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Forecasting & Futurism NEWSLETTER

Delphi Studies Past, Present and Future

By Ben Wolzenski

Actuaries
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FROM THE EDITOR:

Actuaries: Do We Know Our Limits?

By Dave Snell

An infinite number of actuaries enter a bar. The first one orders a pint of beer. The next one orders a half pint. The third wants a quarter of a pint; and the fourth is about to order an eighth of a pint when the bartender stops her. "All right, I get it! Collectively, you want two pints of beer. ***You actuaries should learn your limits***."

At a recent meeting of the Boston Actuaries Club, Scott McInturff opened with a variant of that joke. But perhaps there is a more serious lesson here.

The theme of this issue is recognizing (and then extending) our limits. In the last year or two we have talked about the limits of classical actuarial modeling and forecasting techniques. Here, you will read about several ways to supplement your toolset. Nobody is suggesting that you abandon the older tools—just that you recognize their limits, and consider some newer ways to give you a broader perspective.

Ben Wolzenski has written an excellent summary of the Delphi methodology ("Delphi Studies Past, Present and Future"). There are many ways to approach most real-world problems. Why limit ourselves to only one at a time? A Delphi study can be a useful "second opinion" to our sophisticated mathematical models. It can surface alternative ideas that might otherwise be overlooked by the recognized "experts" in a judgmental study. We all have read the story about the blind men and the elephant; and how our immediate or past impressions frame our perspective. Perhaps together, the blind men in a Delphi study could have, through rounds of discussions, assimilated their divergent opinions and discerned that an elephant is a large animal with sides like a wall, legs like a tree trunk, a tail like a rope and a trunk like a hose.

Perhaps, in life, we cannot see all of the attributes or dependencies of our own models. The perspective of a Delphi study can help. In a Delphi study, we gather the opinions of many; and the results seem to benefit more from a variety of opinions than from a single expert. Many actuaries are recognizing how the wisdom of the collective is often superior to that of a single expert or a small group of experts. In fact, Forecasting and Futurism (F&F) is combining forces with Actuary of the Future (AOF), Entrepreneurial Actuaries (EAS) and the Canadian Institute of Actuaries (CIA), as well as the SOA Risk Management staff partners for a Delphi study on "Future Career Opportunities for Actuaries." We'll have more information for you about that later this year.

Brian Grossmiller wrote a review of *Linked: How Everything Is Connected to Everything Else and What It Means for Business, Science, and Everyday Life*, by Albert-László Barabási. In *Linked*, we learn that many of our models may be underestimating the covariance among us—that many of the variables where we assume independence are actually interrelated. Network theory can help us deal with this former limit to our understanding of relationships.

I have added a short summary of deterministic chaos "When Algebra Gets Chaotic." I show that a very simple popula-

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tion growth equation can give unexpected results when you change your starting values just a tiny amount. This equation showed a limit to our ability to exactly predict results that involve any real-world measurements of our starting values. It spawned a whole new branch of science called chaos theory.

I've also given a quick overview of the very successful sessions we co-sponsored with AOF on various aspects of complexity science. It's titled "Standing Room Only!" You said you wanted them; we produced them; and you showed up for them. We have momentum. Let's keep it going.

Frank Grossman addresses our visual limits in an innovative article "Hidden in Plain Sight," which questions "I know what I see" logic with examples of "what you see is not what you think you see." It's an engaging look at changing our perspective—in vision and in thought.

Here in the newsletter we reached a limit of a different type. Scott McInturff is writing a multi-chapter wild romp through the actuarial past, present and future. In "2020 Hindsight," he takes a shocking look at the insurance industry through the eyes of well-traveled 62-year-old actuary and baseball lover, Geraldine Springer. The plot takes twists and turns that are guaranteed to blow your mind. We couldn't fit this in a printed edition (his story is already over 40 pages and growing) so we put in a link to it. *http://dl.dropbox.com/u/52684680/2020%20Hindsight.pdf* Scott plans to make this a serial. Geraldine is not a serial killer, but this is a killer serial. Be sure to check it out.

I am also proud to include an excellent article from "down under," where a distinguished Australian futurist, Charles Brass, shows an uncanny similarity in the tools needed to study the future—and the past! Everywhere in his article ("Investigating the Future: Lessons from the 'Scene of the Crime'") that I read the phrase "crime scene investigator (CSI)" or the term "futurist," I felt like substituting "actuary" as a synonym. We seem to have the same limits … and similar ways to stretch them. This article is from the November–December 2011 issue of *The Futurist*—another publication I recommend highly for anyone interested in forecasts, trends and ideas about the future.

Ben Wadsley wrote about our new F&F contest, where we get to test our own forecasting abilities and limits. How well can you predict U.S. unemployment? There is an iPad 2 in store for the winner. Have some fun and potentially get a cool new gadget in the process. I find my iPad 2 is rapidly weaning me away from lugging a heavier laptop around with me … and the apps are fun, and a lot less expensive than their PC counterparts.

Ben also gives his outgoing chair's message; but he is not leaving us, just rolling to another section. F&F and AOF have become kindred spirits. Both Ben and I are on the AOF council now; and we plan to continue the joint F&F and AOF sponsorship of the many complexity science sessions on which we cooperated so well in 2011.

Our new F&F chair, Donald Krouse, is coming in with a lot of enthusiasm, and bringing solid experience and successes from his recent time with the Investment Section. His incoming message is optimistic and inspirational. We are many; we are connected. Read Donald's plans for the coming year. Decide where you can jump in to help us extend our limits. When we join forces, I'm guessing our limit is more than just two pints. ▼

Dave Snell

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NOTE FROM THE OUTGOING CHAIR:

Volunteerism is Rewarding!

By Ben Wadsley

As the council year ends, so does my tenure as the Forecasting and Futurism Section chairperson. The Society of Actuaries (SOA) annual meeting is behind us now, and the great sessions that our council put together represented the fact that we were one of the fastest-growing sections in the SOA last year. It's been a great year and a half, and while I'm sad that my time is over, I am also excited that the council that leads us into 2012 is well positioned to stay strong.

We have elected our officials for next year. Our chairperson is Donald Krouse, who is a great leader and will make sure our section stays on track and continues to provide value to our members. Clark Ramsey is our new vice-chairperson. In his first year as a council member he has already provided a lot of good ideas and guidance. Also, our returning secretary/treasurer is Mike Lindstrom. He held this position last year, and his archival quality minutes and notes provide us the information we need to sustain our continuity. Dave Snell, who also just completed his last year as a council member, is going to continue to be the newsletter editor. On top of his trailblazing research in complexity science, he has taken the newsletter from a discontinued publication to a semi-annual (and very well-read) one. Along with the help from our SOA staff, we're poised for success!

Even though I'm leaving the council and joining the Actuary of the Future council, I am planning on staying on as a friend of the Forecasting and Futurism council, and hope to still contribute to our section. While continuing work on genetic algorithms, I look forward to keep looking at new and underused techniques to apply their uses to actuarial science. One of the ventures I'm undertaking in order to accomplish this is taking an "Introduction to Artificial Intelligence" class sponsored by Stanford University. Some of the most interesting subjects in the syllabus are hidden Markov models, Bayes filters and adversarial planning. I have always been a proponent of discovering new technologies while not forgetting the lessons from traditional techniques, and I'm hoping some of these new (to me) subjects will complement some of our actuarial work.

At the annual meeting this year, the SOA emphasized volunteerism. Volunteerism is what drives our section and many other parts of the SOA. Be sure to thank those who volunteer their time for our profession, and consider contributing time yourself … it can be very rewarding!
Thanks for the opportunity. ▼

Ben Wadsley

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FROM THE CHAIRPERSON:

Exploring, Growing, Learning ...

