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Risks & Rewards

SOCIETY OF ACTUARIES
INVESTMENT SECTION

An Introduction to Private Equity And Infrastructure Investing

By John W. Gray and David Rogers

Given the challenging investment return environment that we are living in, investors have turned to alternative assets in order to generate extra return, capture additional yield and diversify their portfolio. These assets include private equity and infrastructure. The risk and return profiles of these emerging asset classes matter to actuaries in various functions: asset-liability management, pension valuation, risk management and asset management. At the last Society of Actuaries Investment Symposium, held in Philadelphia on March 26-27, John Gray, a partner with Adams Street Partners, a private equity firm based in Chicago, and David Rogers, a founding partner with Caledon Capital Management, an advisory firm dedicated to the private equity and infrastructure market and located in Toronto, provided an overview of these asset classes. Following the positive reviews received from symposium attendees, they have agreed to write an article based on their presentation. The article will start with a review of private equity investing and will conclude with an overview of the infrastructure market.

PRIVATE EQUITY OVERVIEW

Although private equity investing has been around for more than 40 years, in its infancy it was considered a boutique asset class, comprising a relatively small percentage of the investable universe of available assets. Even today as awareness of private equity has increased, and it has become an accepted and commonly used investment by many institutional plans, private equity still only represents about 4 percent of the investable pool of global assets.

In the early days, the private equity universe was limited to venture capital (VC) funds—often located either on the West Coast (Silicon Valley) or the Northeast corridor of the United States (near Harvard University and MIT). As private equity gained greater exposure and acceptance, so have the

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To join the section, SOA members and non-members can locate a membership form on the Investment Section Web page at http://www.soa.org/professional-interests/investment/invest-detail.aspx.

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EDITOR'S NOTE:
On the cover of the March 2015 issue of *Risks & Rewards*, there was an error in the title of Figure 1. The correct title should read, "The Yearly Average of Elections and Mass Protests in Major Markets ..." *Risks & Rewards* regrets any confusion caused by the error.

Next Submission Deadline
Content due to Nino Boezio by Nov. 2, 2015.

CHAIRPERSON'S CORNER

Investment Section Matters

By Frank Grossman

As you may have noticed, *Risks & Rewards* is a newsletter. Indeed, years ago it used to say as much on its front cover: "The Newsletter of the Investment Section of the Society of Actuaries." Not a journal, a review, a periodical, or a magazine, but a collection of topical and newsworthy items—a *news*letter. And to this end, we've endeavored to deliver shorter articles by a wider range of authors, introducing some new authors too, in recent issues of *Risks & Rewards*.

Writers take some slight risk, however, when tackling fast-moving investment topics in the pages of a semi-annual publication. They strive to submit clean copy today to be read in roughly two-and-a-half months' time—like the proverbial message in a bottle. Writing "forward-starting articles" in derivatives-speak!

Three weeks ago, on the cusp of the Canadian Institute of Actuaries' annual meeting, a nice lady pierced my risk adverse world view by asking me, "Where's your sense of actuarial adventure?" as we finalized some session logistics. Given that it may take nearly 80 days (from pen to print to postman) for this newsletter to arrive in your locality, a spirit of adventure à la Jules Verne seems somehow fitting. So,"Passepartout, pack a travelling-bag!" And please accept this column as my Phileas Fogg missive to you, dear reader.

SECTION COUNCIL ELECTIONS

Many of you already know that section members may cast their ballots during the August 17 through September 4 voting period. Note that the small number of members who did not pay their $25 annual dues for the 2014-15 membership year were (regretfully) struck off of our section's membership roll at the end of June. However, if you did in fact pay your dues but did not receive an e-ballot, please contact Leslie Smith at the SOA head office to set things straight.

Vice chair George Eknaian, secretary/treasurer Tom Egan and I are pleased to announce that six section members have tossed their hats into the ring for the upcoming council elections: Ming Chiu, Kelly Featherstone, Joonghu Huh, Jim Kosinski, Fred Ngan, and Emmanuel Vézina. Three positions on council will open up as the senior class rolls off at the 2015 annual meeting in Austin, Texas, therefore three of the candidates will be elected. Please take a few minutes to read their on-line candidate profiles so that you may exercise your democratic franchise more effectively by making an informed choice.

2015 REDINGTON PRIZE

Work on the 2015 Redington Prize is underway, led by organizing committee chair Nino Boezio and vice chair Jeff Passmore. Earlier this year, your section council concluded that it was time to renew the Redington Prize by increasing the award to $10,000—effectively taking a "go big, or go home" stance. We're looking forward to announcing the winning paper at our section breakfast on October 14 during the upcoming annual meeting. And for those who can't join us in Austin, we're planning a Redington Prize webcast on Nov. 17, 2015.

The prize was named for Frank M. Redington, author of the landmark 1952 paper "Review of the Principles of Life Office Valuation." Yet naming a best investment paper prize for a valuation paper may seem slightly incongruous. During the presentation of his paper to the U.K.'s Institute of Actuaries, Redington conceded that his paper dealt primarily with valuation and that "matching" (or immunization) was a by-product.

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Redington subsequently wrote an article, "The Origin of Immunization," for the January 1982 issue of *The Actuary* (i.e., the chatty black and white newsletter and ancestor of today's full-color SOA magazine). It describes the fateful "Saturday morning lie in" epiphany that prompted him to hastily re-write the first portion of his paper—and thereby launch immunization theory. His article concludes as follows:

> Our "valuations" are conditional statements made on the particular hypothesis contained in the valuation basis. They are photographs taken from one particular spot. The basic lesson which immunization theory taught me was that for a valuation to have even that limited validity the photograph of the assets and liabilities must be taken from the same place.

Actuaries who have struggled with the implementation of fair valuation and other market consistent approaches will doubtless appreciate Redington's photograph metaphor. I know I do.

MERCI BEAUCOUP

Next up are a few words of appreciation. First, a brace of sincere thank you's to our newsletter editors Nino Boezio and Joe Koltisko for their steadfast and long service to the Investment Section. Both gentlemen's involvement with *Risks & Rewards* extends back more than 20 years—the masthead of the June 1994 issue lists them as Associate Editors. And their current tandem approach, with Nino stick-handling the winter issue and Joe fielding the summer number, was adopted some 10 years ago. Truly theirs must be a "labor of love" or else why would they continue to do what they have done so well for so long?

Second, thank you to my senior class colleagues on council. Thanks to Tom Egan for his buoyant optimism and spirit of enterprise. I've lost count of the number of times that Tom said, "How about we try …" at the end of a telephone line, providing just the antidote to the issue of the day. It must be the North Carolina sunshine in his voice. Thank you, as well, to Martin Bélanger who has been one of the few constants amid the shifting sands of our investment symposium over the past few years. Martin is blessed with an enviable clarity of thought and purpose that, combined with his industry, has rendered his many contributions simply indispensable. *Merci beaucoup a tous.*

THE ROAD AHEAD TOGETHER

It's a fact of history that I wrote my first piece for *Risks & Rewards* back in 1999 during Richard Wendt's tenure as newsletter editor-in-chief. And three short years ago, Tom Anichini asked whether I'd care to run for council. That's roughly a 15 year arc from writing a rather fluffy newsletter article to serving as your section council chair.

It wasn't really possible at the outset to foresee where my Investment Section volunteerism might lead, and how much I would learn along the way. I'm still glad that I contacted Richard to ask what had happened to the 1998 edition of the investment triathlon—which had been an interesting diversion in each of the preceding four years. And he was dead right to tell me that if the triathlon was going to happen again that it was up to me to do it.

I wonder if you, too, might consider—in the best sense of actuarial adventure—beginning your own volunteerism journey by taking the essential first step? For example, by writing a short item for the next issue of *Risks & Rewards?* And if writing's not really your thing then let's find some other way to get you on the road. At present, we definitely have many more section opportunities than volunteers. Join us—the actuaries mentioned in this newsletter and others too—so that we may work together to ensure that the Investment Section matters. ■

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number of private equity vehicles, strategies, consultants and investor groups.

In today's environment, investors can access private equity through VC funds or a leveraged buyout (LBO) fund, or a hybrid of the VC/LBO—such as a co-investment vehicle or secondary vehicle. Each of these types of funds has a unique combination of private equity assets and each generates unique risk return characteristic.

The following graphic illustrates the evolution of private equity as an assets class:

	Origin of PE *1950-1970*	Rapid Expansion *1970-2000*	Global *2000-Today*
Description:	• Began with Venture Capital space being invested in by high net worth individuals • The growth of Silicon Valley drove high returns and investor interest	• Driven largely by changing regulation, institutional investors flooded the private equity space • Leveraged buyouts rapidly grew in popularity culminating with the buyout of RJR Nabisco	• Rapid asset growth has continued, but become more specialized… • …moving toward niche strategies and new markets (Europe, Asia, Latin America)
PE Strategies:	• Venture Capital	• Venture Capital • Buyout • Fund of Funds • Distressed investing	• Buyout • Fund of funds • Secondaries • Co-investments • Private Debt/Mezzanine Lending
Key Investors:	• Wealthy families and individuals	• Pensions • Endowments/Foundations • Family Offices/High-net worth	• Pensions • Endowments/Foundations • Family Offices/High-net worth • Sovereign wealth funds
Representative Investments:	FAIRCHILD SEMICONDUCTOR	Genentech	facebook Hilton twitter

As an asset class, private equity does not scale as easily as other mainstream asset classes such as publicly traded equity or fixed income markets. In fact, one characteristic we have strong convictions about, based on our observations of many private equity cycles is that **size is the enemy of return in private equity.** In the chart on page 6, we track the amount of assets raised annually in various private equity vehicles (as represented by the vertical bars). The dots represent vintage year returns (a combination of all fund returns that come to market in a specific year). As one can clearly see, in the years leading to the peak of assets raised there is a corresponding decline in returns for the aggregate market of private equity assets.

