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Economic Scenario Generators, Part I: Motivation for Stochastic Modeling

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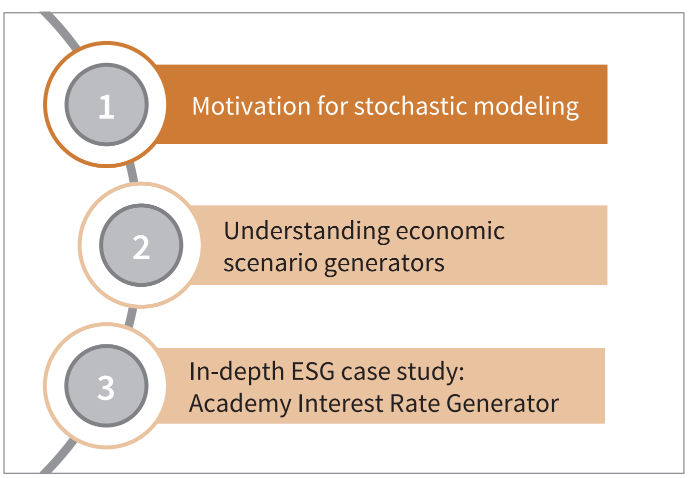
Stochastic modeling has gained increasing relevance in life insurance in recent years, driven by regulatory changes and other factors. Consequently, the use of economic scenario generators (ESGs) by actuaries is becoming ever more common.

This article is the first installment of a three-part series that aims to provide an overview of ESGs and will focus on the general motivation for stochastic modeling, its advantages and its limitations. Future articles will further break down the key factors underpinning ESGs and relate these to the American Academy of Actuaries Interest Rate Generator (AIRG), the most commonly used ESG by U.S.-based actuaries. See Figure 1 for an overview of upcoming articles in this series.

WHAT IS STOCHASTIC MODELING?

Stochastic modeling simply refers to modeling with a random variable rather than purely pre-defined assumptions; it is a powerful tool used in many fields from biology to cryptography. Applications in finance and actuarial science focus on representing seemingly random behavior for factors such as asset returns, exchange rate movements or interest rates.

Figure 1
ESG Three-Part Series Structure



Actuarial models consume information about the past, which is known, and assumptions about the future, which is estimated, in order to project potential outcomes. Predicting the future can be achieved through a single deterministic track or by iterating through multiple potential outcomes. ESGs play a key role in stochastic modeling by simulating future paths of economic and financial outcomes.

ADVANTAGES OF STOCHASTIC MODELING

Stochastic modeling of certain key assumptions can have significant benefits over deterministic methods, as illustrated in Figure 2.

Figure 2
Stochastic Modeling Advantages

1. Measuring "Tail Risks"

Stochastic modeling is a valuable tool for quantifying the extreme events that may arise from market and economic volatility. Unlike traditional actuarial risks, these exposures are generally not diversifiable. Stochastic methods allow for the likelihood of outcomes to be measured and also provide valuable information about the most impactful risk drivers.

Consider a risk management context where stochastic analysis indicates a company's portfolio cannot survive an equity market shock similar to the 2008 financial crisis. The need to react to and mitigate this risk varies greatly depending on the likelihood of that event occurring. A near-certainty versus a one-in-a-million anomaly will drive very different reactions.

2. Enabling Market-Consistent Valuation

Certain financial reporting frameworks require assets and liabilities to be held at fair value. Given the rise of complex financial derivatives and insurance liability offerings that do not have market-observable prices or closed-form solutions, stochastic modeling techniques facilitate valuation of these complex assets and liabilities in a market-consistent fashion.

Consider the exercise of assigning a market-consistent value to a variable annuity (VA) product with a guaranteed minimum accumulation benefit (GMAB). The future outcomes associated with that offering are tied to a wide range of assumptions (interest rate, general and separate account performance, mortality, lapse, withdrawal, annuitization, etc.) which have complex interactions (consider dynamic lapse assumptions driven by market performance). An actuarial model projecting this product across a large number of risk-neutral scenarios is often the only practical method for market-consistent valuation.

3. Satisfying Internal and External Stakeholder Requirements

Stochastic modeling may not be a preference but rather a requirement. Whether driven by the needs of external or internal stakeholders, the application of stochastic modeling techniques is ever-growing.

The recent push toward principles-based reserving methods for U.S. life insurers has supplanted decades of traditional formulaic methods and introduced additional stochastic requirements.

