JOINT RISK MANAGEMENT SECTION

Published by CAS Canadian Institute of Actuaries Institut canadien des actuaires SOCIETY OF ACTUARIES

RISK MANAGEMENT

APRIL 2020

Council's Corner

By Frank Reynolds and Florian Richard

First and foremost, we hope everyone is staying healthy and safe in the face of this extremely difficult situation that the world finds itself in. In this first article of the April issue of *Risk Management*, the Joint Risk Management Section (JRMS) Council would like to take the opportunity to share with our JRMS members a number of initiatives that have taken hold in 2020. From ebooks and webcasts to LinkedIn activities and getting involved with the section, we want to make sure that you are aware of what the JRMS Council has planned for you in 2020!

The rest of this issue will be a deep dive into the world of economic scenario generators.

Hope you enjoy the reading!

E-LIBRARY

One of the many benefits of belonging to the Joint Risk Management Section is that you have *free* access to the section's e-library. This library has about 110 books that can be borrowed for a two-week period and renewed if desired. The books cover a full range of risk management topics and include all the books on the Canadian Skills and Knowledge Inventory, a comprehensive list of books, articles and other publications with which a Canadian actuary is expected to be familiar if working in risk management.

The council is pleased to announce it has purchased six new books (published between 2018 and 2020) to keep the library up to date. The new books include *Cyber Risk Management* and *Psychological Perspectives on Risk and Risk Analysis*.

We hope you will take the time to browse through the library and enjoy the new books.

Table 1
2020 JRMS Webcast Schedule

Month	Date	Topic
March	23	Model Governance for Advanced Analytics
April	30	ALM Modeling
May	26	Professionalism—ASOP 55
June	TBD	Liquidity—NAIC Activities
	16	Cyber Security
	26	Policyholder in the Tail
July	7	Risk Intelligence and Risk Agility
	16	JRMS Research—ESG
August	4	ERM in Banking
September	3	Regulatory Risk: Part 1, ORSA
	29	Regulatory Risk: Part 2, Risk Culture
October	14	Climate Risk and Impact on Investment
	23	JRMS Research: Unifying Method for Allocating Capital
November	3	New Technology in ERM, Part 1
	19	New Technology in ERM, Part 2

2020 WEBCASTS

The council also would like to announce the calendar of JRMS webcasts for 2020 (Table 1).

In this period of uncertainty, we acknowledge that it might not be possible for our members to travel to conferences and attend presentations in person. To make sure that you can still obtain your continued education credit for 2020, we have increased the number of webcasts to 15 in 2020. This means you can choose from two to three webcasts within a given month—or attend all of them!

Webcasts in the first half of the year will focus on modeling, cyber and professional education topics. We will also share with you the results of our recent research activities.

The second half of the year will be dedicated to addressing the two major topics that the council has identified for 2020:

- risk associated with a changing regulatory environment, and
- new technology in enterprise risk management.

LINKEDIN

We have created a task force to ramp up the JRMS's presence on LinkedIn.

With all the research work that is about to be published and the numerous webcast opportunities that are about to start, we need to keep our members informed at all times. LinkedIn will help us do that. The JRMS Council will be sharing news, articles and continued education opportunities on a regular basis.

We look forward to capturing your comments and reactions in the coming weeks.

GET INVOLVED!

Finally, just a quick reminder that if you are willing to help the council by driving some of these efforts, please run for the JRMS Council or join as a friend. To do so, please fill out the Expression of Interest form on the Society of Actuaries (SOA) website.

If you would like to share a risk management idea, share some insight on a risk topic or volunteer for any JRMS activities, please contact David Schraub or Florian Richard. ■

