JOINT RISK MANAGEMENT SECTION

Canadian Institute of Actuaries
Casualty Actuarial Society
Society of Actuaries

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Risk management

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ARTICLES NEEDED FOR RISK MANAGEMENT

Your help and participation is needed and welcomed. All articles will include a byline to give you full credit for your effort. If you would like to submit an article, please contact Sim Segal, editor, at *sim.segal@watsonwyatt.com*.

The next issues of *Risk Management* will be published:

PUBLICATION DATES	SUBMISSION DEADLINES
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March 2010	December 1, 2009

PREFERRED FORMAT

In order to efficiently handle articles, please use the following format when submitting articles:

- Word document
- Article length 500-2,000 words
- Author photo (quality must be 300 DPI)
- Name, title, company, city, state and email
- One pull quote (sentence/fragment) for every 500 words
- Times New Roman, 10-point
- Original PowerPoint or Excel files for complex exhibits

If you must submit articles in another manner, please call Kathryn Baker, 847.706.3501, at the Society of Actuaries for help.

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Continuing on the Right Track

By Sim Segal

LAST YEAR, when I took on the role as editor of *Risk Management*, we adopted a goal of broadening our coverage of enterprise risk management topics. We introduced five topic categories, and pledged that with each new issue we would try to bring you at least one article in each topic category. This has been successful. This is the fourth quarterly issue in which we have honored that pledge. More importantly, your feedback has been extremely positive. In addition, our approach will be highlighted as a best practice for other SOA newsletter publications.

To continue bringing you a diverse range of perspectives, we are making more changes. First, having completed my self-imposed one-year term limit, we have selected a new editor, Andrew Rippert; please give him all the support that you generously gave me. We are also instituting a three-person panel of assistant editors, to have at least one member from each Joint Risk Management Section sponsoring organization. Steve Craighead will continue as the Society of Actuaries representative (Steve, thank you for your invaluable and continuing service). Steve will be joined by Mohammed Ashab as a representative of the Casualty Actuarial Society. As of publication date, we are still seeking a representative from the Canadian Institute of Actuaries.

As my last official act as editor, I am pleased to announce last issue's winner for best article in one of the qualifying topic categories (risk identification; risk response; and risk culture & disclosures). Please join me in congratulating David Cummings for his article "Communicating Risk: Presentation Matters" in our June 2009 issue. David, you will be receiving a check for $500.

I have thoroughly enjoyed care-taking this publication over the past year. I hope you have equally enjoyed reading it. So, read on, and please enjoy this issue. If you have a chance, please send me an e-mail with any feedback you may have, and consider authoring an article for publication. ✦

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Perception of Risk and Crisis Response

By Don Mango

IN OUR ERM STRATEGY to date, actuaries have reached out to other risk professionals operating in the financial domain, particularly banking. This made sense since the nature of the risks and techniques seemed highly comparable. However, as we venture deeper into the risk management space, we are discovering the importance of relatively unexplored dimensions including risk perception and communication. It is becoming clearer that there are kindred risk professionals out there; we just need to cast a wider net.

In some of that casting around perception of risk, I found the journal *Risk Analysis*, which I received as a member of the Society for Risk Analysis. Their Web site (*www.sra.org*) tells their story:

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The Society for Risk Analysis (SRA) provides an open forum for anyone interested in risk analysis. Risk analysis is broadly defined to include risk assessment, risk characterization, risk communication, risk management, and policy relating to risk. Our interests include risks to human health and the environment, both built and natural. We consider threats from physical, chemical, and biological agents and from a variety of human activities as well as natural events. We analyze risks of concern to individuals, to public and private sector organizations, and to society at various geographic scales. Our membership is multidisciplinary and international.

Many of the SRA articles referenced Paul Slovic's 1987 article,[1] which appears to be the seminal article on perception of risk. Slovic examines the judgments people make when asked to evaluate hazardous activities and technologies—in short, how people think about and respond to risk. Slovic highlights two critical factors or dimensions of risk perception, "dread risk" and "unknown risk." Dread risk is characterized by perceived lack of control, catastrophic potential, fatal consequences and the inequitable distribution of risks and benefits. Unknown risks are unobservable, new, and delayed in their manifestation of harm. Research has shown that lay people's risk perceptions and attitudes are closely related to the location of a risk within this space of factors. There are also indications that dread risk is the more dominant factor.

IMPACTS OF CRISES

Risk analyses of severe events (e.g., industrial accidents, pollution spills, product recalls) often focus on the immediate material and human damage. However, the full impacts extend far beyond the direct harms to include significant indirect (including non-monetary) costs. For example, all companies in a given industry sector can be negatively impacted by an incident involving one of their member companies. This type of "reputational spillover" was evidenced in the 2008 financial crisis when the stability of all banks was called into question by the failure of Bear Stearns and Lehman Brothers. The amount of spillover or ripple effects relate less to tangible damage and more to portend—what the incident implies regarding the unknown and the dreaded. Clear examples of this include Three Mile Island, Bhopal and September 11. Slovic discusses Three Mile Island which, despite resulting in no deaths and limited if any latent cancer impact, nevertheless led to a wave of regulatory and societal impacts to the nuclear power industry, including massive regulation and a persistent reputational hole which is at odds with the scientific evidence surrounding the safety of nuclear power. Per Slovic:

> *It may even have led to a more hostile view of other complex technologies, such as chemical manufacturing and genetic engineering. The point is that traditional economic analyses tend to neglect these higher order impacts, hence they greatly underestimate the costs associated with certain kinds of events.*

In terms of portend and subsequent impact, it is hard to overstate the repercussions of September 11. This "dread and unknown" framework puts worldwide response in clear context: a covert network enemy, unlike any seen before, capable of wreaking havoc through conventional explosive, airplanes, anthrax, or dirty bombs (had we ever

FOOTNOTES:

[1] Slovic, Paul S., "Perception of Risk," Science, New Series, Vol. 236, No. 4799. (Apr. 17, 1987), pp. 280-285.

heard of that before?), has rendered us in a chronic state of shock. In this state, we have rationalized the sacrificing of personal freedoms and civil rights in exchange for the increased vigilance we have been told is necessary to battle such foes (see the Patriot Act). Imagine the collective state of mind necessary for the American public to agree to such retractions of constitutional protections. This is risk perception on a national scale.

CRISIS RESPONSE

Risk management professionals can use these research insights to help forecast public responses to crises and formulate appropriate communication strategies. For opaque financial firms like insurers, perhaps the most pressing post-crisis need is to restore public confidence and trust. In a very timely SRA article from 2009,[2] Timothy C. Earle differentiates between these two terms which are (improperly) used interchangeably:

> *Trust is social and relational; confidence is instrumental and calculative. We define trust as the willingness, in the expectation of beneficial outcomes, to make oneself vulnerable to another based on a judgment of similarity of intentions or values. Confidence is the belief, based on experience or evidence (e.g., past performance), that certain future events will occur as expected.*

Trust is based on a sense of shared values or aligned incentives—membership in the same group, a reputation to uphold, or a brand to preserve. Trust is more emotional and intuitive, and does not require specific demonstrations. Trust is also a resilient asset that is quick to build. When trust is strong, potentially damaging information can be construed in benign or even positive ways—your firm will receive the benefit of the doubt and the incident will likely be dismissed as not indicative (portentous) of greater troubles to come.

Confidence on the other hand is rational and scientific, based on demonstrations of past performance, with evidence of processes and procedures designed to prevent future blowups and mishaps. Confidence is evidence-based, specific and detailed, making it difficult to build, fragile, and therefore easy to lose. A loss of confidence can cause potentially beneficial information to be interpreted in negative ways—indicative of more problems to come.

Clearly this is fertile ground for research. The takeaways for risk professionals:

- risk perceptions are complex and subjective;
- they are influenced by trust and confidence, reputational assets which are built-up during periods of calm then drawn upon in crisis;
- post-crisis interpretations of the ongoing viability of a firm can swing on the potential for spillover effects and indications of further problems;
- timely and effective post-crisis response communication, informed by an understanding of the underlying psychology, can mitigate potential damage. ✦

FOOTNOTES:

[2] Earle, Timothy C., "Trust, Confidence, and the 2008 Global Financial Crisis," Risk Analysis, Vol. 29, No. 6, 2009, pp. 785-792.

The Causes and Cures of the Financial Crisis

By Ira Robbin

Editor's Note : This essay was originally published in the essay collection, Risk Management: The Current Financial Crisis, Lessons Learned and Future Implications.

WHY ARE WE IN A FINANCIAL CRISIS AND HOW DO WE GET OUT OF IT?

The "why" can be simply explained: there is little confidence in balance sheet valuations because too many assets are overstated, too many liabilities are understated, and too much information is hidden. The crisis has spread due to a systematic failure of the regulatory system. Over the last 20 years regulations that fostered market stability were eliminated, and new financial instruments were allowed to propagate without any real oversight.

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The history of markets is one of booms and busts. The volatility of the cycles is magnified by leverage and tempered by transparency. The development of new financial instruments set the stage for this crisis because they were effective at pumping up the amount of leverage and masking the magnitude of risk in the system. A telling symptom of the crisis is that leaders of many institutions claim to be surprised at the amount of risk their firms were exposed to: they did not know they were placing large bets in the financial casino.

It is important to disentangle the initiatives that have been made and to understand which have worked and which have not. First consider the bailouts. These have been proffered to a select group of financial institutions whose collapse was feared to imperil the overall workings of the world financial system. The cost of bailouts has been enormous and threatens to grow even larger. The arbitrary way bailouts have been implemented in the financial sector presages a possible expansion of bailouts to many sectors of the economy, with political pull and not financial efficacy being the ultimate determinant of who gets bailed out and who does not. Despite tremendous cost, the program of arbitrary bailouts of financial firms has not been effective. While it has forestalled immediate crises and saved some firms from imminent collapse, it has not pulled the economy out of the larger crisis.

What have been successful are efforts central bankers have made to stop runs on the banks. By extending insurance for bank deposits before a general panic could commence, government bankers have instilled enough confidence in the system that people have, by and large, not felt the need to withdraw their funds and hide their savings under mattresses.

Central banks have made efforts to ensure liquidity, and they have applied doses of monetary stimulus. They have reduced interest rates and pumped money into the system. However, these stimuli have not yet proved effective at reversing the downturn. Why not? The problem is twofold. On the one hand, even with money readily available at low rates, bankers are hesitant to lend to questionable borrowers, and more and more borrowers are becoming questionable each day. On the other hand, overextended consumers are not clamoring to borrow money. They are frightened as their 401ks plummet and the equity in their homes shrinks toward zero. The financial crisis has sparked a general recession in the larger economy. Until demand recovers, firms in many sectors have little need to borrow to finance expansion of plant and equipment. To summarize, monetary stimuli alone are insufficient to revive demand.

How do we get out of this crisis? If our diagnosis of "why" is correct, and if our assessment of measures undertaken to date is accurate, then it becomes clear that a solution to our economic woes must be focused on two major objectives. First, all reasonable measures must be taken to stabilize and restore demand. Fiscal stimulus ought to be applied vigorously to do this. The federal government should send money to state and local governments in order to keep police, firefighters, schoolteachers and librarians in their jobs. It should increase the size of the armed forces. It should provide seed money to finance an accelerated schedule of highway and bridge construction, port improvements and alternative energy investments. It should loan money to auto manufacturers and other industrial firms that employ large numbers of people. Unemployment insurance should be extended even further. Anything that has a multiplier effect that will foster demand and keep unemployment down should be considered.

The second major objective is force an accurate, if not conservative, revaluation of all balance sheets and to impose

strong capital requirements on financial institutions. To do this will likely cause many large firms to fail. But that is what is needed. Credit will begin to flow once all players are sure of the net worth of others in the market.

The federal government should stop bailing out financial firms. That is throwing good money after bad. It should definitely not be taking an equity stake in them. This confuses the market about the net worth of the firms: are they implicitly backed by the government? It also undermines the value of other financial firms that do not have government backing.

Part of the process of ensuring adequate valuations is to impose stringent regulations and capital requirements on whole classes of new financial instruments. Any recent financial mechanism that appears to mask risk or increase leverage should be subject to such treatment. In effect, all the leverage and hidden risk needs to be unwound, before we can reach the floor and start the way back up on a sound and sustainable basis.

The philosophy inherent in the regulation of property and casualty insurance companies provides an interesting paradigm for how a wholesale revaluation could be accomplished without mortally wounding the whole economy. When an insurance company has inadequate capital, it is subject to seizure by state regulators even though it is technically not bankrupt. The state authority stops the company from writing any more business and then proceeds to liquidate it. This stops the company from trying to raise cash by writing a boatload of underpriced business. Meanwhile the claimants are not left with worthless paper; instead they are partly compensated by guaranty funds. These funds are partially replenished by recoveries from the liquidation. A variant of this idea is when the existing company is split into a New Company that writes new business and an Old Company that is liquidated.

The liquidation and guaranty fund approach provides a way out of the crisis. The government should seize weak financial companies and liquidate them. It should act as a partial guarantor of some of their financial instrument obligations, paying them off at 50 percent or some other set rate. The choice of which instruments should be partially honored needs to be thought through. Overall, instead of

investing in AIG, lending money to AIG, and paying off its credit default swaps at 100 percent, the government should put padlocks on its doors, liquidate it, pay off regular insurance contracts according to existing state guaranty fund rules, and guarantee to make good on 50 percent of its financial insurance obligations. This could be coordinated with foreign governments so policyholders and counterparties the world over would be treated to the same degree of painful but not fatal fallout.

For another example, Fannie Mae and Freddie Mac should be split into old and new companies. The old ones should be liquidated, and the new ones should be forced to operate under stringent lending rules. The same approaches can be used all the way through the nested chains of tranches and derivative instruments that wind through the economy. It will be very costly, but, in the end, it will cost far less than trying to revive a select few of the comatose and pay off 100 percent of their ill-considered financial obligations.

In conclusion, what is being called for here is not more of the same. Instead of bailing out weak financial firms, we should be liquidating them. All doubtful assets need to be written-downs; the sooner the better. We need accurate and transparent accounting. Government can help in this effort to clean up our accounting system. But it needs to stop being an investor propping up those that should be in the morgue. It needs to conservatively regulate all financial instruments. It should foster liquidity and stoke demand. That is what needs to be done to get out of this crisis. ✦

The views expressed are those of the author and are not represented as the position of Endurance Holdings or any subsidiary or affiliate.

Emerging Risk—The Signs Are There

By Neil Cantle and Neil Allan

INTRODUCTION

AS THE WORLD STEADIES itself after one of the biggest economic shocks on record, there has naturally been considerable reflection in the risk community over where it all went wrong. A common theme is that some people were able to piece together parts of the story, some even raised warning flags. However, very few organizations were able to substantiate their concerns with evidence from risk management systems, let alone have the conviction to act upon the evidence. By the time most traditional risk systems did start to notice problems, it was far too late to avoid the inevitable fallout.

We began our research into emerging risk more than six years before the recent crash. Even then we had a sense of discomfort with the rather simplistic framework used to conceptualize and model "risk," particularly for the types of risk that emerge at the enterprise level. Essentially risk was framed as some sort of event, which threatened an enterprise's ability to achieve its objectives. Risk management has therefore developed a deductive approach to searching for the events comprising the risk occurrence and aims to avoid those precursory events.

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NOT THE SUM OF THE PARTS

Despite the evolution of "risk management" into "enterprise risk management" the tools for managing and quantifying risk are still essentially focused on individual types of risk which are then "added up" to achieve the "enterprise" aspect. It is this focus on enterprise risk as being an aggregation of risk types which causes difficulty when trying to make sense of complex integrated and interconnected risks.

We know that the financial services sector is essentially service-based and relies heavily upon people to achieve its outputs. It is very far from the equilibrium and optimized world with which most risk management tools were designed to cope. Our insights from complexity science bring the bad news that the old approach to assessing and analyzing risk is flawed and is fundamentally not capable of achieving the holistic perspective that is needed.

Our research suggested we should start by framing risk in a different way. At the enterprise level we observe that risks are not "events" but tend to emerge continuously over time through a process of complex interactions of multiple factors. When people refer to "a risk event" we translate this to mean that the emerging risk process has pushed the organization over some tipping point where a sort of unstoppable cascade has begun. However, the risk will continue to evolve even after this point. This framing creates a more realistic perspective of enterprise risk.

Enterprise risks are rarely, if ever, the same twice and they seem to emerge rapidly and chaotically in the later stages. With this new paradigm for risk we can look to the science of complex systems to provide some of the tools we need to start making sense of what is going on.

ON THE EDGE

The study of "systems theory and systems thinking" has evolved rapidly, particularly as computing power has become more accessible at reasonable cost, and this has enabled some of nature's most impenetrable secrets to be, at least partially, understood. Weather prediction is an example where the insights gained by scientists into how weather systems work enables them to make relatively reliable predictions – although they occasionally get it wrong, it is surely more incredible that they are able to ever get it right when you think about the complexity of the globe's weather!

