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The Coming Revolution in Risk Management

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Author's Note: Actuaries have a new tool at their disposal that has the potential to revolutionize the way that insurance companies model and manage risk. The highly sophisticated program produced by Santa Fe, New Mexico-based Assuratech, Inc.(www.assuratech.com) *uses simulation and data mining techniques to take modeling on a quantum leap in accuracy, reliability and versatility.*

If you can look into the seeds of time, And say which grain will grow and which will not, Speak then to me.

Macbeth Act I, Scene 3

Macbeth's challenge might have been addressed to an actuary. Actuaries attempt to project grain growth, as well as many other future events. They may prefer to call their business "analyzing the financial consequences of risk" or "calculating the current business cost of uncertain future events," but they could equally say that they are in the business of examining the seeds of time.

A huge body of science, technology and speculation revolves around defining the best methods of analyzing risk, the breadth of financial consequences that should be studied and the scope of risk that is pertinent to the business being managed. Now, a new technology developed by Assuratech, Inc. allows managers a glimpse at the seeds of time. While they cannot say which seeds will grow, they can say what the field of grain might look like.

Technology to Manage Risk

Recent unimaginable catastrophic events have catapulted enterprise risk management to the forefront of the insurance industry. How can an insurance company be prepared for the inconceivable? Until recently, insurance companies built their theories of the future through mathematical analysis of the statistics of the past. But the past contained no trend lines that pointed to the events of September 11, 2001.

This is the first in a series of articles that will introduce a newly emerging technology for risk management pioneered by Assuratech, Inc., a sophisticated software company that has developed practical applications that use advanced theories of computer science, complexity science and mathematics originating from work done at the Los Alamos National Laboratories and the Santa Fe Institute.

In this article, we will describe some of the industry issues that new-generation risk modeling technologies can address and talk about the emerging technology of simulation as it applies to risk modeling. In the next edition, we will describe the applied complex adaptive systems technology that lies at the core of Assuratech's revolutionary approach to risk management.

Foretelling the Future

The traditional actuaries' toolbox begins and ends with mathematics. Traditionally, actuaries applied mathematical formulae to historical statistics to define a trend and make a projection. An accurate projection, though, depends on an accurate estimate of future contingent events—the ability to descry the future.

Of course, men have sought the ability to foretell future events since the beginning of consciousness. From the hallucinogenic fumes of the Oracle of Apollo at Delphi, to the scrying globe of the Celtic witch, to the casting of coins or twigs that yielded the hexagrams of the I Ching, the earliest "technologies" of foretelling sought answers in the murky realm of the intuitive, with inconsistent, unreliable results.

In the past hundred years, foretelling has moved from the realm of the intuitive to the realm of the scientific, focusing on the use of mathematics and the "law of large numbers" to provide a statistical confidence that actual results would be close to expected results. For a period of time, the technology of mathematics sufficed to provide a high level of confidence in actuarial calculations. By and large, distributions worked well enough to contain risk within acceptable parameters. There remained some discomfort around the tails, but for a long time the discomfort was well within the risk tolerance of most managements.

The Tails Wag the Business

In the past decade, however, the discomfort around the tails has escalated. We can list defining events such as Hurricane Andrew and the attack on the World Trade Center that have brought to light the potential impact of imprecision in traditional risk management techniques.

In the property and casualty industry, the unthinkable and unimaginable are becoming the norm. In the health insurance industry, with its finite resources, the potential for losses is infinite. In the field of life insurance, disintermediation recently put one of the largest U.K. companies out of business. And equity markets that fluctuate from the anemic to the hyperactive pose an ongoing challenge to capital management.

Consolidation in the insurance industry adds to the potential impact of miscalculations in risk management, as does consolidation in the industries that are insured. The scale of operations of global conglomerates and the

scale of a single catastrophe render the potential financial impact of a tail risk miscalculation devastating. Now the task of extreme value management is to accurately plan for the inconceivable.

The magnitude of the problem is quickly told, if less easily comprehended. While the full count is not yet agreed upon, total losses arising from September 11 are assumed to be as high as $90 billion, with insured losses around $58 billion. It is the worst workers' comp disaster in U.S. history. In health care, the largest sector in the U.S. economy, costs continue to escalate at double-digit rates. A.M. Best suggests national health expenditures are expected to climb to $2.6 trillion in 2010, twice as much as they were in 2000. In the face of such staggering numbers, the insurance industry is re-examining every aspect of risk management.