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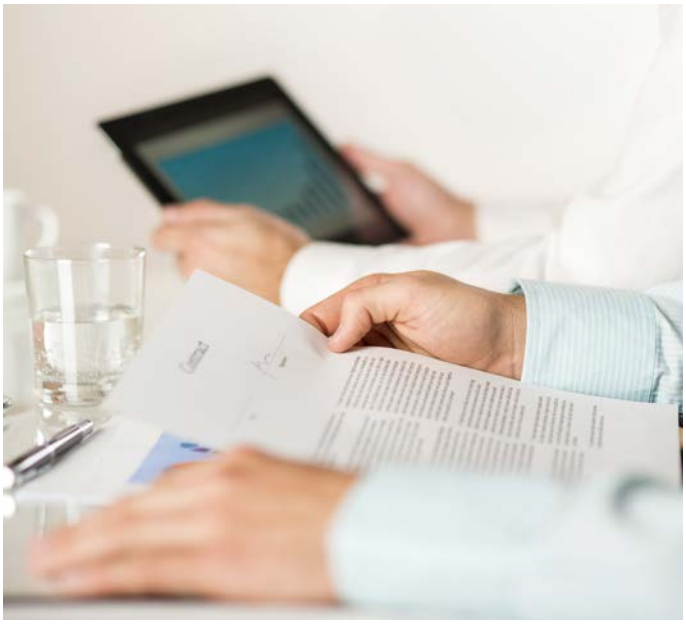
RISK MANAGEMENT

APRIL 2020

CAS Research Paper on Economic Scenario Generators

By Brian Fannin



Editor's note: Over the past couple of years, economic scenario generators (ESGs) have been a major topic of research, with most research taking place within the life insurance industry. However, ESGs have a variety of applications that can span both life and property and casualty (P&C) industries.

The following article is adapted from the introduction to Users' Guide to Economic Scenario Generation in Property-Casualty Insurance, *a new report written by Conning and published by the Casualty Actuarial Society (CAS).*

The Casualty Actuarial Society (CAS) has published a new research paper titled *Users' Guide to Economic Scenario Generation in Property-Casualty Insurance*. Although there are cases in the literature about the use of economic scenario generators (ESGs) in the property and casualty (P&C) industry, they are far more commonly used for life insurance companies. The CAS paper is intended to serve as a comprehensive guide to the implementation of ESGs in the nonlife space and spark interest in research into new applications of ESGs.

An economic scenario generator is a computer-based model that provides many simulated examples of possible future values of various economic and financial variables. These scenarios, along with analysis of the stochastic distribution of scenario outcomes, illuminate the nature of risk elements within the economy that drive financial variability. As such, an ESG can provide insights into the relative advantages and disadvantages of alternative operating and strategic decisions.

Compared to deterministic economic scenarios, econometric models and macrofinance models, an ESG simulation can provide a better view of scenario probabilities, a broader range of scenario outcomes and greater complexity of scenarios. Modeling can follow either risk-neutral or real-world approaches: Risk-neutral (or market-consistent) frameworks are required by certain regulatory authorities for valuation of insurance liabilities, whereas real-world modeling is appropriate when projecting future values of economic and financial variables.

The most common ESG-driven applications for property and casualty are asset-liability management (ALM) systems (used in assessing, establishing and monitoring investment strategies) and economic capital systems (used to calculate and monitor economic capital). ALM systems deal primarily with economic risk mitigation, in which the range of adverse economic events are narrowed or reduced while still maintaining a healthy likelihood of positive investment growth. Economic capital systems typically focus on shorter time horizons and involve significantly more scenarios in order to establish reliable tail metrics.

For P&C insurers, the ability to assess financial statement values, as well as the impact of operational or strategic decisions, requires being able to enumerate and describe a wide range of possible states of economic and financial conditions. Some of the more important variables that a P&C insurer should consider when building an ESG include the valuation of assets and liabilities,

economic capital and regulatory requirements, strategic and operational decision making, and risk management.

Investment portfolio decisions may be based on regulatory requirements as well as the need for maintaining a certain level of liquidity. General characteristics of P&C insurers, including prospective cash flows in the context of a going concern enterprise, can dictate many of their asset and liability cash flow patterns, and consequently their ALM decisions. ALM portfolio values may be influenced by financial factors such as interest rates (risk-free, risk premia and term premia), credit risk (credit rating migration, default risk intensity), inflation (general and line-of-business specific), equity returns, and mortgage delinquency and prepayment patterns. These characteristics, along with the specific attributes and business models of individual companies, and the purpose for which the model is designed, dictate the kinds of economic and financial variables that should populate an ESG.