By Donald Krouse

Welcome to another exciting and informative *Forecasting & Futurism Newsletter*. Although complexity science has been around for some time, it is only relatively recently that applications to the area of insurance have been made. This is "new ground," and I look forward to more "mainstream" application of some of these processes in the everyday life of an actuary. I'm proud to say that, last year, this section experienced the largest percentage growth in its membership of all the Society of Actuaries (SOA) sections. I think this serves as testimony to the importance and potential of these concepts in the actuarial "toolbox."

Recent feedback from the section membership shows the need for two types of information. The first is what could be called "basic education"—many of us have heard about Network Theory, Delphi Studies, Black Swans, etc., but seek more formalized definitions of the principles. The second is what could be called "applications"—given the "tools," HOW and WHERE and WHEN could they be applied. It is only with practice that the power of these concepts will be fully appreciated.

The articles in this newsletter address one or both of these needs. I'm sure you'll find these articles as interesting and stimulating as I do. Best of all, in my experience, these articles serve merely as the "jumping-off" point for further discussion, investigation and application.

Complementing this newsletter, our section will continue to sponsor sessions at various SOA meetings this year, and is also considering webcast(s) or other educational forums.

As an initiative this year our section plans to make available a list of references on various pertinent topics. Addressing item one above, a list of reading material is being reviewed. Addressing item two, numerous experts have been identified for various techniques/processes. Some have graciously allowed themselves to be identified as contacts for you to find out more about these exciting areas. Anticipate a resource list, with both readings and personal contacts, on the section's SOA website later this year.

In closing, I'd like to welcome three new section council members: Alberto Abalo, Peter Hou and Ben Wolzenski. Look for them, and the continuing section members, at meeting sessions, and please don't hesitate to offer feedback or ideas, or to volunteer for the section! I'd also like to thank the retiring council members for their work over the past few years. Ben Wadsley, as chair for close to two years, led the section through this expansion phase. Ben also presented at many meeting sessions and served as the Investment Section liaison. Dave Snell not only shared his knowledge and experience at meeting sessions, but also served as newsletter editor (a role that he is continuing as a "Friend of the Council") and relationship coordinator. Raza Zaidi served as our website coordinator. Please extend your gratitude to these members when you see them. ▼

Donald Krouse

Donald Krouse is vice president and appointed actuary with Transamerica Life Insurance Company in Cedar Rapids, Iowa. He can be reached at *donald.krouse@transamerica.com*.

Delphi Studies Past, Present and Future

By Ben Wolzenski

ABSTRACT

This article is about research studies that use the Delphi technique. It describes what a Delphi study is; gives a thumbnail sketch of two Delphi studies the Society of Actuaries (SOA) has sponsored in the past 10 years as well as a recently initiated Delphi study; and asks readers for their ideas for future studies.

WHAT IS A DELPHI STUDY?

Here are two answers: the Wikipedia definition followed by a question-and-answer approach:

"The **Delphi method** is a systematic, interactive forecasting method which relies on a panel of independent experts. The carefully selected experts answer questionnaires in two or more rounds. After each round, a facilitator provides an anonymous summary of the experts' forecasts from the previous round as well as the reasons they provided for their judgments. Thus, participants are encouraged to revise their earlier answers in light of the replies of other members of the group. It is believed that during this process the range of the answers will decrease and the group will converge towards the "correct" answer. Finally, the process is stopped after a pre-defined stop criterion (*e g*., number of rounds, achievement of consensus, stability of results) and the mean or median scores of the final rounds determine the results."

WHAT'S A DELPHI STUDY? THAT SOUNDS PRETTY ESOTERIC. ARE WE HIRING A HIGH-PRICED ORACLE TO PONTIFICATE ABOUT THE FUTURE FOR US?

No way! A Delphi study sounds fancy (and high-priced); but actually, it can be a very low-cost way to get information—often much better information than you get from a high-priced consultant. The idea behind this is collaboration ... the synergy of many minds ... the wisdom of the many.

REALLY! HOW DOES IT WORK?

We send a round of questions to a panel of interested people. Everyone's comments are anonymous so no one person or clique can unduly influence the others by their stature, volume or assertiveness. Each person sees the anonymous responses and then gets to change her or his mind in round two of the process. The rounds continue like this until a steady state is reached.

YOU MEAN, WHEN EVERYONE AGREES?

No, not necessarily. You keep going until the answers seem to stop changing. Some folks may converge to one answer, but another group may settle on a different value. The Delphi study considers all of the decision groupings as valid answers.

IT SOUNDS A BIT DISORGANIZED. THAT CAN'T BE AS GOOD AS THE OPINION OF AN EXPERT, CAN IT?

Surprisingly, Delphi studies have often resulted in findings that are much better than those of the so-called experts. They bring in the power of diverse opinions.

IS A DELPHI STUDY APPROPRIATE FOR QUANTITATIVE STUDIES, OR IS IT FOR QUALITATIVE STUDIES?

Yes, and yes … the SOA has sponsored both types.

WHAT DELPHI STUDIES HAS THE SOA SPONSORED IN THE PAST?

No.1: On Oct. 6, 2005, the SOA released "A Study of the Use of the Delphi Method, A Futures Research Technique for Forecasting Selected U.S. Economic Variables and Determining Rationales for Judgments."

This article presents only a bit of background and a few items from the report; the complete study is available on the SOA website at the address below. The quotations below are from the full study.

http://www.soa.org/research/research-projects/finance-investment/research-delphi-study-of-economic-variables-report.aspx

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Ben Wolzenski

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"From August, 2004 to September, 2005 an inaugural in-depth Delphi Study was performed by the Society of Actuaries designed to obtain insights into the rationales and thought processes experts used in making judgments about the long range (20 year) values of four U.S. economic variables:

1. Annual increase in the Consumer Price Index
2. 10 Year Treasury Spot Yields
3. S&P 500 Total Rate of Return
4. Corporate Baa Spot Yields"

	Annual increase in the Consumer Price Index	10-Year Treasury Yields	S&P 500 Annual Rate of Return	Corporate Baa Spot Yields
2004–2005	3.1%	4.3%	7.9%	6.2%
Delphi Round 2 (for 2024)	3.4%	5.9%	7.8%	7.8%
9/30/09–9/30/11	2.5%	3.2%	5.5%	6.0%

THE STUDY HAD SOME INTERESTING RESULTS, ESPECIALLY VIEWED IN THE LIGHT OF THE SIX YEARS THAT HAVE PASSED SINCE THE REPORT WAS ISSUED.

The study had some interesting results, especially viewed in the light of the six years that have passed since the report was issued. But first, a cautionary note from the report about Delphi studies:

"Because the number of participants is usually small, Delphi studies do not (and are not intended to) produce statistically significant results. In other words the results provided by any panel do not predict the response of a larger population or even a different Delphi panel. The estimates and the rationale, techniques and methods for estimating the variables represent the synthesis of opinion of the particular group involved, no more, no less."

That said … what did the panel of experts predict, and what has happened since then?

First, let's just look at the numeric data. The table at left shows the average **expected** values produced in Round 2 of the Delphi study (for the year **2024)**. (Participants also identified the highest and lowest plausible 2024 values for each economic variable.) Also shown are the average values for the two calendar years during which the study was performed and the average values for the eight quarters prior to the date this article was submitted for publication.

So far, the trend in the indicators has not met that of the Delphi panelists' average expected value for 2024, although all the values are well within the ranges put forward by the panelists. But there is a lot of time remaining until 2024.

Now let's see what events the Delphi panelists thought were most likely to influence the outcomes. The following were the median values of participants' "realistic expectations during the next 20 years."

1. Oil prices rise to above $70 per barrel for at least five years.
2. New technologies drop the cost of production of most products by 10 percent.

3. Confidence in the United States drops; direct foreign investment falls to 65 percent of current levels.
4. U.S. government current account deficit increases to 10 percent of GDP.
5. Productivity increases 5 percent for five continuous years.
6. Profit margins of most U.S. companies drop to 70 percent of current levels for 10 years.

