This came out of session with@vladzamfir earlier this week.

In financial theory, we can roughly approximate how compelling an investment is by comparing the returns (excess of risk-free rate) to a proxy of risk (commonly the standard deviation of the returns i.e. Sharpe ratio).

Therefore, comparing returns / risk

is a common way to compare various assets in portfolio theory. However, that approach is often limited to one perspective of what risk is. Therefore, when discussing a heterogenous validator set, Sharpe ratio is far too simplistic to model a validator's risk assessment. While we will continue to improve this definition, here is a proposed working model of a validator's perception of risk:

$\delta_i = \frac{\sigma_{perfect} + \sigma_{error}}{1-p_{byzantine}} * (1+b_i)$

Perceived risk proxy with respect to (1) risk of the perfect game, (2) unknown risk, (3) perception of byzantine peers, and (4) portfolio concentration risk

where:

- δ_i

is a behavioral model of a validator's own view of the perceived risk of participation at any given point. * While a validator's perspective may change at any point, it can act only decide to participate, stay or exit. There will be another section that handles withdrawal delay and related costs to staying & exiting (and consequently participating)

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- $\sigma_{perfect}$

is the theoretical standard deviation of being a validator (i.e. perfect execution). * Should be same a priori

and a posteriori

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- Just using this would result in a Sharpe ratio.

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- σ_{error}

is the additional risk due to perceived errors outside of the game (i.e. client bugs, new systems). * Highest a priori

and should asymptotically approach zero a posteriori

(validator bugs or commonplace aversion to new processes).

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- $p_{byzantine}$

is the validator's perceived proportion of byzantine validators in the validator set. * It is a proxy for thecommon prior assumption in Bayesian games (with incomplete information).

- This will diverge to either a honest supermajority or a byzantine quorum over an iterated game, but the perception of this state on any given round will affect the marginal validator's perceived risk.

- $\frac{1}{1 - p_{byzantine}}$

can range from 1 when there is full belief that they are honest to larger multiples of risk when people believe there are significant byzantine proportion of actors).

- This magnifies the overall risk. We can tune the relationship with a constant k_0

as well.

- Also, we can replace $1 - p_{byzantine}$

with $k_{byz} - p_{byzantine}$

where k_{byz}

is the byzantine quorum threshold of $\frac{1}{3}$

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- b_i

is a proxy for portfolio concentration and need for diversification & liquidity. We can begin this by approximating amount validated / total investment budget

for a given validator (without having optimized, let's start the framework at [up to double the risk for going "all-in"]). * This will model how an investment with the same Sharpe ratio equivalent will make the investment far more risky for someone with a lower total investment budget and therefore makes a given absolute amount investment more risky as a percentage of their portfolio.

- For example, the same $25k angel investment in a startup is exceedingly more risky for someone with $100k vs $100m in wealth. So for a given sharpe ratio, validators will need to be more risk-taking to invest in an asset with a higher % of its own investment budget. This proxy reflects that.
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While WIP, we can imagine replacing the Sharpe Ratio with this proxy ratio (name tbd

, PRR

ratio below; for "Perceived Risk/Reward" ratio) that captures various factors that model validator perceived risk.

$PRR = \frac{r_v - r_f}{\delta_i}$

where high V values represent a more compelling mechanism for validators. (where r_v

is risk of validation and δ_i

is defined above. r_f

is mentioned for completeness)