So what makes private equity interesting and would lead an investor to include it as part of a diversified portfolio? The simple answer is the potential for higher risk-adjusted returns which are not perfectly correlated with other asset classes. The additional alpha (the return in excess of the compensation for the risk borne), is achieved because of market inefficiency and negotiated transactions.

There are a number of attributes of the private equity model that foster an environment of strong long term investment performance. First, the long holding periods allow the General Partners (GPs) to focus on fundamentally building the business to maximize results in the long-term—since they are not concerned about meeting quarterly earnings estimates. On the other hand, if you invest in an LBO fund that will buy eight to 12 companies over the next four years, your investment is subject to each one of those companies maturing and/or restructuring over several more years. In most cases, you will experience a long holding period for some portion of your original investment that may be in excess of 12 to 15 years.

Nonetheless, to draw the conclusion from this long-winded answer that private equity is an illiquid asset that can be subject to high volatility is short-sighted. There have been many studies by leading academics that prove that higher private equity returns more than compensate an investor for the illiquidity that comes with the asset class. In fact, based on industry data and academic studies, private equity has consistently outperformed the public markets, making it a very attractive asset class for investors with long-term investment objectives such as funding and meeting pension plan obligations. In addition, an investor that builds a private equity portfolio with multiple high quality and proven managers, diverse private equity sub-classes, and numerous vintage years can protect against poor outcomes and potentially capture outsized returns.

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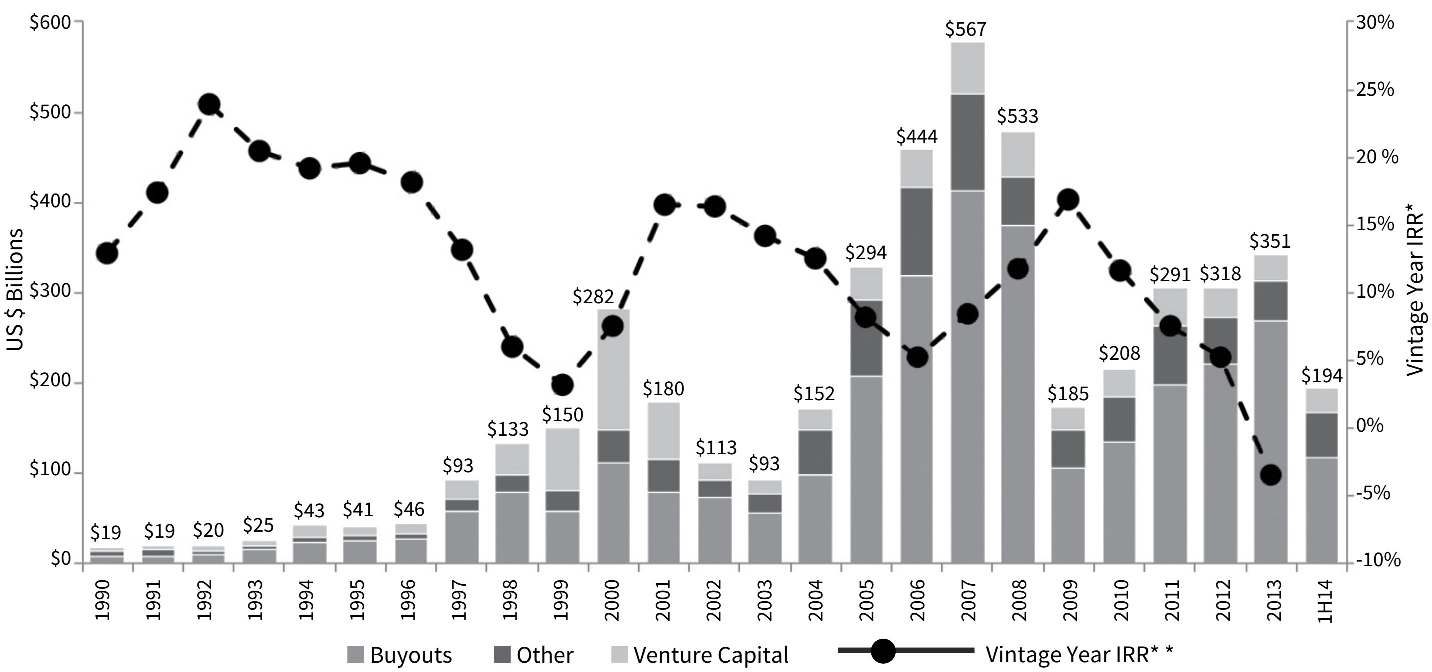
Private Equity Capital Raised Globally



* Includes: US, Asia, Europe and Latin America data as of June 30, 2014. *Sources:* Private Equity Analyst, Thomson Reuters Private Equity Fund Performance Survey; net of general partner fees, carried interest, and expenses. Asian Venture Capital Journal.

** *Source:* Thomson Reuters Private Equity Fund Performance Survey (as of 05/14/15 using 12/31/14 data).

With regard to portfolio construction, we used our company's risk model to estimate the impact of private equity[1, 2] exposure[3] on a standard equity[4]/bond[5] portfolio's Sharpe Ratio (The Sharpe ratio is the average return earned in excess of the risk-free rate per unit of volatility or total risk. The higher the Sharpe Ratio, the better the fund's historical risk-adjusted performance).

Our research indicated that if an institution is not subject to illiquidity risk, additional private equity assets[6] added to the portfolio will increase the overall return as well as increase the Sharpe Ratio.[7] After approximately 40 percent of the stock/bond portfolio was invested in private equity, the overall volatility reversed and began to increase with any additional private equity added to the portfolio.

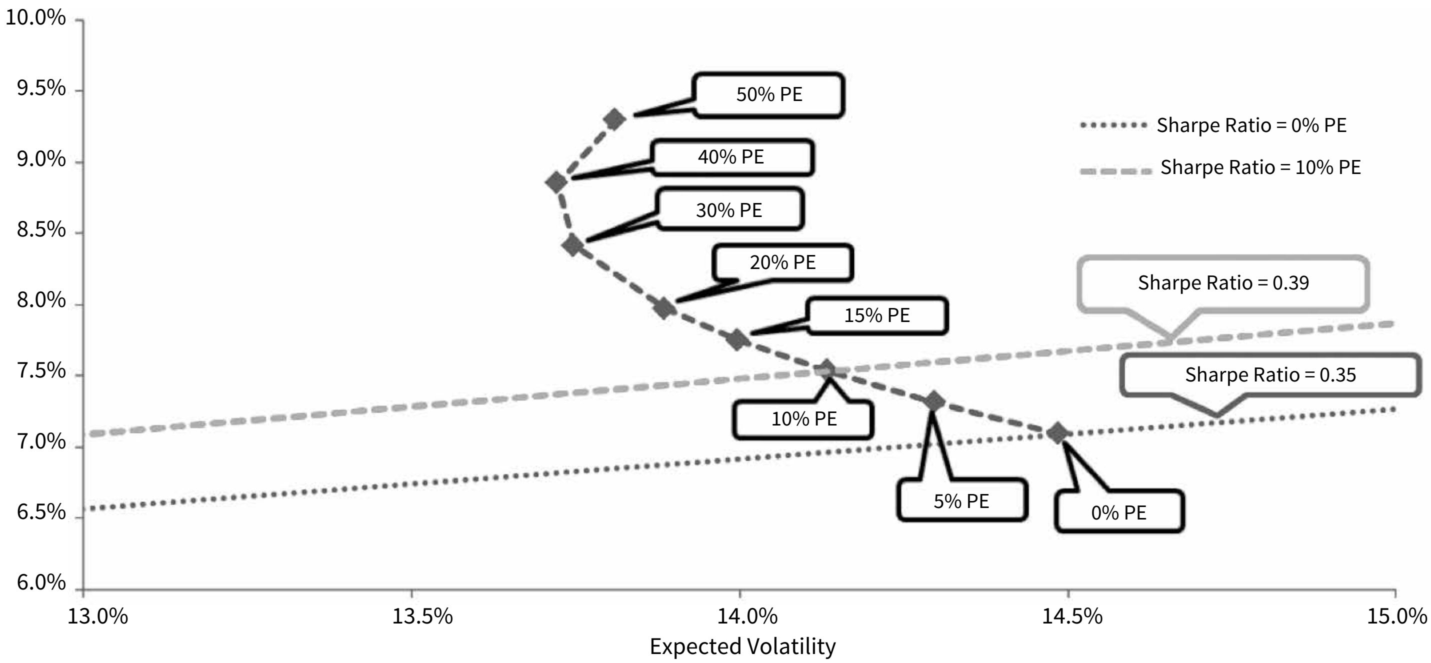
Up until now we have focused on "private equity" as an asset class without explaining the different types of fund investments or strategies that are available to private equity investors. An institution can be a private equity investor a number of different ways, such as:

- **buying a private company** and managing it internally (sometimes referred to as a "portfolio company");
- **investing in a fund** that will buy and manage companies; or
- **hiring a fund-of-funds manager** that pools your capital with others and has more buying power and diversification, and hopefully more private equity knowledge.