4. Quantifying Asymmetric Responses and Path Dependency

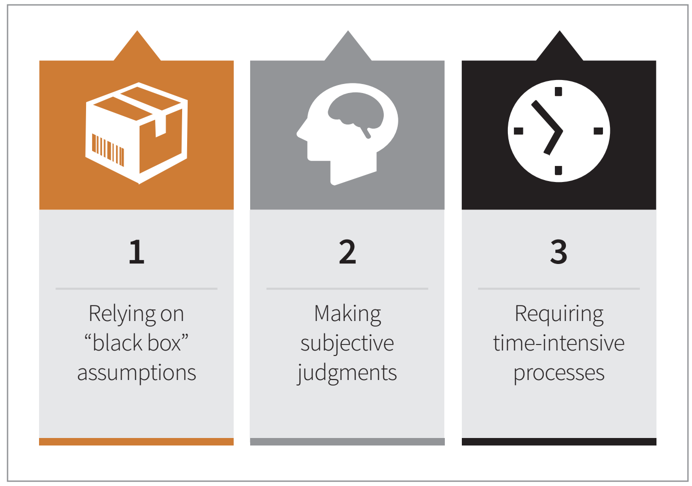
Certain risks cannot be captured adequately by projecting a single outcome. Many product features behave asymmetrically against risk factors or exhibit strong path dependency. This may be exacerbated by dynamic modeling techniques that tie decisions to market outcomes. In these cases, stochastic modeling of many randomly generated paths offers a natural solution to assessing risk.

Consider a put option that has value tied to decreases in a stock price. A traditional deterministic assumption representing "best estimate" does not offer much insight into the risk of issuing such an option—that is, one may erroneously conclude that because the "expected path" of a stock is to increase, selling this option is risk free. To accurately assess the value of such an option, one needs to weigh the likelihood of payoffs across a number of paths.

LIMITATIONS OF STOCHASTIC MODELING

It is important to note that stochastic approaches are one method of forecasting future outcomes; they do not innately represent a more accurate view of the future. The following factors, seen in Figure 3, should be considered when evaluating the use of stochastic modeling.

Figure 3
Stochastic Modeling Limitations



1. Relying on "Black Box" Assumptions

It is common to accept a set of scenario data as a handoff—companies often separate the producers and users of economic scenarios, leading to incomplete knowledge transfer. Scenario users may not have the ability to glean the various assumptions, decisions and compromises that are baked into scenarios from observation alone, potentially leading to misapplication.

Risk-neutral scenarios "look and feel" just like real-world scenarios but serve vastly different interpretations. While there are techniques to differentiate these rather distinct views, an uninformed user can readily draw illogical conclusions such as "in the worst 5 percent of cases, the liability is expected to be valued at X" when, in fact, risk-neutral scenarios are not meant to represent a plausible outcome of future real-world outcomes.

2. Making Subjective Judgments

Stochastic modeling is a projection of the future that can potentially bury biases and expectations. Everything from the choice of ESG, selection of process and parameters, calibration methodology and subjective future outlook drives significant differences in the characteristics of produced scenarios. Coupled with the "black box" nature of economic scenarios, these decisions may not align with the intent of the scenario user.

If two actuaries were asked to project interest rates over the next 10 years, they would more than likely arrive at different answers. Even when the objective is clear, such as generating real-world scenarios and aiming for historical fidelity, a simple decision such as how much historical data to leverage will fundamentally change the outcome. In projecting interest rates, an individual using five decades of historical information, including the higher interest rates of the 1970s, 1980s and 1990s, will have a very different outlook than someone only reflecting the lower interest rate environment of the past decade.

3. Requiring Time-Intensive Processes

Stochastic modeling typically requires significant processing time. Increasing the number of scenarios leads to a direct increase in modeling workloads (i.e., two scenarios will double runtime in the absence of distributed processing).

The large amounts of data being stored to create and model with an ESG, along with the downstream model processes that leverage those scenarios, may stress existing workflows and information technology infrastructure. While advances in computing power and distributable processing options have dampened the impact on processing times, these solutions undoubtedly come at an additional cost when compared to deterministic modeling approaches.

Doubling model runtime in the context of model development would be an inferior outcome. However, processing a model through 500, 1,000 or 10,000 stochastic scenarios fundamentally changes the scale of model runs (e.g., a five-minute run, across 1,000 scenarios, takes more than three processing days). Running stochastic-on-stochastic projections further increases runtime.

CONCLUSION

Stochastic modeling and, by extension, the use of ESGs, is being adopted in many aspects of actuarial work including risk management, hedging, pricing and regulatory compliance. It is essential that model users comprehend the strengths and weaknesses of stochastic modeling and proper application of ESGs.

Stay tuned for the next two installments of our three-part series as we look to discuss the key factors underpinning ESGs and have a closer look at the AIRG, the most commonly used real-world ESG for U.S.-based actuaries. ■

The views or opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of Oliver Wyman.

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