We are about one-third of the way to 2024 from the study date … what have we seen so far?

1. Oil prices were above $70 per barrel in parts of each year from 2006 to 2009 and all of 2010 and 2011 to the article submission date.
2. I am unaware of any objective measure of the effect of technology on the cost of all products. However, a Google search for "technology reduces cost of production" produced "about 101,000,000 results."
3. As reported by the Bureau of Economic Analysis of the U.S. Department of Commerce, foreign direct investment in the United States has increased every year since the study through 2010. (Results for 2011 were not available when this article was written.)
4. The U.S. government federal deficit was approximately 10 percent in fiscal 2009 and at the time this article was written was expected to top 10 percent in fiscal 2011.
5. Productivity of nonfarm labor, as reported by the Bureau of Labor Statistics, has increased each year since the study was published, by an average of 2 percent per year. (However, reported productivity decreased in each of the first two quarters of 2011.)
6. Measured by GAAP earnings of the S&P 500, profits took a hit in 2007 and 2008; in the latter year earnings were 82 percent lower than 2006. However, by 2010, earnings were within 6 percent of the 2006 peak.

No. 2: On Feb. 27, 2009, the SOA released "Blue Ocean Strategies in Technology for Business Acquisition by the Life Insurance Industry."

Once again, this article presents only a bit of background and a few items from the report; the complete study is available on the SOA website at the address below. The quotation and strategy description below are from the report. *http://www.soa.org/research/research-projects/life-insurance/research-blue-ocean-strat.aspx*

"'Blue Ocean Strategy' has come to mean a strategy that allows for a vast open blue area of undiscovered and, consequently, unexplored and unoccupied, territory. It means finding a completely new approach to an existing concept, approaching a market from an entirely new direction."

The purpose of the study was to gather expert opinions as to whether there were any such "Blue Ocean Strategies" that could foreseeably affect the life insurance industry over the next 10 years. In total, 43 experts participated in the three-round Delphi study. As a result of these panelists' feedback in Round 1, 10 possible strategies were identified, as follows:

- Strategy No. 1: Earth Friendly Insurance Company—"Paperless processing"

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- Strategy No. 2: Super Fast Insurance Company—"Quantum leap in time to market"
- Strategy No. 3: Insurance Without Borders Company—"Global Internet sales where regulations allow"
- Strategy No. 4: Global Insurance Company—"Global data mining, marketing"
- Strategy No. 5: Your Way Insurance Company—"Prospects custom-design coverage online"
- Strategy No. 6: Strategic Partners Insurance Company—"For operational excellence"
- Strategy No. 7: Just What You Want Insurance Company—"Micro-policies"
- Strategy No. 8: Holistic Insurance Company—"Risk 'agents' help mitigate all risks"
- Strategy No. 9: Big Brother Insurance Company—"Monitor individuals' health, risk profile"
- Strategy No. 10: Virtually Real Insurance Company—"Virtual world insurance."

These 10 strategies can be grouped into three themes:

- Greater efficiency in marketing and underwriting traditional business. These have promise, but they are not "Blue Ocean Strategies."
- Micro approach to insuring [currently] undesirable risks. These are "Blue Ocean" because they create a viable approach to insuring a set of risks others avoid.
- Holistic approach to risk financing and mitigation. These are "Blue Ocean" because they open up a whole set of risks not previously insured and encompass an integrated approach that no one is implementing.

Two of the strategies that the respondents voted the most promising were:

Strategy No. 1: Earth Friendly Insurance Company—"Paperless processing"

Earth Friendly Insurance Company plans to adopt a "Blue Ocean Strategy" called: "Paperless processing: do it all online!" "Part 1" of this strategy is to use technologies and processes that do away with paper applications, which may include the pre-population of some information about the applicant from internal or external sources. Information will be obtained through the Internet or all-in-one communication devices either directly from the applicant or a field agent. Policy approval and an option to print coverage verification will be directed back by similar routes. Earth Friendly also foresees a "part 2" of this strategy: the use of a "Touch the Screen" system in which the applicant would touch the computer/laptop screen and the fingerprint would automatically pull all medical files and other lifestyle data. One slight prick of blood, similar to that used by diabetics for blood sugar testing, would provide immediate analysis of all physical conditions, which would be fed through the computer at the same time as the one-touch activity.

Strategy No. 7: Just What You Want Insurance Company—"Micro-policies"

Just What You Want Insurance Company believes that there may be an emerging opportunity for a "Blue Ocean Strategy" around offering "micro-policies." These products cover narrow risks, at targeted periods, for specific consumers, at highly specialized prices. Sophisticated—often diverse—technologies are frequently required to enable distribution, segment markets, price risk and issue coverage. Although these policies have the potential to replace broader "blanket" coverage, the greater potential is to open markets for risks otherwise uninsurable.

One final note on these two Delphi studies sponsored by the SOA … less than 40 percent of the Blue Ocean panelists and less than 25 percent of the Economic Variables panelists were actuaries. In both cases, the project oversight group (POG) took seriously the charge to assemble a diverse group of participants.

WHAT DELPHI STUDY IS THE SOA SPONSORING IN THE PRESENT?

A Delphi study on Future Jobs for Actuaries is currently in the formative stage. The investigative team was chaired by Steve Easson, who has agreed to chair the POG. (Steve also chaired the POG of the Economic Variables Delphi). The Project Scope lists these two purposes:

- Facilitate the identification of strategies to increase the demand for and supply of actuaries in North America thereby ensuring actuaries have a market to apply their skills, to minimize suffering diminished job opportunities and to attract more individuals to the profession.
- Provide valuable input into the SOA's strategy setting, risk management and cultivating opportunities initiatives.

As noted above, Delphi studies involve multiple rounds of input and feedback—it will likely be a year or so until the results are released.

WHAT DELPHI STUDIES MIGHT THE SOA SPONSOR IN THE FUTURE?

Delphi studies are a technique; the subject matter is open. To date, the Forecasting and Futurism Section has been a co-sponsor of the three studies mentioned above. Each time, one or more other sections have been involved in providing the subject matter and topical expertise. So any area of investigation where judgmental forecasting is needed could be a legitimate candidate. We would love to hear your suggestions! Feel free to contact any member of the section council listed in this publication. ▼

Investigating the Future: Lessons from the "Scene of the Crime"

By Charles Brass

Futurists investigate clues and evidence to attempt to answer difficult questions, much like crime-scene investigators. But while CSIs try to determine things that have already happened, futurists look to what may yet happen, and what we can do now to influence it.

As practitioners of a relatively young profession, futurists are frequently asked to explain what they do. Often, the askers have some skepticism. I personally have lost track of the number of times people have asked to see my crystal ball or my time machine when I have shown them my business card.

Charles Brass

Many people seem to be unable to get their heads around the idea that it is possible to learn something useful about events or situations that have not yet happened. Yet, when archaeologists report on what they have learned, no one doubts their professionalism, despite the fact that they were not at the time and place they are observing.

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This is why, when I am asked to explain what a futurist does, I use the analogy of an archaeologist or, for younger audiences, a crime-scene investigator. Most practicing futurists are at least as interested in the past as they are in the future, but my use of this analogy goes far beyond simply acknowledging that how we arrived at the present has a powerful impact on what will happen in the future.

Both crime-scene investigators and futurists are interested in learning more about a time and place remote from themselves, and both use increasingly sophisticated sets of tools and techniques to help them expand their knowledge. Before they begin to use any of these tools, however, they follow a series of protocols that are designed to ensure that they do their job rigorously and that others can validate and replicate their work. This article looks at some of the rules that crime-scene investigators (CSIs) follow. These rules have direct parallels in helping to shape not only good crime-scene analysis, but good futures practice, as well.