For our risk study we are interested in a particular class of systems, known as "complex adaptive systems," and particularly those which fall into the category of being "self-organized." Complex adaptive systems are characterized by having components interconnected in such a way as to create feedback loops, and where the components themselves can change. These systems exhibit the following basic properties:

- A purpose – they have evolved to fill a niche in their given environment.

"Systems which operate in a mode that is close to the maximum threshold they can tolerate are highly fragile and prone to collapse…"

- Emergence – the system overall exhibits properties not held by the components.
- Self-organization – it has structure and hierarchy which can form and change spontaneously.
- Interacting feedback loops creating highly non-linear behavior.
- A critical complexity limit beyond which it collapses or goes chaotic.

Systems which involve people are nearly always in this category due to the way they interact and adapt.

Each system will have a maximum level of complexity it is able to handle. This limit will be a function of its structure and operating capabilities, for example, as well as the environment it operates in. Systems which operate in a mode that is close to the maximum threshold they can tolerate are highly fragile and prone to collapse if the operating environment changes by even a relatively small amount.

In the context of risk management we are seeking to examine the limits of complexity that an operation can tolerate, and to assess how close that operation is to the limit. Further, we want to understand why the business is operating at the levels of complexity that it does. To do this requires a number of different tools in combination.

MANAGING RISK

If we consider the tasks that are needed in a well-formed risk management process, we can represent those tasks in the following way:

Management's job is to identify, as accurately as possible, the risk exposure that the enterprise faces as a consequence of executing the business plan. From this they form a hypothesis about which risks may emerge over time and produce a summary of this that they can monitor against. They evaluate key indicators relating to risk and operating performance, and also look for signs of emerging risk so that the hypothesis can be tested and updated. This learning cycle should be at the heart of every enterprise risk framework.

The difficulty starts right upfront in knowing what the risk exposure is. We have developed techniques based around cognitive mapping to capture the knowledge of the firm and structure it in such a way as to make visible the interconnected features and dynamics of the risk exposure. This technique very quickly and successfully documents how the strategy translates into risk exposure.

From this solid base we can explore and model the dynamics of the risk exposure to determine a core dataset which is needed to describe the behavior of the organization's performance. The risk exposure analysis also provides a robust platform for creating the scenarios needed to complete the hypothesis about where and how risks may emerge.

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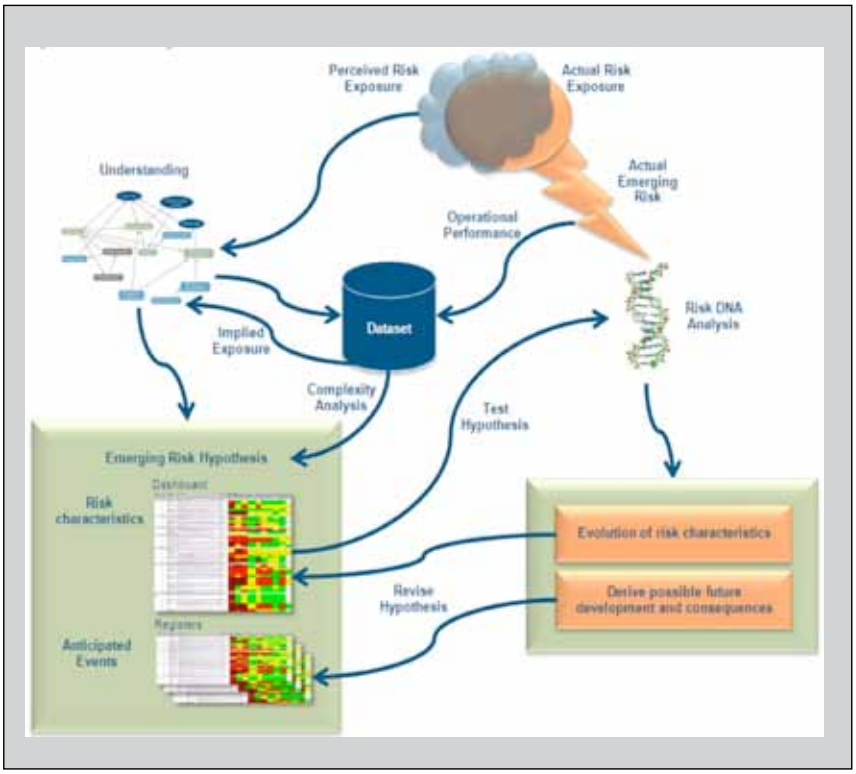
Figure 1: Risk Management Process



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In preparing the hypothesis it is important to formulate a relatively static baseline. A "Top 10" list of concerns as the top level reporting device simply will not do. The top level reporting is best achieved as a manageable list of risk characteristics, which can be used to classify risk scenarios. For example, it is common to start from very broad headings which are now in common use, such as: strategic; market; credit; insurance; operational; etc. These can be customized one stage further to generate more detailed characteristics such as: fraud; business discontinuity; adverse regulatory changes; etc. This list of around 20 to 30 items essentially forms the list of risk "DNA" for an enterprise.

A series of risk registers are then used to construct plausible risk scenarios, which may combine certain of these characteristics into real-world situations that could lead to harm. The choice of scenarios is made easier by having a good understanding of the risk exposure in the first instance. By capturing the connections between different scenarios in the risk registers we can also work out which scenarios seem to be the most important overall.

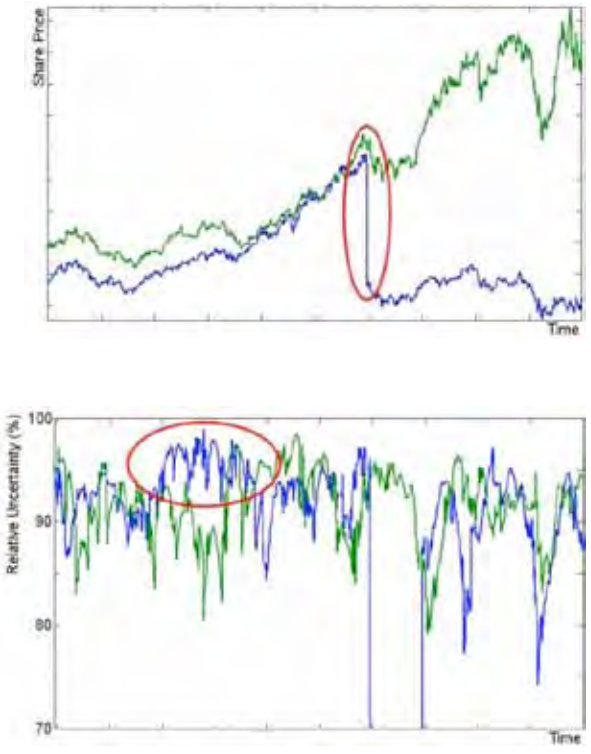
Having defined the core dataset, management can look for evidence that their organization's performance is either robust or fragile. Initially we can use a simplified complexity measure, "system uncertainty." According to Information Theory, the amount of information in an observation x is –log p(x) where p is the probability of x being the information we want. We look at the average amount of information in the organization's performance variables and this is then equivalent to looking at the uncertainty removed after seeing the actual performance of the organization. So, if we are perfectly certain about what will happen next, then we learn nothing by watching the actual performance and our "uncertainty" is zero. When it is perfectly unclear to us what will happen next our "uncertainty" is 1.

An organization needs a certain level of complexity in order to be capable of generating a good level of performance, but we need to avoid it becoming too high and hence unstable. Complex systems have a critical maximum amount of complexity that they can handle before becoming unstable, so we are particularly interested in looking at the current amount of uncertainty in an organization's performance relative to this maximum. Management is therefore interested in maintaining their performance such that the level of uncertainty is sufficient to permit good operational performance, but which is below the maximum.

ECHOES OF RISK

The following simple example (Figure 2) shows two banks whose share prices follow broadly similar paths until one suddenly collapses. Even by looking only at the share price data in terms of uncertainty, we can see that the evidence for collapse was visible some time before. The bank which collapsed suddenly starts to operate around 95 percent, at which level the organization must be highly fragile and sensitive to perturbations, and remains operating at this high level for some time. In contrast, the other bank occasionally operates briefly at high levels of uncertainty but its management seems able to take action to reduce it before the organization becomes unstable.

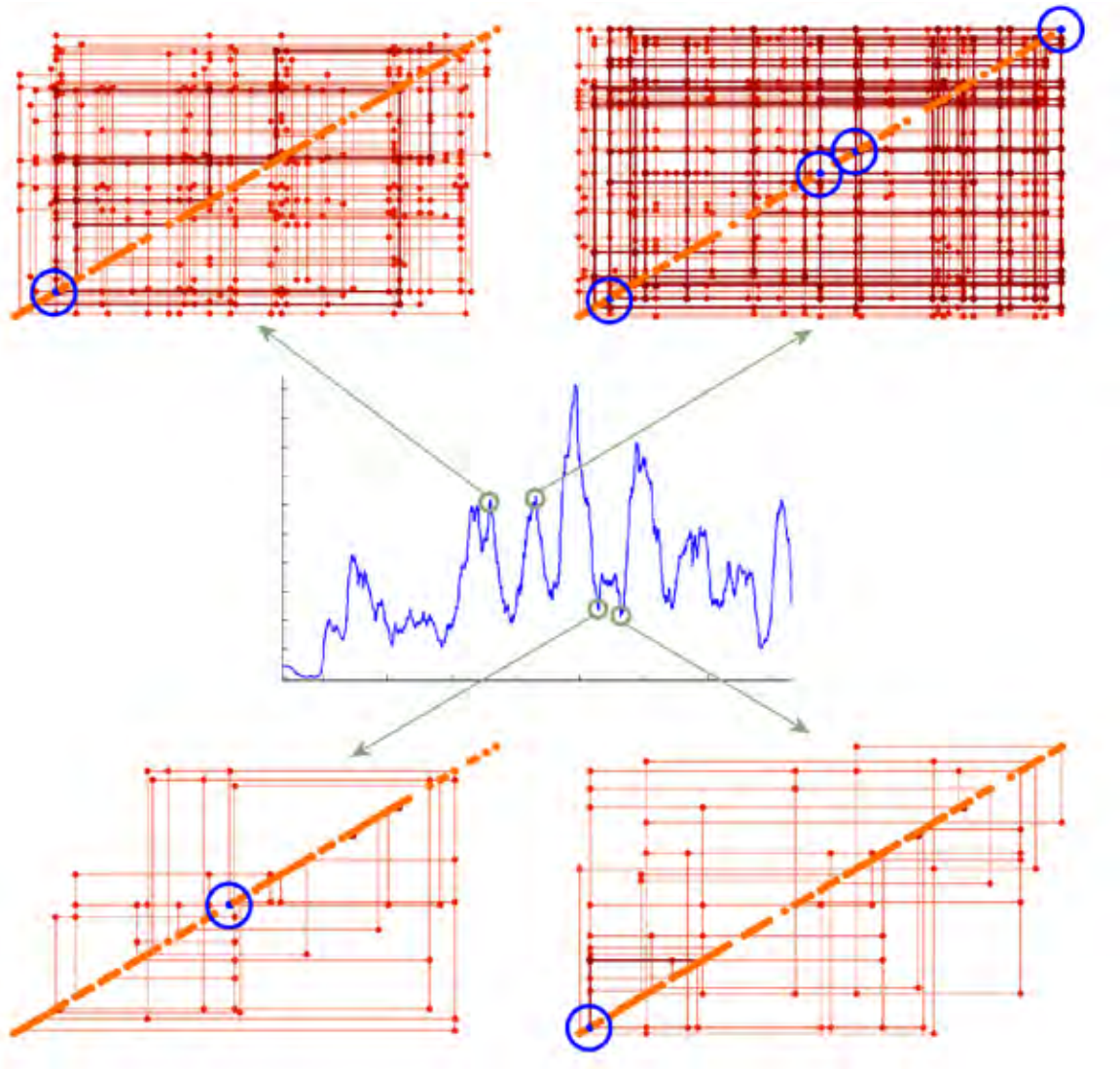
Figure 2: Using "Uncertainty" to Identify Building Trouble



"…through complexity-based approaches we are able to better understand and articulate risk exposure…"

Management will typically have much more than one variable to look at, and so they have the possibility to use more sophisticated measures of complexity and try to understand where this build-up is coming from. The following chart (Figure 3) shows the complexity of a particular system taking into account uncertainty and the manner in which the variables are connected. Note that these "connections" are not correlations. They represent actual information sharing and are therefore much more profound than correlation since they tell us about how the connections of the organization are actually working, thereby giving insights into its structure and performance. The calculation was carried out using DACORD™, a proprietary development of DRTS Limited.

Figure 3: Analyzing System Structure to Understand Complexity



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We can examine the structure and connectivity of the system at key variables (these are shown along the diagonal with the connections drawn between them to indicate the information sharing taking place) and see that the variables which drive the system (shown in blue) change with time, and the way they connect with other variables also changes. This is very significant in the context of trying to understand emerging risk. Traditional approaches to risk analysis use qualitative and/or quantitative models as a way of understanding the behavior of the organization. Our insight here shows that these models may need to change quite frequently if they are to represent what is actually going on. This lack of correspondence between the traditional models and reality explains the "surprises" that people have when apparently new risks appear – in truth they were often simply looking at the wrong things.

So, through the use of complexity-based approaches, we are able to better understand and articulate risk exposure, making full recognition of the interconnected nature of its dynamics. We are also able to more intelligently find out what our data is telling us.

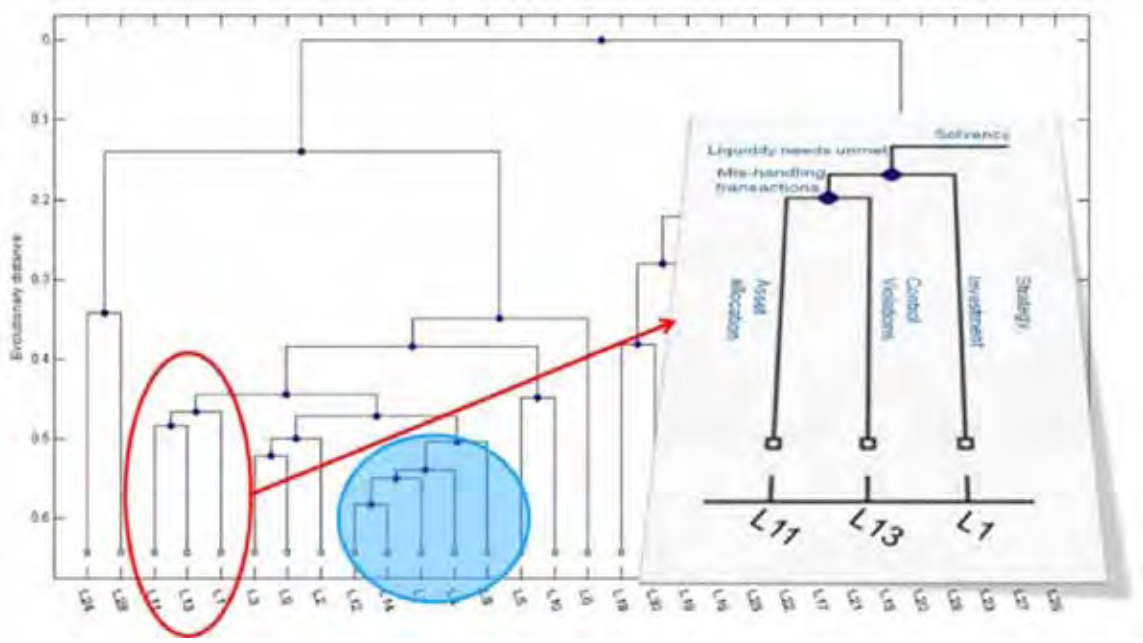
RISK DNA

The next area where we can gain insight is in the analysis of actual emerging risks. Even if we successfully avoid the risk it is valuable to learn about which risks we actually faced and test to see if our hypothesis is correct.

We gather information about emerging risks in a log which contains a description of the risk, a time reference and an assessment of whichever combination of risk characteristics seems most appropriate to each risk. We then conduct a Risk DNA Analysis on this information to gain insight into how the risks are evolving in the business and which characteristics are more prone to combining to create new risks to the business. The analysis is carried out using cladistic algorithms, which group the risks according to their characteristics, searching for the simplest representation. In practice the calculation is not trivial and is a proprietary process developed by the authors.

The following example (Figure 4) shows the cladistic system of 30 entries from an emerging risk log that were analyzed.

Figure 4: Analysis of Emerging Risk in Terms of Risk Characteristics



"By measuring the effort involved in different combinations, we provide insight into which new combinations of risk characteristics are most possible …"

As you work down the diagram from the top, each bifurcation point represents an important evolutionary phase when characteristics are either lost from, or added to, the risk branch to the right but not those to the left. For example, risk L11 and L13 still have "Liquidity Needs Unmet" whereas L1 does not.