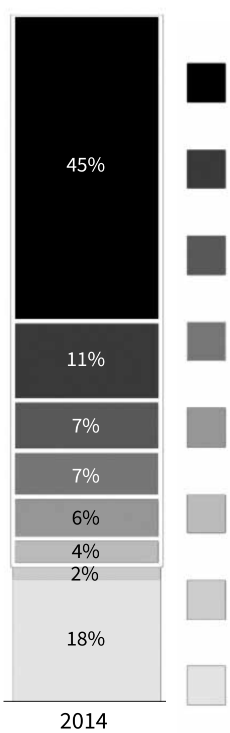
Some of the most common private equity subclasses are outlined below.

By investing directly into a VC Fund or LBO Fund, one is making a legal commitment through the life of the vehicle (12 to 15 years). Although secondary buyers have created a way of transferring this legal obligation, one should assume that once you commit you will have a "long only" position in the asset class through this obligation—all the way to the maturity of the investment, when portfolio funds and companies have been liquidated and the distribution of their proceeds has been returned to its investors or Limited Partners (LPs).

The long life of a fund is troublesome for portfolio construction and tactical asset allocation. If an investor evaluates their portfolio's asset allocation and determines that the expected return for private equity may be lower relative to historical returns, there is a cost to sell a long-only position in the marketplace. To turn the example around, a shift in market trends and relationships may give rise to an opportunity for private equity managers, Sharpe Ratio Improvement from Private Equity



2014 PE Capital Raised by Strategy



Strategy	% of Capital Raised	Description
Buyout	45%	• Invests in established companies, often with the intention of improving operations and/or financials
Venture	11%	• Provides capital to new or growing businesses with perceived, long-term growth potential
Growth	7%	• Targets profitable, but still maturing, investee companies with significant scope for growth
Distressed PE	7%	• Buys corporate bonds of companies that have either filed for bankruptcy or appear likely to do so in the near future
Secondaries	6%	• Acquires stakes in private equity funds from existing limited partners
Fund of Funds	4%	• Invests in a diversified mix of private equity partnerships
Mezzanine	2%	• Debts used to finance acquisitions and buyouts
Other	18%	• Includes infrastructure, natural resources, and other private asset classes

Source: Preqin

which you can access through private equity funds. However, the factors that gave rise to the opportunity can change quickly; after 24 months of good returns you may have to live with that fund for another 10 years or more. Therefore, it is very difficult to "time" investments in private equity. In fact, we believe strongly that private equity investors should maintain a steady, balanced approach to investing in the asset class.

Secondary funds have a place in a private equity portfolio, and they can invest tactically based on economic market conditions. A secondary fund will buy a private equity fund from another investor (or Limited Partner) that needs liquidity. The fund will hold or own interests in companies that the GP purchased during its invest-

CONTINUED ON PAGE 8

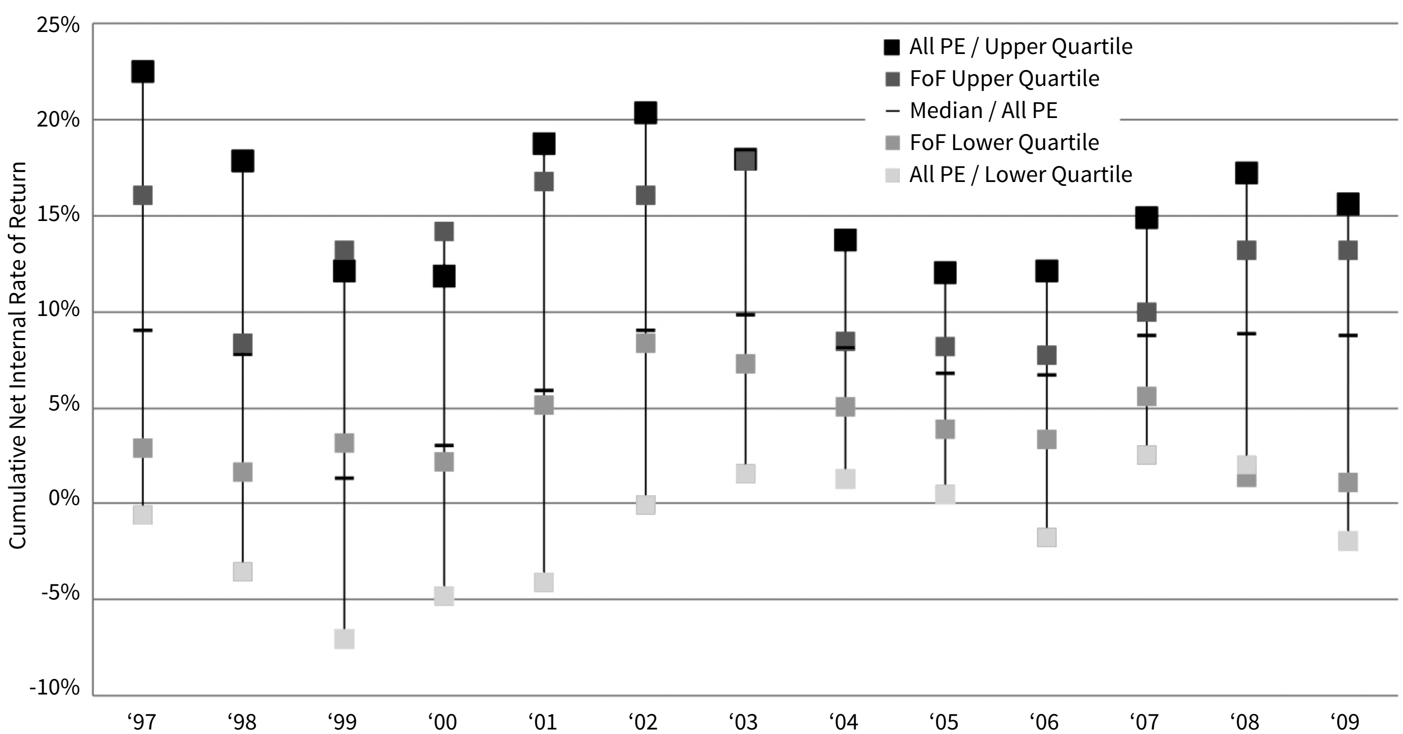
ment period (typically three to five years). Since the secondary manager has the ability to price the underlying companies based on their analysis, and negotiate with the seller, they have the ability to take advantage and set pricing based on economic conditions and current growth prospects for the companies. During the financial crisis of 2008, there were numerous opportunities for secondary managers to create liquidity for distressed sellers at a deep discount to the market value of their portfolio. It may have come with risk, but it was an example of how the secondary funds were tactical in private equity investing.

What are the options available to an institution for building a private equity portfolio? One could invest in private equity by purchasing companies, growing revenues, making them more efficient on the cost side and then selling them at a price higher than the purchase price. The large Canadian public pension plans (Ontario Teachers, CPP, OMERS, etc.) have been investing in companies for years and have been very successful. However, the organizations that have done this successfully are large programs, with experienced and well-paid professionals conducting the activity and have enough resources to diversify away the risk with multiple companies. This strategy is difficult to replicate without substantial resources in assets and expensive investment professionals. Therefore, there are really three primary ways of beginning a private equity program:

1. hire a staff of private equity experts and pick funds;
2. hire a non-discretionary manager to choose funds on your behalf and piggyback off of their research; or
3. hire a fund-of-funds advisor to pool your capital with others and build a diverse portfolio of funds, secondaries and co-investments.

From a cost perspective, the most cost effective option depends on the size of the private equity allocation. As an example, if you determine you would like to invest $20 million dollars every other year into the asset class and you want to pick funds yourself, you may have difficulty achieving the proper amount of diversification. You may also have an issue with regard to accessing the best—the highest quality and potentially top-performing funds, as these are more likely than not going to be oversubscribed—leaving you with only second or third tier managers as investment options. Access to the top tier funds remains an issue no matter what route one chooses. The graph that follows is quite busy, but it displays the range of returns of vintage year funds for different managers. The chart shows the top tier (i.e., quartile) fund versus the bottom tier fund, as well as top tier for fund-of-fund providers versus the bottom tier. The critical point that this graph makes is the differential in the range of returns. In some years,

Fund-of-Funds Manager Selection is also Important



there is nearly a 25 percent gap between upper tier and bottom tier performers, highlighting the need for quality fund selection. Consistent quality fund selection and access to the top oversubscribed funds are most critical in building a successful private equity program.

No matter what route you choose to build a private equity portfolio, the key components to consider in a manager are: direct access into top tier funds, a well-written trade allocation policy that distributes the funds fairly, and one that is multidisciplinary to help diversify away the risks associated with private equity volatility.

Finally, although private equity investments are long-term binding commitments, portfolio monitoring can still also add value. Monitoring involves playing an active role after investments have been made, with the objective of reducing risk, improving/creating liquidity, properly gauging valuations, evaluating reporting performance and ensuring conformance with various terms and covenants. Examples of portfolio monitoring activities include analyzing quarterly reports, attending annual meetings and making visits to the underlying portfolio companies as required. In addition, private equity investors are often invited to sit on advisory boards.

INFRASTRUCTURE—A GROWING ASSET CLASS

Infrastructure as an asset class is growing increasingly attractive as institutional investors seek investments that are more resilient to economic cycles, have lower correlations with traditional asset classes, provide predictable current yield, offer less volatility and provide some inflation protection. There's no question that infrastructure investing is becoming more popular in institutional portfolios.

The deterioration of aging infrastructure in developed markets coupled with a surge of new projects in developing and emerging markets is expected to generate a steady four percent annual growth rate for infrastructure investment into the second half of this decade, pushing total investment requirements to $4 trillion dollars, according to Bain & Company.

Pension fund investors and other institutional investors continue to look to infrastructure as a growing part of their asset allocation mix as it can assist them in hedging some of their long term liabilities, while providing ongoing yield.