Planning For The Inconceivable

Traditional modeling techniques look at individual risks, examining one aspect of the universe of risks at a time. Yet it has become clear that it is not possible to understand the whole picture of risk and threats by simply examining its parts. It is no longer appropriate to manage different risks independently.

Best's Review's June 2002 article about the Risk and Insurance Management Society's 2002 Annual Conference highlighted the message from experts that another terrorist attack is a virtual certainty. The companies that will not re-emerge from the devastation of September's terrorist attacks, said panelists, will fail because they were ill-prepared to manage a crisis of unprecedented proportions. As an industry, it is imperative that we learn to prepare for the inconceivable before the next catastrophic event occurs.

What is needed is a method of managing uncertainty as a portfolio of risks rather than as a series of independent events. The interaction between financial, hazard, strategic and operational risk must be accounted for, as must the risks of being part of the global insurance community and the interconnectedness that goes along with that.

Assuratech's president, Terry Dunn, has over 30 years of experience in the insurance industry. He proposes that the industry is perched at the edge of a revolution in its approach to risk management, and he proposes to lead the revolution. "By using agent-based simulation, counter-intuitive threats and opportunities emerge as various scenarios are played out," he says. "The use of our simulator suggests possible scenarios that other models ignore. Counter-intuitive 'hedging strategies' can be developed through the use of the 'what if' generator. It provides a 'bird's-eye-view' of the business and its environment. This broad perspective allows managers to truly model risk on an enterprise-wide basis and in a global context."

Modeling: Science and Art

Statistical modeling has been at the heart of risk management for the past century. Industry actuaries develop elaborate modeling formulae or programs that are applied to historical data and resolve to describe a probable future to which a current-dollar price tag can be attached. One reason that there is an almost infinite variety of actuarial models is that each model necessarily incorporates an element of judgment or intuition or speculation in the definition and weighting of probable future events.

A February 2000 article in the *Actuarial Review* quoted this dictum: "An actuary is what you get when you cross a computer with a gypsy fortune teller." The kernel of reality behind this fanciful statement is that, in traditional modeling, the reliability and precision of mathematics is leavened by the need to incorporate untestable hypotheses about future events.

Models come in several varieties of form and purpose. *Would-Be Worlds: How simulation is changing the frontiers of science*, by John Casti[1], contains an excellent discussion of the nature and purposes of models. Casti is a globally recognized science writer, mathematician and complexity science expert and one of the scientists who serves on Assuratech's Board of Directors. He proposes several taxonomies of models. The first taxonomy we will discuss is based on the purpose of a model. In this taxonomy, models are categorized as predictive, explanatory or prescriptive.

Predictive Models

Predictive models, says Casti[1],"enable us to predict what a system's behavior will be like in the future on the basis of the properties of the system's components and their current behavior." A good example is

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1) Casti, John L. Would-Be Worlds: How simulation is changing the frontiers of science, New York, John Wiley & Sons, Inc., 1997.

Ptolemy's model for the motion of the planets, which allowed astronomers of his time to accurately predict the location of specific planets. That Ptolemy's model was based on the erroneous assumption that these bodies rotated around the earth was irrelevant to its usefulness as a predictive tool.

A very simple predictive model in insurance, for example, is one based on risk-adjusted return on Capital (RAROC). The prediction here is that if your RAROC is too low (or too high), then you can expect your company to behave poorly (exactly how it will behave poorly requires a more detailed predictive model).

Explanatory Models

Explanatory models, on the other hand, are static descriptions of the framework within which past observations can be understood as part of an overall process. They give reasons and origins, and may or may not make predictions. Newton's First Law of Motion explains the motion of bodies in terms of a "force" that acts on a body. This law explains the "cause" for the motion. The cause for planetary accelerated motion is the gravitational force that draws them to the sun. The First Law can also be integrated in time to predict the location of a planet at the current time given its location and velocity at a previous time. Newton's model serves as both an explanatory and a predictive model.

Like the First Law, dynamic financial analysis (DFA), for example, is a predictive/explanatory model used by actuaries to forecast the probabilities of the various financial outcomes of a company given a universe of risk events.