We can investigate the analysis and look for areas of rapid evolution, for example, which suggests that certain characteristics are not being held in check and are combining freely. In the above, the blue shaded area shows such a group. Alternatively we might look for areas of more stable evolution to understand some of the root characteristics that exist almost in the culture of the organization.
Just as in biological evolution, there is an "effort" associated with characteristics trying to recombine in different ways. This is represented by the length of each branch leg. By measuring the effort involved in different combinations we are able to provide insight into which new combinations of risk characteristics are most possible, given the current state. This information helps to reassess the risk hypothesis and also to explore the possibility of different risk scenarios.

CONCLUSION

In summary, we know that risk, as a human construct emerging from predominately people-based organizations, is going to behave like a complex adaptive system. Hence there are some important messages from complex system theory that help us understand and manage risks more effectively. First, complex systems have special properties such as hierarchy, emergence, self-organization and connectivity; but importantly, they also follow the laws of entropy. Applying these concepts to risk management we get new insights such as:

1. Emerging risks are essentially the emergent property from a complex system.

2. History is important. We already know this in the insurance industry, but including an evolutionary approach provides us with a unique understanding of the connectivity between elements of an enterprise's risk system. It shapes what happens next and unlocks a new way to identify how and where risks emerge.

3. The critical limit of complexity, sometimes called the "edge of chaos," is real. The techniques above provide a rigorous approach to determining when an enterprise or sub-system is close to this threshold and subsequent collapse.

4. Understanding the connectivity of a risk system is fundamental to understanding the dynamics, structure and hierarchy of the system. It is important to understand how these connections can be made explicit from qualitative and quantitative data. We have illustrated several proven techniques to enable this.

5. Finally, industry systemic risk is essentially an aggregation of sub-systems behavior, such as enterprises and people. The nature of their interaction can cause self-organization, which can lead to significant non-linear behavior. The tools and techniques we have discussed in this article make it possible to anticipate, and observe, the onset of such systemic risks.

The concepts described above are well researched in the science journals. The techniques we have developed over the last six years are unique to risk management, but are based on physical, psychological and mathematical theories. Framing risk in the right way and using the right tools for the job offers us the chance to see the signs of emerging risk early, and to make better sense of what is happening. ✦

Modeling Tail Behavior with Extreme Value Theory

By Damon Levine

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MODEL BACKLASH

ONE OF THE MANY THINGS to come out of the recent market turmoil is a long list of scapegoats. Experts and laymen alike have assigned varying amounts of blame to a wide variety of sources ranging from greed and conceit, to rating agencies, the government, and executive bonus plans, which rewarded excessive risk taking. Of course, they also blamed the risk models.

The idea that a model is not meant to capture reality or have significant predictive power is such a pervasive concept that it borders on truism. That being said, it is likely that models should take some of the blame for the subprime meltdown and the subsequent crisis in the financial markets in general.

Perhaps the biggest problem was that, by design, a lot of the models could not warn of the potential for an observation significantly worse than outliers in the historical data. To use Nassim Taleb's phrase, they failed to provide information about the magnitude of potential "black swans."

Ideally, a statistical distribution that is used in a risk model should fit historical data well, both in the central portion of the data set and in the tail. But the distribution should not be "constrained by history." Rather, it should make use of previous extreme values to offer information on the probability and magnitude of potential values *more* extreme than those seen previously. Extreme Value Theory provides a theoretical basis for such a model. This theory quantifies, in a statistically sound manner, the potential black swans hinted at by historical extremes.

EXTREME VALUE THEORY

Extreme Value Theory (EVT) is a branch of statistics dealing with the extreme deviations from the median of probability distributions. Under very general conditions, EVT's main results characterize the distribution of the sample maximum or the distribution of values above a given threshold.

It is this second result, the Pickands-Balkema-de Haan (PBH) Theorem, which will be used here. This theorem describes the distribution of observations above a high threshold as a generalized Pareto distribution.

This result is particularly useful because it can be applied in a great many situations with a minimal set of assumptions about the "true" underlying distribution of an arbitrary data set.

THE DISTRIBUTION OF EXCESSES

Given a data set, choose a large threshold value u such that we have several data points larger than u. Assume for example, that in a data set of 1000 insurance claim amounts (in dollars) we choose u to be the 95th percentile, and there are 50 points above u.

For each of those 50 points, $\{p_1, p_2,\ldots, p_{50}\}$, we compute the excess above u: $\{p_1\text{-}u, p_2\text{-}u,\ldots, p_{50}\text{-}u\}$. These may be interpreted as random observations from a population with some underlying "distribution of excesses."

The PBH Theorem states that for a very large family of distributions, for a sufficiently large threshold value u, the distribution of excesses over u can be well approximated by a generalized Pareto distribution.

The generalized Pareto distribution (GPD) can be expressed as a two parameter distribution with cumulative distribution function (CDF):

$G_{s,k}(x) = 1 - (1 - kx/s)^{1/k}$ for nonzero k, and $G_{s,k}(x) = 1 - \exp(-x/s)$ for $k=0$

Note that if there is a left tail consisting solely of negative values, below some negative threshold far less than the median, we may apply the PBH theorem by simply looking at absolute values. The "excess" of an observation in this tail is the (positive) distance from the observation to the threshold. This idea will be used in the example shown later.

"Perhaps the biggest problem was that a lot of models failed to provide information about Black Swans."

MODELING WITH A HYBRID EMPIRICAL/ GPD MODEL

Let F represent the "true," underlying cumulative distribution function of the full set of claim data in the above example. We assume the observed data set is a random sample drawn from some population following a statistical distribution. Based on a particular choice of the threshold u, the cumulative distribution function of the excesses denoted by $F_u(y)$ is defined for non-negative y as:

$F_u(y) = P\{X - u \le y \mid X > u\} = P\{\text{excess} \le y \text{ for a random observation exceeding } u\}$

It is important to realize this CDF describes the distribution of the *excess* over the threshold. It gives a probability that the excess over u, of a random observation larger than u, will be less than or equal to y. It does not refer to the magnitude of the extreme value itself, but it is straightforward to make use of F_u to do so.

For $x \ge u$ we have:

$$F(x) = P\{X \le x\} = (1 - P\{X \le u\})\, F_u(x-u) + P\{X \le u\} \quad [1]$$

Now, F_u can be estimated by some GPD, $G_{s,k}$, and $P\{X \le u\}$ can be estimated from the data by $F_n(u)$, the empirical distribution evaluated at u. [2] So for $x \ge u$ we can approximate $F(x)$ by:

$$F^*(x) = [1 - F_n(u)]\, G_{s,k}(x-u) + F_n(u)$$

The two parameters of the distribution $G_{s,k}$ can be estimated by a variety of methods including maximum likelihood and the method of moments, which is used in the example shown later.

A CDF modeling the entire underlying distribution, F, can therefore be described as a hybrid empirical/GPD:

$F(x) = F_n(x)$ for $x < u$, and $F(x) = [1 - F_n(u)]\, G_{s,k}(x-u) + F_n(u)$ for $x \ge u$

If desired, one can perform simulation by regarding a random digit, r, from (0,1) as a percentile of $F(x)$, i.e. employ the mapping $r \rightarrow F^{-1}(r)$.

THE CHOICE OF THE THRESHOLD VALUE

In choosing the threshold value it is important to understand some of the technical aspects of the PBH theorem. The technical statement of theorem makes use of the notion of "right endpoint" of a distribution F. This is the smallest value, r, such that the CDF evaluated at r is equal to 1, i.e., $F(r) = 1$. In many cases r is infinite.

For our purposes, we can look at a somewhat simplified version of the theorem: for a large class of distributions, as the threshold u approaches the right endpoint of F, the excess distribution F_u approaches a GPD. The class of distributions conforming to this theorem includes *all* the common continuous distributions an actuary or statistician typically employs including the normal, lognormal, beta, exponential, F, gamma, Student t, uniform, etc. [3] Note that the only returns that are used in the parameter estimation of the GPD are those which are in the tail defined by the choice of threshold.

When fitting any distribution to a data set, a larger number of data points is ideal. By selecting a smaller value of u we can expect a fair amount of data points to exceed that value, perhaps improving the GDP fit.

Contrary to this notion is the fact that the PBH theorem states a result based on the assumption of threshold values approaching the right endpoint of the distribution F. This implies that better GPD fits are expected for larger choices of the threshold u.

One must strike a balance between choosing u large enough so that the theorem is applicable from a practical standpoint and small enough so that a sufficient number of data points can be used in estimation of the parameters of the GPD.

There is no hard and fast rule describing the "right" choice of the threshold value. Some methods for threshold selection can be found in Bensalah's "Steps in Applying Extreme Value Theory to Finance: A Review." [4]

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EXAMPLE: MODELING MONTHLY TOTAL RETURN FOR A-RATED 7-TO-10-YEAR CORPORATE BONDS

The data sample consists of monthly total returns for the A-rated 7-to 10-year corporate bond component of Citi's U.S. Broad Investment Grade Bond Index. The data was taken from Citi's Yieldbook application and consists of monthly returns from January 1980 to August 2008.

Table I

Selected Percentiles of the Return Data

Percentile	Return
99th	5.97%
90th	2.94%
80th	2.05%
70th	1.59%
60th	1.18%
50th	0.83%
40th	0.44%
30th	-0.14%
20th	-0.77%
10th	-1.54%
5th	-2.33%
1st	-3.87%

The data set consists of 344 returns ranging from a minimum of -7.16 percent to a maximum of 10.84 percent with selected percentiles as shown in Table I.

We focus on returns in the left tail; in other words, we are interested in returns less than some low value. Consider a choice of threshold u as the absolute value of some low, negative return and then, for returns less than u, define the excess to be the distance between u and the absolute value of that return. Note that a large excess is equivalent to a poor return. The application of the PBH theorem to the left tail was introduced in the Distribution of Excesses section.

Setting u=1.54 percent, corresponding to the 10th percentile, we may then approximate the excess distribution F_u as a GPD with parameters s and k. We determine these parameters by the method of moments.[5] Note that the only returns that are used in the parameter estimation of the GPD are those above the threshold.

Recording this threshold value and its corresponding pair of parameters for the GPD, we will then choose a value of u farther out in that left tail and find the resulting pair of parameters for the associated GPD. This process will continue so that we have sequence of threshold candidates $u1$, $u2$,… , etc. moving further and further into this tail of poor returns.

Our choice of threshold will be the first of these candidate values for which there is stability in the GPD parameter estimates from that point on.[6] If no such stability is seen then the fitting of a GPD to the tail may not be pragmatic.

Table II

Threshold Candidates: Associated Tails and GPD Parameter Estimates

Percentile	Raw Data Value	Thereshold Candidate* = abs(return value)	Numbers of Returns Worse than Threshold**	*GPD Parameter Estimates*	
				*s**	*k**
10th	-1.54%	1.54%	35	0.01	-0.12
8th	-1.68%	1.68%	28	0.01	-0.06
6th	-1.93%	1.93%	21	0.01	0.03
5th	-2.33%	2.33%	18	0.01	-0.12
4th	-2.52%	2.52%	14	0.01	-0.07
3rd	-2.82%	2.82%	11	0.01	-0.07

* these are threshold candidates in the left tail of rhe return data; in all cases the value prior to taking absolute value is negative
** e.g. worse than the 5th percentile means less than -2.33% or a negative return whose absolute value exceeds 2.33%

"The alternative to well-founded methods like EVT may be reliance on intuition or fitting of distributions that are dangerously misleading."

We begin with the 10th as a threshold candidate. The results are summarized in Table II.

Taking incrementally larger values of a threshold choice u, we begin to see stability in the parameter estimates with the threshold set to the (absolute value of the) 4th percentile of the data set and this is our choice for the threshold.

As a result, for returns below -2.52% we may model the distribution of distances below that threshold as a GPD with s=.01 and k=-.07. The CDF can be written as:

$G(x) = 1 - (1 + .07x/.01)^{1/-.07} = 1 - (1+7x)^{-14.286}$ for x>0

Assume we are interested in the probability of a monthly return being less that -5% assuming it is less than -2.52%. This is equivalent to probability that the excess is greater than or equal to 2.48% (i.e. 5% - 2.52%) and can be found as 1 - G(2.48%) = 1 - .898 = .102. This is, of course, a conditional probability. The unconditional probability that a monthly return is less that -5% is .102 multiplied by the probability of being in this tail: .102*.04 or .004.

Keeping in mind that we've applied the PBH theorem to a left tail, the CDF for the entire underlying distribution, F, can be written as a hybrid empirical/GPD:

$F(x) = F_n(x)$ for $x \geq u$, and $F(x) = F_n(u) * [1-G(u-x)]$ for $x<u$

KEY MODEL RESULTS

The model implies that for a *return in the tail,* the monthly probability of the return being at least 8.29 percent less than the threshold of -2.52 percent (i.e., less than or equal to -10.81 percent) is about .001. The unconditional probability is then .001*.04 or .00004. Because this is a monthly probability, the probability of seeing a return at least this low in a year is $1- (1 - .00004)^{12}$ or .00048. Over a period of 30 years the probability of seeing a return at least this low is $1- (1 - .00004)^{30*12}$ or 1.4 percent.

This is certainly not a large likelihood but we are, after all, talking about a black swan. As of August 2008, the idea of a monthly return worse than -10.81 percent was generally thought to be out of the realm of possibility. At that time, the worse monthly return since 1980 had been -7.16 percent and this occurred back in February of 1980! So the methods of EVT allow us to say:

P(at least one monthly return ≤ -10.81 percent over a 30-year period) = 1.4 percent.

What would the estimate of this probability be if we fit a normal distribution to the data? Based on the sample mean and standard deviation of 0.77 percent and 1.98 percent respectively, we are talking about a return of -10.81 percent, which corresponds to a Z-score of -5.858 and a probability of 2.34×10^{-9}. From this we have, under the normal distribution fit,

P_{NORM} (at least one monthly return ≤ -10.81 percent over a 30-year period) = 8.42×10^{-7}

The difference is clear: EVT points to low likelihood but puts the result on the radar screen. The probability of the event using EVT is found to be more than 16,000 times greater than had it been calculated according to a normal distribution assumption!

In September 2008 the monthly return for this bond index was -10.94 percent. A risk manager or bond trader who has worked with EVT might think the event was surprising in that there was only about a 1 percent chance of its occurrence over a 30-year time period. Had other methods been used the result might have seemed on par with a flipped coin landing on its edge! For all intents and purposes it would have been considered impossible.

The key point is that such an unimaginably bad result would have shown up, before the fact, in the analysis based on EVT.

CONCLUSIONS

Models based on EVT, like other risk models, work best in concert with subjective tools such as intuition, judgment and common sense derived from experience. A risk quantification approach that incorporates both the Delphi method and EVT may very well be the best approach to making decisions under uncertainty.

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Of course, EVT is no panacea. It is, however, a scientific approach that allows the modeler to make the best use of a small number of prior extremes. The alternative to using well founded methods like EVT may be full reliance on potentially flawed intuition or the fitting of distributions that are both dangerously misleading and possibly costly. ✦

NOTES

1 For $x \geq u$, we have $P\{X \leq x\} = P\{X \leq u\} + P\{u \leq X \leq x\}$ and $P\{u \leq X \leq x\}$ can be expressed as $(1 - P\{X \leq u\})\, F_u(x - u)$.

2 An empirical distribution fitted to a data set defines a CDF consistent with percentiles directly observed in the data set. In other words, it defines a CDF, F(x), such that F(x) is equal to the proportion of data points in the set less than or equal to *x*.

3 See below in References: McNeil's "Estimating the Tails of Loss Severity Distributions using Extreme Value Theory" (pp. 7-8).

4 See below in References: Bensalah's "Steps in Applying Extreme Value Theory to Finance: A Review"

5 Let $\bar{x} = (1/n)\sum (x_i - u)$, $w=(1/n) \sum (x_i - u)^2$, where the summations extend over those *n* values, $\{x`, x_2, \ldots, x_n\}$, that exceed the threshold *u*. So $\bar{x}$ is the mean of the excesses, and *w* is the mean of the *squared* excesses.

Also, define $A= \bar{x}^2 / (w - \bar{x}^2)$. Then for the GPD described by: $G_{s,k}(x) = 1 - (1 - kx/s)^{1/k}$ (for nonzero *k*), the Method of Moments parameter estimates of s and k are: $s^* = .5\,\bar{x}\,(A + 1)$ and $k^* = .5(A - 1)$

6 The stability will begin to wane as the threshold become large enough to significantly shrink the count of data values in the associated tail; so there is a sort of "window of stability."

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Replicating Portfolio Implementation

By Andrew Ng

INSURANCE COMPANIES use a variety of risk management and performance measurement techniques that involve the valuation of liabilities under a wide range of scenarios that reflect different market risk factors. Some examples include: economic capital calculations, asset-liability management, hedging and attribution analysis (e.g., hedgeable vs. non-hedgeable investment returns, investment vs. non-investment operating income). However, a major challenge of embedding such techniques into management's decision-making is the massive simulations required, which result in unwieldy complexity and long run times.