DETERMINING THE INVESTIGATION'S BOUNDARIES

The first thing that CSIs do is to define the physical space in which they are interested and then cordon this area off. This is no trivial exercise. The CSIs expect to invest considerable time and energy in examining the interior of that quarantined space, recognizing all the while that drawing too wide a boundary may yield only marginally more knowledge. Similarly, drawing too narrow a boundary will increase the likelihood that important information will be overlooked. In any case, no boundary can possibly capture everything or everybody of interest.

Futurists, too, have to delineate boundaries around the themes in which they and their clients are interested. As good systems thinkers, futurists are acutely aware of the extent to which everything is interconnected, and they are always concerned that important information may lie outside the immediate area of their focus.

They also know (and if they don't, their clients always remind them) that they don't have an infinite amount of time within which to explore the future. Futures work is designed to enhance the quality of decisions made in the present, and clients most often want to make decisions quickly. For instance, those responsible for public-school

systems must anticipate numbers of incoming kindergarteners some years in advance, but this is difficult in the absence of detailed information about such things as decisions to open or close local factories, or planned changes in zoning regulations.

The CSI has an advantage over the futurist in that the boundary of an official crime scene is marked with very visible tape that everybody understands and most people respect. Even if futurists are meticulous and explicit about defining the boundaries of a particular assignment, the nature of their work and the people they work with mean these boundaries regularly get challenged or ignored. Nonetheless, most futurists find it very helpful in their consulting work to take time early in the process to discuss, and hopefully agree on, the boundaries within which any particular assignment will take place.

Of course, good CSIs know that a new discovery might at any time cause an expansion of the taped-off area. Similarly, futures work is made easier if the futurist and the client can explicitly acknowledge that some proposed new action is taking the assignment beyond the previously agreed boundaries. In the school system example, chronic flooding in the region may also impact families' relocation decisions, so the futurist's boundaries might need to expand to include environmental factors.

There is more to the tape around a crime scene; however, than just simply defining where the CSI will focus attention. The tape reminds others that the space inside is a special place and needs to be treated carefully.

This is another way in which the CSI has an advantage over the futurist. CSIs can pretty well ensure that no one will enter their area of interest unless they have been invited, and even then they will follow the CSI's rules of conduct. In effect, the CSIs attempt to freeze the crime scene until they complete their investigation.

Futurists' areas of interest can rarely be as conveniently frozen while the analysis takes place. Nonetheless, if people who do continue to move around inside the demarked area are aware that, for the moment, this is a special space, they are more likely to think more carefully about the actions they take. Perhaps the members of the school board might need to be reminded to factor their yet-to-be completed future scanning into their current budget cycle.

For futurists, marking out the territory of interest in a particular investigation includes identifying the people who habitually occupy that territory. Letting all these people know that an investigation is taking place can often reduce the accidental damage done by those who aren't aware of the significance of the space.

Of course, not everyone's motives are pure and wholesome. Both CSIs and futurists need to be aware that some people will deliberately try to mislead or taint the crime scene or the future space.

ANALYZING EVIDENCE OBJECTIVELY

Having drawn a boundary around their area of interest, CSIs then get down to work. They know that their primary role is to carefully notice and document as much as possible. In addition to their five human senses, they bring their experience and a variety of technological tools to help them in this work.

They are acutely aware that their mere presence on the scene changes things, and that their human prejudices and biases color what they notice and how they report on what they notice. They are aware, too, that some of their work is unpleasant, and that it is a natural human reaction to try and cover up some of this unpleasantness.

Futurists, too, are most often outsiders that other people bring in to a situation to help make sense of it. Like any other human beings, too, futurists are prone to bring biases and prejudices to everything they do. Just as the fingerprints of all CSIs and police officers are recorded so they can be eliminated from the investigation, so futurists need to be careful to eliminate as much of their influence on the scene as they can.

Futurists also should know that, whatever specialist expertise they claim to bring, many others on the scene will nonetheless seek to bring their perspectives to the situation. In particular, futurists need to be aware of the natural human tendency to avoid unpleasantness. The best futurists are

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skilled at presenting the results of their work in such a way that all relevant aspects are given their appropriate weight.

Placing a tape around a crime scene gives the impression that the moment of the crime has been frozen for analysis by the CSI. The skilled investigator, whether CSI or futurist, knows that everything changes, even during an investigation, so the more they know about how things change, the more useful they will be.

In this regard, the training that futurists receive might give them an advantage over the CSIs. Learning to appreciate all the dimensions within which change takes place is an integral part of futurist training, and good futurists are aware that only dead things change in regularly predictable ways.

The CSIs are almost always examining purely physical, geographic space. Futurists, on the other hand, explore landscapes that are shaped and populated by human beings for whom change is an unpredictable inevitability.

CSIs' specialist expertise is most often accepted by all those involved. They can often rely on the legal system both to support their efforts and to compel the participation of all those in whom they are interested.

Alas, futurists have no such legal mandate. Where the CSI can usually assume that those who commission their work are genuinely interested in their professional analysis—such as identifying a cause of death or indicating a probable perpetrator—futurists often confront unwilling participants or even clients unwilling to listen to what has been learned.

FUTURISTS, ON THE OTHER HAND, EXPLORE LANDSCAPES THAT ARE SHAPED AND POPULATED BY HUMAN BEINGS FOR WHOM CHANGE IS AN UNPREDICTABLE INEVITABILITY.

CSIs are provided with an ever-expanding toolkit, much of which is the result of developments in science and technology. In particular, they have access to many tools that enhance or extend human senses and give precise quantitative data.

Futurists, too, have access to an expanding toolkit. Like the CSIs', much of the futurists' equipment is designed to supplement individual human senses, often by aggregating information across larger populations. Some of the futurist toolkit is also designed to tap into underutilized areas of the human experience, such as myth, metaphor, and worldview. Often, the futurists seek to sharpen human senses by focusing them in a variety of ways. Modern technology enhances the futurist toolkit by allowing the collection, analysis, and interpretation of quantities of data that would otherwise stretch human capability.

Whatever tools are used, both the CSIs and the futurists need to be aware of the limitations of human ability to understand and interpret the information before them. And they also need to be aware that some people have malicious intent and can either inadvertently or consciously taint the data.

STUDYING THE PAST AND STUDYING THE FUTURE

CSIs and futurists are both part of our modern world because human beings are relentlessly interested in the world around them. Since none of us can be everywhere at all times, we are collectively prepared to invest in developing the skills of that special subset of people who can help us make sense of a world we did not, or could not, experience: the past and the future.

Good CSIs know that the past is not a space that anyone can completely understand. No matter how many resources we bring to bear on studying it, our comprehension of the past—even of very recent events—will always be imperfect. What CSIs expect to do is to work diligently to reduce this imperfection as much as they can.

Futurists can relate to this: The future is also inherently uncertain. They strive to reduce the uncertainties as much as possible by applying systemic and systematic approaches to understanding the future.

There is a final, crucial difference between CSIs and futurists, however. CSIs primarily exist to help others understand what has happened. Futurists are interested in what may happen and are even more interested in what we would like to happen. Futures work is about both understanding the future and creating it.

In *The Clock of the Long Now,* futurist Stewart Brand wrote: "Our experience of time is asymmetric. We can see the past, but not influence it. We can influence the future, but not see it." He may have been wrong on both counts. Many people behave as though they could influence the past, and we all strive to see the future. What both CSIs and futurists remind us is that doing all these things will be improved if it is done systematically and rigorously.

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Crime-Scene Futurists: Six Rules from CSI

1. Explicitly describe the boundary marking the edges of the space in which you are interested. There often will be physical, temporal, and/or organizational dimensions of this boundary, and all need to be identified.
2. Ensure that all the people who normally inhabit this space, or are likely to enter the space during the project, are aware of the project and its aims.
3. Document the current contents of the space in as much detail as time and resources permit.
4. Investigate the provenance of the space with as much diligence as you can.
5. Notice how, and why, the space changes during the project. Look for both the internal and external forces that might explain these changes.
6. Use appropriate tools from your futurist toolkit to begin to tease out the future for the space.

