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Risk, Uncertainty and Time Horizon: What Most Risk Models Get Wrong!

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Motivation for Today

Providers of risk systems often gloss over the most important attribute of any investment risk estimate.

It is obvious that *all risk of investment performance is in the future.* If so, how far in the future: a day, a month, or a century?

As we move from the intraday horizons of trading operations to the multiple-decade actuarial horizons of a sovereign wealth fund, the nature of the estimation problem changes profoundly, a fact which risk system providers often prefer to ignore or obscure in an effort to present their commercial offering as "one size fits all".

Common Errors

- Failure to properly distinguish models of immediate solvency as distinct the risk of future investment performance.
- The failure to distinguish between statistical risk (a known return distribution) and "uncertainty" (true distribution unknown)
- Failure to take account of how the distribution of asset returns changes as we increase the frequency of observations.
- Including too many factors in the model than the available data can support in an effort to make risk reports *appear* more granular.
- The most common problem is the obvious mathematical error of using a relatively short estimation sample period in order to make a model "more responsive" to changes in volatility levels, *while annualizing those same time-varying risk assessments under mathematical assumptions that are valid only if volatility is constant and serial correlation is zero.*

Solvency Risk is Divorced from Investing

- Many risk systems that were created for commercial banks focus on the *current solvency of the entity.* The current position of a financial entity is summarized in the Balance Sheet as of a moment in time.
- If the assets of the entity would have to be liquidated in order to pay liabilities, the value of the assets would subject to market fluctuations during the process.
- Value at Risk, and Conditional Value at Risk are really ways of expressing a confidence interval on the balance sheet asset value.
- This conception of risk may be of great interest to organizations like a highly geared hedge that wishes to avoid risk levels that would potentially exposure the organization to non-survival.
- The vast majority of institutional investors do not actually face economically material solvency risk, so systems focused on solvency risk are the proverbial "square peg in a round hole."

Risk in Investing

- The purpose of risk assessment and risk management in investing is not about avoiding risks. If it was, an investor could just hide their wealth under their mattress and declare themselves successful.
- The purpose of risk assessment and risk management in investing is to allow investment in risky assets that are likely (but not guaranteed) to produce a greater long term return that risk free assets, while confining the dispersion of cumulative investment performance over time to a range acceptable to the investor.
- Like any business activity or project, the risks of investing are about the future profitability of the investment activity. From a financial statement perspective, this is manifested in the Income Statement not the Balance Sheet.

Different Risks May Be of Opposite Sign

- Consider a sovereign wealth fund with portfolio of bonds with effective duration 15, priced at par with an 8% yield.
  - Interest rates instantaneously rise to 10%
  - The value of the portfolio falls by 30%, which most investors would see as a very painful loss.
- However, consider the long run investment outcome over a 50 year horizon
  - The original 8% yield would produce $46.91 for every dollar of current value
  - Losing 30% of the value but then investing at 10% would produce $82.17 per dollar of current value.
  - Why should we fear making almost twice as much money?

Risk Versus Uncertainty

- We begin by drawing a sharp semantic distinction between "risk" and "uncertainty." Let's define risk as the precisely known probability of unfavorable outcomes from an investment. Let's define uncertainty as our inability to precisely define the probability of a bad outcome.
- For illustration, consider two gamblers in a casino. The first gambler is playing roulette, where the odds and economic payoffs associated with winning or losing any particular bet are precisely known and do not change over time. This gambler is facing risk only. Our second gambler is playing poker with both a dealer and several other players participating. This gambler is facing both risk and uncertainty. While there is certainly some probability of losing your bet on a given hand of poker, this gambler does not know what those odds are because the odds depend on the cards as well as the skills and financial resources of the other players which are unknowns to the gambler.

Risk, Uncertainty and Time Horizon

- Under the preceding definition of risk, the "risk" of an investment may change with time but only in ways that we understand and for which we are prepared.
- Uncertainty on the other hand describes the conception of *what we don't know* (see Knight 1927).
- As we increase the time horizon, the set of outcomes from arising from draws of a distribution will get closer to the true distribution as we increase the sample size. Our risks are clearer.
- On the other hand, uncertainty is an increasing function of the time horizon. The world may change far more in the next 30 years than between today and tomorrow.

Risk Systems and Uncertainty

- Most risk systems ignore the concept of uncertainty completely.
  - We form some representation of the past that we believe is relevant, and then make the heroic leap that the future will be very much like our rendition of the past.
- In reality, the past through which the current state of the world has evolved is only one of an infinite number of paths history might have taken.
  - Statistical procedures such as bootstrap analysis can at least help define a range of possible alternative paths that history might have taken and which might again in relevant in the future.
  - Our new Optimized Scenario Analysis method is quite handy in this area.