In direct response to this challenge, some companies are adopting replicating portfolios. A replicating portfolio is a basket of financial instruments designed to replicate, as closely as possible, the value and market sensitivity of a target portfolio of liabilities in different economic scenarios. Using replicating portfolios allows the market-risk section of risk dashboards to be monitored in real time, as instruments in a replicating portfolio can often be quickly re-valued under different economic scenarios using closed form formulae. As a result, the use of replicating portfolios can drastically reduce the time and resources that would otherwise be required.

To take full advantage of replicating portfolios, companies would benefit from carefully addressing considerations in two areas:

- Selection of the replicating portfolio tool
- Enterprise-wide implementation

SELECTION OF THE REPLICATING PORTFOLIO TOOL

There are currently a number of replicating portfolio tools in the market. To select the most appropriate one, companies should consider issues that significantly affect the tool's ability to generate the optimal portfolio, with sufficient power to replicate market sensitivities of target portfolio of liabilities in a wide range of market scenarios, and do so in a relatively short period of time.

Replicating Power Issues

- *What market risk factors are supported?* The ideal tool will allow a user to identify the optimal replicating portfolios, which can be re-valued under economic scenarios comprising all key market risk factors that affect the company's major businesses.

- *What economic scenarios are used in the fitting process to identify the optimal replicating portfolio?* Generally, cash flows of the target portfolio of liabilities under the set of market-consistent scenarios at the valuation date are used for fitting. The ability to incorporate additional extreme investment scenarios can improve the fitting of the optimal replicating portfolio to some of the more severe market shocks. This can be very valuable for exercises with a focus on tail risks.

- *What existing candidate financial instruments are supported?* The richness of the candidate financial instruments available for fitting is one of the most important success factors in a tool's ability to find the optimal portfolio with strong replicating power. The universe of candidate financial instruments should include not only the tradable assets available in financial markets, but also a wide range of synthetic ones.

- *How easy is it to incorporate new financial instruments?* The ability for a user to create and include additional financial instruments for fitting can be a huge plus, particularly when working with a target portfolio of complex liabilities with unique investment philosophies, crediting strategies, and embedded options and guarantees.

Run-Time Issues

- *How easy is it to restrict the candidate financial instruments for fitting to identify the optimal replicating portfolio?* The ability of a user to quickly narrow the universe of candidate financial instruments to

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allow only relevant ones to be considered can substantially shorten the time required to identify the optimal portfolio. For example, allowing only certain tradable assets to be part of the optimal portfolio might be necessary when dealing with performance attribution related to hedging activities.

- *What optimization algorithm does the tool use?* The speed with which the tool can effectively search the universe of all possible portfolios, with different asset combinations from all candidate financial instruments, and locate the optimal replicating portfolio, is a critical factor in its success. Understanding the underlying algorithm methodology, how it is implemented and its performance are therefore important. One can expect a good tool to provide performance measures of its optimizer and offer meaningful descriptions of its optimizer in the tool's user manual.

- *How fast can the tool re-value (i.e., re-price) the optimal replicating portfolio under new economic scenarios?* A tool that is slow to re-price the optimal replicating portfolio under new scenarios destroys the very benefits and causes for its use. As a potential benchmark, a good tool can typically re-price an optimal portfolio, consisting of only financial instruments that can be valued through closed form formulae, under tens of thousands of economic scenarios in a matter of minutes.

Some additional issues surrounding tool selection are listed below:

- *Is scenario bucketing supported?* Typically, if a set of market-consistent, or risk-neutral, scenarios is used for fitting, the majority of the scenarios would concentrate somewhere near the average of all scenarios. Scenario bucketing, also called clustering as it relates to statistics and data mining, allows a user to put more emphasis on the more extreme scenarios of interests.

- *Is term bucketing of cash flows supported?* A good fit to instantaneous market sensitivities of the liabilities does not guarantee a good fit to the liabilities over time, and the ability to fit over time is largely dependent on the ability to fit the profile of liability cash flows.

- *Is the replicating portfolio suitable for the company's planned usage?* A robust tool that addresses the above issues should have a very good chance of identifying the right optimal portfolios with excellent replicating power for many types of liabilities. However, there is no guarantee that an optimal portfolio that meets the company's fitting error tolerance will exist. It is important to conduct a pilot study by applying the tool to blocks of the company's main business lines to gauge the effectiveness of the technique before making a commitment.

ENTERPRISE-WIDE IMPLEMENTATION

Once the tool and technology provider have been identified, companies will need a detailed implementation plan to roll out the tool to all users in the enterprise. In addition to the usual considerations in implementing any business application, companies might also want to consider the issues below, which are unique to replicating portfolio implementations:

- *Governance:* To achieve better consistency, efficiency and accuracy across the organization, companies should make choices about who has decision-making power regarding the issues that will affect the quality of the replicating portfolios. Companies should give guidance on the following areas: the universe of candidate financial instruments, the economic scenarios to use for fitting, the fitting measures and fitting error tolerance levels. Standards and controls might be established for different levels of users, based on their level of sophistication and experience in using the tool.

  A related but more general issue is the choice in the type of control. A centralized approach might simplify the overall process, provide better controls, and reduce the time and cost associated with training and communication. On the other hand, a decentralized approach might allow local users to better use their unique insight and knowledge of the risk characteristics of the target liabilities to improve the quality of the optimal replicating portfolio and shorten the time it takes to get it finished.

"There are many challenges to effective implementation ... with the proper planning and guidance, companies can be more confident of reaping the rewards of replicating portfolios ..."

- *Level of Granularity:* A decision will need to be made regarding the optimal level for the creation of replicating portfolios (e.g., by product or by line of business). The decision involves balancing tradeoffs between a variety of factors, including timing, accuracy, complexity in process management and ability to interpret the resulting replicating portfolio.

- *Frequency of Recalibration:* Optimal replicating portfolios should be periodically recalibrated to reflect non-economic changes in target portfolio liabilities and enable it to stay meaningful and relevant. The frequency of recalibrations should be defined and guidelines should be given to allow for interim updates with unusual market movements.

- *Data Integrity:* Large amount of information and data might be produced and exchanged between corporate and local users. For most companies, establishing the proper controls to maintain data integrity will not be a small challenge.

- *Independent Validation:* Depending on the nature of the particular application, a third-party review of the whole process and methodology might be warranted.

The promise offered by replicating portfolios to significantly reduce model run time for the valuation of liabilities with complex options and guarantees under a variety of market scenarios is attractive. However, there are many challenges to effective implementation. Armed with the above list of issues, and with the proper planning and guidance, companies can be more confident of reaping the rewards of replicating portfolios – faster run times without sacrificing quality. As a result, it is possible to incorporate better risk and performance analysis into management information and better support decision-making. ✦

The Financial Modelers' Manifesto

By Emanuel Derman and Paul Wilmott

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A SPECTRE IS HAUNTING MARKETS–the spectre of illiquidity, frozen credit, and the failure of financial models.

Beginning with the 2007 collapse in subprime mortgages, financial markets have shifted to new regimes characterized by violent movements, epidemics of contagion from market to market, and almost unimaginable anomalies (who would have ever thought that swap spreads to Treasuries could go negative?). Familiar valuation models have become increasingly unreliable. Where is the risk manager that has not ascribed his losses to a once-in-a-century tsunami?

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To this end, we have assembled in New York City and written the following manifesto.

MANIFESTO

In finance we study how to manage funds – from simple securities like dollars and yen, stocks and bonds to complex ones like futures and options, subprime CDOs and credit default swaps. We build financial models to estimate the fair value of securities, to estimate their risks and to show how those risks can be controlled. How can a model tell you the value of a security? And how did these models fail so badly in the case of the subprime CDO market?

Physics, because of its astonishing success at predicting the future behavior of material objects from their present state, has inspired most financial modeling. Physicists study the world by repeating the same experiments over and over again to discover forces and their almost magical mathematical laws. Galileo dropped balls off the leaning tower, giant teams in Geneva collide protons on protons, over and over again. If a law is proposed and its predictions contradict experiments, it's back to the drawing board. The method works. The laws of atomic physics are accurate to more than ten decimal places.

It's a different story with finance and economics, which are concerned with the mental world of monetary value.

Financial theory has tried hard to emulate the style and elegance of physics in order to discover its own laws. But markets are made of people, who are influenced by events, by their ephemeral feelings about events and by their expectations of other people's feelings. The truth is that there are no fundamental laws in finance. And even if there were, there is no way to run repeatable experiments to verify them.

You can hardly find a better example of confusedly elegant modeling than models of CDOs. The CDO research papers apply abstract probability theory to the price co-movements of thousands of mortgages. The relationships between so many mortgages can be vastly complex. The modelers, having built up their fantastical theory, need to make it useable; they resort to sweeping under the model's rug all unknown dynamics; with the dirt ignored, all that's left is a single number, called the default correlation. From the sublime to the elegantly ridiculous: all uncertainty is reduced to a single parameter that, when entered into the model by a trader, produces a CDO value. This over-reliance on probability and statistics is a severe limitation. Statistics is shallow description, quite unlike the deeper cause and effect of physics, and can't easily capture the complex dynamics of default.

Models are at bottom tools for approximate thinking; they serve to transform your intuition about the future into a price for a security today. It's easier to think intuitively about future housing prices, default rates and default correlations than it is about CDO prices. CDO models turn your guess about future housing prices, mortgage default rates and a simplistic default correlation into the model's output: a current CDO price.

Our experience in the financial arena has taught us to be very humble in applying mathematics to markets, and to be extremely wary of ambitious theories, which are in the end trying to model human behavior. We like simplicity, but we like to remember that it is our models that are simple, not the world

Unfortunately, the teachers of finance haven't learned these lessons. You have only to glance at business school textbooks on finance to discover stilts of mathematical axioms supporting a house of numbered theorems, lemmas

"Finance is not one of the natural sciences, and its invisible worm is its dark secret love of mathematical elegance and too much exactitude."

and results. Who would think that the textbook is at bottom dealing with people and money? It should be obvious to anyone with common sense that every financial axiom is wrong, and that finance can never in its wildest dreams be Euclid. Different endeavors, as Aristotle wrote, require different degrees of precision. Finance is not one of the natural sciences, and its invisible worm is its dark secret love of mathematical elegance and too much exactitude.

We do need models and mathematics – you cannot think about finance and economics without them – but one must never forget that models are not the world. Whenever we make a model of something involving human beings, we are trying to force the ugly stepsister's foot into Cinderella's pretty glass slipper. It doesn't fit without cutting off some essential parts. And in cutting off parts for the sake of beauty and precision, models inevitably mask the true risk rather than exposing it. The most important question about any financial model is how wrong it is likely to be, and how useful it is despite its assumptions. You must start with models and then overlay them with common sense and experience.

Many academics imagine that one beautiful day we will find the 'right' model. But there is no right model, because the world changes in response to the ones we use. Progress in financial modeling is fleeting and temporary. Markets change and newer models become necessary. Simple clear models with explicit assumptions about small numbers of variables are therefore the best way to leverage your intuition without deluding yourself. All models sweep dirt under the rug. A good model makes the absence of the dirt visible. In this regard, we believe that the Black-Scholes model of options valuation, now often unjustly maligned, is a model for models; it is clear and robust. Clear, because it is based on true engineering; it tells you how to manufacture an option out of stocks and bonds and what that will cost you, under ideal dirt-free circumstances that it defines. Its method of valuation is analogous to figuring out the price of a can of fruit salad from the cost of fruit, sugar, labor and transportation. The world of markets doesn't exactly match the ideal circumstances Black-Scholes requires, but the model is robust because it allows an intelligent trader to qualitatively adjust for those mismatches. You know what you are assuming when you use the model, and you know exactly what has been swept out of view.

Building financial models is challenging and worthwhile: you need to combine the qualitative and the quantitative, imagination and observation, art and science, all in the service of finding approximate patterns in the behavior of markets and securities. The greatest danger is the age-old sin of idolatry. Financial markets are alive but a model, however beautiful, is an artifice. No matter how hard you try, you will not be able to breathe life into it. To confuse the model with the world is to embrace a future disaster driven by the belief that humans obey mathematical rules. ✦

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MODELERS OF ALL MARKETS, UNITE!
You have nothing to lose but your illusions.

The Modelers' Hippocratic Oath

~ I will remember that I didn't make the world, and it doesn't satisfy my equations.

~ Though I will use models boldly to estimate value, I will not be overly impressed by mathematics.

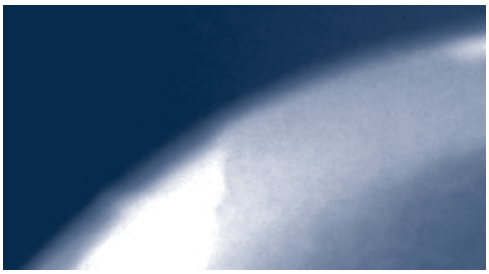
~ I will never sacrifice reality for elegance without explaining why I have done so.

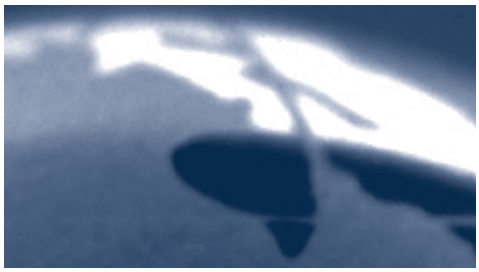
~ Nor will I give the people who use my model false comfort about its accuracy.
Instead, I will make explicit its assumptions and oversights.

~ I understand that my work may have enormous effects on society and the economy,
many of them beyond my comprehension

Emanuel Derman
January 7 2009

Paul Wilmott
January 7 2009





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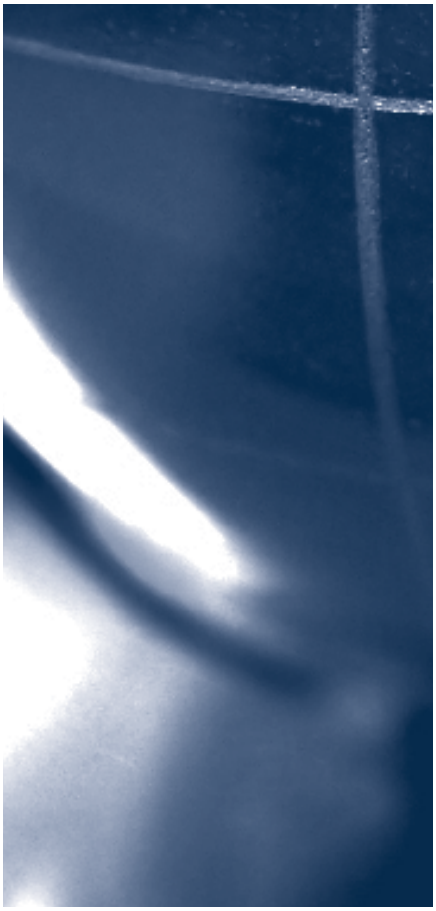

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Chicago, IL

Testing Loss Reserve Assumptions Limited Attendance Seminar
August 24, 2009
Chicago, IL

Reserve Variability Limited Attendance Seminar
August 25-27, 2009
Chicago, IL

Casualty Loss Reserve Seminar (CLRS)
September 14-15, 2009
Chicago, IL

London CARe Seminar: Pricing and Issues in Today's Market
September 15, 2009
London, England

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Risk-Based Pricing—Risk Management at the Point of Sale

By Dominique Lebel

BY FAR, THE MOST COMMON primary pricing measure is the statutory internal rate of return (IRR). The 2008 Tillinghast Pricing Methodology Survey showed that this was the pricing measure used by 57 percent to 82 percent of respondents, depending on the product. No other pricing measure came close.

The statutory IRR pricing objective is based on achieving a rate of return in excess of the company's hurdle rate, where the hurdle rate is often based on a company's overall cost of capital. While statutory IRR is a useful pricing metric, it is not perfect.

The hurdle rate typically does not vary by product; but different products have different levels of risks. Does a product with a higher pricing IRR create more shareholder value than a product with a lower pricing IRR? Not necessarily—it depends on the risks inherent in each product.

Products are often priced under the implicit assumption that arbitrage opportunities exist. Asset risk premiums (e.g., credit spreads in excess of assumed defaults, and equity risk premiums) are capitalized and are treated as earned before insurers/shareholders are released from risk. If insurers believe that these arbitrage opportunities exist, why not just borrow at the insurer's credit rating and invest in riskier assets rather than manufacture and distribute insurance products?

Consideration should be given to pricing products such that all risks undertaken are measured in an objective and consistent way.