There are several points of intersection between P&C underwriting and operational results and the economic and financial variables generated by an ESG. For example, premium volumes and losses associated with many P&C lines of business are related to economic conditions, often causally. Furthermore, underwriting and operating factors tend to undergo significant cyclicality, from periods of high premium rates and low loss ratios to low premium rates and high loss ratios. Thus, the ability to model a P&C insurer relative to a range of different economic conditions over time is critical.

Valuation of the reserves for outstanding losses (the largest liabilities of a P&C insurer) is largely the purview of actuaries. Although the reserve shown on the insurer's balance sheet is a single "best estimate" value, the loss reserve is actually a stochastic value with variability around the best estimate, and the best estimate may itself vary under different scenarios or conditions. A good ESG provides an actuary with a robust tool to build deeper insight into the potential volatility of future loss payments.

Other important factors in P&C balance sheet considerations include the volatility of assets (and the leverage of invested assets against surplus), the impact of foreign exchange models and multieconomy factors, and the effect of different time horizons on different line-of-business models with variable claims payout periods.

Some aspects of asset risk can be evaluated through a strategic asset allocation analysis. An important aspect of strategic asset allocation is developing an efficient frontier of investment classes to optimize risk and return. For example, assessing the duration behavior of the investment portfolio against the duration of liabilities on the balance sheet throughout a range of economic scenarios can lead to a deeper understanding of the effect of interest rates and other economic factors on assets, liabilities and surplus.

Economic capital and regulatory requirements for P&C insurers tend to be influenced by extreme tail events, requiring responses in the form of stress testing. Often, extreme events can influence multiple aspects of the business—for example, catastrophic events that influence the general health of the economy—leading to a potential double impact on the P&C insurer. Inflation could also accelerate due to supply-demand issues after a major catastrophe. This is precisely the type of application at which a good ESG can excel.

Analysis of extreme events can also influence strategic and operational decision making. An ESG cannot itself make decisions about strategic or operational alternatives, but it can provide a consistent basis for evaluating the impact of a decision across a range of possible future circumstances.

The new research from CAS is intended to serve as a basic guide to economic scenario generators, with an emphasis on applications for the P&C insurance industry. The first half of the report provides more general information on the nature of ESGs, general applications and specific applications in the insurance industry. It also discusses essential features of a good ESG and provides guidance on stochastic processes and modeling of certain economic and financial variables. The importance of financial market model specification, model calibration and model validation are discussed, to assure that the ESG will produce simulation results that (1) are relevant and sufficiently robust and (2) will realistically reflect market dynamics.

The second half of the publication provides an illustration of how one group of researchers approached the development of an ESG, describing issues and decisions made in constructing and using this specific ESG. It also discusses sources of data and illustrates a validation process using the model to visualize outcomes and support recalibration. Specific considerations relating to the projection time frame (short horizons vs. longer horizons) are explored in depth. These are particularly relevant in the calibration process of ESGs in the P&C environment. Finally, a discussion of the range of choices for software in developing ESGs is presented, contrasting open-source ESGs with solutions that are available from commercial vendors.

The ability to model a P&C insurer relative to a range of different economic conditions over time is critical.

The paper concludes with an extensive review of the ESG literature, including descriptions of several of the major "classic" papers that deal directly with ESGs. These papers include material with which every designer, builder and probably even user of ESGs should be familiar. There is also an annotated bibliography of major papers categorized according to their particular subject matter. Deeper understanding of this material is appropriate for those involved or interested in the specific modules or aspects of an ESG. Finally, there is a list, without comments, of additional readings in ESG-related areas that provide either deeper analysis of material or alternative approaches to modeling. The final section offers brief suggestions for where future research may likely be found as it emerges.

The paper was written by Conning. Financing and interim draft review were provided by the CAS. The full report will be available on the CAS website in mid-April 2020. ■

Brian Fannin, ACAS, MAAA, CSPA, is the research actuary for the Casualty Actuarial Society. He can be reached at *bfannin@casact.org*.