Prescriptive Models

Prescriptive models offer decisionmakers an explicit prescription to optimize the behavior of the modeled system through targeted interventions. A prescriptive model, for instance, can tell you at what angle to place your cannon so that the cannonball will strike its target. In insurance, a prescriptive model can tell you which markets to enter to minimize your risk profile.

Current modeling techniques present several drawbacks. One is that they do not do a good job of dealing with simultaneous changes to multiple variables in complex environments. Another is that when they are applied to large complex systems such as the national economy, there is no way to validate or test them without incurring additional, unacceptable risk. Is one, for instance, willing to force people out of their jobs in order to test the effect of unemployment on credit card delinquency?

Complexity of Risk

The fact is that the proper objects of risk modeling in today's global economy are what scientists call "complex systems," and traditional modeling techniques have been shown to be poor predictors of the behavior of complex systems. This is because there is an elemental incompatibility between the assumptions that underlie traditional modeling techniques and the nature of complex systems. Let us look first at the nature of complex systems, as defined by complexity scientists.

Complex Systems

Complex systems consist of a large number of individual agents that can change their behavior on the basis of information they receive about what the other agents in the system are doing. Complex systems come as a unified whole; they cannot be studied by breaking them into their component parts and looking at the parts in isolation; and the behavior of the system is determined by the interaction among the parts. Complex systems are unstable, exhibiting many possible modes of behavior, often shifting between these modes as the result of small changes in some factors governing the system. The global insurance market is a complex system.

Roger Jones, Ph.D., is Assuratech's chairman and chief scientific officer. He pioneered many of the dramatic advances in computer and algorithmic capabilities necessary for this type of work. Jones believes that complexity science is the natural handmaiden of insurance risk management. "During the Industrial

Age, science was the servant of business. Science developed products to sell. Now, in the Information Age, modern business-persons manage their firms as much with the science of complexity as with the principles of accounting. Science has become the partner of business."

Data vs. Information

For some time, advances in modeling have focused on adding granularity of data to the mathematical calculation, pre-supposing that more data will yield better modeling. It is true that many modeling systems depend on the availability of large quantities of accurate data. Modern data mining techniques yield enormous amounts of data. We can mine a huge field of available data about complex systems, yet the dilemma of how to extract meaningful information from those terabytes of data remains. More data does not necessarily yield more or better information.

To turn the data into actionable information for insurers and reinsurers, models must somehow account for the interactions and interrelationships between different risk segments. The behavior of this complex system—the global insurance market—depends on the interaction of customers, financial markets, competitors, investors, governments, nature, terrorists and others. Forecasting must incorporate the entire complex universe of interrelated variables that describe all the agents in the global insurance market. To be accessible, the information must be presented in a context that is familiar and understandable to decisionmakers. And finally, the information must be timely and instantaneously available, to accommodate a 24/7 universe.

Granularity

To see why simply increasing the amount of data we have about complex systems will not improve the reliability of traditional modeling, we must return for a moment to Casti's descriptions of models. Alongside the taxonomy that categorizes models based on their purpose, Casti describes a taxonomy based on the granularity of the data that feeds the model. In this taxonomy, models may be high-level, mid-level or low-level.

High- or Mid-Level Modeling

For a variety of reasons, traditional models have focused on high- or mid-level modeling, using statistically aggregated trend data. In this taxonomy, a Keynesian economic model is described as a prescriptive, high-level model. It aggregates several hundred thousand unemployed individuals residing in 54 states and territories into a single percentage unemployment index and uses that datum as one of its variables. A Keynesian economist will then demonstrate that increasing income will decrease unemployment and propose policies to do that.

Low-level modeling has heretofore been limited primarily to scientific disciplines, where researchers have thought nothing of devoting huge quantities of computational resources to the calculation of the path of a single electron. In fact, the perceived limitation imposed by the available technology has been one of the motives for keeping the modeling focus primarily on mid- or high-level granularity. Another has been that there has been relatively little interest in examining the details of lower-level interactions.

TO TURN THE DATA INTO ACTIONABLE INFORMATION FOR INSURERS AND REINSURERS, MODELS MUST SOMEHOW ACCOUNT FOR THE INTER-RELATIONSHIPS BETWEEN DIFFERENT RISK SEGMENTS.