RISK-BASED PRICING

Risk-based pricing (also known as market consistent pricing) addresses some of the shortcomings of traditional pricing methods by building on modern financial and economic concepts. It differs from traditional pricing methods in the following respects:

- The discount rate is set to reflect the risks inherent in each product.
- Credit spreads and equity risk premiums are earned as insurers/shareholders are released from risk.
- The costs of options and guarantees are valued in a manner that is consistent with how they are valued in the financial markets.

Under market consistent valuation methodology, if a replicating asset portfolio can be found that exactly matches a set of liability cash flows, then the value of the set of liability cash flows is equivalent to the value of the replicating asset portfolio. This would involve discounting each cash flow with the discount rate that would be used to value the cash flow in the capital markets. An equivalent approach is typically used for practical purposes. Under this approach, the cash flows are risk-adjusted, such that all assets earn risk-free or near risk-free rates (e.g., swap rates) and all cash flows are discounted using these same rates (for stochastic simulations, risk neutral scenarios are used).

The use of risk-free or near risk-free rates is based on the assumption that policyholder liabilities are certain to be paid. However, an adjustment to the risk-free rate could theoretically be made for the insurer's own credit risk (i.e., allowing for the possibility that the insurer will default on its obligations). This is not common, because it results in a lower value of liabilities as the insurer's own credit risk increases.

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Other adjustments to the risk-free rate have been made in recognition of the recent dislocations in the markets using methods such as the minimum cost replicating portfolio method. This method proposes that where there are alternative replicating portfolios that can be constructed for a liability that has largely predictable cash flows, such as a payout annuity liability, the cheapest replicating portfolio may be used to value the liability. For example, a combination of corporate bonds and credit default swaps is one potential minimum cost replicating portfolio. This is currently an evolving topic.

Typically, for each product, a value of new business (VNB) is determined which reflects the value to shareholders created through the activity of writing new business.

VNB = Present value of future profits after tax – time value of financial options and guarantees – frictional costs of required capital[1] – cost of non-hedgeable risk.[2]

Risk-based pricing provides a robust, transparent and objective economic perspective on new business profitability that is consistent across products. If the VNB is greater than zero, the return is greater than the market price of the risks undertaken. A VNB less than zero will reduce shareholder value.

While a positive VNB is necessary to increase shareholder value, it may not be sufficient. Product charges (e.g., premiums) should be set such that the overall value of new business generated (based on anticipated sales volume) maintains the franchise value of the company, which could be approximated as the market capitalization of the company less its embedded value. This is where management has a significant role to play. A VNB of zero determines the minimum price for taking risk, but the final product charge requires management input. For example, product charges need to be balanced with sales volumes and, for a company that is capital-constrained, capital efficiency needs to be factored into the new business pricing process.

Additional metrics commonly used include:

- Profit margin: VNB/PVP, where PVP equals the present value of premiums.
- Implied discount rate: The discount rate such that the traditional value of new business equals the VNB. This is sometimes used to compare the relative level of risk between products. A product with a higher implied discount rate is riskier than a product with a lower implied discount rate.

WINNERS AND LOSERS

Some products will perform better than others under a market consistent framework. Results will vary depending on:

- The level of guarantees (e.g., minimum interest rate guarantees or variable annuity/segregated fund guarantees).
- The amount of asset risk borne by insurers/shareholders (e.g., the credit quality of assets).
- Whether the product allows management discretion to mitigate adverse experience (e.g., ability to adjust future premiums, credited rates or policyholder dividends).

This makes sense. Everything else being equal (e.g., assuming the same product charges), a product (Product A) with more guarantees, more asset risk and without management levers to mitigate adverse experience ought to be considered more risky than a similar product (Product B) with opposite characteristics. The pricing metric used should show a less favorable result for Product A relative to Product B. This is the case under a market consistent framework.

Table 1 splits common products into two categories: those that show an increase in the profit margin when moving from a traditional approach to a market consistent approach and those that show a decrease in the profit margin.

FOOTNOTES:

1 Typically includes costs related to investment expenses and taxation.

2 Typically equal to the present value of between 0 percent to 6 percent per year of the projected non-hedgeable risk capital.

"Recent developments have motivated many companies to look at the profitability of their products under a market consistent framework."

TABLE 1
Typical Winners and Losers:
Risk-Based Pricing vs. Traditional Pricing

Winners	Losers
Term Insurance	Payout Annuities
Short Term Group Life and Health/Employee Benefits	Fixed Annuities
	Variable Annuities/ Segregated Funds
Universal Life/Variable Universal Life*	Universal Life/Variable Universal Life*

* Depends on orientation of product (accumulation vs. protection), cost of insurance structure, investment options available and level of guarantees.

While risk-based pricing should be an important part of product design and pricing strategy, it should not necessarily be the only measure used. Other approaches, such as statutory IRR, for example, can provide useful insights into the potential future profitability of a product.

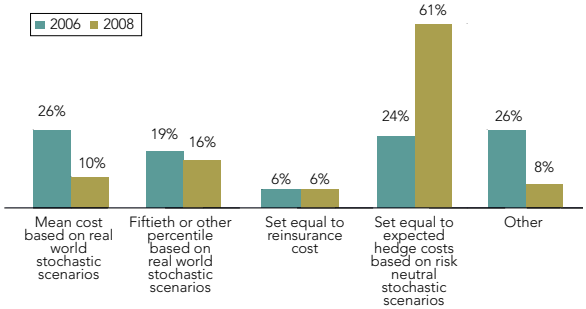
RISK-BASED PRICING IS NOT NEW, IS INCREASILY BEING USED AND ITS USE IS EXPECTED TO CONTINUE TO INCREASE

As shown in Chart 1, the approach used to set the cost of guarantees on variable annuity business has evolved from a deterministic real-world approach (many years ago) to a stochastic real-world approach (a few years ago) to a stochastic risk-neutral approach (where we were in 2007 and where we are today).

Chart 1:

Method Used to Determine Cost of Guarantees on VAs

(Percent of Responses)



Note: Companies selected multiple responses if they used different methods for different guarantees.

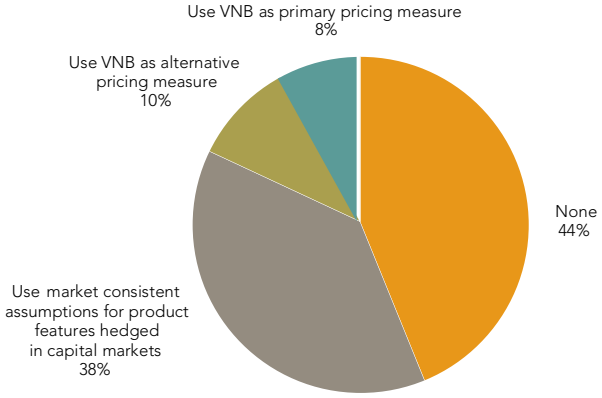
Source: 2006 and 2008 Tillinghast Pricing Methodology Surveys (i.e., methodology used to price products in 2005 and 2007)

So, risk-based pricing is not new. As shown in Chart 2, some companies were using risk-based pricing for products other than those hedged in the capital markets (i.e., variable annuity guarantees in most cases), but its use was not prevalent in the pricing of 2007 products. If this approach is considered best practice for setting costs on variable annuity guarantees, why wasn't it broadly used for other products?

Chart 2:

Use of Risk-Based Pricing Methodologies or Assumptions

(Percent of Responses)



Source: 2008 Tillinghast Pricing Methodology Survey (i.e., methodology used to price products in 2007)

While risk-based pricing was not broadly used in 2007 for a wide range of products, this is gradually changing as market consistent techniques make their way into financial reporting, economic capital calculations, merger and acquisition and securitization transactions and asset-liability management. For example,

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- U.S. GAAP contains standards related to fair value measurement and options (FAS 157 and 159).
- The European Insurance CFO Forum Market Consistent Embedded Value Principles,[3] which were published in June 2008, require member companies to publish year-end 2011 embedded values and values of new business using market consistent techniques.
- Many companies, domestic and international, are using market consistent methodologies to determine economic capital (a la Solvency II).
- More and more merger and acquisition and securitization transactions are being valued using both traditional and market consistent techniques.
- Some companies are embracing market consistent techniques because they believe these methods provide useful insights into asset-liability management.

The above developments have motivated many companies to look at the profitability of their products under a market consistent framework. As a result, some of these companies have made or are in the process of making changes to their products and/or pricing. Other companies have embraced risk-based pricing for its own sake. A few use it for incentive compensation to align compensation with risks undertaken.

IFRS Phase II, which is based on a fair value approach, could become required in 2014 in the United States and in 2013 in Canada. Consequently, the use of risk-based pricing should continue to increase in North America.

THOSE THAT ACT EARLY CAN GAIN A COMPETITIVE ADVANTAGE

Risk-based pricing could be used to develop strategic options. Companies could target products where current product charges are greater than prices required by the market. Companies moving first would gain leverage by targeting profitable products. Eventually inefficiencies will be corrected as competitors catch up.

Companies could also use risk-based pricing analyses to better understand the relative risks of their products. Depending on a company's risk appetite, measures could then be taken to de-risk certain products by increasing product charges or making changes to the product design. Product design changes could include decreasing interest rate guarantees, making variable annuity/segregated fund guarantees less rich, introducing market value adjustments upon surrender and changing premiums from a guaranteed basis to an adjustable basis.

In addition, companies could use risk-based pricing techniques to protect themselves against similar tactics used by competitors.

CONCLUSION

Risk-based pricing addresses some of the shortcomings of traditional pricing methods by providing a framework for understanding the tradeoffs between shareholder risks and rewards using a robust, transparent and objective economic methodology that is consistent across products. The use of risk-based pricing has recently extended beyond variable annuity guarantees to a wide range of life, health and annuity products. More and more companies are looking at the profitability of their business under a market consistent framework motivated by FAS 157 and 159, MCEV Principles, economic capital calculations, insurance company transactions, asset-liability management and IFRS Phase II. Companies that are among the first to take action may benefit. ✦

FOOTNOTES:

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Variable Annuity: Risk Management Through Breakthrough Product Innovation[1]

By Xiaokai Shi and Yungui Hu

IT IS INCREASINGLY ACCEPTED that large variable annuity writers will not get out of this severe market stress unless tail risks of GMxBs are well mitigated. Under today's environment, variable business faces an uncertain future as the guarantees are more frequently in the money, and this has created extreme stress on the insurers' balance sheets. The current high volatility and low interest rate environment has worsened this situation. Mark-to-market reserves on these embedded derivatives have jumped 10- to 15-fold when compared with the results during 2007 and 2008. In the past insurance writers generally mitigate these GMxB risks through hedging, reinsurance or taking a naked position. However, the current financial crisis shows that these traditional risk mitigation strategies cannot work well under severe market shocks:

- During market turmoil, insurers incur much higher hedging costs to retain the same hedging effectiveness level when done under normal market conditions;
- The reinsurance supply becomes scarce and expensive;
- Capital becomes even more scarce and precious.

Today variable annuity business is facing an uncertain future due to capital strain, regulatory uncertainties and negative market perceptions. The magnitude of the variable annuity writers' dilemma is determined by the nature of the GMxBs and by the limitations of their existing risk management approaches:

- GMxBs are embedded non-standard puts sold to policyholders that imply insurers will benefit from bull markets, but they will be hurt with losses due to increased basis risk and high volatilities. The current market meltdown with soared volatility and low interest rates has harmed the insurers' balance sheets and has created significant stress on their financial standings. Further, some VA features such as rachets, step-ups, and roll-ups make those options difficult to move out of money, even equity market cycle reverses.
- Hedging programs are conducted by purchasing derivatives to offset the positions that insurers have on their liabilities. However, there can be a timing mismatch. Fees or charges (e.g. the prices of these embedded derivatives) were determined months or years before by using valuation tools calibrated to the market at that time. On the other hand, hedging programs rebalance the hedging portfolio under the current market conditions. Therefore, hedging costs will increase if insurance companies sell their guarantees at a "good" time (e.g. during low volatility) and purchase their hedging derivatives during "bad" days (e.g. high volatility). Escalating basis losses, and higher vega and gamma exposures will put insurers in an extremely difficult situation. This is exactly what has happened since October 2008, when volatilities have soared and interest rates have dropped dramatically.

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In the authors' view, current hedging programs are not working very effectively under severe economic shocks. The cause is the downside risk exposure from the GMxBs and the timing mismatch mentioned above. Under today's environment, reasonable increases in GMxBs charges are far from being adequate to compensate for the increased hedging costs. The nature of the business and the existing risk management approach make it very challenging for the insurer to manage this type of risk during downturns in the economy.

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Given the difficult situation that the insurer is facing and the insufficient effectiveness of various hedging approaches, it will be a significant task to develop new

CONTINUED ON **PAGE 30**

FOOTNOTES:

[1] The views in this article only represent the authors' personal opinions. This article does not represent any statements from the organizations where the authors are employed.

Variable Annuity: Risk Management … | from Page 29

strategies to manage the various risks associated with the variable annuity business. To this end, we propose an innovative risk management strategy through product design of variable annuities. The primary feature of the new product is to offer the policyholder access to negatively correlated funds. We believe that these additional funds will significantly reduce the downside risk, thus the stress on an insurer's balance sheet.

"NATURAL HEDGING" THROUGH PRODUCT DESIGNS

Current variable annuity product designs only allow account value to change in one direction: policyholders can grow their money only when the equity market rises. When the equity market drops, the policyholder's wealth remains at the guaranteed level and the insurer is responsible for the deep in-the-money GMxBs benefits. Unlike this unilateral design, the proposed new product innovation allows a policyholder's account value to have the opportunity to grow in both directions of equity market movements. It is achieved by providing additional ***"inverse funds,"*** which are ***negatively correlated*** with the funds available in the current existing variable annuity products. These inverse funds would mirror the "regular funds" (currently available funds, which are linked to the performance of various equity indices such as S&P 500, Russell 2000, etc). Said differently, these inverse funds could move in the opposite direction with the indices. They can be directly linked to the performance of some traded indices (such as Exchange-Traded-Funds), or linked to the performance of synthetic indices. For example, for a fund to mimic the opposite performance of the Russell 1000 financial sector, an underlying synthetic index can be developed by packaging a one third position in the Financial Bear 3X (FAZ) index and two thirds in the Russell 1000 Financial index.

So, as a result, during a bear market, with a certain portion of the funds moved to inverse funds, part of the GMxBs will move out of the money. So, an insurer's stress should be largely reduced due to lowered GMxBs in-the-moneyness. Of course, the upside potential is reduced in a bull market as some policyholders may continue to direct some of their fund allocation to these inverse funds. Note that if the distribution to regular funds and inverse funds are equal then the in-the-moneyness of the GMxBs will not change over the equity market cycle. From a policyholder's perspective allocation to regular funds are taking a long position on puts on these funds and the GMxBs will protect them from bear markets. On the other hand, those who distribute their wealth to inverse funds are longing puts on the underlying funds that move *inversely* with equity market. From an insurance company's perspective, pooling these two cohorts of people together will lower the total GMxBs in-the-moneyness and substantially diversify the tail risks. The key of this new product design is to allow policyholders to dynamically manage their funds under the different economic cycles. An Insurer's current hedging programs will be essentially actively shorting the market "on the back-end" to offset their positions of the embedded derivatives on the liabilities. This new product design, however, essentially allows policyholders to short the market themselves under bear markets and an insurance company then only takes on a limited residual risk exposure of an extreme market.

During equity market transitions, allowing fund transfers between regular funds and inverse funds would further reduce an insurer's tail risk, assuming that there is a certain level of rational policyholder behavior. In a bear market, it is reasonable to assume that a greater portion of policyholders would move their deposits into the inverse funds. Hence the in-the-moneyness will reduce during severe economic distress as in the last year. In a bull market a greater portion of policyholders will move their deposits into the regular funds to benefit from the favorable equity performance.

A NUMERICAL EXAMPLE AND ANALYSIS

The variable annuity product for this example is a simplified version with only one time period considered. Without loss of generality, we will assume that there will be no reduction in the units in force due to mortality, lapse, partial withdrawal, or annuitization. Other product features and assumptions are listed as follows:

"Offering variable annuity policyholders access to negatively correlated funds significantly reduces downside risk, thus the stress on an insurer's balance sheet"

Product Specification:	
Account value at the beginning of the period:	BOP AV = $100,000
Base of guarantee at the beginning of the period:	BOP GMxB base = $100,000
The guarantee has a roll-up feature:	roll-up rate = 0%
Charges and expenses:	MER = 2.00%
GMxBs utilization/selection rate (e.g., annuitization):	15%
Policies in-force:	1000

For simplicity, only two funds in the separate account are considered: a regular fund and an inverse fund. The first is linked to the performance of S&P 500, and the latter to the opposite of this index. Table 1 shows the hypothetical returns of the two funds during the period for both bear and bull markets.

