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The Growing Demand for More Robust Economic Scenario Generators

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Many actuaries, risk officers and investment professionals use economic scenario generators (ESGs) in their risk analysis applications and have a passing familiarity with their strengths and weaknesses. Today, in response to the more challenging market environment, they need to use ESGs more effectively. Interest rates may become more volatile and divergent, with prospects for continued low or negative interest rates (in Japan and Europe and possibly the United States), juxtaposed with a gradual end to monetary easing policy at the Federal Reserve (despite continued monetary easing in Europe). Risk considerations may be highlighted further with expanding regulatory oversight on capital and solvency, and the increasing complexity and sensitivity to changing economic conditions embedded in investment products and interest-sensitive insurance products. ESGs are in demand today for valuing complex insurance contracts, managing derivatives hedging programs and dynamic asset allocation strategies, and calculating capital requirements.

This raises the question of what characteristics of an ESG are necessary and appropriate for the applications and increasing risk environment that investment professional will be encountering. **The Society of Actuaries** is releasing a major white paper that serves as a practical guide to ESGs, providing both context and technical insights into the makeup and composition of these tools. All investment actuaries are encouraged to review the white paper, both for a refresher on familiar ESG issues and an overview of more challenging ones.

ESG CONSIDERATIONS IN LIFE, PROPERTY & CASUALTY AND PENSION APPLICATIONS

Applications of ESGs for **life insurance liabilities** are primarily focused on the interaction of interest rate changes and policyholder behavior regarding lapses and other optionality. Life insurance enterprise and product results are determined by the interaction of investment performance on assets built up from the collection of premiums, and the payout of liabilities based on events of mortality, morbidity (in health or disability) or policy surrender or annuity payout. Because of the complexity of the interaction of these factors over an extended time horizon, an ESG provides the type of comprehensive tool that is necessary to understand both the range of potential outcomes and the likelihood of scenarios. Representative applications in life insurance best understood through the use of an ESG include life liability valuation, effective duration analysis, stress testing, economic capital (EC) and strategic asset allocation (SAA).

Applications of ESGs in **property & casualty** insurance are more focused on the impact of inflation on liabilities and assets, and economic cyclicality characteristics affecting both exposures and policy pricing. Property & casualty products have different characteristics of liability development, with many casualty products involving significant time lags in settlement or even discovery.

For **pensions**, ESGs can be useful to sponsors looking to compare their options, especially with options where they are still completely in control of the pension plan: choosing to freeze the plan; implementing liability-driven investment (LDI) (whether plan is open or frozen) against options that involve transferring the risks to third parties. LDI is an investment strategy that defined-benefit pension plans use to dynamically adjust equity risk and/or interest rate risk exposure in response to progress in fully funding future benefit obligations.

SOME ESG BASICS

An ESG is a computer-based model of an economic environment or multiple environments that is used to produce simulations of the interconnected behavior of financial market values and economic variables.

An ESG should produce simulation results that reflect a sufficiently comprehensive view of the economy and certain financial variables that are relevant to the need being addressed. The simulation results should include some extreme but plausible results, and the generated scenarios should embed realistic market dynamics that stand up to rigorous scrutiny when validating the model output.

Analysis of historical data is commonly used as the basis for determining principles and facts that an ESG must accommodate, but expert judgment also plays a role in establishing and prioritizing the properties that the ESG model must have to be useful for a given application.

Some examples of these "stylized facts" might include:

- Interest rates can be negative.
- Corporate credit spreads are wider for lower credit quality instruments, but credit costs represent only a fraction of the spread on corporate bonds and this suggests that some portion of corporate bond spreads is due to factors other than credit costs (e.g., liquidity).

- There is a tendency for corporate credit spreads to fluctuate more during recessionary periods.
- The volatility of equity returns fluctuates significantly over time.
- Correlations between modeled economic and financial market variables are not stable over time and can depend on whether monthly, quarterly or annual observations are being used.

CALIBRATION OF REAL-WORLD AND MARKET-CONSISTENT SCENARIOS

Users of these models need to incorporate a view of future market dynamics into their risk modeling environment. The process of reflecting these views into an ESG is referred to as model calibration. More specifically, calibration is the process of setting the parameters of the equations within an ESG model to produce the distributions and dynamics (e.g., volatility, correlations, tail characteristics) of economic and financial variables that are required by the application for which they are being used.

Calibration (also referred to as parameterization) of real-world ESG models requires users to make choices about the future economic environment that they want to reflect in their risk analysis work. Most risk management applications, for example, require ESGs to be capable of producing dynamics (e.g., volatility, correlations) that are representative of the possible future paths of economic variables. Because real-world parameterizations are forward-looking, they require explicit views as to how the economy will develop in the future and, as such, require a significant amount of expert judgment to determine the veracity of the scenarios that result from the parameterization process.

Market-consistent valuation applications require ESGs to be capable of generating scenarios that can reproduce the observable prices of traded derivative instruments. ESGs that are used for these purposes need to adhere to strict mathematical properties in order to satisfy risk-neutral and arbitrage-free conditions. Because the model calibration process is designed to reproduce the prices of traded derivatives, the ultimate calibration is dependent on both the pricing date and the set of traded derivatives used to calibrate the model.