—Charles Brass

Hidden in Plain Sight

By Frank Grossman

One of the earliest tales in the detective fiction genre concerns the search for a stolen letter that has been hidden in plain view. This original idea—hiding the Hitchcockian "MacGuffin" in a place where it could be readily seen by all—proved to be a very effective plot device. So popular was this concept, over the intervening century and a half since its debut, that what was once a novel idea seems very nearly a cliché today. Yet the basic key for successful sleuths remains unchanged: knowing how to look for what one is seeking—or, just maybe, knowing how to *see* what is already there.

A moment's reflection may bring to mind sundry items that can be both seen and not seen at the same time, depending on one's point of view. A present-day example of how shifting one's physical point of view literally transforms what one sees is located within the Toronto Transit Commission's Bayview subway station. The walls and floors of this station's subterranean passages are decorated by visual illusions, otherwise known as *anamorphoses*, created by Panya Clark Espinal. Her large-scale pictures—of a butterfly, or a ladder, or a pocket watch—are plain to see, but *only* if one looks at them in the right way, to the perennial amusement of youngsters en route to and from the subway platform.

Indeed, there is a long tradition of paintings that incorporate anamorphic elements requiring an appliance or visual aide to decipher. Mirrors or other shiny objects—cylinders, cones or spheres—placed just so, or a lens of one form or another, are needed to reveal these hidden images. Hence, this type of anamorphosis is accessible only to those having both the requisite knowledge and the proper tool to unlock its secret.

There are, as well, other types of anamorphoses, namely those visible to the unaided eye but requiring a unique vantage point, akin to those in the Bayview subway station. A notable example is *The Ambassadors*, Hans Holbein's famous double portrait painted nearly 500 years ago. Located in the foreground of this painting, between two full-length pictures of French emissaries to Henry VIII's court, is an apparent smear or blurred image. Only when viewed at an extremely acute angle is the smear transformed to reveal a human skull. This traditional symbol of death in the 16th century artist's lexicon is just one part of a complex message hidden in plain sight within Holbein's masterwork.[1]

How might the foregoing description of hidden items and images, and various viewpoints, speak to contemporary actuarial practice? Well, consider the ongoing debate enjoined by proponents of a market-consistent world view and their confreres, those who cleave to its counterpoint, a more traditional best estimate world view. This is an example of how similar information, when examined from different perspectives, can lead actuaries to radically different findings and recommendations.

A recent book about Hans Holbein describes the coexistence of conflicting perspectives within *The Ambassadors* that conspire to constrain or limit the viewer's perspective. (Please note that the following excerpt is taken from an English translation which may account for its slight idiosyncrasy.)

> Holbein placed an apparently anamorphous (sic) shape before the two men; if the picture is viewed at close range from below on the left or from above on the right, this shape transforms—suddenly—into a human skull, while at the same time the rest of the image becomes illegible[2] … Thus the image is constructed according to two perspectival (sic) systems, one organizing the living figures and the world of phenomena around them, the other articulating the skull, the metaphor of Death. These two systems coexist in one painting but are at the same time mutually exclusive: to comprehend fully one of them (sic) the viewer has to lose sight of the other.[3]

The particular passage "These two systems coexist … but are at the same time mutually exclusive: to comprehend

Frank Grossman

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fully one of them the viewer has to lose sight of the other." seems an apt description of the duality of the market-consistent and traditional actuarial approaches. It also underscores the challenge of satisfactorily reconciling market value liabilities with statutory reserves: to comprehend one of them fully, the actuary has to temporarily lose sight of the other.

I once heard an actuary deftly attribute the acrimony that sometimes accompanies the market-consistent versus best estimate debate to differing, and yet equally valid, *belief systems* held by opposing actuaries. Clearly, the risk of embracing a point of view too strenuously is that it can simultaneously render one unable to see from an alternate vantage point. Avoiding such professional blindness means that actuaries ought to shed their preconceived notions and biases from time to time, and (however temporarily) strive to see things differently. In this way, actuaries may overcome the self-imposed limitations implicit in a particular mind-set, and possibly gain both a greater insight into their present circumstances and a clearer glimpse of the future too.

The detective story mentioned at the outset of this article was "The Purloined Letter" written by Edgar Allan Poe in 1844. Within this story, Poe's prototypical private detective, C. Auguste Dupin, didn't set his meerschaum pipe down and rise from his chair to physically change his vantage point—aiming to see more clearly and hence solve the mystery. Rather, Dupin's crucial insight stemmed from his decision to challenge a fundamental assumption made by the Paris police and adopt an alternate viewpoint in figurative terms. Ultimately, it was flexibility of thought—and a willingness to part ways with conventional wisdom—that enabled Dupin to locate what others sought but could not see, and thereby discover a letter which had been there all along hidden in plain sight. ▼

From one vantage point, Panya Clark Espinal's mural within the TTC Bayview subway station appears skewed …

… yet moving several steps to the right brings her picture of a pocket watch into view.

END NOTES

1 Devotees of Dan Brown's later-day fiction *The DaVinci Code* and others interested in learning more about the creation of *The Ambassadors* and its hidden message are referred to John North's *The Ambassadors' Secret: Holbein and the World of the Renaissance* (Hambledon and London, 2004).

2 A utility that enables one to virtually manipulate *The Ambassadors*, and hence make its anamorphosis plainly visible, is located at *www.michaelbach.de/ot/sze_anamorph/index.html*.

3 Bätschmann, Oskar, and Pascal Griener, *Hans Holbein* (Princeton University Press, 1997, English edition) page 188.

Standing Room Only! Complexity Grows at Annual Meeting

By Dave Snell

It just doesn't get any better than that! Forecasting & Futurism (F&F), along with Actuary of the Future (AOF) sponsored three sessions on complexity science; and the attendance and audience participation was great. In addition, the Health Section sponsored another session, and it was great too. We have been promoting the new tools and techniques of complexity science for a couple of years now, and 2011 looks like the year when the general membership really took an interest in it.

I was privileged to present the introductory session, "Complexity Science: What It Is Why It Is Important to You." Brian Grossmiller was my moderator and broke the monotony of just me with poignant questions along the way. In 75 minutes we covered deterministic chaos, behavioral economics, predictive modeling, network science, fractals, genetic algorithms and cellular automata, along with the history of classical economics and where it broke away from the association with physics. OK, in 75 minutes we did not actually do much more than touch upon these subjects; but we did give a taste of a little of the world beyond classical actuarial techniques. The reception was very good. This was the fourth SOA big meeting presentation of this overview and we still are finding a lot of interest in the subjects.

Feedback from our previous presentations on complexity science (at the Annual Meeting 2010, Life & Annuity Symposium 2011 and Health Meeting 2011, plus some regional actuarial clubs and university actuarial science programs), though, asked for more depth on a few topics like genetic algorithms and behavioral science.

Addressing those requests, Ben Wadsley and I (with Brian again as moderator) conducted a workshop on genetic algorithms. Attendees brought their laptops, and, together, we went through genetic algorithm examples. The group even broke up into smaller teams, in competition for a copy of Melanie Mitchell's new paperback version of *Complexity: A Guided Tour*. We all learned from each other; and the feedback we heard from participants directly and through tweets (yeah, I did not expect that type of feedback) was enthusiastic. We hope to continue these workshops and expand the number of genetic algorithm converts. At one point in the presentation, I tried to explain genetics 101 (actually 0.001) and made the comment along the way that real genetics is very complex; and we are not God so we have to seriously scale back the micro world of our algorithms. I was particularly amused by one tweet Ben showed me afterwards that stated the takeaway was, "We are not God."

Ben gave a presentation of his asset and liability management (ALM) model that is an excellent actuarial application (see his article about this in our July 2011 issue). Later, we summarized our experience with the "art" of this new science. There are a lot of items that are not cookbook in nature. You have to get involved; and tweak parameters and develop a rough intuitive sense for what will help your robots learn the particular situation more quickly.