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JOINT RISK MANAGEMENT SECTION

Published by

RISK MANAGEMENT

APRIL 2020

Macroeconomics Based Economic Scenario Generation

By Kailan Shang

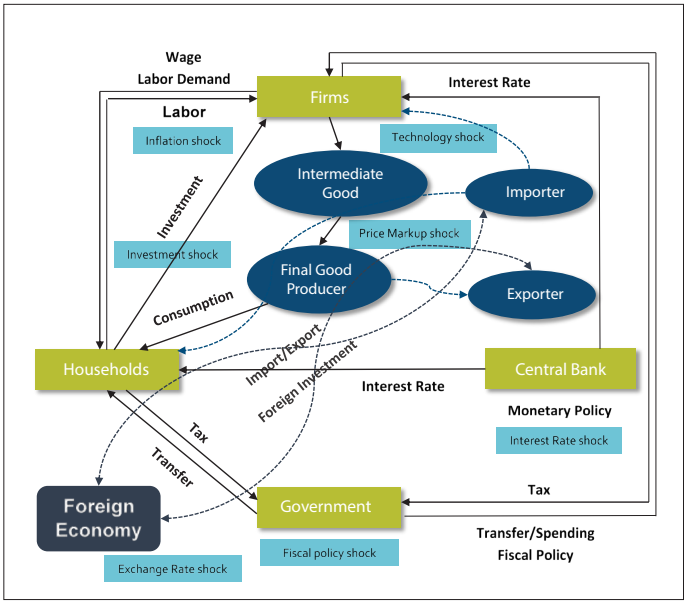
Editor's note: The following article is the second in our April issue that focuses on economic scenario generators (ESGs). The article summarizes key points from the recently published research paper Macroeconomics Based Economic Scenario Generation, *which was sponsored by the Joint Risk Management Research Committee and the Financial Reporting Section of the Society of Actuaries (SOA).*

The paper looks at how dynamic stochastic general equilibrium and multifactor regression models can be combined to create an ESG. The full paper will be available in mid-April 2020.

Economic scenario generators (ESGs) are used in the insurance industry to assess the uncertainty of economic conditions. Many real-world ESGs model asset returns and yield curves directly based on historical data. Others may model systemic risk separately using a macroeconomics model. However, some macroeconomics models can be data-driven as well. They may reflect the historical realization of an economic system but not necessarily how the economic system really works and other possible outcomes.

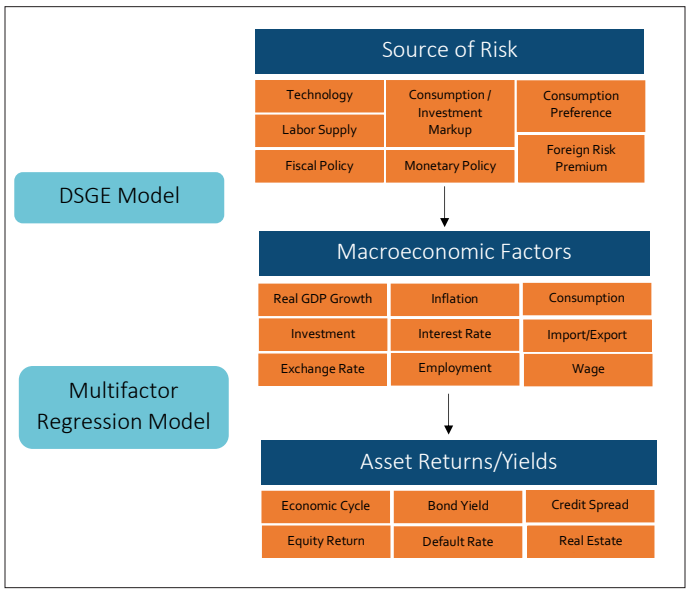
As a unique part of this new type of ESG, dynamic stochastic general equilibrium (DSGE) models are complex macroeconomics models and have been increasingly popular in central banks for analyzing monetary policies. Behaviors of economic agents such as households, firms, central banks and governments are usually defined explicitly, as shown in Figure 1. Based on that, observable economic variables such as real gross domestic product (GDP) growth rate, inflation, imports/exports and employment are estimated, while acknowledging economic shocks to the causes, such as labor supply and technology development, but not to the results, such as unemployment rate and GDP growth rate. With the given nonlinear cause-and-effect relationships defined, historical data is used to calibrate the models. As a potential candidate for modeling macroeconomic factors in an ESG, DSGE models are well equipped for maintaining economic patterns in individual scenarios and explaining the causes behind individual scenarios.