WHAT IS INFRASTRUCTURE?

From an investment perspective, infrastructure can be defined as asset-based businesses providing essential services that offer predictable returns. Infrastructure assets are often divided between economic and social infrastructure assets.

Economic infrastructure encompasses assets that support and sustain the economic activities of a region. These assets, such as roads, bridges, airports, ports, electric, gas and water utilities, pipelines, and power generation stations, can be developed and owned by either government or private sector enterprises. Private financing for economic infrastructure, particularly new projects has been one way of financing infrastructure in OECD countries and is now becoming more common in emerging economies.

Social infrastructure broadly refers to facilities that provide services to a community, such as hospitals, courthouses and schools. Historically, social infrastructure has been financed exclusively by governments. Several developed countries, however, have a relatively long track-record of allowing private financing for social infrastructure, generically referred to as public-private partnerships (PPP). We will discuss PPPs later in this article.

To drill down deeper within economic and social infrastructure, a further categorization exists based on the stage of development of an infrastructure project. Greenfield assets are those that are in the development or construction phase, while brownfield assets are fully developed, operating and generating revenue. While brownfield assets tend to provide returns immediately after acquisition via cash yield, greenfield assets require a longer time frame to be developed and constructed. Investment in greenfield assets assumes construction and ramp-up risk and thus should provide for higher returns.

BENEFITS OF INFRASTRUCTURE INVESTING

Diversification Benefit – Infrastructure has historically had a low correlation to other asset classes, which consequently provides good diversification for an institutional portfolio containing equities and bonds. Given the monopolistic characteristics of many infrastructure assets and the relatively low elasticity of demand for the services provided, infrastructure assets tend to weather the downward storms that are inevitably reflected in the public markets. In this respect, infrastructure can provide a defensive component to an investment portfolio and is an effective way to help diversify market risk.

Liability Matching – Infrastructure as an asset class can be instrumental in providing long-term return profiles that resemble the long-term liabilities of many institutions. Some public pension funds will even place their infrastructure investments in the liability hedging bucket. Infrastructure contracts and industry regulations, often include provisions that tie service price increases to the rate of inflation or allow the operator to pass along higher costs, helping to maintain profit margins as inflation changes. This is particularly of benefit to pension funds and insurance companies with inflation-linked liabilities.

Low volatility – Infrastructure investments should provide relatively stable cash flow profiles that are emphasized over cap-

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ital gains in the overall return equation. This return profile, therefore, provides attractive risk-adjusted returns with relatively low volatility compared to public markets.

Yield – With the continuing low interest environment, institutional investors are hungry for yield enhancing investments. With the right partner and asset, infrastructure is able to provide stable and attractive yields with limited risk in low interest rate environments.

Duration – Infrastructure assets tend to be long lived. When matched with appropriate commercial and/or regulatory environments, infrastructure investments can provide the preceding characteristics over a relatively long time horizon.

RISK/RETURN PROFILE OF INFRASTRUCTURE INVESTMENTS

Now that we understand what infrastructure is and why institutions have chosen to invest in it, we can begin to deconstruct the asset class and start assessing the different categories that exist within it. As you can see in the chart attached, we have broken out certain assets into categories that reflect their typical risk-return profile.

i) Social Infrastructure: As mentioned above, social infrastructure refers to facilities and structures that are built to support communities. While social infrastructure projects in the U.S. have generally been built by governments, in Canada, Australia and the U.K., governments have been active in using the PPP model for new projects. In this model the role of government is essentially transformed from that of a project developer who retains and manages the risks of the construction, delivery, and operation and maintenance of a facility, to that of the long-term purchaser of the services provided by the project sponsors who are contracted to build and maintain the facility. Under this model, the government agency provides an availability-based payment in return for the facility being made available for public use on time and on budget. In order to maintain integrity in the bidding process for these projects, it must be conducted in a fair and open manner, where strong governance is set initially and the process is run transparently, thus reducing the risk of third party improprieties. While the benefits of this model to government are arguably extensive, they are beyond the scope of this article.

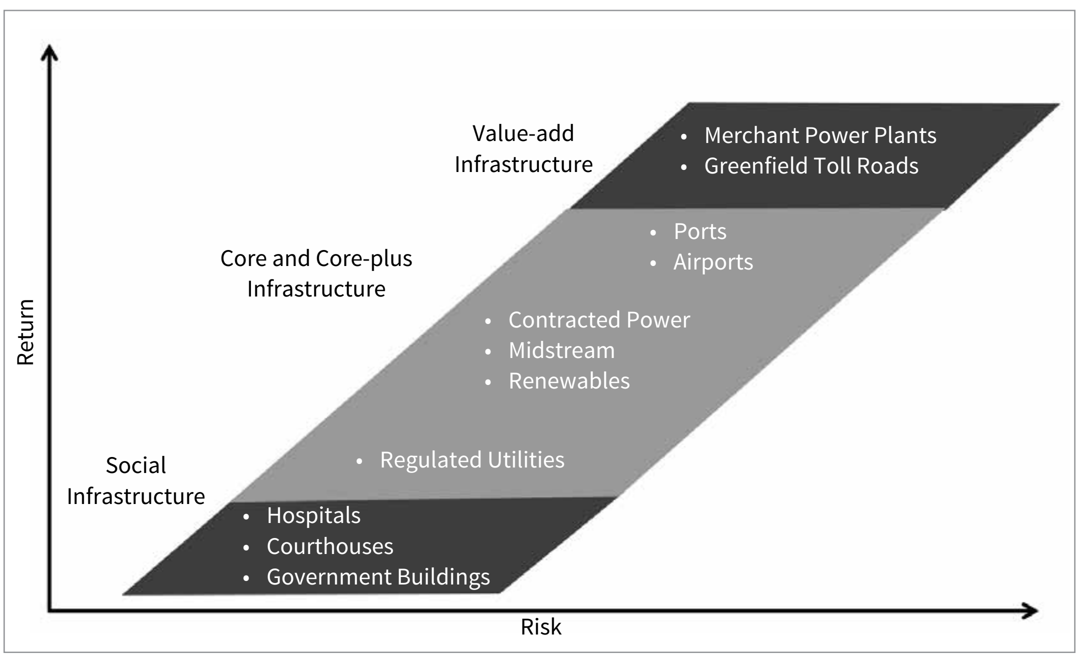
ii) Core and Core-Plus: Core infrastructure assets are relatively stable in nature and often have high sustainable barriers to entry. It allows for a long-term hold period which provides pension fund investors the flexibility of using the cash flows from the asset to offset their long duration liabilities. Core infrastructure assets are considered low risk and generally provide most of their return through a healthy yield. Core-Plus infrastructure assets may also be regulated, however, they are much more susceptible to demand risks. Assets that fall under this category include airports, ports and railways. One key attribute for both core and core plus infrastructure assets is the ability to generate inflation linked cash flows which may prove instrumental in hedging inflation linked liabilities.

iii) Value-add: These types of assets reside higher on the risk curve and can be greenfield or are operating in unregulated industries/markets. These higher risks though are justified by the higher return targets these assets seek to generate through both yield and capital appreciation.

ACCESSING INFRASTRUCTURE

How does one obtain exposure to infrastructure? An institutional investor can utilize various structures to gain exposure to this asset class. The most feasible approach depends on the investor's strategy, liquidity requirements, budget, size and experience of the in-house investment team.

Unlisted Infrastructure Funds: This approach is very similar to a private equity funds model. A high-caliber fund manager provides access to quality infrastructure assets and enhanced risk-adjusted returns. However, with annual management fees and performance fees, this ap-



proach is typically the highest cost method to access the space. This approach does not require a large in-house team of infrastructure investment professionals and relies on the investor identifying top quartile fund managers, which can often be a difficult task. One drawback of this structure for closed-end funds is the tradeoff between short- and long-term commitment as many unlisted funds start divesting after holding an asset for a relatively short time. A possibility exists to invest in open-end unlisted funds which theoretically put an investor's money to work immediately and have the flexibility to hold assets indefinitely. However, competition for access to open-end funds has grown recently with investors waiting in long queues before their money is put to work. Liquidity may also become a concern as it is limited to specific time periods and may not be offered if an investor is seeking a quick exit.

Direct Infrastructure Investments: Another method of access is unlisted direct infrastructure investments. This consists of direct investments in the equity or debt of infrastructure assets, and it requires a strong degree of expertise in infrastructure investing and a higher risk appetite. Compared to the fund method it is a lower cost alternative and can be done through either leading or co-investing with partners in a particular asset. This approach can also be implemented by entering into a separately managed account with an experienced asset manager.

Listed Infrastructure: This approach is ideal for investors with significant liquidity requirements. The investor simply buys shares or an index of listed infrastructure companies on an exchange. While this is the lowest cost approach, these investments are subject to public market volatility and have the highest correlation to equity markets.

CONCLUSION

As institutional investors search for further portfolio diversification, improved yield and inflation hedges, infrastructure should continue to grow as an asset class. The strong growth profile it provides combined with an increasing number of investment opportunities and strong return characteristics, will make it an attractive asset class for many years to come. ■

John W. Gray, CFA, is a Partner and member of the Adams Street's Client Service Team. He works closely with clients and their consultants in the management and development of their private equity portfolios. Additionally, he is actively involved in the portfolio construction, monitoring and reporting of the various ASP programs and separate accounts. John is a sports enthusiast and coach to local community and his three grown children. He can be reached at *jgray@aspllc.com*

David Rogers, CPA, CA, CBV, is the founding partner of Caledon Capital Management, an independent customized portfolio management and investment solutions provider. He was one of the founding members of the Institutional Limited Partners Association ("ILPA") where he helped establish best practices for limited partners investing in alterative asset classes. When David is not working, he enjoys spending time with his family in the great white north. He can be reached at *drogers@caledoncapital.com.*

ENDNOTES

1 Defined as a globally diversified set of private equity investments—companies (or funds that invest in companies) that are not listed on a publicly-traded exchange.