INVESTMENT MARKET COMPONENTS AND CONSIDERATIONS

At its foundation, an ESG is concerned with simulating future interest rate paths, including yield curves. Other components, including equity markets and foreign exchange considerations, and other economic components such as inflation and gross domestic product (GDP) may be considered.

ESG models often span a wide range of market instruments and require complex mathematics to reasonably reflect the behavior of these instruments in a wide range of economic conditions. The default-free interest rate model is a key component of most ESG models. Its primary purpose is to generate the prices of risk-free bonds and for use in discounting liability cash flows. The collection of risk-free rates at various maturities makes up what is called the term structure of interest rates; this in turn allows for the construction of yield curves and the pricing of all default-free interest-rate contingent cash flows.

An ESG typically builds off core **default-free interest rate modeling,** then considers implications of corporate bond yields and returns that include default, transition behavior and stochastic spreads. **Corporate bond models** are further complicated by the contingency of payments by the issuing name being dependent on both willingness and ability to pay both coupons and principal components of the bond as scheduled. Therefore, prices of a corporate bond will contemplate not only changes in the general level of interest rates, but also changes in the outlook for potential default or for potential recovery from default.

Equity index models allow for a degree of randomness, jump behavior, stochastic volatility and correlation of total return to other factors. Realistic equity models are available today with accurate return characteristics. However, these more robust models may introduce sources of risk that cannot be hedged away by trading in the universe of available assets, and as a result a unique price for cash flows that may be contingent on the equity index by arbitrage-free pricing considerations alone cannot be determined. Whether this is a problem for theory or practice is an open question. Fair value may be a range and not a point. Or, additional assumptions may be needed to price certain derivatives, or to model hedging of a variable annuity.

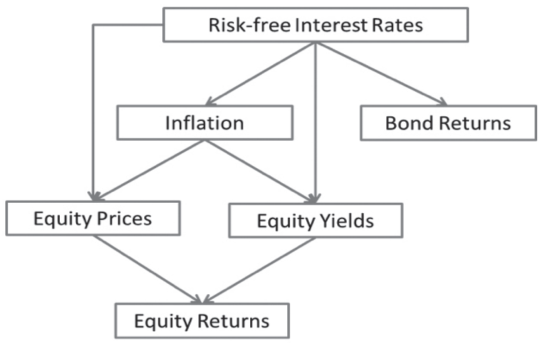
Often, these variables and their inter-relationships are modeled through a **cascade structure** to maintain model integrity. A **cascade structure** is a framework whereby each subsequent variable depends only on prior values of the variable and the values of variables that lie above them in the cascade structure.

VALIDATING ESG MODEL PARAMETERIZATION

Model validation ensures that the estimation of a model's parameters results in simulated behavior that is a good representation of the variable or market under consideration. Effective validation of an ESG requires comparing simulated output data to some predefined benchmark of acceptance criteria.

An automated validation system is preferable to manual validation. Validation should be repeatable and consistent through time. Before any data is analyzed or validation performed, it is helpful to form the acceptance criteria upon which the model output will be judged. This type of approach to validation, whereby the particular desirable features of an ESG are based on analysis of a firm's risk exposures, is preferable to what might be

Cascade structure of a hypothetical ESG



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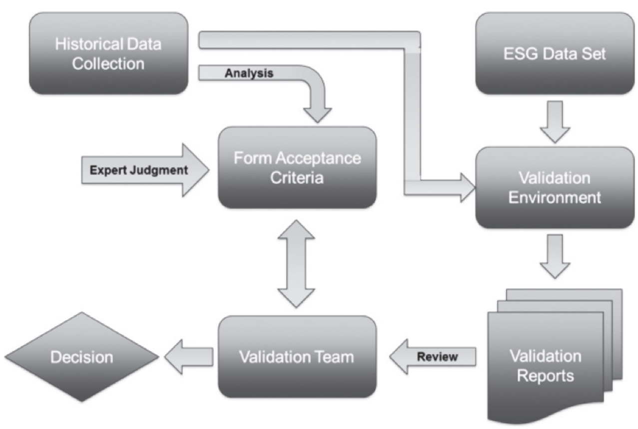
Main steps in an idealized validation process



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called a "problem discovery" approach. In a problem discovery approach a user first runs the ESG, creating a large output data set, and then tries to discover problems with the output.

LIMITATIONS OF ECONOMIC SCENARIO GENERATORS

While ESGs are extremely useful in gaining insight into future financial risk and rewards, like any model, they have limitations. Modeling the future dynamics of the economy and financial markets presents many challenges, such as accounting for extreme events and regime changes. Users of these models must understand the strengths and weaknesses of any particular ESG to ensure that the ESG is appropriate for the analysis that is being performed.

Professional standards apply to actuaries who calibrate and use ESGs, as in all other aspects of actuarial work. ESG calibrations should be generally understood by the principal, while documentation of the expert judgment applied in the calibration process should be retained. Actuarial communications should provide context where needed, to reduce the risk of misinterpretation and misuse of the results of stochastic modeling based on an ESG calibration. The rules of professional conduct and the actuarial standards of practice of the American Academy of Actuaries (AAA) and Canadian Institute of Actuaries (CIA) provide important guidance for ESG users.

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