	Regular fund (S&P500)	Inverse fund (-S&P 500)
Bear market	-20%	20%
Bull market	20%	-20%

We will assume that there are only three types of policyholder behavior: a bear market view, a bull market view and a neutral view. We assume that policyholders who hold the bear market view will tend to allocate more of their money to the inverse fund. Where, on the contrary, policyholders who hold the bull market view will be inclined to allocate more into the regular fund. For the third case, policyholders are not sure about the market, and then allocate equally between the two funds to hedge their market risk. Our funds allocation assumptions are displayed in Table 2.

Table 2. fund allocation

	Regular fund (S&P500)	Inverse fund (-S&P 500)
Bear market view	0%	100%
Bull market view	100%	0%
Neutral market view	50%	50%

At an aggregate level, the net effect of overall policyholder behavior can result in the following three scenarios:

- *Balanced allocations:* allocations to the two funds are roughly equal. This scenario is likely to happen when the market is neither a bull nor a bear market. Consequently, most of the people may hold neutral view, or the number of bear views and the number of bull views do not dominate one another.
- *Rational allocations:* here more is allocated to the regular fund than the inverse fund in a bull market, and more to the inverse fund than the regular fund in a bear market. This scenario happens in a typical bull or bear market.
- *Irrational allocations:* more is allocated to the regular fund than the inverse fund in a typical bear market, and more to the inverse fund than the regular fund in a typical bull market. This is less likely to happen if we assume that policyholders want to maximize their wealth.

Table 3 provides hypothetical fund distributions on an aggregate basis under the three scenarios mentioned above.

Table 3. assumption of policyholder distribution under various scenarios

	Bear market		Bull market	
	Regular fund	Inverse fund	Regular fund	Inverse fund
Balanced allocations	50%	50%	50%	50%
Rational allocations	30%	70%	70%	30%
Irrational allocations	70%	30%	30%	70%

Given the above product features and assumptions, the account value (AV), the GMxB guaranteed base, in-the-moneyness (ITM), GMxB charges, and profits are readily calculated. To see how differently this new product behaves from the currently existing VA products, the same quantities of an existing VA contract are also computed using the same assumptions. The existing VA has the same product features except that it only provides a regular fund. Table 4 summarizes the comparison of the results under various scenarios and equity market conditions. Note that the PH AV is taken as the maximum of the guaranteed base and the actual account value, to reflect their actual wealth.

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Table 4. Results of numerical example ($mm)

		Bear market		Bull market	
		Existing VA	Proposed VA	Existing VA	Proposed VA
Balanced allocations	PH AV	100.00	108.80	117.60	108.80
	ITM	21.60	10.80	0.00	10.80
	Profit	-1.60	0.38	2.40	0.38
Rational allocations	PH AV	100.00	112.32	117.60	112.32
	ITM	21.60	6.48	0.00	6.48
	Profit	-1.60	1.19	2.40	1.19
Irrational allocations	PH AV	100.00	105.28	117.60	105.28
	ITM	21.60	15.12	0.00	15.12
	Profit	-1.60	-0.43	2.40	-0.43

It can be seen from table 4 that the existing product incurs a large loss of 1.6 $mm in the bear market and harvests a profit of 2.4 $mm in the bull market. For this new product, the insurer's profit ranges from -0.43 $mm to 1.19 $mm. The maximum loss is only a quarter of that of the existing product, thereby significantly reducing the stress on their balance sheet. At the same time, however, the upside potential is reduced in a bull market. These two products have the same average PH AVs across the various market conditions and allocation scenarios. But, the volatility is dramatically reduced by the new design. We conclude that a policyholder's wealth is increased on a risk adjusted basis. This is due to the fact that, when compared with the existing product, an option of allocating to the inverse fund is granted to policyholders.

CONCLUSIONS

The new product feature presented in this paper helps insurance companies manage the equity market tail risk and also adds value to policyholders. However, it takes several steps to turn ideas to reality. We suggest that practitioners need to understand any potential risks of this new product and perform complete stress testing under different economic scenarios as well as sensitivity tests on the key actuarial assumptions such as fund allocation and withdrawal. We also would like to extend our conclusions to the original intension of this new idea.

1. Enhance business values on a risk adjusted basis

Current variable annuity product designs are not consistent with the long-term operational nature of insurance business as they have exposed insurers to extreme tail risks. Companies that wish to survive hundreds of years will find it inevitable to avoid difficulty during severe economic shocks. The management of insurance carriers needs to develop risk management strategies considering various economic and underwriting cycles.

The use of insurance is to manage unintended consequences of actions or activities from a massive population by the use of diversification of these risks. Insurance may cease to function in situations where it is exposed to extreme tail risks or the insured can effectively anti-select against it. Current GMxBs designs fall into one of these situations.

The proposed product design significantly reduces a VA writer's tail risk and increases their business value. At the same time, the new feature is more valuable to policyholders on a risk adjusted basis than the existing counterpart because a non-standard "chooser" option is offered instead of a non-standard put option.

2. Manage risks through product designs

Another intension of this product innovation is to manage business risks through product design. Like the "natural hedging" against mortality risk by running both life insurance and annuity businesses, management needs to consider developing risk management strategies during the product development process, as part of a holistic risk management view. "Back-end" risk management (such as reinsurance, hedging, or securitizations) can then supplement and work seamlessly with the "front-end" risk management (such as product design) to manage risks in an entire control cycle. Solely relying on back-end risk management makes it challenging to keep up with the pace of dynamic market movements.

As a caveat, if, as many believe, today's market is at its bottom level, the authors would warn that it may be risky to offer inverse funds to in-force VA products as there is possibility that policyholders' account values could be locked-in at the current or reduced level. Further, policyholder behavior on these contacts would add greater uncertainty to the insurer's business portfolio.

At the present time, large VA writers are actively re-pricing or re-designing their GMxBs to reduce the risk from their VA products. We believe a large portion of business risk emerges from the product development phase and these can be mitigated by designing risk management strategies during that stage. We hope our suggestions will inspire more innovative ideas in product design. ✦

The Efficient Policyholder Approach to Pricing Guaranteed Minimum Withdrawal Benefit Riders

By Lloyd Foster

ABSTRACT

THE GUARANTEED MINIMUM Withdrawal Benefit (GMWB) rider, despite its many attractive design features, poses a pricing challenge because of the flexibility afforded the policyholder in choosing when to start withdrawals. Policyholder behavior is consequently a very significant (and virtually unknown) factor in determining the cost of the guarantee.

The proposal in this paper is that the product should be priced on the assumption that the policyholder is financially efficient. In other words, the policyholder will choose the start date that maximizes the cost to the insurer.

PRICING THE GMWB RIDER

The Challenge

The GMWB rider allows a policyholder to make a series of withdrawals from a variable annuity fund, with the guarantee that the total value of the withdrawals will never be less than a stipulated amount (usually the net deposit made by the policyholder).

In addition, the rider affords a sizable window period (typically several years) for commencing the withdrawal process. It is this feature that poses the policyholder behavior challenge: By the very nature of the underlying equity funds supporting the rider, the cost to the insurer will vary considerably, depending on the actual start date chosen by the policyholder.

This is a product that will probably grow in popularity as its benefits become more well-known. Risk management protocol requires that the insurer have a firm understanding of the financial exposure associated with those benefits. Unfortunately, as has been pointed out by experts in this product area (e.g. see Mary Hardy's text Investment Guarantees), it is virtually impossible to model policyholder behavior.

Choosing the correct pricing approach for a product so dependent on the behavior of the customer is therefore certainly not a trivial matter. Recent experience in the equity markets (and the attendant effects on life insurers marketing variable products) amply demonstrate the importance of this issue.

The position taken by this paper is in line with the general consensus of the experts: Anticipating the policyholder's actual choice is a virtual impossibility.

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Hence the challenge: The insurance industry should either develop a pricing philosophy that adequately protects the insurer's financial and capital interests (despite the inability to model policyholder behavior), or seriously consider withdrawing the GMWB product from the market.

Balancing Risk Management Protocol and Marketing Needs

It is (hopefully) no longer the view of the industry that risk management is necessarily at odds with marketing needs. Professionals are becoming aware that risk managers bring very valuable skills to bear on otherwise unsolvable business problems. The case of the pricing philosophy for GMWB riders is one such situation.

First, a very clear statement of the seemingly conflicting views posed by the risk manager and the marketer in this case.

Marketer: *Bring to market a very useful Variable Annuity rider, at a cost that can be supported vis-à-vis the competition and the perception of the customer.*

Risk Manager: *Ensure the financial self-sufficiency of said Variable Annuity rider, so the insurer adequately accounts for the investment risks inherent in the product.*

This situation does not have to degenerate into an untenable tug-of-war. Resolution requires all parties concerned to agree that:

- It is in the best interest of the insurer to be in this business and market this product;
- It is not in the best interest of the insurer to price the product in a manner that results in sub-optimal protection against adverse equity-market developments;

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The Philosophy of the Efficient Policyholder
The philosophy of the efficient policyholder addresses the issue in a uniquely intuitive and financially sound manner: Rather than second-guess the actions of the policyholder under various permutations of emerging economic conditions, impute a financially efficient knowledge base to the policyholder.

Based on this financially efficient base, the policyholder automatically chooses the optimal (from the policyholder's point of view) starting point in exercising the benefit. Note that this optimal choice for the policyholder will be the worst possible choice from the point of view of the insurer.

Put another way, the pricing exercise consists of repeatedly finding the cost of the product at various withdrawal starting points, and choosing the maximum of all such possible prices.

Admittedly, such an approach readily satisfies the requirements of a purist risk manager. But does it meet the needs of the marketer, or of the enlightened risk manager whose view is more attuned with optimizing the company's operations, including its acquisition of new business?

Objections to the Philosophy
Objections to this approach will more likely come from the marketing team, and will center around the argument that the resulting cost will be excessive, relative to what the market is able to sustain.

If the comparison is made between what is currently charged on a typical GMWB rider today (80 basis points) and the corresponding expected cost under the Efficient Policyholder approach (170 basis points), the argument certainly seems valid.

A second objection may come from the pricing and IT professionals. The grounds for this objection will be that implementing such an approach would be very difficult (very nearly impossible) operationally.

Responding to the Objections

PRICE SUSTAINABILITY

How much is a good or service supposed to cost, really? Economists have struggled with the concept for centuries and are still not sure.

For purposes of this discussion, it can be presumed that the market determines the price. There is latent danger in such a supposition, of course: The floor on any market price must necessarily be the actual cost of production (otherwise the company falls for the well-worn joke about selling below cost and making up the difference on volume).

The above statement about the floor on market price is not as trite as it might at first appear: There are many respectable professionals who believe that the life insurance industry violated this rule with respect to term products, during the last two decades of the 20th century. Worse, the indications are that the industry fell prey to a spiraling effect, each company outdoing the other in ever-lower term premium scales, all the time knowing that the mortality tables and expense schedules could not sustain those prices.

The need for rational approaches to pricing insurance products has been highlighted by the recent financial crisis that came very close to engulfing the life insurance industry along with the banks. Now may be the very best time to re-think our view of how products (especially those with equity-related guarantees) are priced.

What would a rational approach to pricing the GMWB rider entail? At a minimum it would have to insist on the following:

- The pricing approach must ensure that the benefit is adequately covered in a self-financing manner
- The approach must account for benefit coverage even under worst-case scenarios
- The approach must pass the scrutiny of prudent risk management professionals

The efficient policyholder approach satisfies all the above requirements. Satisfying the above requirements is tantamount to meeting the basic floor limitation on market price: It must at least equal production cost.

"Rather than second-guess policyholder actions under various economic conditions, impute a financially efficient knowledge base to the policyholder."

One of the dangers of an industry caught in the frenzy of under-pricing is that no company wants to be the first to step forward and do what is economically sane. Each company walks in lock step with every other company, following the instinctive herd concept that "100,000 lemings can't be wrong."

The most important point of this paper (and it cannot be emphasized too strongly) is that any insurance price that deviates too far from what is considered prudent in terms of risk management, potentially spells disaster for the insurer.

IMPLEMENTING THE PHILOSOPHY

The second objection to the efficient policyholder approach, that it is difficult to implement operationally, is much easier to answer. As demonstrated in the remaining sections of this paper, nothing could be further from the truth.

General

This section illustrates how the pricing philosophy can be readily implemented. The illustration is done using *Mathematica,* but it could just as easily be implemented in whatever software platform the user sees fit.

Mathematica is used here primarily because of the ease with which it can illustrate mathematical concepts.

Assumptions

The illustration is built around the following product design:

- The GMWB rider provides a seven-year withdrawal period for taking equal monthly payments from the variable annuity fund
- The window of opportunity for starting withdrawals is the seven-year period starting from the effective date of the rider
- The policyholder is presumed to have purchased one share of the underlying equity, worth 1,000.00 at inception
- The guarantee is the initial net fund value of 1,000.00, with the assumption that no partial surrenders of any kind are made between the initial deposit date and the commencement date for withdrawals
- The monthly withdrawals are assumed to be a fixed percentage of the original net fund value of 1,000.00
- No assumptions about expense charges are included in the calculations (presumably if the expense charge is considered as a percentage of the fund, the effect of incorporating expenses could be obtained by appropriate adjustments to the risk-free rate assumption)
- All considerations of lapses and/or mortality are ignored

THE *MATHEMATICA* IMPLEMENTATION PROCESS

Initial Fund Value

$$S_0 = 1000;$$

Fund Accumulation Function

The formula below gives the value of the fund at time n, assuming that withdrawals commenced at time m (< n). Here $\mathcal{R}$ represents the underlying fund value based on equity movements, and $\mathcal{P}$ represents the fixed percentage withdrawn each period. The derivation of this formula is shown in the appendix.

Note: In this regard, $S_0 = \mathcal{R}[[0]]$.

$$\mathcal{V}[n\_, m\_, \mathcal{R}\_, \mathcal{P}\_] := \mathcal{R}[[n]] \left(1 - S_0 \mathcal{P} \left(\sum_{j=m}^{n} \frac{1.}{\mathcal{R}[[j]]}\right)\right)$$

Stock Accumulation Matrix

In this section, a matrix is created for developing the equity movements underlying the variable annuity fund. It will have 1,000 rows (because 1,000 simulations will be run), and 360 columns representing 360 monthly time periods.

NOTE: For purposes of this illustration, only 168 columns are strictly needed.

Number of Simulations

```
rows = 1000;
```

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Number of (Monthly) Time Periods

```
columns = 360;
```

Define a Standard Normal Random Variable

```
ndist = NormalDistribution[0,1];
```

Declare a Matrix to Hold the Generated Instances of the Variable

```
StandMat= Table[0,{i,rows},{j,columns}];
```

Proceed to Fill the Matrix

```
Do[StandMat[[i,All]] = Table[Random
[ndist],{columns}];,{i,rows}]
```

Declare the Periodic Factor

$$\Delta t = \frac{1}{12};$$

Adjust the Standard Normal Matrix

```
StandMat *= √Δt
```

Declare a Matrix to Hold the Running Total of the Above Standard Matrix

```
RunStandMat = Table[0,{i,rows},
{j,columns}];
```

Proceed to Fill the Matrix

```
Do[prev = 0.; Do[RunStandMat[[i,j]] =
prev + StandMat[[i,j]];
prev = RunStandMat[[i,j]];,{j,columns}];,
{i,rows}]
```

FUND ACCUMULATION MATRIX

This subsection defines a matrix of fund values, using the above results as a base.

First, the fund accumulation function is given, based on the variables:

t = time since rider effective date
ω = accumulative adjusted standard normal
s = assumed fund return volatility
r = risk-free rate

The formula is the familiar Geometric Brownian Motion stock process found in standard textbooks on derivatives pricing.

Fund Accumulation Formula

$$fS[t\_,\omega\_,s\_,r\_] := S_0 e^{(r-\frac{s^2}{2})t+s\omega}$$

Declare Fund Accumulation Matrix

```
AccumMat = Table[0,{i,rows},{j,columns}];
```

Declare Risk-Free Rate and Volatility

```
rate = 0.04; σ = 0.25;
```

Proceed to Fill Fund Accumulation Matrix

```
Do[Do[AccumMat[[i,j]] =
fS[jΔt,RunStandMat[[i,j]],σ,rate];,
{j,columns}];,{i,rows}]
```

APPLICATION OF THE EFFICIENT POLICYHOLDER ASSUMPTION

Withdrawal Period (Years)

```
years = 7;
```

Withdrawal Rate

$$WR = \frac{1}{years}\Delta t;$$

Window of Opportunity for Starting Withdrawals (Months)

$$WO = \frac{years}{\Delta t};$$

Period for Withdrawals (Months)

$$Per = \frac{years}{\Delta t};$$

Vector of Possible Prices Based on Withdrawal Starting Point

```
VecPrice = Table[0,{i,WO}];
```

Accumulated Withdrawals as of Time n

```
AccWith[n_, P_] := n P S0
```

Determination of Whether a Claim is Payable, and How Much

```
DetClaim[n_, m_, R_, P_] := If[V
[n, m, R, P] ≤ 0, Max[0, S0 - AccWith
[n - m, P]], 0]
```

Calculation of Payoff and Cost

This is the heart of the calculation process that determines the price (on a net single premium basis) of the GMWB benefit.