2 Based on total return for the trailing 10 year period ended 9/30/2014

3 Based on Adams Street Partners' factor-based risk model. Additional details on the methodology are available upon request.

4 Represented by the MSCI World Total Return Index

5 Represented by the Barclays US Aggregate Bond Index

6 Source: Burgiss. The Burgiss data presented here includes a global set of funds which are invested on a primary basis in buyout and excludes secondary investments. Numbers are subject to updates by Burgiss. Burgiss is a recognized source of private equity data, and the Burgiss Manager Universe includes funds representing the full range of private capital strategies; it may not include all private equity funds and may include some funds which have investment focuses that Adams Street Partners does not invest in. Data and caluclations by Burgiss, sourced on February 5, 2015.

7 Calculated as (Expected Return — Risk Free Rate)/(Expected Volatility). Risk Free Rate is assumed to be 2%.

On The Importance Of Hedging Dynamic Lapses In Variable Annuities

By Maciej Augustyniak and Mathieu Boudreault

Variable annuities (U.S.) and segregated funds (Canada) are life insurance contracts offering benefits that are tied to the returns of a reference portfolio. These policies include various forms of capital and income protection in the event of market downturns such as a guaranteed minimum death benefit (GMDB) or a guaranteed minimum withdrawal benefit (GMWB).

An important feature of variable annuities is the possibility for the policyholder to lapse or surrender the contract. In the latter case, the policyholder gives up the underlying insurance protection, ceases to pay fees to the insurer and receives a surrender value. Lapse assumptions are critical inputs in pricing and hedging models of variable annuity guarantees and can be divided into two types: deterministic (or static) and dynamic lapses (see Eling and Kochanski, 2013, for more details). Deterministic lapses are due to unforeseen events in the policyholder's life (for example, loss of employment creating liquidity needs) and are generally seen as diversifiable. On the other hand, dynamic lapses result from an investment decision on the part of the policyholder. For instance, when the guarantee is deep out-of-the-money, the policyholder has a strong incentive to lapse the contract and choose an alternative investment product. This is simply because the insured is paying high fees (fees are generally deducted in proportion to the sub-account's value) for a guarantee that is very unlikely to be triggered in the future. Therefore, dynamic lapses are generally driven by the moneyness of the guarantee and since the evolution of markets affects most VA contracts in a similar fashion, these lapses are clearly very difficult to diversify.

There is growing evidence that dynamic lapsation is important to take into account in variable annuities. For example, Milliman (2011) and Knoller et al. (2015), found a strong statistical relationship between lapse rates and the moneyness of the guarantee in empirical data. Moreover, the Canadian Institute of Actuaries (2002) and the American Academy of Actuaries (AAA) (2005) both recommended to take dynamic lapsation into account by varying the lapse rate with the moneyness of the guarantee. According to a survey from the Society of Actuaries performed in 2011, approximately 60 percent and 80 percent of participating insurers followed this practice when modeling death and living benefits, respectively.

The objective of this article is to investigate the importance of hedging dynamic lapses in variable annuities. More precisely, we aim to answer one very practical question, that is, what is the impact on hedging effectiveness when an insurance company chooses not to hedge dynamic lapses, or alternatively, to hedge them but with the wrong assumptions.

GMMB CONTRACT

Suppose that an insured invests in a guaranteed minimum maturity benefit (GMMB) product with a set maturity T. The sub-account value is credited with the returns of an underlying reference portfolio and fees are continuously deducted from the sub-account as a percentage of the account balance. Denoting the value of the reference portfolio at time t by S_t, the sub-account value at time t is given by

$$A_t = S_t\, e^{-at}$$

where a is the aforementioned annual fee rate, and $A_0=S_0$ is the initial investment.

If the policyholder does not surrender his contract before maturity, he is entitled to $\max(A_T,G)$ at time T where G denotes the amount of the guarantee (for a return-of-premium guarantee, we have $G=A_0$). If $A_T < G$, the guarantee matures in-the-money and the insurer is responsible for the shortfall, i.e., its liability is the payoff of a put option: $\max(G - A_T, 0)$.

If the policyholder surrenders his contract at any time prior to the maturity of the policy, he receives the balance of the sub-account value minus a surrender charge which we suppose is expressed as a fraction κ κ of A_t. Therefore, the surrender value at time t corresponds to $A_t(1-\kappa)$.

DECOMPOSITION OF THE PAYOFF TO THE POLICYHOLDER

We integrate dynamic lapsation into the GMMB contract by assuming that the policyholder will surrender his contract at the first moment (before maturity) the sub-account value net of surrender charges hits a predetermined barrier known as the moneyness threshold or level. We will use the term moneyness ratio when this moneyness threshold is expressed relative to the guarantee G. Table 1 shows that the

Table 1

Decomposition of the payoff of a GMMB contract with dynamic lapsation risk

Components of the portfolio	Barrier is *hit* before maturity	Barrier is *not hit* before maturity
(I) Up-and-out put	0	$\max(G - A_T, 0)$
(II) Rebate option	Moneyness level paid upon surrender	0
(III) Up-and-out call with zero strike	0	A_T
Total payoff	Moneyness level paid upon surrender	$\max(A_T, G)$

payoff of a GMMB contract with dynamic lapsation can be viewed as a basket of barrier options.

The decomposition presented in Table 1 renders the analysis of the GMMB product tractable because closed-form expressions for each of the underlying options are available under the Black-Scholes model (see McDonald, 2006, Section 22). Therefore, the valuation of a GMMB contract (from a financial engineering perspective) under dynamic lapsation risk and the computation of Greeks required for establishing a dynamic hedging strategy are both straightforward to perform.

FAIR FEE

Having decomposed the payoff to the policyholder into a basket of barrier options, we now focus on how to compute the fee rate for the GMMB contract. Defining the insurer's net liability as the payoff of the contract net of fees and surrender charges, we say that the fee is fair if it is determined such that the net liability of the policy is zero at inception of the contract. This is similar to the equivalence principle in actuarial mathematics.

To analyze the effect of dynamic lapsation and surrender charges on the fair fee, we begin with a baseline contract in which surrendering is not allowed. For an initial investment of $100, a fixed guarantee of $100, a (continuously compounded) risk-free rate of 3 percent, an asset volatility of 16.5 percent (see below) and a contract maturity of 10 years, the fair fee rate is 1.07 percent per annum. This contract is equivalent to a plain vanilla put option financed by fees deducted periodically from the sub-account.

We now incorporate dynamic lapsation into the pricing framework and assume that there are no surrender charges. Figure 1 illustrates the behavior of the fair fee as a function of the moneyness ratio. As expected, if the policyholder only lapses when the moneyness ratio is extremely large, the fair fee converges to the one computed for the baseline case where surrendering was not allowed. However, if the insured lapses at smaller moneyness ratios, the fee needs to be increased to compensate the insurer for its lost future income. Indeed, when the guarantee is deep out-of-the-money, it is very unlikely that the guarantee will cost something to the insurer and surrender therefore leads to a loss for the insurer.

Figure 1

Fair fee as a function of the moneyness ratio assuming no surrender charges

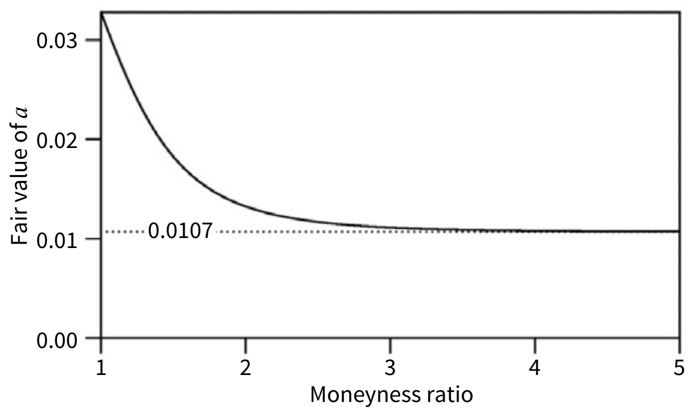


Figure 1 shows that dynamic lapsation can be priced into the contract by raising the fee rate. However, we observe that the required fee increase is rather steep: at a moneyness ratio of about 150 percent, the fair fee almost doubles. One way to reduce this fair fee is to include surrender charges. In fact, when a surrender charge of 4 percent is applied at the moment of surrender, the fair fee lies in between 1 percent and 1.2 percent for any given moneyness ratio. Therefore, the addition of a surrender charge has almost totally mitigated the effects of dynamic lapsation risk on the fair fee. In the following section, we examine how dynamic lapsation risk impacts hedging effectiveness.

HEDGING EFFECTIVENESS

When fees are collected as a percentage of the sub-account value, the fee income is affected by fluctuations in the value of the reference portfolio. For example, in a bear market, the sub-account value drops, the guarantee is in-the-money and the fee income decreases (at the worst possible time for the insurer). In contrast, the fee income is much greater in a bull market, but policyholders also tend to lapse more.

These observations show that both the payoff of the contract (at maturity or on surrender) and the fee income should be hedged if the objective of the hedge is to protect the insurer against changes in its net liability. In what follows, we lay down the main market and hedging hypotheses needed to analyze the impact of dynamic lapsation on hedging effectiveness.

MARKET ASSUMPTIONS

We will assess hedging effectiveness under two different types of market environments.