Our third offering was on behavioral economics. Our speakers here were Bob Wolf, SOA staff partner, Risk Management, and David Wheeler, a recent graduate in the emerging field of, you guessed it, behavioral economics. Bob quickly showed us how our background and experience led us to incorrect answers when dealing with financial decisions; and David followed up with other examples from the current literature. It was a great mix of industry experience (Bob is not only a member of the Society of Actuaries, but also a fellow of the Casualty Actuarial Society) and academia (David brought the latest teachings from DePauw University); and once again, the attendees enjoyed the mind-opening exercises and left chatting (and tweeting) about this cool new area of complexity science.

Dave Snell

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WE HOPE TO CONTINUE THESE WORKSHOPS AND EXPAND THE NUMBER OF GENETIC ALGORITHM CONVERTS.

The Health Section followed up with still another complexity science offering. Doug Norris, an ASA and Ph.D., gave a presentation on "Modeling Complex Systems in Health Care." He talked about the strengths and weaknesses of complexity science modeling, and how to apply what he called the four archetypal complexity science models—networks, cellular automata, virtual worlds and serious games—to solve actuarial problems in health care.

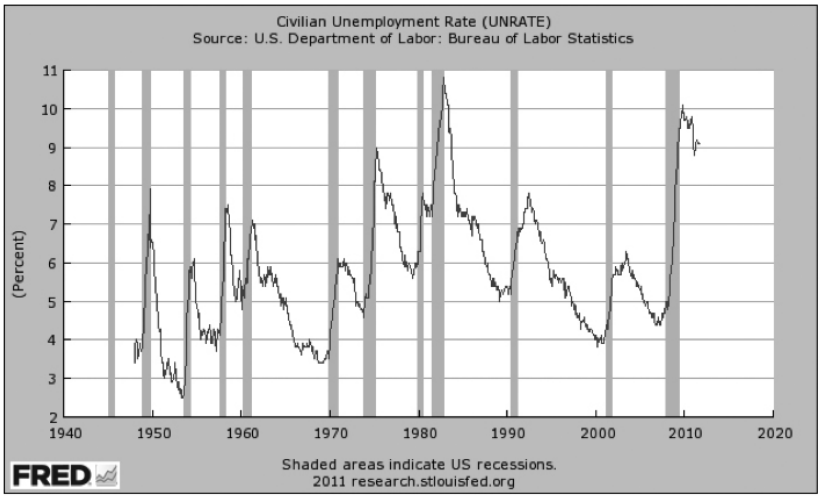
Obviously, this year saw a turning point in actuarial interest in complexity science. Next year, we hope to see a further expansion. Please be a part of it. Volunteer to show how you are using this exciting new toolset. ▼

F&F 2nd Annual iPad 2 Forecasting Competition

By Ben Wadsley

Attention: Anyone who would like to win an iPad 2 … and sharpen their forecasting skills.

I'm proud to announce the second annual iPad forecasting competition sponsored by the Forecasting and Futurism Section! The winner will be the one who develops the best model that predicts the Civilian Unemployment Rate (UNRATE), measured on a monthly basis, from March-end 2012 through September-end 2012. The contestants may use any combination of actuarial techniques to arrive at the model, including but not limited to: time series, regression, genetic algorithms, agent based models, judgmental forecasting, etc.



THE WINNER WILL BE THE ONE WHO DEVELOPS THE BEST MODEL THAT PREDICTS THE CIVILIAN UNEMPLOYMENT RATE (UNRATE), MEASURED ON A MONTHLY BASIS, FROM MARCH-END 2012 THROUGH SEPTEMBER-END 2012.

For a data source, we are going to use the Federal Reserve Economic Data (FRED) database. This can be found at: *http://research.stlouisfed.org/fred2/*. The statistic of interest will be the tracking error for each of the submitted models, defined as the sum of the (six) squared monthly deviations between the forecast and the actual UNRATE data points over the forecast period. All input variables into the model must also come from the FRED database (except for time variables, mathematical operators and constants). This shouldn't be a problem, since the FRED database has 35,000 economic time series! The only exception is that data series that have some form of unemployment included in them (state unemployment or jobless claims for instance) are not allowed. Also, it is recommended that each of the variables included are measured at least on a monthly basis. Quarterly reported variables are allowed, but will use the quarterly statistic for the next three months. Also, because we hope to announce the contest winner at the 2012 SOA Annual Meeting, all data is cut off as of Oct. 12, 2012, so any September data not reported by that date will be replaced with August data.

A sample model submission may look like this (but doesn't have to):

Y= Y(t-1) + a * CPI for all urban consumers + b * 10Y Treasury Rate/ FED Funds + c * log (Y(t-1) / Y(t-2)) ; Where a, b, c are constants.

Also, a short description of how the model was developed is recommended. If there needs to be a tiebreaker, the Forecasting and Futurism Section Council will use the best or most innovative description of the model to decide the winner of the iPad.

You may be asking yourself, "Where do I start?" A great place to start may be looking at one of the previous Forecasting and Futurism newsletters. In the September 2009 issue of the newsletter, there is a great article outlining the different classes of forecasting methods found at: *http://www.soa.org/library/newsletters/forecasting-futurism/september/ffn-2009-iss1.pdf*. There is a list of five main catego-

ries that can be used with other techniques (such as genetic algorithms).

1. Extrapolative methods—Methods based on data patterns rather than explanatory variables.
2. Explanatory variable methods—Methods incorporating causal variables to forecast dependent variables.
3. Simulation modeling methods—Methods using the computer to simulate real-world agents, behaviors and events.
4. Judgmental methods—Methods based on expert opinion or intuition.
5. Composite methods—A combination of the above.

Many of the forecasting methods in the above categories are very powerful, yet not frequently used by actuaries. Some of them are exponential smoothing, autoregressive moving average, econometric modeling, system dynamics simulation and multi-agent simulation. This may be a great time to get to practice one of these methods, and think about how it could apply to our profession. On the other hand, a tried-and-true method may be the best way to go.

Please submit your model and description by Feb. 28, 2012 to Christy Cook at *ccook@soa.org*. The only requirement is that you are a member of the Forecasting and Futurism Section. There will be a periodic update on the frontrunners of the contest as it progresses. The iPad 2 will be given to the winner around the 2012 SOA Annual Meeting (attendance at annual meeting is not required to win). If you have any questions on the contest rules, feel free to contact me at *Ben.Wadsley@transamerica.com.* ▼

Ben Wedsley

Ben Wadsley, FSA, MAAA, has worked for Transamerica in Cedar Rapids, Iowa for eight years in a range of asset/liability management, investment, and economic capital roles. He is currently a risk manager for the Employer Solutions and Pensions division. He can be reached at *Ben.Wadsley@Transamerica.com.*