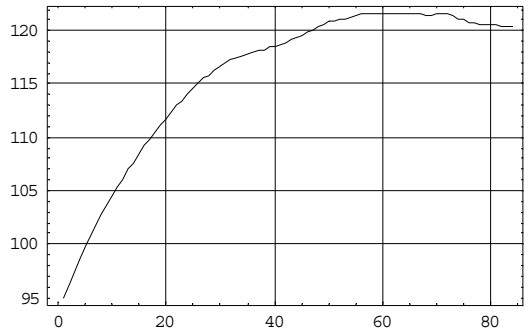
```
Do[Do[Do[RR = AccumMat[[i, Range
[Per + WO]]];
 VecPrice[[j]] += e^-rate (j+k-1) Δt
DetClaim[j + k - 1, j, RR, WR] /
/ rows;
 If[DetClaim[j + k - 1, j, RR, WR]
 > 0, Break[]];, {k, Per}];,
 {i, rows}];, {j, WO}]
```

Display All Possible Prices, In Start Date Order

```
VecPrice
{94.9323,96.12,97.3166,98.4641,99.6454,10
0.713,101.729,102.741,103.663,104.547,105.2
85,106.062,106.997,107.625,108.458,109.278
,109.852,110.438,111.107,111.644,112.295,11
2.964,113.396,114.095,114.649,115.003,115.5
83,115.776,116.358,116.683,116.935,117.254,
117.498,117.598,117.746,118.016,118.225,11
8.135,118.45,118.528,118.74,118.914,119.099
,119.42,119.519,119.826,120.105,120.373,120
.486,120.816,120.836,120.98,121.097,121.29,
121.453,121.509,121.566,121.494,121.609,121
.503,121.588,121.568,121.521,121.617,121.54
7,121.586,121.632,121.481,121.436,121.606,1
21.492,121.505,121.338,121.124,121.08,120.
77,120.724,120.529,120.528,120.562,120.511,
120.447,120.43,120.446}
```

Graph the Price Results

```
ListPlot[VecPrice,Frame→True,PlotJoined→
True,GridLines→Automatic]
```



□ Graphics □

Determining the GMWB Price as the Maximum of All Possible Prices

Inspection of the graph shows approximately where the maximum possible price lies. It can be pinpointed precisely by employing the following routine.

```
Price = 0.;
Do[Price = Max[Price,VecPrice[[i]]];,
{i,WO}]
```

This is the actual price for the rider

```
Price
121.632
```

This shows the withdrawal start month that corresponds to the maximum possible price

```
Position[VecPrice,Price][[1,1]]
67
```

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CONCLUSION

For a product as popular as the GMWB rider, it is important that the insurer be in full control of the risk management ramifications underlying the guarantees: The larger the sales volume, the greater is the potential for severe financial consequences if the pricing proves to be inadequate.

The philosophy proposed in this paper demonstrates a rigorous, defensible, and easily implemented method for ensuring the financial integrity of this product.

Derivation of Fund Accumulation Formula

THIS DERIVATION ASSUMES that withdrawals are made at the beginning of each period.

TIME m

Assume that the fund is being viewed at time m, immediately after the first withdrawal has been taken. The Fund will be identically equal to the indicative equity value, less the withdrawal:

$$R[[m]] - PS_0 \equiv R[[m]] - PS_0 \frac{R[[m]]}{R[[m]]}$$

TIME m+1

Next, assume that we proceed to time m + 1. The fund value would have changed based on market movements, and the second withdrawal is taken. We now have the following result:

$$R[[m]](1+r1) - PS_0 \frac{R[[m]]}{R[[m]]}(1+r1) - PS_0 \equiv$$
$$R[[m+1]] - PS_0 \frac{R[[m+1]]}{R[[m]]} - PS_0 \frac{R[[m+1]]}{R[[m+1]]}$$

TIME m + 2

At time m + 2, the fund value would again have changed based on market movements, and the third withdrawal taken:

$$R[[m+1]](1+r2) - PS_0 \frac{R[[m+1]]}{R[[m]]}(1+r2) - PS_0 \frac{R[[m+1]]}{R[[m+1]]}(1+r2) - PS_0$$
$$R[[m+2]] - PS_0 \frac{R[[m+2]]}{R[[m]]} - PS_0 \frac{R[[m+2]]}{R[[m+1]]} - PS_0 \frac{R[[m+2]]}{R[[m+2]]}$$

TIME m + 3

Similarly for time m + 3: The fund value changes based on market movements, and the fourth withdrawal is taken, yielding:

$$R[[m+2]](1+r3) - PS_0 \frac{R[[m+2]]}{R[[m]]}(1+r3) - PS_0 \frac{R[[m+2]]}{R[[m+1]]}(1+r3) - PS_0 \frac{R[[m+2]]}{R[[m+2]]}(1+r3)$$
$$- PS_0 \equiv R[[m+3]] - PS_0 \frac{R[[m+3]]}{R[[m]]} - PS_0 \frac{R[[m+3]]}{R[[m+1]]} - PS_0 \frac{R[[m+3]]}{R[[m+2]]} - PS_0 \frac{R[[m+3]]}{R[[m+3]]}$$

TIME n (≥ m)

It then becomes a matter of simple induction to derive the generalized formula for time n ≥ m:

$$R[[n]](1 - PS_0 \sum_{j=m}^{n} \frac{1}{R[[j]]})$$

Risk Disclosures and the Credit Crisis

By Parr Schoolman

THE SEC INSTITUTED a requirement for public corporations to provide quantitative information about market risk exposures in January 1997. Since then, major banks have been providing Value-at-Risk (VaR) based risk disclosure in their financial statements in order to satisfy this requirement. Recently, the amount of information provided in these disclosures has increased, with more detail comparing actual daily returns to the daily VaR risk measures for the relevant portion of the company's trading portfolio. However, reconciliation to reported financial results is still lacking.

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With the recently published Federal Reserve Supervisory Capital Assessment Program (SCAP) stress test loss estimates, an additional risk disclosure is available for these major banks. Following is a summary of the VaR based risk disclosures provided by J.P. Morgan, Citigroup, and Goldman Sachs in their 2008 year-end annual reports, with a comparison of these disclosures to the Federal Reserve SCAP stress test reported loss estimates released in May of 2009.

2008 VAR DISCLOSURES

Exhibit 1 demonstrates that for all three firms, the reported VaR metrics are up substantially in 2008. In nominal terms the VaR's increased between 82 to 208 percent, and relative to total reported assets on the balance sheet, the increases were 115 to 131 percent.

Using more simplistic risk measures, the year-end 2008 reported asset leverage is down for both Citigroup and Goldman Sachs, and is unchanged for J.P. Morgan relative to year-end 2007. While there are many problems related to this simplistic leverage ratio due to accounting treatment of off-balance sheet structures and derivatives, it does provide a quick estimate for how problematic general asset deflation can be for mark-to-market capitalization levels for banks.

The daily VaR for these companies is also very small compared to the reported assets on the balance sheet. The daily VaR is between 1.5 to 1.6 basis points for J.P. Morgan and Citigroup, and 2.8 basis points for Goldman Sachs. As a comparison, the standard deviation of the 2008 S&P 500 daily returns was 2.6 percent, or 260 basis points.

The daily VaR is also low relative to the credit crisis related losses reported in 2008. According to Bloomberg, the credit crisis related write-downs for 2008 were $41, $102, and $8 billion for J.P. Morgan, Citigroup and Goldman Sachs respectively. If the daily VaR is compared to these write-downs, it would take 204 and 376 consecutive one-in-100 days to achieve the J.P. Morgan and Citigroup losses, respectively, and 44 consecutive one-in-20 days to achieve the Goldman Sachs write-down.

Exhibit 1: Risk Disclosure Comparisons

	JPMorgan			Citigroup			Goldman Sachs		
	2008	2007	Change	2008	2007	Change	2008	2007	Change
2008 Reported Net Income ($B)	5.6	15.4		-27.7	3.6		2.0	11.4	
Year End Equity ($B)	166.9	123.2	35.4%	142.0	113.0	25.7%	64.4	42.8	50.5%
Year End Total Reported Assets ($B)	2,175.1	1,562.1	39.2%	1,938.5	2,187.0	-11.4%	884.5	1,119.8	-21.0%
Reported Asset Leverage	13	13		14	19		14	26	
Reported VaR Metric	Daily 99%	Daily 99%		Daily 99%	Daily 99%		Daily 95%	Daily 95%	
Year End ($M)	317	103	207.8%	311	163	90.8%	244	134	82.1%
Average ($M)	202	106	90.6%	271	123	120.3%	180	138	30.4%
Year End VaR to Reported Assets	0.015%	0.007%	121.0%	0.016%	0.007%	115.3%	0.028%	0.012%	130.5%
Year End VaR to Reported Equity	0.190%	0.084%	127.2%	0.219%	0.144%	51.8%	0.379%	0.313%	21.0%

"… the reported VaR metrics are up substantially in 2008. In nominal terms, the VaRs increased between 82-208%"

Exhibit 2: VaR Comparison to Writedowns

	JP Morgan	Citigroup	Goldman Sachs
2008 Average Daily VaR ($B)	0.20	0.27	0.18
Credit Crisis Cumulative Writedown to date ($B) *	41.2	101.8	7.9
Cumulative Reported Writedowns to 2008 Average VaR	204	376	44

* Source: Bloomberg Cumulative Credit Crisis Writedown, as of 6/30/2009

Without disclosure regarding what portion of the overall portfolio the VaR metric is supposed to represent, along with reconciliation to the published financial results, the ability to assess these daily VaR disclosures across companies and compare them to other market based risk measures is limited.

OTHER RISK DISCLOSURES

In 2008 each company reported additional information regarding the daily performance of the trading portfolios upon which the VaR metrics are based. Citigroup only showed 2008 results, while J.P. Morgan and Goldman Sachs reported 2007 and 2008 results. The reported number of days with a trading loss was up for both J.P. Morgan and Goldman Sachs, with both reporting 97 trading day losses in 2008, compared to 46 and 52 in 2007 for J.P. Morgan and Goldman Sachs respectively. Citigroup reported 109 trading days with a loss in 2008, but did not report similar performance metrics for 2007.

Exhibit 3: Trading Portfolio Daily Results

	JPMorgan		Citigroup		Goldman
	2008	2007	2008	2007	2008
Number of days with gains	165	215	151	*	162
Number of days with losses	97	46	109	*	97
Total	262	261	260	*	259
Number of days > VaR	3	8	*	*	13

* Not Disclosed

This daily report provides a measure of the methodology reasonability, as a 99 percent VaR implies one should expect 2.6 days a year in excess the measure, while a 95 percent VaR should result in 13 days in excess of the threshold, just as the JP Morgan and Goldman Sachs disclosures show for 2008. Although the number of trading days with losses were up for both J.P. Morgan and Goldman Sachs, the number of days where there VaR threshold was exceeded was down.

In addition to these summary gain/loss statistics, each company reported information regarding the number of days with gains and losses of certain sizes.

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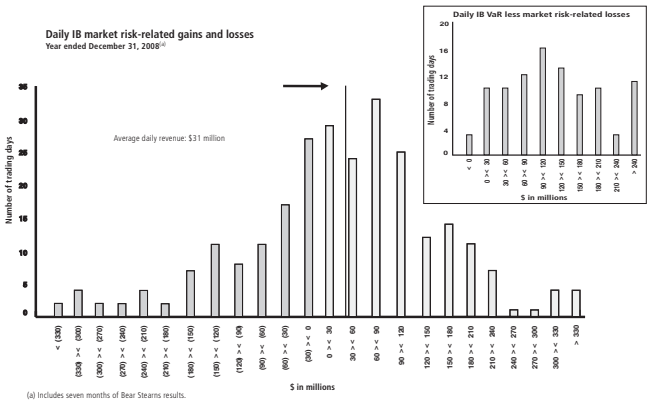
Risk Disclosures … | from Page 41

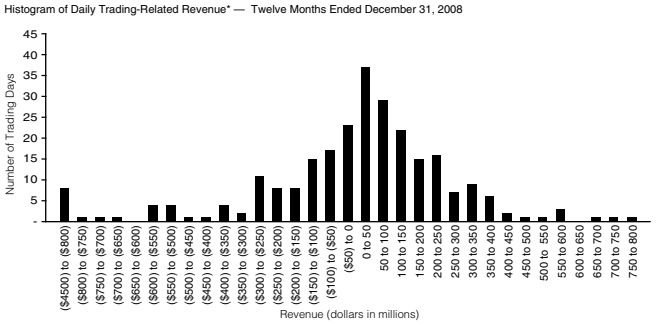
JP Morgan daily market risk gains and losses



(a) Includes seven months of Bear Stearns results.

J.P. Morgan's histogram shows the number of days that gains and losses fell within a specified range. Average daily revenue for 2008 was $31 million. The embedded second chart demonstrates the amount by which the 99 percent VaR exceeded the actual loss on days where a loss. This embedded chart demonstrates the daily loss exceeded the 99 percent VaR confidence level metric three times during 2008.

Citigroup daily trading related revenue



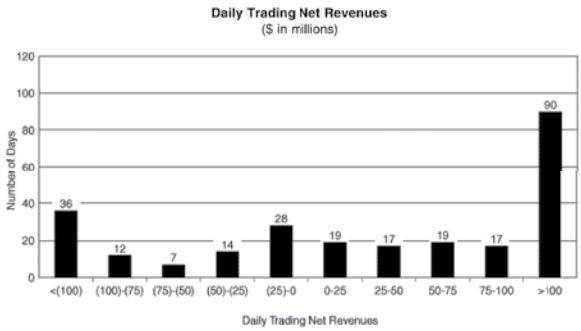
*Includes subprime-related losses on credit positions which were marked intermittently during each month. Most of the loss events in the $800-$4,500 million category are due to cumulative write-downs on these positions.

Citigroup's disclosure is similar in format, but demonstrates a wider spread of losses than J.P. Morgan's exhibit. The fact that the left most loss column of the distribution is a $4.5 billion to $800 million loss range highlights why many actuaries advocate Tail Value at Risk (TVaR) over VaR. TVaR is based upon the expected value of events beyond a loss threshold, rather than just the loss at the selected threshold that VaR uses. TVaR would better reflect the loss potential of this thick tailed distribution.

Goldman Sachs daily trading related revenue

Trading Net Revenues Distribution

The following chart sets forth the frequency distribution of our daily trading net revenues for substantially all inventory positions included in VaR for the year ended November 2008:



The Goldman Sachs version of this disclosure contained fewer buckets and less information regarding the tail of the distribution, providing information only around +/- $100M of revenue. However, even this limited information implies that the nature of the trading portfolio for Goldman Sachs is different than that of J.P. Morgan and Citigroup.

With these daily distribution disclosures, even more information is being provided to investors regarding the nature of the daily return distributions, but again, reconciliation to actual annual financial results would increase the usefulness of this disclosure.

"If the daily VaR is compared to these write-downs, it would take 204 and 376 consecutive 1-in-100 loss days to achieve the JP Morgan and Citigroup 2008 write-downs."

COMPARISON OF VaR DISCLOSURE TO SCAP LOSS ESTIMATES

On May 7, 2009, the Board of Governors of the Federal Reserve System released their summary report for The Supervisory Capital Assessment Program (SCAP). This program consisted of an assessment of the capital adequacy of the largest 19 U.S. bank holding companies based on a standardized stress test. The stress test was a two-year prospective loss estimate under a "baseline" and a "more adverse" macro economic scenario. The participating firms were required to estimate their potential losses on loans, securities, and trading positions, which were used with independent benchmarks by the supervisors to develop the bank supervisors' loss estimate. The total two-year loss estimate for these 19 firms under the "more adverse" scenario was $599 billion.

Exhibit 4: SCAP Stress Test Loss Estimate Comparison to VaR

	JP Morgan	Citigroup	Goldman Sachs
SCAP Loss Estimate ($B)	97.4	104.7	17.8
% of Year End 2008 Assets	4.5%	5.4%	2.0%
% of Year End 2008 Equity	58.4%	73.7%	27.6%
Total Loss Rate on Loans	10.0%	10.9%	0.9%
SCAP Trading + Securities Loss Estimate($B)	17.9	25.3	17.5
Year End 2008 VaR ($B)	0.317	0.311	0.244
Reported VaR Metric	Daily 99%	Daily 99%	Daily 95%
Annualized VaR Estimate ($B)	5.1	5.0	3.9
2 Year VaR Estimate ($B)	7.2	7.1	5.6
2 Year 99.9%VaR Estimate ($B)	9.6	9.4	10.5
SCAP Trading Loss to 2 Yr VaR Estimate	1.9	2.7	1.7
Required daily auto-correlation at VaR(99.9%)	55%	76%	48%

Exhibit 4 compares the published SCAP more adverse scenario loss estimates for these three firms to their corresponding daily VaR disclosure. J.P. Morgan's total SCAP loss estimate is $97.4 billion, while Citigroup and Goldman Sach's loss estimates are $104.7 billion and $17.8 billion respectively. These loss estimates are not directly comparable to most VaR disclosures, as the VaR calculation is typically limited to a firm's trading portfolio.

