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WHAT MAKES AN ECONOMIC SCENARIO GENERATOR "REALISTIC"?

By Bahram Mirzai

Economic scenario generators (ESGs) are becoming vital tools of insurance and pension firms in managing their investment risks. This trend is in part due to the financial crisis of 2008 and in part due to stricter regulation that already started pre-crisis and became more pronounced during the crisis. What markets experienced in 2008—a Standard & Poor's (S&P) 500 drop by 50 percent in six months—is not a 1-in-200-year event, to speak Solvency II jargon. Less than a decade earlier, the S&P 500 also fell by 45 percent (in 2000 to 2001 over a period of 1.5 years). It can be difficult to assure that scenario risk calibration is as conservative as intended and no more.

This difficulty is compounded by the inappropriate use of traditional risk measures such as value at risk (VAR), which are deeply embedded in many applications. VAR techniques were developed for trading portfolios that are liquid or hedged with short risk assessment horizons, e.g., 10-day VAR, rather than for investment portfolios with mid- to long-term risk assessment horizons. The assumptions of normally distributed returns or covariance matrix-type dependencies belong to the annals of history—one would think. Not even the daily returns of a wide range of asset classes support such assumptions, let alone monthly or quarterly returns. Curiously enough, often a one-year moving window is used to calibrate the VAR model parameters, practically speaking a short memory in the context of investment portfolios.

ESGs provide projections of portfolio relevant risk factors into the future given the current state of the markets and in a wider sense that of the economy. The projections must provide realistic paths for the future development of the risk factors. Albeit ESGs provide information about the expected return, rate or growth of the respective risk factors, the main purpose of an ESG is not to outperform expectation forecasts. In a perfectly efficient market, available information (about the future) should already be encoded in observed market data. Therefore, as long as an ESG is calibrated with the latest market data, an unbiased expectation means the assumption of efficient markets. In case of information asymmetry or diverging assumptions, market participants will adjust the unbiased expectations according to their views. The main purpose of an ESG is rather to provide a realistic distribution of possible outcomes around the expectations. The notion of realistic requires ample consideration. This will be our focus in what follows.

To be more concrete on what constitutes a realistic distribution of projected scenarios, we consider two examples. Our first example considers equity returns. Equity log returns are typically modeled by specifying the expected return, the volatility of the return, and the distribution of the stochastic residual term for each projected time step ($R_t = \mu_t + \sigma_t \epsilon_t$). An unbiased estimate of the expected return is obtained from historical data. Biased estimates can be obtained by weighing the information content available in the market. By virtue of the argument that in the long run equity returns should exceed risk-free returns, the term structure of the interest rate may be used to define lower expected return bounds. Moreover, when analyzing historical time series of equity return volatilities, it is observed that volatility clusters in time. When equity volatility is low, it tends to stay low for a while until the returns move or jump to a higher volatility regime. Therefore, in projecting equity volatility returns it is important to start the model in the current volatility regime and move to other regimes based on all current information. In the case of a low volatility regime, the distribution of the projections should have a reduced probability mass for volatile scenarios and an enlarged one for scenarios with calmer volatility. In summary, the choice of the volatility model should take into account the observed clustering of returns in the data.

The stochastic residual term captures the stochasticity of returns beyond expectation and volatility. The historical data suggests that the observed returns are heavier tailed than normal or even lognormal distributed returns. The choice of the stochastic residual distribution must account for the observed tails of returns for both market booms

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and market crashes. Inappropriate choices will result in unrealistic projections of the tails. It is worth stressing that the selection criteria for an appropriate stochastic residual distribution is not to introduce heavy tails artificially but rather to fit observed return data as well as possible for a given application. However, there should be still some probability that projections exhibit not yet observed return and volatility levels.

Our second example considers modeling of risk-free interest rates. Projecting a term structure consistent with different regimes of low or high rate levels within a single modeling approach is a challenging but achievable task. Here we confine ourselves to four aspects that render the distribution of projected rates realistic. First the notion of term premium—i.e., higher rate levels for longer maturities—requires that scenarios with upward-slanted term structures should have higher probability than those with a downward-sloped term structure. Second, interest rates, both nominal and real, have a mean-reversion property. When starting a simulation at a low interest rate regime, the probability that the projected rates exhibit an increase in interest rate levels should be higher than the one associated with decrease in interest rate. Third, historical interest rate levels usually move in tandem with simultaneous inflation rate levels. The projected rates should therefore exhibit an interaction between nominal rates and inflation. Fourth, interest rate levels can temporarily fall below zero. The interest rate model should treat negative rates at short maturity and positive rates at long maturity in a consistent manner. The negative rates are typically bound by a floor in the range of tens of basis points. It is unrealistic to generate negative rates that would fall to -100 bps or more. Taking the Japanese yen as an example of a regime where the rates have been low for more than 20 years, excessive negative rates were never observed during this period. In fact, strongly negative rates are not sustainable for a longer period due to an implied arbitrage opportunity.

This article addresses some relevant aspects of realistic scenario generation in a qualitative manner. These aspects should be treated rigorously within a robust ESG framework. Clearly the scope of criteria that an ESG needs to meet is broader than what is outlined in this article. Nevertheless the author hopes to have increased the sensitivity to some relevant aspects in the selection of an ESG. An assessment of ESGs should consider these aspects and other relevant aspects for the risk factors of interest such as risk-free rates, spreads or FX rates.

Bahram Mirzai is managing partner at EVMTech responsible for advisory services and product strategy. Previously he was senior vice president and chief actuary for Global Banking Practice at Swiss Re. Mirzai has worked with numerous financial institutions in development of regulatory and economic capital frameworks, scenario generation, operational risk and model validation. He studied physics at ETH Zurich and obtained his Ph.D. from ETH Zurich. He can be reached at bmirzai@evmtech.com.