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Joint Consideration of Market Risk and Operational Risks

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Motivation

- The recent implosion of the FTX cryptocurrency exchange has reminded investors that there are two kinds of risk.
  - *There are always elements of both market risks and operational risks to every investment process.*
  - The economic loss due to operational risks are greatly minimized through organized securities exchanges whose transactional integrity is guaranteed through a clearing operation that is independently capitalized.

- The general solvency of financial institutions has been de facto supported by governments and central banks as in the "bailouts" of the Global Financial Crisis of 2007-2009,
  - However, investor losses associated with the collapse of Lehman Brothers and other financial institutions during the GFC were certainly substantial.
  - SEC Act of 1934 Rule 15c3-1, CFTC Rule 1.17(a)1(i) are relevant for investors

Investor Joint Risk

- There are several common investment situations such as “over the counter” derivatives and digital assets where calculations of financial risk assessments where the joint consideration of market risk and counterparty risk is necessary, and often required by regulation (e.g. Counterparty Valuation Adjustments in banking).

- In this presentation we will provide a computational framework to combine market risk and operational risks into a single numeric magnitude to be used in risk assessment and decomposition.

- We will illustrate the methodology using the example of the digital asset token called a “stablecoin” that were designed to have fixed dollar values (i.e. no market risk) but where design flaws in their financial engineering amplified operational risks to the point of widespread collapse.

FTX and Archegos Are Reminders of Lehman Bros.

- Since the GFC there have been many "counterparty" risk incidents where the stability of financial institutions has been brought into question.
  - Collapse of cryptocurrency exchange FTX and numerous other "operational risk events" (theft by hackers, lost passwords) impacting digital assets
  - *Not including FTX*, theft losses increased from $1.7B in 2017 to $3.8B in 2022
- In 2021, the prime broker units of Credit Suisse, Nomura, Morgan Stanley, UBS and Goldman Sachs lost an aggregate of approximately $11 Billion dollars on failed margin calls for "swaps" with the Archegos fund.
  - About $5.5 Billion was lost by Credit Suisse whose future as a prominent global bank is very much in doubt.
  - The prime broker unit of CS was a Northfield client from 2007 to 2014 (including the GFC), *having suffered zero losses on "contingent market risks".*
  - The terms of OTC derivatives are still largely unregulated, and so are often subject to CVA rules

Basic Framework for Joint Risk Estimation

- Our framework assumes that there are 2 to N states of the world
  - The predominant state with probability P1 is one where there is market risk on financial asset but no relevant "operational risk" events occur
  - *In another state of the world with probability P2 market risk is unchanged, but there is an "operational risk event" (e.g. theft) that endangers investor assets.*

- There may be situations where the two risk sources reinforce each other
  - A third state with probability P3 where market risk events spillover and cause an operational risk event, such as January 2021 when retail broker Robinhood had to restrict client trading in fifty stocks (e.g. Game Stop) because they could not meet SEC capital requirements for normal operation.
  - A fourth state with probability P4 where an operational risk event triggers a large market risk event, such as the October 1987 market crash that became much worse when "dot matrix printers" on the floor of NYSE could not keep up with the flow of orders.

Normal Mixture Distributions

- *Within each state, we will assume that the distribution of return outcomes is normal,* with an estimated mean and standard deviation.
- For each state we need to assume a probability value along with the parameters of the outcome distribution.
  - This process is like estimating the probability of default for a bond or the bankruptcy of a company.
  - If nothing bad happens, we have our usual risk assessment process.
  - There is a finite probability of default (PD) and a conditional distribution of losses the investor might experience (Loss Given Default)
- Combining multiple normal distributions is algebraically tractable
  - See fm.dvi (princeton.edu) for derivation and details covering both independent and correlated states
  - Robertson and Fryer (1969)

Four Lines to Mix N Normal Distributions

$\upsilon = \Sigma_{(i=1 \text{ to } n)} [p_i \, \upsilon_i]$

$\sigma^2 = \Sigma_{(i=1 \text{ to } n)} [p_i (\sigma_i^2 + p_i^2) - \upsilon^2]$

$\text{skew} = (1/\sigma^3) \, \Sigma_{(i=1 \text{ to } n)} \, p_i (\upsilon_i - \upsilon)[3\sigma_i^2 + (\upsilon_i - \upsilon)^2]$

$\text{kurt} = (1/\sigma^4) \, \Sigma_{(i=1 \text{ to } n)} \, p_i \, [3\sigma_i^4 + 6 \, (\upsilon_i - \upsilon)^2 \sigma_i^2 + = (\upsilon_i - \upsilon)^4]$

Edgeworth Expansions and CF

- The mixture distribution process will generally result in an oddly shaped distribution with four moments
  - For an intuitive solution for investors, we will now convert the four-moment distribution to the "closest economically equivalent" normal distribution.