Distributional Change and Time Horizon

- Just as uncertainty increases with time horizon, risk is generally a declining function of time horizon.
  - For many types of assets, investors assume that investment returns are normally distributed. For longer horizons like quarters or years, most statistical tests for normality would not reject this hypothesis. We reject for higher frequency data.
  - The assumption of normality arises out the Central Limit Theorem which assumes the distribution of events is the summation of a very large number of independent distributions.
  - Given that for every financial transaction there must be a buyer and a seller, the assumptions of the CLT are not wholly tenable.
  - As we get to shorter and short time spans, the distribution of asset returns gets more and more "fat tailed", so the expected likelihood of extreme return events (e.g. risk) is increased.

One Simple Fix Illustrated

- As an example, let's consider daily equity returns.
  - A large number of research papers suggest that a T distribution with five degrees of freedom is a good fit to observed data.
  - For a given confidence interval (P value), the T distribution will include a broader range of events.
  - The cumulative normal density function covers 99% of events at 2.32 standard deviations, while using the T-5, we need 3.37.
  - If we have a volatility estimate that assumes normality and we are interested in a 99% confidence interval, we can multiply our estimate by (3.37/2.32)
  - The failure to do this kind of correction is why many investors believe parametric VaR understates actual balance sheet risk.
  - Many other more sophisticated corrections are available to address fat tails

Failure to Correct Non-Synchronous Data

- Risk systems which observe security behavior over daily horizons often omit a very material issue. The moments in time for financial trading around the world on the same day are not synchronous.

- While this effect is small in low frequency return like monthly, the effect is pronounced when using daily return observations.
  - Shanken (1987)
  - Engle, Burns, Mezrich (1998)

Two Wrongs Don't Make a "Right"

- Ignoring uncertainty in longer horizon returns will cause the expectation of total dispersion of outcomes to be understated.

- Using high frequency observation data (e.g. daily) may capture fat tails that actually do not exist in lower frequency data, thereby overstating risk over longer horizons.

- Many risk systems seem to assume thinking that these two effects will miraculously cancel each other out. This is at best, wishful thinking and at worst, just foolish.

Risk Factors Versus Risk Descriptors

- Many risk systems confuse the concept of estimating risk with the describing sources of risk in an intuitive fashion.
  - This has led to models which have far more factors in their analytical construction than the available amount of data can mathematically support.
  - We often see models with hundreds or thousands of "factors" in an effort to convince users that the risk reporting is as granular as possible.
  - We should all recall the problem of "equations with five unknowns" from basic algebra. The more variables you have with the same data the worse things get.
  - Various statistic techniques (see Ledoit and Wolf, 2003) can be used to paper over this very basic flaw.

Borrowing from Strunk and White

- Vigorous writing is concise. A sentence should contain no unnecessary words, a paragraph no unnecessary sentences, for the same reason that a drawing should have no unnecessary lines and a machine no unnecessary parts. This requires not that the writer make all sentences short or avoid all detail and treat subjects only in outline, but that every word tell.

- There you have a short, valuable essay on the nature and beauty of brevity — fifty-nine words that could change the world. *Just as in writing every word must tell, in risk assessment every factor must tell.*

A "Responsive" Model

- The most common error made in commercial risk models is to try to models responsive to day to day events by shortening the historical sample period
- We've seen models with sample periods as short as 60 trading days being offered by vendors.
  - Can we really entertain the concept that nothing of relevance to the risk of a financial market could have occurred more than three months ago?
- A more sensible approach is the conditional risk model.
  - We first estimate risk based on a long sample period, and then adjust the estimates to reflect current information which would say current conditions are different from typical conditions.

Adding Insult to Injury

- The same models that are estimated on short sample periods in order to capture changes in risk levels over time, then annualize the magnitude under the clearly conflicting assumption that serial correlation is zero and *volatility is constant.*
- This is where the "square root of time" scaling of volatility fails. You can't have it both ways: Either volatility is changing or volatility is constant.
- There are other problems with square root of time scaling, which relate to the fact that returns compound. See Kaplan (2013).

The Dirty Little Secret of Illiquidity

- The square root of time scaling assumes that returns are independent over time.
  - This clearly conflicting with many concepts of active portfolio management like “value”, “mean reversion”, and “momentum”.
- For many illiquid assets like real estate the bias is enormous. Consider an asset with true volatility of 10% annually and a one lag serial correlation of .8 (realistic for non-traded assets). The reported volatility will be

$$S = (T^2 * (1-r)/(1+r))^{.5} = 3.33\%$$

Conclusion

- The time horizon dimension of risk assessment has been very badly obscured in many parts of the investment industry.
- The potential for undesirable investment outcomes always exists over some future horizon, whether short or long.
- As we move from very short horizons to very long ones, many things change including the relative contributions of risk and uncertainty, sensible assumptions about return distributions, model estimation methods, and the ways in which we can try to make risk assessments intuitive.
- To go from short horizons to long horizons in a coherent fashion often involves complexity that is often ignored or intentionally obscured. **One size does not fit all.**