Luckily, the SCAP loss estimates provided detail that allows the segmentation of the losses into loan exposures vs. trading and securities activities. A more realistic comparison would be to use the portion of the SCAP loss estimate that was attributed to the trading and securities activities. The SCAP trading and securities loss estimates were $17.9, $25.3, and $17.5 billion for J.P. Morgan, Citigroup and Goldman Sachs respectively. From this measure, it is evident that JP Morgan and Citigroup have much larger mortgage and commercial loan exposure, while Goldman Sachs stress test loss estimate is dominated by this trading and securities portion of the stress test.

The corresponding reported year end 2008 daily VaR was $317, $311, and $244 million for the three firms. J.P. Morgan and Citigroup report a 99 percent VaR, while Goldman Sachs reports a 95 percent VaR. In order to be put on a similar time horizon as the two-year basis of the SCAP loss estimates, the daily VaR needs to be converted to a two-year measure.

If daily returns are assumed to be independent, then annual VaR can be estimated as the aggregation of daily VaR's. The relationship between daily VaR and an n day VaR can be described as [1]

$$\mathrm{VaR}_{99\%}(D_n) = \mathrm{VaR}_{99\%}(D)\sqrt{n} = 2.326\,\sigma\sqrt{n}$$

For a one-year horizon, assuming 260 trading days in a year, the daily VaR multiplier would be

$$\sqrt{260} = 16.1$$

For a two-year horizon, the daily VaR multiplier would be

$$\sqrt{520} = 22.8$$

The same adjustment can be applied to a 95 percent VaR, as used by Goldman Sachs, with 2.326 replaced by 1.645 in the formula above. An additional adjustment could be to extend the return period to a 99.9% threshold to be more consistent with what firms would use for a Basel II based capital measure.

$$\mathrm{VaR}_{99.9\%}(D) = 3.090\sigma$$

The corresponding estimated two-year $\mathrm{VaR}_{99.9\%}$ is then $9.6, $9.4, and $10.5 billion for J.P. Morgan, Citigroup and Goldman Sachs respectively. The SCAP trading loss

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estimate is still 1.9, 1.7, and 2.7 times this adjusted VaR measure.

We can relax the independence assumption between days and allow for a one-day lag auto-correlation, where the correlation of loss between one-day and the next subsequent day is ρ, the two-day lag correlation is ρ2, and the N day lag correlation is ρ^N. The 2 year return standard deviation then becomes

$$\sqrt{N + 2\sum_{i=1}^{N-1}(N-i)\,\rho^{i}}$$

The last row of Exhibit 4 shows the daily auto-correlation (ρ) required enough to reach the SCAP loss estimate is 55 percent, 76 percent, and 48 percent, respectively.

These simplistic conversions of daily VaR are far from ideal. Market volatility is not constant through time, and neither is the composition of the portfolios for these firms. Furthermore, while the normality assumption simplifies the math, it understates the likelihood of extreme daily changes. Finally, reported VaR's have not been stable, potentially limiting their usefulness as the reported information may be dated by the time the disclosure is published. Nevertheless, the SCAP loss estimates appear to be more conservative than these daily VaR metrics would imply.

CONCLUSION

Risk disclosures of the major banks are improving. Disclosure of the daily returns corresponding to the daily VaR reported metrics provides information regarding how often the VaR measurements have been exceeded, and the SCAP loss estimates provide an additional risk estimate data point. However, without transparency regarding what portion of the portfolio is included in the VaR calculation, or a reconciliation to the internal models used for Basel II regulatory capital requirements, investors and counterparties are still missing critical pieces necessary to use these disclosures to assess the adequacy of a bank's capitalization.

More useful risk disclosures would build upon the example from J.P. Morgan's 2008 annual report, which attempts to reconcile their economic risk capital to their total GAAP equity.

Exhibit 5 - JP Morgan Economic Risk Capital Disclosure

Economic risk capital	Yearly Average	
(in billions)	2008	2007
Credit risk	**$37.8**	30
Market risk	**10.5**	9.5
Operational risk	**6.3**	5.6
Private Equity risk	**5.3**	3.7
Economic risk capital	**59.9**	48.8
Goodwill	**46.1**	45.2
Other [(a)]	**23.1**	24.7
Total common stockholder's equity	**$129.1**	118.7

(a) Reflects additional capital required, in the Firm's view, to meet its regulatory and debt rating objectives.

p. 82 JP Morgan Chase & Co./ 2008 Annual Report

Reconciling the economic risk capital to GAAP equity is a good start towards creating a more useful set of risk disclosures. However, the $10.5 billion economic risk capital measure for market risk should be comparable to the reported VaR, and the lack of reconciliation between the two numbers limits their usefulness. Better reconciliation of VaR to profitability and capital measures is a worthy goal and something more financial firms should pursue in their effort to increase transparency for their investors. ✦

FOOTNOTES:

[1] Assume the daily return (D) is normally distributed with constant volatility, where D~N(0,σ).

For N(0,1)

$Z_{99\%} = \Phi^{-1}(99\%)$ in Excel, NORMINV(0.99,0,1)

For N(0,σ),

$VaR_{99\%}=Z_{99\%}*\sigma$

$VaR_{99\%}(D) = 2.326\sigma$

For a multiple day VaR measure of n days, where volatility is constant and daily returns are independent:

Standard Deviation $(D_n)= \sqrt{\sigma_1^2+\sigma_2^2+\sigma_3^2+\ldots+\sigma_n^2} = \sigma\sqrt{n}$

$VaR_{99\%}(D_n) = 2.326\,\sigma\sqrt{n}$

$VaR_{99.9\%}(D_n) = 3.09\,\sigma\sqrt{n}$

Can Bad Culture Kill a Firm?

By Stephen W. Hiemstra

UNFORTUNATELY, YES. Weak cultures leave firms exposed to risks that formerly had been assessed and mitigated. In my previous two articles on this subject (see *Risk Management* issues December 2008 and June 2009), I cited case studies showing how market and organizational changes have undermined risk management decisions and analyzed how cultural influences can impede learning and weaken risk management. In this article, I present prescriptions for meeting cultural challenges with large financial firms in view.

BUILD ESPRIT DE CORPS

Craft a vision for the firm carefully.

Building esprit de corps is a deliberate strategy needed to offset the organizational inertia caused by high and increasing decision costs. The rapid pace of change in the Internet age heightens the premium on adapting to change.

Managers and staff should know the firm's objectives and be able to anticipate their firm's response to changing circumstances. The ideal for risk management should be the basketball player that instinctively passes the ball when opportunity to score arises for any member of his team and can slip seamlessly into defense when possession passes to the other team.

LEARN THE RIGHT LESSONS FROM LOSSES

Learn from losses and move on.

Learning the right lessons is increasingly important. Conflict arises in post modern organizations as they confront the Internet age. The pace of market changes has increased as the Internet allows business to expand worldwide. Opportunities and threats come and go at a more rapid pace increasing the need for decisions and the opportunity for mistakes. The ability of the firm to adapt and learn quickly carries a higher premium in the current environment just as cultural trends show a proclivity to slow adjustment and raise decision costs.

The preference for democratic processes in the post modern firm raises decision costs (Buchanan and Tullock 1974, 96-116). Increased decision costs implies that fewer rational decisions will be attempted, but more inclusive decision processes also have the potential to render better decisions and greater compliance with decisions that are made. The downside is that decisions are recycled longer because they are more expensive.

The high cost of organizational decisions is magnified when decisions are executed badly or poorly anticipate states of the world.[1] Decisions associated with losses leave a larger cultural footprint than profitable decisions because upfront costs are tied to backend costs (losses), not offset by gains. It is accordingly important that the right lessons are learned.

So, what are the right lessons? If poor execution was the problem, the best solution is to improve execution. If poor forecasting was the problem, the best solution is to improve the forecasting. If the firm is recruiting and encouraging good people, personnel actions are likely not

CONTINUED ON **PAGE 46**

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FOOTNOTES:

[1] Casting aspersions on the rating companies and big four accounting firms, Bert Ely (2009, p. 97) wrote: *While the division of labor can justify much of today's reliance on expert opinion…Financial and legal analysis of complex financial transactions is hard work; it is mentally taxing; and it can take a lot of time, and therefore is expensive.*

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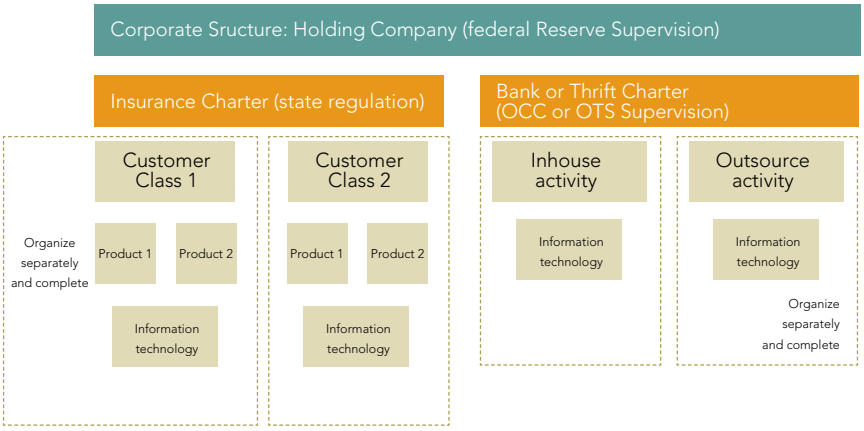
the best solution in meeting organizational challenges. This is because the current staff and managers carry forward the lessons learned in adapting to a changing environment.

CAVEAT DECISIONS UP FRONT

Define a risk appetite for each business activity and know when to revisit decisions.

Organizational inertia manifests itself in placing the burden of proof in recognizing problems on the risk manager. This presumes the wrong incentive. The two prominent strategies for overcoming organizational inertia work by moving the burden of proof in managing risk from the risk manager to the operational manager proposing a particular activity. These strategies are: develop explicit risk appetite guidance from directors/senior managers and employ risk management caveats.

Financial Conglomerate Structure



A target risk appetite is an explicit policy established to determine how much risk the firm is willing to tolerate. Having this policy determined outside of the decisions on particular programs to pursue means that risk managers need only measure the risk in particular proposals to get a hearing with senior management. No criticism of the merits of a particular proposal is required. The burden of proof in continuing to pursue the proposal then requires those presenting the proposal to hedge the risk implied in the proposal.

Risk management caveats work the same way, but in a different context. A risk management caveat is a plain English statement of when a particular decision needs to be revisited that is crafted when the decision is made.[2] In other words, decisions are handicapped at the time they are made to make sure that they are not taken out of context later on. In software, such caveats could be written into the computer code in comments. In models, they could be placed up front in the internal documentation. In decision documents or contracts, they could appear as template language required of every decision by the attorneys drafting these documents.

USE COMPETING DIVISIONS TO CREATE INFORMATION

Create decision information in mission critical business activities by risk-based pricing and allocating capital competitively among competing divisions.

A lack of market disciple has evolved with the growth of firm size and exacerbated the problem of cultural lethargy by reducing the information content of the market prices. Because markets compete with processes internal to the firm, the most effective way to offset the loss of market information is to encourage its creation within the firm (see chart).

One way to accomplish this is by creating internal markets in the firm along the General Motors model where divisions own particular products (or brands) or customers and compete among themselves for capital allocation (Williamson 1981). While this has been done by conglomerate firms since their inception, it is not clear that financial firms have explicitly employed this practice to improve the quality of internal allocation of resources and capital. This is an important benefit of encouraging deliberate redundancy within the firm.

FOOTNOTES:

[2] This is, in part, an application of a sunset clause to risk management. *In public policy, a sunset provision or sunset clause is a provision in a statute or regulation that terminates or repeals all or portions of the law after a specific date, unless further legislative action is taken to extend it* (http://en.wikipedia.org/wiki/Sunset_provision).

"Decisions associated with losses leave a larger cultural footprint..."

A second benefit of internal divisioning is to improve the resiliency of large firms to operational and systemic risk.[3] In competitive markets, the insolvency of individual firms is a natural consequence of poor management and markets are not seriously impaired by poor performance or failure of individual firms. Poor performance or failure of large, noncompetitive firms can be catastrophic. Building redundancies into large firms can be used to force internal managers to reveal their cost structures (risk-based pricing) and improve their allocation of resources (capital and staff allocation).

A third benefit of divisioning is that it facilitates the layering of regulatory oversight and regulatory specialization. Public policy and regulation define and maintain market boundaries. Regulators facilitate the dissemination of best-practices information across firms in a market and, if functioning properly, facilitate healthy competition by improving market price content.

Product lines subject to a switching problem are obvious candidates for creation of separate divisions. A switching problem exists when products differ in significant, but subtle ways that are hard to coordinate among the teams required to execute transitions from producing one product to another. To draw on the automotive illustration, a group responsible for design, marketing, and production of high-priced cars might, for example, be perfectly capable of switching over to manufacture economy cars over the course of several years. They may lose market position, however, if they cannot execute the switch in a single product cycle or cannot execute without a substantial increase in defects. Creating separate divisions (or outsourcing) could presumably both accelerate market response and reduce the incidence of defects.[4] In the financial arena, the same switching problem may manifest itself in moving from fixed to variable rate mortgages or from serving prime to serving subprime customers because of substantive differences in mortgage contracting risks.[5]

INVESTING IN LEARNING CREATES REAL HEDGES

Hedge risk by encouraging a deliberative decision culture.

Couched in risk management terms, the modern firm maximizes profits while the post modern firm maximizes profits conditional on hedging the implied risks. An important hedge for the post modern firm is to encourage a culture where senior management articulates objectives clearly, promotes risk management (rational decision making), takes steps to be involved with and support staff, and encourages mistakes to be openly and honestly discussed without retribution.

One way to describe the difference between the modern firm and a post modern firm is in terms of Pareto efficiency. Pareto efficient solutions require that a proposed change make at least one person in the firm better off while leaving no one worse off. If compensation can be offered, a Pareto efficient solution making at least one person better off and able to compensate those made worse off (Buchanan and Tullock 1974, 171-99). The modern firm seeks a Pareto efficient solution, but generally neglects to pay the compensation. The post modern firm generally strives to pay.

Hedging risks and paying compensation (in the Pareto sense) are related. The post modern manager works to channel the energy in peer leaders through encouraging esprit de corps, honest discussion, and positive incentives.

CONTINUED ON **PAGE 48**

FOOTNOTES:

[3] I owe this insight to a presentation by Nassim Nicholas Taleb at the World Bank. *Forum 2009: Markets and Crises—What Next and How?* February 24, 2009. Taleb spoke about the inherent resiliency of biological systems because of physical redundancies.

[4] This is hardly a new topic, but it remains a timely concern even for the automobile industry. See: (Salter, Webber, and Dyer 1985).

[5] Variable rate mortgage customers bear interest rate risks that fixed rate mortgage customers do not. Subprime mortgage customers are economically fragile while prime mortgage customers should not be.

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CHANNEL LEARNING TOWARD PROFITABLE INVESTMENTS

Pick projects that teach profitable lessons.

Projects taken on with an explicit (perhaps secondary) objective of learning a new line of business have been described as an expansion option (Mun 2002, 28). This morphing of the business is an important hedge against obsolescence risk—a key risk in maturing sectors—where the more typical response is to acquire new units through acquisition and diversification without reforming the culture of the firm. The ability to adapt and learn along new and more profitable lines of business over time accordingly becomes an organizational comparative advantage.

Speaking at a recent conference on systemic risk, Alan Greenspan (2009, p2), highlighted the need for firms to take prudent risks:

Effective financial systems are too often underappreciated as major contributors to economic growth and standards of living. Economic growth requires that obsolescent, i.e., low productivity, capital facilities be replaced with cutting edge, i.e., high productivity, technologies. The role of a financial system is to facilitate this process of "creative destruction" by directing a nation's scarce savings to fund capital facilities with the greatest risk-adjusted rates of return—almost always those that offer the highest rates of productivity growth.

Risk management is a key principle in organizational strategy. A modern firm engaged in risk minimization could respond to an increase in the volatility of the demand for its products or services, for example, by morphing into a traditional firm employing a venture capitalist approach. This change in strategy and culture could actually improve the profitability of the firm but would require a serious revamping of its business model and aggressive restructuring. One way to accomplish this result would be to start small: commission a small affiliate with seed money to fund multiple small projects and a mandate to experiment with the new business model. If the affiliate is successful, more resources can be allocated from the old to the new line of business increasing the profitability and diversification of the firm as a whole. ✦

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