When Algebra Gets Chaotic

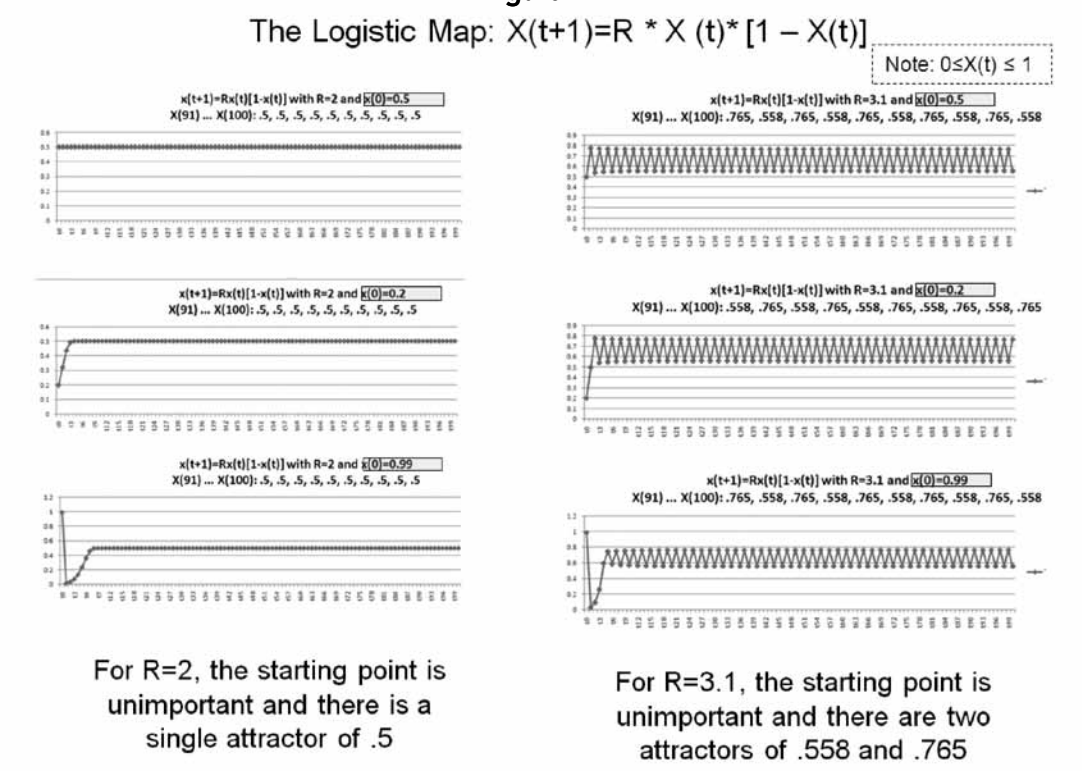
By Dave Snell

Pierre François Verhulst first published his logistic growth function in 1838 after he had read *An Essay on the Principle of Population*, by Thomas Malthus. Benjamin Gompertz, of actuarial mortality function fame, also published work developing the Malthusian growth model further.

It is a very simple equation: X(t+1)=some constant, R, times X(t) times [1-X(t)]; but it has some interesting properties. When R=2, it does not matter what starting value you choose, 0.5, 0.2 or even 0.99—the equation moves toward a single attractor of 0.5. Note that X(t) is bounded by 0 and 1. The general idea is that while population is small and resources are large, growth is fostered. When population becomes large, resources are less plentiful, and population growth is constrained.

If you increase R to 3.1, two attractors emerge, and the value oscillates between them. At slight increases in R, according to something called Feigenbaum's constant, the amount of attractors keeps doubling. Both of these cases are shown on Figure 1.

Figure 1



Dave Snell

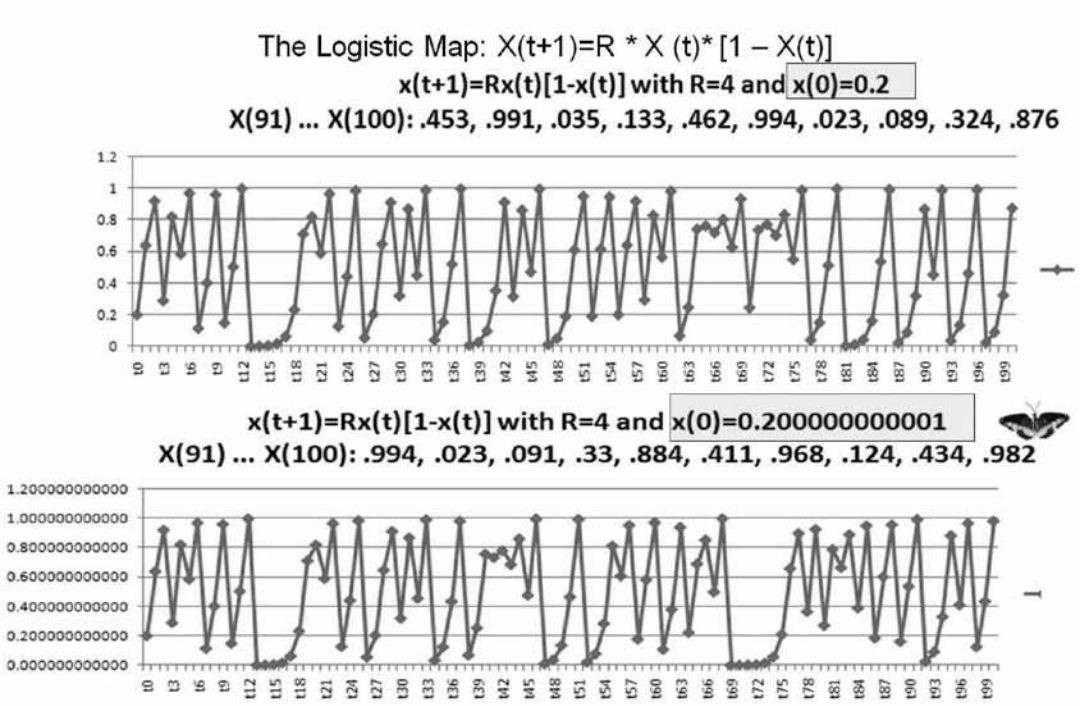
Dave Snell, ASA, MAAA, is technology evangelist with RGA Reinsurance Company in Chesterfield, Mo. He can be reached at *dsnell@rgare.com*.

By the way, Feigenbaum's constant is around 4.6692016, and it shows up in a lot of different scientific applications. Read about it in *Chaos: Making a New Science*, by James Gleick. Do you know how Feigenbaum derived his constant? He used a calculator. This is an example of what is called experimental mathematics. Use a computer, calculator or other means to find the answer, then go back and develop a formal proof for it. The term was coined in 1972, but I think the Egyptians used it way back when they were building the pyramids.

Now, here is the cool part!

Looking at Figure 2, we see that once you reach R=4, just a tiny change in one of your assumptions may cause an undetermined effect on the validity of your model. The two graphs are somewhat similar; but there are definite differences in some areas.

Figure 2
DETERMINISTIC CHAOS



When R=4, starting point is critical and there appear to be no attractors

CONTINUED ON **PAGE 24**

WHEN ALGEBRA GETS CHAOTIC | FROM PAGE 23

Everyone has heard of the butterfly effect. Here is the butterfly effect in action in very basic algebra. Keep in mind the only thing that caused the two graphs to differ so noticeably at the later durations is a starting assumption difference beyond the trillion decimal place. That's 0.2 versus 0.2000 blah, blah, blah, 001.

Some of you may be thinking: So what! So what if some trick equation can do this? My equations are not so vulnerable. I deal with more clear boundaries in my pricing or valuation or modeling work. Do you?

What about pricing for a last-survivor policy? In computing the probability of survival for two individuals X and Y in a last-survivor situation, we often assume that:

$$p_{\overline{xy}} = p_x + p_y - p_x\, p_y$$

In English, the probability of the last survivor of X and Y living through the coming year is the probability of X living, plus the probability of Y living, minus the double count if both live through the year.

This equation implicitly assumes that the survival of X is completely independent of the survival of Y. Yet, don't we all know of several instances where a parent or grandparent died and the spouse died soon afterwards because of what medical professionals call "losing the will to live"? Is that in our equation? Do you really think the death of one spouse has no impact on the survivorship of the lifelong mate?

In modeling, we make assumptions about mortality, morbidity, investment returns, tax rates, etc., and we project these forward for 60, 80 or even 100 years. Then, just to be safe actuaries (and because regulations sometimes encourage it), we vary the initial assumptions slightly and execute 10,000 stochastic runs to come up with conditional tail expectation (CTE) results to assure ourselves we are in complete control. But is that true if the tail of one assumption will more likely than not precipitate the tail of others and then cause the whole set of assumption dominoes to start falling down? And even if by some stretch of the imagination our theory is correct, do 10,000 stochastic runs using starting assumptions correct to four but not 40 decimal places actually guarantee accurate results on the other end of a model far more complicated than the logistic equation?