Figure 1
Sample DSGE Model Structure



This report builds an ESG that uses a complex macroeconomics model type to generate macroeconomic factors. The ESG consists of two parts: a DSGE model that generates macroeconomic factors and multifactor regression models that generate asset returns and bond yields (Figure 2).

Figure 2
Sample Structure of DSGE Model-Based ESG



With this structure, sources of risk are used to generate scenarios for modeled variables, instead of using the features of the modeled variables directly. The ESG is a real-world scenario generator that tries to model systemic risk based on macroeconomic models. Therefore, it is not mark to daily market conditions but reflecting economic patterns that persist in a longer time horizon. That means it is not suitable for hedging, financial option pricing, market consistent valuation and tactic asset allocation. It is more suitable for real-world strategy analysis such as strategic asset allocation, business planning, economic forecasting and long-term capital management. It may be used for reserving and capital management with an ongoing view of the business. As a rule of thumb, the ESG is not preferred for any decision making that considers important those patterns that persist less than a quarter. Although this may seem to be a disadvantage of this ESG, it allows users to incorporate their own forward-looking views by adjusting the input data, the models or the scenarios.

The U.S. economy is used as an example to demonstrate the DSGE model. Bayesian Monte Carlo Markov Chain (MCMC) method is used to calibrate the model based on historical macroeconomic data, while some model parameters are determined based on additional economic analysis to overcome the difficulties in model calibration. Economic factors generated by the DSGE model govern the systemic risk in the remaining process of the ESG. Asset returns and bond yields are simulated using multifactor regression models, reflecting both systemic risk and idiosyncratic risk.

Several regression models are tested, including linear regression, Lasso, ridge regression, elastic net, K-nearest neighbors (KNNs), classification and regression trees (CARTs), artificial neural networks (ANNs) and gradient boosting machines (GBMs). Given the data volume, overfitting is a critical issue in the example. ANN models showed very good estimation on the training data but the worst estimation on the validation data. With only 103 data records and many more model parameters, the superficial performance of ANN models is caused by overfitting with a lot more parameters than other models. CART models face the issue of overfitting as well, but less severely. In addition, the possible values predicted by CART models are limited given that the estimation is based on the average of a subset of historical data. KNN models had similar issues as CART models, with limited possible values and unsatisfactory prediction accuracy based on validation data. Linear regression models, especially elastic net models, did a good job predicting government bond yields, credit spreads and dividend yields. For public equity, real estate investment trusts (REITs), and commodities, idiosyncratic factors contribute much to the volatility. GBM models have better prediction accuracy than linear regression models for REIT equity returns. However, the improvement of accuracy may not justify a much more complicated model type. For succinctness, elastic net models are used for multifactor regression in this example. Elastic net models show relatively high prediction accuracy in most cases. Therefore, they are chosen to describe the relationships between asset returns and economic factors. Additional adjustments to the correlation among idiosyncratic risks are made to incorporate nonlinearity in the capital market during economic recessions.

Generated sample real-world economic scenarios can be compared to historical data (Table 1) or to market predictions to assess their reasonableness and identify areas of further improvement.

Because of the complexity of the DSGE model, efforts need to be made to mitigate model risk. Although we can rely on traditional measures such as log-likelihood and Akaike information criteria to compare the model against others,