(1) The ideal case in which the value of the reference portfolio follows a geometric Brownian motion, exactly as in the Black-Scholes model. In this case, log-returns are independent and identically distributed as normal random variables. Because Greeks will be computed under the Black-Scholes model as well (see below), there will be no discrepancy between the hedging and market models in this scenario, i.e., there will be no model risk.

(2) A (two) regime-switching GARCH (RS-GARCH) market model that captures most of the stylized facts of asset returns (see Campbell et al., 1996; Tsay, 2012). In a RS-GARCH model, the state of the economy is driven by a latent Markov chain and in each state, the market follows a GARCH(1,1) model. This model encompasses the regime-switching log-normal (RSLN) model of

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Hardy (2001). Furthermore, Hardy et al. (2006) showed that the RS-GARCH model has a better overall fit than the stochastic volatility model of the American Academy of Actuaries. We believe that this better fit is achieved because the RS-GARCH model allows for jumps in the mean return and volatility dynamics.

The data set used to estimate the parameters of these two market models consists of weekly log-returns on the S&P500 index from Dec. 30, 1987 to Aug. 1, 2012. Data was extracted on Wednesdays to avoid most holidays. The time series includes 1283 observations and descriptive statistics are provided in Table 2 (the mean and standard deviation (abbreviated StDev) are given on an annualized basis).

Table 2:

Descriptive statistics of weekly log-returns on the S&P500 index from 12/30/1987 to 08/01/2012

Mean	StDev	Skewness	Kurtosis	Minimum	Maximum
7.0%	16.5%	-0.61	7.3	-16.5%	10.2%

Both market models were estimated by maximum likelihood (ML). Estimation of the Black-Scholes model by ML is straightforward as one only needs to compute the sample mean and variance of log-returns. The RS-GARCH model is more complicated to estimate because of a path-dependence problem. The most common ML estimation algorithm used for the RS-GARCH model is given by Gray (1996), but Augustyniak et al. (2015) generalized Gray's approach to reduce bias in the estimated parameters. R code for this technique is available on Maciej Augustyniak's website.

HEDGING ASSUMPTIONS

In what follows, we assume that the insurer uses delta-hedging under the Black-Scholes model to manage the risk of the GMMB contract in a frictionless market (no transaction costs, no constraints on short selling, lending, etc.). For the insurer to be delta-hedged at time t, it must ensure to hold a position of Δ_t in the underlying index. This can be accomplished using futures or, equivalently, by taking a long position in Δ_t shares of the underlying index and borrowing the cost or lending the proceeds. The Greek Δ_t corresponds to the first derivative of the insurer's net liability with respect to the asset price and can be computed in closed-form based on the decomposition presented in Table 1.

Four hedging scenarios are analyzed.

I. Baseline: The insurer hedges a GMMB product assuming that the policyholder will not surrender his contract and the policyholder conforms to this behavior. The fair fee in that case has already been calculated and corresponds to 1.07 percent.

II. Correct moneyness assumption: The insurer hedges a GMMB product assuming that the policyholder will lapse his contract if the moneyness ratio hits 150 percent and the policyholder conforms to this behavior. A surrender charge of 4 percent is applied in the event of surrender. This scenario allows us to better analyze the magnitude of the discrepancies in an inappropriate hedge scenario (see scenarios III and IV). The fair fee in this scenario is 1.17 percent per annum which is only slightly higher than in scenario I since surrender charges approximately cover the loss in fee income due to lapsation.

III. Dynamic lapsation is not hedged: The insurer hedges a GMMB product assuming that the policyholder will not surrender his contract but the policyholder does not conform to this behavior and lapses when the moneyness ratio hits 150 percent. A surrender charge of 4 percent is also applied. This situation allows us to assess the impact of dynamic lapsation on a hedging program when this risk is ignored. We assume that the product is correctly priced (1.17 percent per annum) even if the hedge is not properly constructed. This prevents hedging errors from being inflated because of a mispricing.

IV. Incorrect moneyness assumption: The insurer hedges a GMMB product assuming that the policyholder will lapse his contract if the moneyness ratio hits 175 percent, but the policyholder actually lapses his contract once the moneyness ratio hits 150 percent. A surrender charge of 4 percent is also applied. This situation allows us to assess the impact of incorrectly setting lapse assumptions on hedging effectiveness. As in scenarios II and III, the fee is set to 1.17 percent per annum which implies that the product is correctly priced but the hedge is not properly constructed.

For these four hedging scenarios, we will analyze the distribution of the net hedging error at maturity. If the GMMB product is held until maturity, the net hedging error at maturity for a given scenario is

max(G - A_T, 0) + accumulated mark-to-market hedging gains/losses - accumulated value of fees.

If the GMMB is surrendered prior to maturity, the net hedging error becomes

accumulated mark-to-market hedging gains/losses - accumulated value of surrender charges and fees.

ANALYSIS OF HEDGING ERRORS

Table 3 shows the mean, standard deviation (StDev), 95 percent Conditional Tail Expectation (CTE) and 99 percent Value-at-Risk (VaR) of the net hedging error at maturity assuming weekly rebalancing of the hedge portfolio for each of the four scenarios that were presented and under the two market models considered (200,000 paths of the log-return process were generated for each model). As before, we assume an initial investment of $100, a fixed guarantee of $100, a risk-free rate of 3 percent, an asset volatility of 16.5 percent and a contract maturity of 10 years.

Table 3

Net hedging error at maturity for the four scenarios and two market models considered

	Mean		StDev		95% CTE		99% VaR	
Scenario	Black-Scholes	RS-GARCH	Black-Scholes	RS-GARCH	Black-Scholes	RS-GARCH	Black-Scholes	RS-GARCH
I	0.0	-0.7	0.7	1.8	1.6	3.6	1.9	4.4
II	-0.1	-1.1	0.8	2.0	1.9	3.6	2.2	4.4
III	1.2	0.0	3.8	4.0	8.2	7.7	8.6	8.3
IV	0.5	-0.6	1.7	2.4	2.7	3.7	2.9	4.3

We can first focus our analysis on the results obtained under the Black-Scholes model. By analyzing scenarios I and II, it is quite obvious that hedging under ideal conditions (no model or policyholder behavior risks) yields an important risk reduction (for example, the 95 percent CTE of the net unhedged loss at maturity is 28 if the policyholder does not lapse). However, the relevant practical issue is to determine whether it is advantageous for the insurer to hedge dynamic lapsation risk if he is unsure about the exact moneyness level at which the policyholder exercises his option to surrender. To address this issue, we must compare scenarios II, III and IV. For the Black-Scholes model, when there is no discrepancy between the hedging and market models, we observe that even if the moneyness ratio assumption is set wrong in the hedge, the risk measures in scenario IV are much lower than those obtained in scenario III where dynamic lapsation risk is not hedged at all. In fact, the standard deviation and risk measures in scenario IV (wrong moneyness ratio) are approximately twice as large as in scenario II (perfect hedge), but under scenario III (dynamic lapses are not hedged at all), they are five times larger. Therefore, even if the assumption on the moneyness ratio is set wrong in the hedge, it is still possible to achieve a very significant risk reduction by hedging dynamic lapses.

The last question that remains is to determine whether the results that we obtain are robust to a more realistic market model. Comparing results for the Black-Scholes and RS-GARCH market models, it is not surprising to observe an increase in the standard deviation when hedging under the RS-GARCH model. However, even if the market model significantly deviates from the Black-Scholes model, we observe that the insurer is still much better off hedging dynamic lapses with the wrong moneyness ratio assumption, than not hedging them at all (for instance, the standard deviation and risk measures are halved).

Finally, it is comforting to note that even when assumptions used to construct the hedge strongly deviate from reality, dynamic hedging can still result in an important risk reduction relative to the actuarial approach. For example, under an RS-GARCH model, the standard deviation of the net unhedged loss at maturity is 13-15 percent of the initial investment (depending on whether the policyholder lapses or not) whereas it is between 2-4 percent when hedging is used. Tail risk measures also decrease by a very important margin in this context.

FURTHER READING

We note that Panneton and Boudreault (2011) have investigated the pricing of lapses in a simpler framework where lapses can only occur at specific dates during the contract. Moreover, we recommend reading Eling and Kochanski (2013) for a recent overview of the research on lapse in life insurance and Kling, et al. (2014), for a thorough analysis of the impact of policyholder behavior on hedging effectiveness in the context of guaranteed lifetime withdrawal benefits. ■

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Investment Section Breakfast in New York City

By Frank Grossman

In conjunction with the 2015 Life & Annuity Symposium in New York City from May 4-5, 2015, the Investment Section sponsored a breakfast session. Ryan Stowe and Frank Grossman offered news and views about recent and upcoming section happenings. And guest speaker Ron Harasym provided his entertaining and insightful take on a "Modeller's Guide to the Universe." Despite the early hour, roughly 25 section members were in attendance, and Kelly Rabin won the door-prize book draw—a copy of Akerlof & Shiller's *Animal Spirits*.

The assembly was challenged to come up with an alternative caption for a vintage Robert Weber cartoon from the pages of *The New Yorker*. The original caption was "Forgive the mess. Warren just put everything into cash." This sentiment played well the first time around in 2001, and works pretty well today too given record low interest rates. Another Warren (viz. Warren Manners) came up with a winning alternative caption: "We call it TARP feng shui." Can you top that? ■

"Forgive the mess. Warren just put everything into cash."

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Mini-Class of 1987 Reunion – Graduates of University of Toronto's actuarial science program, Emile Elefteriadis (left) and Ron Harasym (right) share a laugh in NYC, demonstrating that Investment Section breakfasts are not merely an opportunity to make new acquaintances but to reconnect with old friends too. Ron and Emile last crossed paths at LaGuardia some 10 years ago.

