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Realistic Scenario Analysis and Stress Testing with FASST

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Introduction

- Many investment organizations try to supplement their regular risk models with "scenario analysis" and "stress testing" as originally developed for asset/liability management of banks and insurance companies.

- Unfortunately, the traditional methods embed many unrealistic assumptions (e.g. macro events like the Global Financial Crisis occur instantaneously) such that the analytical output is of minimal value, as pointed out in two Northfield newsletter articles in 2006.

- Unsurprisingly, getting useful output from such efforts requires that the input scenarios be realistic.

- In this webinar, we will explore the limitations of conventional methods, and describe the features of realistic scenarios that produce meaningly informative results.

The Basic Requirements for Realism

- The first requirement is that stress scenarios be of reasonable probability, such that relationships between variables can be estimated with a meaningful degree of reliability.
  - For example, the scenario "How will my US equity portfolio perform assuming that inflation *instantly* moves up to 1000% annually?" is so unlikely that any estimation of the outcome is essentially random.
- The second requirement is that uncertainty in the scenario be explicit.
  - "We forecast that oil prices will rise between 10 and 30% over the next six months," as opposed to "oil prices will rise exactly 20%."
- The third is accounting for serial correlation in conditioning variables (e.g. inflation and interest rates trend rather than being random walks).
  - *Scenarios assumed to act instantaneously omit this key feature.*

FASST

- With a set of realistic inputs in hand, Northfield clients can use our FASST system to produce very rich analytical output.
  - For background on the FASST method, see Northfield News March 2016 (northinfo.com)
  - The FASST system is an extension of the method proposed in Meucci Fully Flexible Views: Theory and Practice by Attilio Meucci :: SSRN

- Unlike traditional scenario methods where the outcome of each element is deterministic, FASST output is a forecast of the entire multiperiod return distribution *including path dependencies (e.g. drawdowns)*, conditional even on scenarios having multiple elements.

- The multiperiod FASST analysis cover can cover all time horizons from intra-day for a trading desk to a decades-long horizon appropriate to asset/liability analysis for a pension fund.

Defining Scenarios

- FASST scenarios can be defined in three ways
- The first is to define a historical sample period, *starting earlier or later* than used in the current Northfield risk models.
- The second is to define a filtered historical sample period.
  - For example, we could estimate the return generating process based on data only from past observations when the US interest rates rose, or the EU was in a recession.
  - Assume the events of a selected historical period (e.g. Global Financial Crisis) reoccur over a future time period.
- Define up to 12 concurrent macroeconomic scenarios on which to condition the forecast distribution of outcomes into the future.
  - Australian interest rates up 3-5% over the upcoming 18 months
  - Brazilian GDP down 2-6% over the upcoming 18 months

Simple Probabilities of Macro Stress Scenarios

- The first question we need to consider when setting up a macro scenario is how extreme (i.e. "not probable") we want our scenario to be.
  - On the one hand, we want our stress scenario to be stressful in that it should represent a relatively rare event.
  - On the other, we don't want our stress scenario to be so extreme that the relationship between "causes and effects" cannot be reliably estimated because *historically similar events are non-existent*.

- Let's assume historical data sample of thirty years (360 months) for a GDP series for country X that has annual mean growth of 3% (6.09% per two years) with a volatility of 6% (8.48 per two years).
  - *We want our stress scenario to represent the 5% negative tail of GDP growth over the next two years (a 1 in 20 probability based on history)*
  - Our forecast should center on a Z-score of 1.65 away from the historical two year mean, or -7.9% over the two-year horizon.

Expressing Confidence on a Macro Scenario

- In the prior example, we've established that the 5% lower tail would be around a 7.9% decline in GDP over the next two years.
- We must express how confident we are that our forecast will come true.
  - If we have no skill at forecasting, a Z=1.65 event has a roughly a 5% chance of being right, or a 95% chance of being wrong, so the forecast should be expressed with a very wide confidence interval
    - Our forecast would something like -7.9 +/- (2 * 8.48) so we would set the range for X accordingly, MIN = -24.86   MAX = 9.06
  - If we want analyze the expected outcome with essentially full confidence that our forecast will come true, we can define a narrow confidence interval of, say, 5% of the distribution around our mean of -7.9%.
    - In Z-score terms 5% of a distribution with Z = -1.65 at the center we get a range of Z = -1.44 to Z=-1.96 or MIN = -10.53 and MAX -6.12
    - *Please note that the "tail probability" and the range of the neighborhood do not need to coincide, but this assumption is often convenient.*

Capturing Serial Correlation in Scenarios

- There are two ways that autocorrelation can be meaningful to scenario analysis problems.

- The first is that a scenario variable (e.g. US interest rates, FX) are highly autocorrelated with long trends.
  - If we test for the AR(1) coefficient, we can calculate how many periods of lag would represent a statistically significant influence.
  - For example, if we find that there is a meaningful relationship between changes in the variable four months ago and the change in the current month
  - We can define a FASST parameter called BLOCK SIZE to simulations that look at five period (current plus four) chunks of time thereby preserving the relationship between adjacent periods.

Capturing Serial Correlation in Asset Returns

- The other possibility is that we expect returns on our assets to be serially correlated positively due to illiquidity, or negatively due to mean reversion of prices.
  - In this case, we want to adjust the volatility of the scenario variable to drive the return of the assets more (less) to compensate for the distortion of the relationship between the scenario variable and asset returns.
  - *The simplest rule on scaling is from Geltner (1992)*

$$\text{Volatility}_{\text{adjusted}} = \text{Volatility}_{\text{raw}} * ((1+R)/(1-R))^{.5}$$

Where R is AR(1), the first order autocorrelation coefficient

See Northfield News-March 2013 (northinfo.com) for discussion.

The Special Case of Non-US$ Investor Base Currency

- When we generate portfolio returns conditional on some external variable such as interest rates or unemployment levels, we don't know in advance what the answer is going to be.

- We use various statistical procedures (regressions, FASST simulations) to estimate what the portfolio return will be. For the EE model, those returns are initially US$

- Base currency effects aren't really like factors in model. Their role is *completely deterministic* on the value of *foreign assets* at different points in time.

- *The FASST system differentiates these effects appropriately, switching returns from US$ to local currency for the investor's local currency assets, and repricing foreign assets.*

Conclusions

- Use of scenario and stress testing done in the conventional fashion embeds many unrealistic assumptions
  - Instantaneous effects with no serial dependencies
  - Deterministic relationships
  - Insufficient (i.e. none) consideration of the reliability of a stress forecast
  - Implausible combinations of variables (oil way up, inflation way down)

- Our FASST methodology overcomes these deficiencies but users operating with macro-scenario forecasts must ensure that scenarios and combinations of scenarios are plausible
  - *This means understanding the likelihood of a scenario based on the dissimilarity to the chosen history sample*
  - *Defining the confidence interval on the scenario element in accordance with the assumed reliability of the forecast*
  - *Account for the serial properties of scenario variables.*