- We will use the method of Cornish and Fisher (1938) that is a set of Hermite polynomials in the class of Edgeworth expansions
  - Similar to "Taylor Series" from introductory calculus
  - *Widely used in financial risk assessment for measures like VaR and CVaR to account for non-normal distributions*
  - CF functions are not monotonic, so several papers such as Chernozuckov, Fernandez-Val, and Galichon (2009), and Martin and Arora (2017) propose smoothing enhancements.
  - See Cornish–Fisher expansion – Wikipedia for algebraic expressions

Cornish Fisher Illustrated

- Assume a normal distribution with mean 10 and variance 25
  - The 95th percentile value (upper tail) is about 18.22
  - 95th percentile lower tail is widely used in financial regulation (e.g. VaR)
- Assume a non-normal distribution coming out of mixture process
  - Mean 10, variance 25 (standard deviation = 5), skew 5, excess kurtosis 2
  - Since both skew and excess kurtosis are positive, we would expect that the upper tail of the distribution to be "fatter" meaning that the 95th percentile value would be greater, which it is at about 22.78.
- We can also work the process backward to compute an adjusted value of variance that would give 22.78 as the 95th percentile of a normal for mean 10.

CF Normal Variance = $((22.78-10)/1.645)^2 = 60.35$

CF Normal Standard deviation = $60.35^{.5} = 7.77$

A Crypto Example of Joint Risk

- An illustration of assessment of joint market and operational risk is presented in Blackburn, diBartolomeo, and Zieff (2022).
  - Published at [Assessment of Cryptocurrency Risk for Institutional Investors - GCARD (jpmcc-gcard.com)]
- The presumed volatility of a digital asset (e.g. Bitcoin) is 5% per trading day (about 80% per year), with an expected return of .1% per day.
  - We assume LGD at an 80% loss with confidence interval of 3%
  - If the daily probability of event loss (PD) is .0001 (once in roughly 40 years), the joint volatility is 5.07%
  - If PD = .001 (once in 4 years) the daily joint volatility increases to 9.08% (about 144% per year)
  - *A realistic daily PD for crypto **theft losses only** is about .00003 based on observations from 2017 through 2022, so theft alone is a small effect on daily volatility or VaR*

Stablecoins and FTX

- While investigations are still ongoing there is considerable evidence that what collapsed "house of cards" in operation at FTX, was a massive reduction in the value of a digital asset known as a "stable coin", which FTX asserted which comprised large portion of the firm's capital.

- When the stable coin fell in value, FTX clients could clearly see the situation via analysis of public blockchains, triggering a "run on the bank".

- *This is curious as "stable coins" were designed to be a digital asset with a fixed dollar value, having no market risk in the same way that conventional investors would view a money market fund.*

- Standard and Poor's is working on a stablecoin rating process.

Stablecoin Design #1

- Three basic designs have been utilized to try to create a digital asset with no market risk and hence a stable value in fiat currency (e.g. US$)
- The first is for a custodian to hold traditional assets (cash in fiat currency, gold, government bonds) as a capital reserve.
  - This is similar to the means by which regulated entities like banks and broker dealers can ensure solvency of customer accounts, especially cash balances.
  - In some jurisdictions banks can still issue own paper currency (Scotland, HK)
  - *However, in the crypto world there is no regulation (or transparency) of what traditional assets are acceptable or how large the reserves must be.*
  - Gary Gorton (Yale) was among the first to express concern about the quality and quantity of capital reserves. An analysis appears in Taming Wildcat Stablecoins by Gary B. Gorton, Jeffery Zhang :: SSRN
- One can apply our joint risk framework to estimate PD and LGD given information on the nature and level of capital reserves.

Stablecoin Design #2

- The second type of stablecoin design is similar to the first, except that the assets held as capital reserves (collateral value) are other digital assets (e.g. Bitcoin, Ether, other stablecoins)
  - The purported benefit of this design is that due to the public nature of blockchain transactions, the amount and nature of collateral assets should be transparent.
  - Some stablecoins claim to be overcollateralized, with more than $1 of digital assets for each $1 stablecoin issued.
  - If we estimate volatility of the digital assets held as reserves, we can compute capital adequacy along the lines of the SEC net capital rule for broker-dealers, but no rules exist in the US or most other countries as to how much capital is sufficient
  - *Again, we can compute PD and LGD in the somewhat unusual circumstance of market risk being assumed very small but operational risk being dominant.*

Stablecoin Design #3

- The last category of stablecoin is the so-called "algorithmic" coin.
  - In this case, the issuer creates two stablecoins, with linked values.
  - *The original "Terra" was legally convertible to one US$ worth of Luna irrespective of the current price of Luna in US$, wherein unlimited numbers of new units of Luna can be created on demand. If the market price of Luna is above one US dollar, the price of Terra should be stable.*
  - If the market price of Luna goes below one US$, the whole process will collapse which it did.
- A revised version of the process Terra/Luna 2.0 was launched May 27th, 2022, with a launch price of around $4.81
  - It traded at high of $9.24 on May 29th, then crashed to around $2 about a week later.
  - Since then, the Terra/Luna (2.0) has traded in a narrow range around $2
  - *The stability of this design requires external capital reserves be involved, so again we can estimate PD, LGD and investor risk measures.*

Conclusions

- In almost every action undertaken by an investor to hold an asset, a variety of financial intermediaries, such as custodians, brokers, and exchanges are involved.
  - Each of the efforts involves some risk that standard processes to ensure the integrity and accuracy of transactions and ownership records may fail, but such risks are small due to the presence of capitalized clearing agents.

- A wide variety of common financial structures such as margin accounts, and "over the counter" derivatives involve non-negligible operational risks so assessments of investment portfolio risk need to be inclusive.
  - *We have presented a framework for joint assessment of operational and market risk for financial assets.*
  - We have illustrated the process with examples from the realm of digital assets where recent experience has shown the clear necessity.