Newsletter Central – August *Risks & Rewards* editor Joe Koltisko (left) contemplates production timelines with your section council's newsletter liaison, and cartoon caption thinker-upper extraordinaire, Warren Manners (right).

Correspondent's Report from the SOA 2015 Investment Symposium

By Martin Bélanger, Ming Chiu, Frank Grossman, and Kevin Strobel

The SOA Investment Symposium returned to Philadelphia last March, the location of the inaugural SOA Investment Actuaries Symposium back in November 2000. The city itself seemed largely unchanged during our absence. Yet the challenges facing actuaries today were no less daunting than they were 14 years ago in the wake of the Russian default and Asian contagion—and on the brink of the tech wreck. Sidebar conversations in the corridors and over cups focused on when (not if) the Federal Reserve would raise interest rates, hopefully sometime soon. The admonition of a founding father who knew colonial Philadelphia well, one Benjamin Franklin, came to mind: "He that lives on hope will die fasting." [FG]

TOOLS FOR EVALUATING INSURANCE PORTFOLIO INVESTMENT PERFORMANCE (SESSION 18)

Most of us agree—the performance of an investment portfolio is best evaluated by its total return relative to a benchmark. On the other hand, our industry's performance is often reported and judged by book value accounting where investment income is largely independent of mark-to-market performance, at least in the short run. During the "Tools for Evaluating Insurance Portfolio Investment Performance" session, David Braun and Peter Miller, both from PIMCO, explained that they use a series of three reports to help clients understand quarterly performance in terms of total return, risk and book yield.

How could a decline in portfolio book yield be decomposed into a component explained by today's low rate environment, and another explained by active management of the portfolio? This session focused on that question, and delivered an answer facilitated by a novel approach to the construction of a benchmark for book yield. The guiding principle? Make the benchmark reflect the yield that would be expected if the manager was truly passive. Cash inflows are assumed to be immediately invested in a neutral portfolio; outflows are funded with pro rata sales. To avoid this calculation escalating into an onerous accounting exercise (in David's parlance, to avoid "trying to boil the ocean"), at the beginning of each period the benchmark is assumed to match the existing portfolio. The result? A practical, understandable tool to help life companies better understand how their investment manager's active decisions have influenced their portfolio's yield. [KS]

CIO/CRO PANEL (SESSION 19)

The last session of Day 1 was a panel of chief investment and chief risk officers. The panel was composed of investment experts working in various areas of the financial services industry: Ellen Cooper from Lincoln Financial, Sadiq Adatia from Sun Life Global Investments, Jeff Hussey from Russell Investments and Lori Evangel from Genworth. The session was moderated by Martin Bélanger, director, Investments at Western University.

The panelists fielded a wide range of questions, including explaining their investment strategy, discussing how they integrate environmental, social and governance factors into their investment process, how they deal with the current low interest rate environment, describing the new products and strategies they've added to their portfolios, how they manage risk, and what is their overview of the market.

The panelists agreed that a good risk management framework is essential. Risk cannot be avoided when pursuing investment objectives, and consequently each investment risk must be identified, quantified, reported and managed. Overall, the panel generally shared a positive market outlook, although some asset classes are getting expensive and the consensus about interest rates was that they will, eventually, go up. [MB]

Can You Tell the Difference? – Following the "Currency, Did You Miss the Boat?" session (Session #21) on the morning of the second day of the 2015 Investment Symposium, one of the panelists, Mark Abbott (left) greets his namesake, Mark Abbott (right). (Photo credit Frank Grossman.)

INVESTMENT STRATEGY & OPTIMIZATION: TREND AND CASE STUDY (SESSION 23)

Larry Zhao moderated this session in which Mary Pat Campbell examined the current trend of insurers' investment strategies, and Ming Chiu discussed two applied asset portfolio optimization case studies.

Mary Pat Campbell of Conning lead off with an overview of the investment portfolio compositions of life, pension, health, and property & casualty insurers. The key results from the 2nd Annual ACLI-Conning CEO Poll showed that increasing investment yield and capital management were of top importance to CEO's in a changing yield environment in the period from year-end 2013 to year-end 2014. As older assets matured, portfolio yields have fallen prompting companies to seek yield outside their core holdings by diversifying beyond traditional fixed income assets, reducing liquidity, lengthening duration, and lowering credit quality. Mary described allocations by asset classes, life industry bond sector allocations, and the trend in credit quality shifts toward more BBB rated bonds and less below investment grade. A closer look at investment returns showed a wide range of investment results across industry with gross book yields ranging from 3 percent to 8 percent in 2014. Mary went on to describe the differences of average gross book yields, and allocation to BBB and below investment grade bonds, by quartile groups. CEO's opinions on which asset classes they thought would maintain or increase yield were ranked. In conclusion, projected book yields under gradually rising interest rate scenario from 2014 to 2023 were presented.

Ming Chiu of AIG then demonstrated a top-down approach to the allocation of assets to various P&C LOBs in three steps via a case study. The first step was to allocate fixed income assets to back P&C LOB statutory reserves. Pseudo code was examined for the Genetic Algorithm used to optimize the fixed income allocation to LOB by minimizing duration mismatch between assets and liabilities. In step two, the S&P capital model was used to calculate the total capital requirement for each LOB, and remaining assets were allocated in proportion to the S&P capital. Step three allocated excess assets to each LOB on a pro-rata basis. A second case study dealt with a high level overview of a risk factor based Strategic Asset Allocation framework for a large international P&C asset portfolio.

The session attendees posed questions to Mary regarding details in trend analysis of the investment portfolios. Ming answered questions regarding the Genetic Algorithm's implementation using Matlab and the advancement of risk factor modeling techniques in a strategic asset allocation framework. [MC] ■


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Dealing With Difficult Data

By Joshua Boehme

Life, so they say, brings with it the two certainties of death and taxes. Actuaries could perhaps make a convincing case that life also offers a third certainty: imperfect data.

Actuaries often encounter difficult data. Traditionally, we deal with problematic data in a number of ways. We check for data quality issues—such as incorrectly mapped codes—and correct them where possible. We question our preconceptions about what the data "should" look like and revise our working assumptions as needed. Mindful of how Simpson's paradox can lead us to incorrect conclusions, we check for additional, confounding variables. When we can, we gather additional data to reduce the influence of random noise. These techniques definitely have their worth and often solve the problem. Sometimes, though, they don't. When the standard methods fail, actuaries can turn to statistical methods to make the most of uncooperative data.

AN ILLUSTRATIVE PROBLEMATIC DATA SET

To illustrate the issues and some of the potential techniques to deal with them, consider the follow data set, which shows the annual default rates for financial institutions in 2012 by S&P rating category.

Table 1

One-year default rates for financial institutions (2012)[1]

S&P Rating	Defaults	Exposure	Default Rate
AAA	0	10	0.00%
AA+	0	25	0.00%
AA	0	12	0.00%
AA-	0	72	0.00%
A+	0	119	0.00%
A	0	130	0.00%
A-	0	107	0.00%
BBB+	0	108	0.00%
BBB	0	134	0.00%
BBB-	0	92	0.00%
BB+	0	48	0.00%
BB	0	50	0.00%
BB-	1	47	2.13%
B+	1	56	1.79%
B	2	65	3.08%
CCC/C	2	13	15.38%

Note: the summary here excludes withdrawn ratings.

As the basis for setting assumptions, this data has many shortcomings. The 12 highest rating levels all have the same observed default rate. In addition, the observed default rates do not increase monotonically, since BB- has a higher default rate than B+ and likewise for B and B-.

This does not necessarily mean that this data refutes the assumption that worse ratings have higher default rates. As a hypothetical example, suppose BB- has a true (unobservable) default rate of 1.80 percent and B+ has a true rate of 2.10 percent. Given the sample sizes we have available in the exposure amounts above, we would have a roughly 43 percent chance of observing a higher default rate for BB- than for B+.

Since we cannot "re-run" 2012, we cannot gather more data.[2] Since the data covers a single type of company and a single year, we have no obvious variables to divide the data into smaller cohorts. If we want an assumption where companies with lower ratings have higher default rates, we will have to work with this data further. In particular, we want to produce an assumption that satisfies this constraint:

Monotonicity: the default rate must strictly increase as ratings get worse.

THREE POTENTIAL TECHNIQUES

To work with this data, we move from looking at single point estimates to looking at distributions of estimates. This shift in perspective makes it easier to adjust the data to reflect any constraints we want to impose (such as monotonicity). With point estimates, we may know that we need to make an adjustment, but the individual values do not provide us with enough information to determine the size of the adjustment to make. With distributions, though, we can eliminate any regions that fall outside of our constraints; in effect, we take the distributions and make them conditional on our constraints.

The resulting distributions depend on the model we apply.

NORMAL DISTRIBUTION APPROACH

One possible approach, which many actuaries may already know, uses the normal approximation for the maximum likelihood estimator. Given d defaults and exposure n, this normal distribution has mean $\frac{d}{n}$ and variance

$$\frac{\left(\frac{d}{n}\right)\cdot\left(\frac{n-d}{n}\right)}{n} = \frac{d(n-d)}{n^3}.$$

Since the normal distribution can take any real values, we will reject any iterations that produce values outside of the [0, 1] interval. This will truncate the normal distribution so that it produces estimates of default probability between 0 percent and 100 percent.