If, for example, you want to predict the price of a particular share on the stock market tomorrow, you can get quite a good prediction by looking at aggregate information about the company's earnings and performance, expected interest rate levels and some indicator of market trends. It is not necessary for such an inquiry to examine in detail the trading patterns of every individual trader in the market and his or her strategies, goals and trading patterns.

Scenarios

The purpose of models used in the insurance industry is primarily prescriptive. The question being asked is: what will happen to my financial situation if this or that event takes place, and how can I ensure that the result is not catastrophic for my company?

Until recently, the methodology essentially took a mid-level predictive model, which might be validated and tweaked by using older historical data to generate a prediction and comparing the predicted results to actual newer data. Assuming the future proceeds linearly from the past, such a model would provide reasonably accurate predictions.

To make such a model prescriptive, scenarios would be created, in which one or more variables might be altered and the same model applied. To create the scenarios, actuaries would weight both the

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alterations to the variables and the predictive model with probabilities.

The inherent flaw in this methodology is that the future does not proceed linearly from the past. At a very low degree of data granularity (a high-level model), this is not so important. As our investment advisors keep telling us, if you look at the value of a mixed basket of stocks over 50 years, the stock market remains the best investment. But if you increase the granularity of your investigation, you may find that stocks are not the best investment over, say, the next six months, and your ability to predict the status of your market basket in six months is subject to a significant margin of error.

From Modeling to Simulation

In the search for better information, Assuratech, and its parent company Complexica, brought together mathematicians, complexity scientists and experienced insurance industry executives. The original consortium formed to explore applications of complexity science to improve insurance risk management included global reinsurance brokers, research institutes, consulting firms and complexity scientists.

Modeling at any level is an attempt to represent reality. But complexity scientists (and, incidentally, gamers and educators) had leaped to representing reality through simulation. A simulation displays on a computer a surrogate reality that appears to behave exactly like the real thing.

Simulations have been used to train airplane pilots, to select from 10,000 chemical formulas the one most likely to be the next wonder drug and to allow millions of apprentice wizards to slay dragons on their home computers. How would it be if, instead of modeling the behavior of markets, one could simulate a market in its entirety and watch it react to unexpected events?

The work of the consortium resulted in a software package that represented a virtual world in which one could simulate the financial results on five insurers and five reinsurers of two types of catastrophic events over a ten-year period. This crude original package has been built on and refined to produce the sophisticated proprietary simulation capability that Assuratech now provides to the industry.

The Revolution

The explosion in the availability of inexpensive computing power and the experience of complexity scientists who had tested simulations of complex systems in laboratory conditions provided the tools. The consortium provided the impetus and the idea. And the journey towards revolutionizing risk management in the insurance industry was begun.

The technology of this revolution is adaptive agent-based simulation technology. Our next article will describe this technology in some detail; we present a brief summary here.

The technology depends on dissecting statistical patterns to find their causes. The rules that drive individual agents to behave and interact the way they do are mined from the aggregate data. Agents and their rules are programmed into a defined environment. Each agent follows its own rules, interacting with the environment and other agents in response to internal imperatives and stimuli provided by the environment.

Agents can be anything from individuals to companies to governments, consumers, suppliers and so on. As the computer watches and keeps track, these agents pursue their goals, learning from their experience and changing their rules of behavior accordingly, influencing other agents to learn and respond in return. The result is a record of the consequences of the collective behavior of many agents navigating many strategies—in other words, a very close, accurate simulation of the real world insurance market.

Assuratech's product, *Insurance World©*, delivers a simulated insurance market in which all of the pieces interact to collectively affect the capital and bottom-line profits of the ten companies that inhabit the simulated market. With this tool, insurance companies can finally build a comprehensive picture of their entire risk environment. The complexity of the tool is in the programming and the definition of the environment and agents. Once that is accomplished, decisionmakers can build scenarios and see the outcomes as ten years of financial reports—in seconds.

Insurance World© meets all the tests we set out above for turning data into actionable information for insurers and reinsurers. The simulation accounts for the interactions and interrelationships between different risk segments and different agents. In fact, it incorporates the entire complex universe of agents that act in the complex system that is the global insurance market. The results are presented in the familiar and understandable form of financial reports. And the entire program can be run on a PC, in real time.

For further information on Assuratech, visit *www.assuratech.com* or contact *tdunn@assuratech.com.*