My wife's cousin, Dan Nolan, was a male in his early 30s. An avid runner and health enthusiast, Danny had a great job as a high-priced consultant working and living in Chicago. Back in 2001, Danny's company sent him to a meeting in New York City at the World Trade Center. Danny, along with about 3,000 other supposedly independent individuals, all perished together in the tragedy of 9/11.

Are we all independent from a mortality perspective; or does our complex network of interrelationships introduce a covariance that can rock our world of accurate calculations … like it rocked Danny Nolan's world … and that of his wife … and his two children?

Do many of us drink the same brand of soda, or fly the same airline, or attend the same actuarial meetings?

Are we sure we are correct that our basic modeling assumptions of independence of key and obscure variables are accurate, or are we just drinking the same marketing Kool-Aid?

Deterministic chaos sounds like something that actuaries, sensible people that we are, would never have to deal with in our financial calculations. Yet, as we see, it can even happen in simple algebra … and life is not always as simple as algebra. ▼

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BOOK REVIEW

Linked: *How Everything Is Connected to Everything Else and What It Means for Business, Science, and Everyday Life* by Albert-László Barabási

Reviewed by Brian Grossmiller

From global economies to the Internet to cancer cells, networks are everywhere. Surprisingly, these networks often have very similar characteristics despite the very different circumstances in which they arise. In his book *Linked*, Albert-László Barabási, a nationally renowned expert on network theory, takes the reader on a journey through the development of science of networks.

The book explores both features common to many networks and theories as to how they develop and grow. Key terminology is also explained, such as how objects in a network are viewed as nodes and the connections between them as links.

One of the first network features explored is the "small world" phenomenon. This occurs when a network has a relatively small average distance between any two nodes compared to its size. For example, the idea in popular culture that there are six degrees of separation between you and any of the other six billion people on this planet is an example of a small world. The results of a study citied in *Linked* showed that of the 800 million documents on the World Wide Web in 1998 they were separated by an average of 19 links. Most networks have this property.

Brian Grossmiller

Another interesting network feature is the idea of a "hub" or "connector." These are nodes with an uncommonly large number of links. Internet search engines such as Yahoo! or Google are examples of hubs, which have far more than the average number of links pointing to them. The nation's air traffic system is another example; hubs such as New York or Chicago have connections to many more destinations than smaller airports.

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Hubs are often critical to navigating a network; in the example of airport travel one can reach much of the country in two flights by flying through a hub. The presence of hubs does have implications for the topology of networks. As explained in *Linked*, the distribution of links by nodes approximately follows a power law distribution in many networks. These are functions of the form $y=1/x^k$, the logistic function.

Networks will often have few hubs with a lot of connections and a much larger number of nodes with few connections. This type of structure provides resiliency against indiscriminate attacks on networks, as the bulk of the nodes targeted in such an attack have few connections, and the rest of the network can continue to function without them. Attacks targeted at hubs, however, can cripple a network by removing a small number of nodes from the network. This effect has been seen in denial-of-service attacks on websites.

Linked contains several examples of real-world networks and the potential risks that are inherent in them. The 1996 summer blackout, for instance, illustrates how a cascading failure can propagate throughout a network. A single power line failed and shifted its load to other nearby lines. These lines then failed and shifted their loads, which continued until 11 states and 2 Canadian provinces were without power. Other networks explored in the book include such disparate subjects as disease transmission and international financial arrangements.

The principal theory of network growth presented in the book is preferential attachment. Under a preferential attachment model, as new nodes are added to a network, they have a higher probability of connecting to existing nodes with a large number of links (the hubs). Intuitively this makes sense—as Barabási puts it, "the rich get richer." Models of networks generated under this theory are referred to as

scale-free networks, as they follow a power law distribution and, if magnified, the tail of the distribution has the same shape as the overall distribution (see Figures 1 through 3).

Network theory can have some useful actuarial and business applications. Though not covered in *Linked*, some obvious examples include studying referral patterns among health care service providers and evaluating how failures at critical companies can propagate through the economy and potentially impact your firm's investment returns. Other applications might include the determination of non-obvious key personnel at your organization or attempting to target a marketing campaign preferentially at the social hubs of a community. Data collection for such efforts can be problematic, but in the absence of a formal evaluation a network approach can still be of use qualitatively.

I would highly recommend *Linked* to anyone interested in learning more about network theory. Though not a cookbook for business applications, it is an engaging read. Since reading *Linked* I have become much more aware of the networks around me. ▼

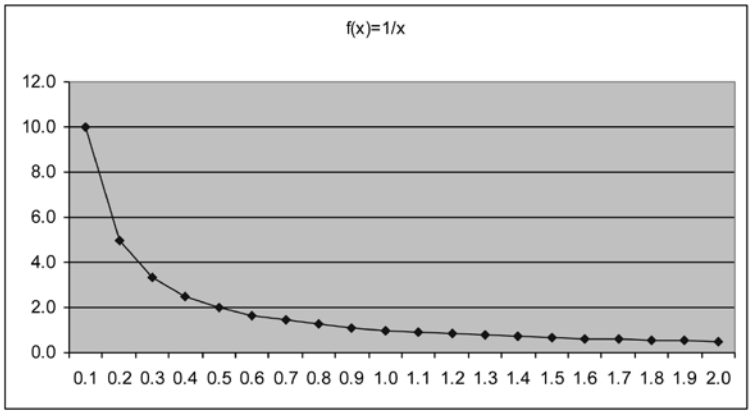

Figure 1: f(x)=1/x as x ranges from 0.1 to 2 with increments of 0.1.

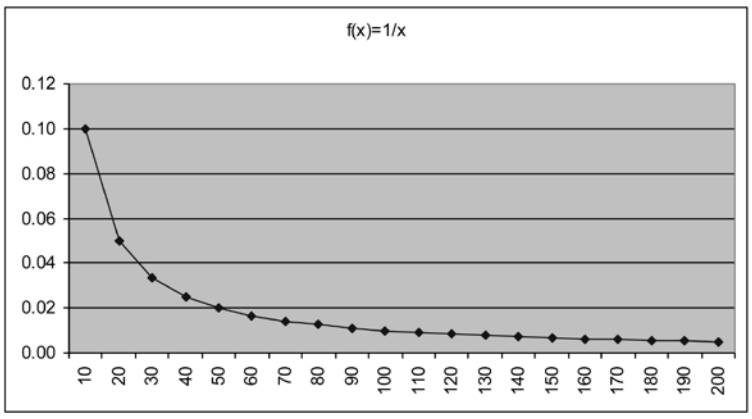

Figure 2: f(x)=1/x as x ranges from 10 to 200 with increments of 10.

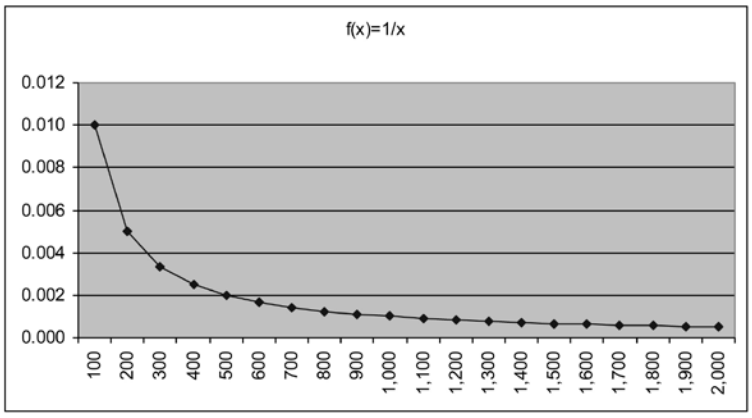

Figure 3: f(x)=1/x as x ranges from 100 to 2,000 with increments of 100.

SOCIETY OF ACTUARIES Forecasting and Futurism Section

Forecasting & Futurism NEWSLETTER

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