Table 1
Moments of Asset Returns and Bond Yields

Asset Class		Mean (%)		Standard Deviation (%)	
		Historical	Simulated	Historical	Simulated
Treasury bond, 0 rate (for given term)	1 year	2.62	2.12	2.18	1.21
	2 years	2.93	2.39	2.24	1.27
	3 years	3.25	2.52	2.25	1.28
	5 years	3.49	2.98	2.18	1.20
	7 years	3.93	3.34	2.02	1.16
	10 years	4.26	3.60	1.90	1.15
	20 years	4.51	3.92	1.75	1.18
	30 years	4.82	4.11	1.56	1.12
AAA-rated corporate bonds	Credit spread	0.47	0.60	0.58	0.64
	Default rate	0.00	0.00	0.00	0.00
AA-rated corporate bonds	Credit spread	0.58	0.71	0.78	0.68
	Default rate	0.02	0.03	0.08	0.34
A-rated corporate bonds	Credit spread	1.04	1.08	0.93	0.65
	Default rate	0.06	0.05	0.11	0.35
BBB-rated corporate bonds	Credit spread	1.83	1.80	1.08	0.67
	Default rate	0.18	0.15	0.25	0.30
Public equity	Dividend yield	2.00	1.93	0.54	0.60
	Capital return	2.04	2.28	9.33	5.49
Real estate investment trusts	Cap rate	1.56	1.21	0.44	1.51
	Capital return	1.43	1.49	9.09	5.58
Crude oil	Total return	2.37	2.48	16.18	11.99
Gold	Total return	1.37	1.45	6.75	5.92

it only assesses the goodness of fit to data inputs. It does not guarantee that generated models are reasonable. Sensitivities to the sources of risk can be examined to make sure that expected economic patterns are reflected in simulated scenarios. Range of forecasts can be compared with those provided by the Fed and professional forecasters. Individual scenarios can be checked to see if they preserve economic cycles and the coexistence of a low GDP growth rate, low interest rates, higher credit spreads and a bear equity market during economic recessions.

If the ESG is used as a tool for some regular tasks such as reserving and asset allocation, the calibrated model can be updated with new data or recalibration if deemed necessary. As the existing calibration may have already covered a long history, an additional quarter's data may not have material impact on the calibration, and therefore, recalibration frequency does not need to be quarterly but could be semiannual or yearly. However, with new data coming in each quarter, the starting point of the projection will be changed. The data input for the simulation part includes the latest two quarters' economic data and capital market data. They need to be updated before the scenario generation.

Overall, this research contributes to existing literature in three ways. First, it contains a step-by-step derivation of the DSGE model and details on model calibration. The purpose is to provide enough information for people to understand and be able to customize the DSGE model to reflect their own economic views. Second, it embeds DSGE models into economic scenario generation. DSGE models have been used for analyzing monetary policies but are seldom used in other areas. With a DSGE model-based ESG, users have the flexibility to incorporate prior knowledge of the economic system and the potential to analyze the causes of individual scenarios. It may be attractive for users who need to make decisions based on individual scenarios. The author is not aware of any previous efforts made in this area. Third, sample codes are made available for educational purposes.

The ESG presented in the report serves as an example of a DSGE-based scenario generator. By no means is it perfect, nor can it be used directly without adjustment. More efforts are needed to improve the ESG and make it attractive for practical applications. ■

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VIRTUAL

SPRING MEETING

MAY 11-13, 2020 • ONLINE EVENT

CAS SPRING MEETING GOES VIRTUAL

The **Casualty Actuarial Society (CAS)** is pleased to announce that we will continue with plans to hold the CAS Spring Meeting, scheduled for May 11-13, 2020, but as a virtual event.

The online meeting will provide opportunities for education and networking in an immersive environment designed to make you feel like you are at an in-person meeting — all with no travel, no additional expenses, and from the convenience of your own desk.

The three-day event will include:

- Featured Speaker, Dr. Charles Wheelan, author of *Naked Statistics: Stripping the Dread from the Data*. Dr. Wheelan will speak on the topic of the unintended consequences of data.
- Five General Sessions
- 20 Concurrent Sessions
- Exhibit Hall
- Networking Lounge

Sessions of particular interest to the risk management community include:

- General Session: Risk Management in Light of the Coronavirus Pandemic
- Risk Agility: Linking Enterprise Risk Management to Strategy
- Enterprise Risk Management – Steering Your Board: A Case Study
- Managing Legacy Risks in 2020
- Professionalism and the Enterprise Risk Management Practitioner

Visit www.casact.org/spring to learn more about the 2020 CAS Spring Meeting and register online today!