

- In Finance people are comfortable with (or should be comfortable with) the idea of good decisions rather than good outcomes being rewarded.
- It is not always easy to measure this.
- But for this corn ethanol plant it is.
- If the plant manager followed the exercise decisions developed here she'd be able to justify why – even if she could have made more money (with 20/20 hindsight).
- In portfolio measurement managers can even get disciplined/fired for doing too well – if it is because they are taking on risks they weren't supposed to take.

Real Options for FireSmart

- We heard about FireSmart and about pre-positioning lines of defence, at least mentally.
- Could a real options framework be deployed to look at the value of this?
- What is very cool to me is the idea of using financial ideas in the context of a spatiotemporal process.
- This happens to some degree in real estate markets, but most financial markets are not spatial.
- Another big difference with fire.