BOOTSTRAPPING APPROACH WITH THE BINOMIAL DISTRIBUTION

Another approach makes direct use of the empirical distribution to draw new samples of the same size and with replacement from the observed results. In other words, we draw from a binomial distribution with *n* trials and *d/n* event probability. This technique—known as bootstrapping—offers a quick way to estimate parameters or variances in situations where we observe a process with an unknown distribution function and do not have a closed formula available.

BAYESIAN APPROACH WITH BETA PRIOR DISTRIBUTION

A third technique would take a Bayesian approach, which combines an assumed prior distribution and the observed data to produce a posterior distribution for our parameters. In this approach, the prior distribution and the data each are assigned a weight based on the credibility of the data; the more observed data points, the greater the relative weight assigned to the data. The example below uses the beta distribution as the prior distribution. The beta distribution is a convenient conjugate prior distribution for binomial data.

The table below presents the results of these techniques, each applied in several different ways, over 5,000 iterations using the same set of random numbers in each case. The estimated default rates in the table represent the means of samples drawn from the respective distributions (and in the case of the rejection method—discussed in more detail below—filtered to exclude observations outside the acceptance region). Note in particular that all of the techniques produce results that satisfy the monotonicity constraint.

The "Rejection" and "Gibbs" approaches are alternate sampling methods used to implement each technique. The "Prior/Adjustment" input is used in revising the initial result. These are explained more fully below.

For clarity, the results focus on just the ratings from BB- through B- (inclusive). The same techniques could apply to the entire table; the results in that case, though, would differ slightly.[3]

Although the specific values vary from technique to technique, some high-level similarities emerge across all the results. If we believe in our monotonicity constraint, then we might assume a significantly higher default for B- than we actually observed. Each of our models suggests this. The size of the increase in default rate from B to B- resulting from each model above may look surprising. However there is an intuitive explanation. If we were to evaluate only the B- default rate in isolation, we would have a range of plausible default probabilities with the observed rate (2.94 percent) most likely somewhere in the middle of the range. Applying the constraint, though, chops off any rates lower than B's default rate (observed at 3.08 percent), which, as a very rough approximation, removes the left half of the distribution.[4] The remaining portion has a mean value out in the right tail of our original unconstrained distribution.

Similarly, we see the results indicate we should assume a lower rate from BB- than we observed. The results show some disagreement about B+ and B, but most suggest somewhat higher default rates than we observed.

MULTIVARIATE SAMPLING

Table 2

Results of estimation techniques

		Default Rates				
Technique	Prior/ Adjustment	BB-	B+	B	B-	Rejection %
Observed Data	Not applicable	2.13%	1.79%	3.08%	2.94%	Not applicable
Normal/ Rejection	0	1.21%	2.26%	3.61%	6.04%	95.3%
Normal/Gibbs	0	1.24%	2.33%	3.77%	5.87%	0%
Bootstrapping	0	0.32%	2.24%	4.20%	7.68%	97.1%
Bayesian/ Rejection	0	0.63%	1.47%	3.00%	6.10%	92.1%
Bayesian/ Gibbs	0	0.62%	1.47%	2.95%	5.84%	0%
Normal/ Rejection	0.5	1.62%	2.96%	4.62%	7.47%	94.3%
Normal/Gibbs	0.5	1.69%	3.07%	4.72%	7.39%	0%
Bootstrapping	0.5	0.83%	2.91%	4.92%	8.71%	95.5%
Bayesian/ Rejection	0.5	1.14%	2.27%	4.01%	7.58%	91.9%
Bayesian/ Gibbs	0.5	1.15%	2.27%	3.96%	7.32%	0%

METHODS - REJECTION AND GIBBS SAMPLING

For the normal and Bayesian approaches, Table 2 shows two different methods of drawing from the respective constrained

CONTINUED ON PAGE 22

distributions. The rejection method draws each parameter independently from its distribution (normal or beta), ignoring our monotonicity constraint. In each random draw, if the resulting four sample default probabilities do not meet the constraints (i.e., among [0,1] and monotonic), they are discarded. We can envision this as drawing samples from a larger (but easier to simulate) distribution than the one we actually want. We then retain only the observations within the desired region—also known as the acceptance region—which leaves us with a sample from the desired (but more difficult to simulate) distribution.

Gibbs sampling, on the other hand, allows us to sample directly from complex distributions. The key to Gibbs sampling comes from observing that each variable, taken one at a time instead of collectively, has a distribution with a more tractable form. For example, in the case of the normal distribution we have four normally distributed variables, which depend on each other via the monotonicity constraint. Thus, the overall multivariate distribution has the same joint distribution as four independent normal variables, except truncated down to the region that satisfies our constraints (and scaled proportionally so the integral of the density still equals 1). That truncation makes it difficult to directly sample from it. If we look at just a single variable at a time, though, we have a univariate normal distribution subject to upper and lower bounds. As long as we know the other three variables, we know the bounds for the distribution of the fourth and thus can easily draw a sample from it. It turns out that the approach suggested by this observation—namely, sample from each variable individually based on the most recent value of the others—converges to the correct multivariate distribution.

ASOP 23 should be consulted for additional guidance on data gathering and disclosure.

Specifically, starting with an arbitrarily picked initial observation, Gibbs sampling generates additional observations through the following algorithm:

> Loop through each variable, one at a time:[5]
>
> 1. Determine the distribution for the current variable, conditional on the current values of all other variables; and
> 2. Set the current variable equal to the value generated from a single random draw from that conditional distribution.
>
> Each time we loop through all variables once, we produce one observation. We repeat this process as many times as needed to produce the desired number of observations.[6]

In our case, those conditional distributions take the form of a truncated univariate normal distribution, with the upper and lower bounds coming from the largest and smallest values that still satisfy the monotonicity constraint. Similarly, in the Bayesian case, we end up with truncated univariate beta distributions.

When we apply the rejection method, we treat the distributions as independent, making it easier to draw samples; however, many of the samples get rejected. Gibbs sampling, though less intuitively straightforward and requiring more up-front setup, draws precisely from the region of interest, making it more efficient.

In the end, both methods give us samples from the same distribution; the specific application dictates which works better. As the number of constraints increases, the rejection method rejects a greater proportion of the samples.[7] The rejection method, though, takes less time to program and to explain to non-technical stakeholders.

THE BAYESIAN PRIOR AND PSEUDO-OBSERVATIONS

The "Prior/Adjustment" column in Table 2 represents the number of pseudo-observations added to the observed number of defaulting and of non-defaulting companies. This provides a mathematical adjustment that reduces the credibility of the observed number of defaults. This is done as an adjustment for the relatively small number of exposures in each rating category. For the Bayesian techniques, it represents the value of the alpha and beta parameters for the assumed beta prior distribution.[8]

The concept of an adjustment factor may seem strange to some actuaries at first. To understand why one would add pseudo-observations to our actual data, consider the implications of not using an adjustment factor. In the extreme, this would mean, for example, that if a rating category had only one exposure and it represented a default we would assume a default probability of 100 percent in that rating category. This would clearly be a rather extreme approach.

A factor of 0.5, on the other hand, means that if we observe one default event after one trial, we would estimate the default probability for that rating category as $(1 + 0.5) / (1 + 0.5 \cdot 2) = 3/4$—not an outlandish place to start given a sample size of one.[9]

SELECTING A SINGLE TECHNIQUE

So, with a plethora of techniques to choose from, how do we narrow things down? The choice depends on the specific situation and must reflect non-technical factors, such as stakeholder buy-in. In this example, though, the technical factors favor one approach over the others.

First, given the small sample sizes and the even smaller number of defaults observed, the normal approximation seems dubious; in addition, the fact that the normal distribution ends up putting a significant proportion of the distribution on negative values gives us another reason to question it.

On the other hand, the bootstrapping technique can only produce certain discrete values (0/n, 1/n, 2/n, etc.). Since the monotonicity constraint leads us to eliminate certain overlapping regions of the parameters' distributions, the discreteness of the values leads to questions about the accuracy of the final distribution. (Consider, for example, the difference between a particular probability mass falling just inside the constrained region versus falling just outside the region.)

This leaves the Bayesian technique as the strongest approach. Further, as discussed above, using a non-zero parameter for the prior distribution produces better results.

In the end, though, these only reflect the technical considerations. The context of the work must guide the selection of the final technique. Actuarial Standard of Practice 23 should be consulted for additional guidance on data gathering and disclosure requirements.

In life we often encounter imperfect data. By using these and other statistical techniques, though, actuaries can prevent uncooperative data from causing as much unpleasantness as life's other certainties. ■

ENDNOTES

1 Table 52 from *http://www.nact.org/resources/NACT_2012_Global_Corporate_Default.pdf*, accessed 2/14/2015

2 Ignoring the challenge of incorporating data from prior years consistently

3 For example, including the BB rating means that our assumption for BB- now has a nonzero lower bound. This would cause us to exclude some of its smallest potential values and would thus increase its estimate. Similarly, including CCC/CC puts a ceiling on our assumed default rate for B-.

4 The extent of the adjustment depends on the likelihood of B's default rate at the given point. If we consider a point much lower than B's observed default rate (i.e., in B's left tail), it is highly likely that B's true value is greater than or equal to that point. Thus, given our monotonicity constraint it is highly unlikely B- can have a rate that small since it must exceed B's rate. In the absence of the constraint we would have assigned some probability to B-'s rate being that small; with the constraint, though, there is an even smaller chance. Conversely, for values much larger than B's observed rate (i.e., in B's right tail), there is a relatively small chance that B has a default that large; therefore, applying the constraint has only a minor impact on the likelihood of B- having a rate that high.

5 Or multiple variables at a time, in which case we draw from the joint distribution conditional on all the other variables.

6 In practice, we often make some adjustments to the resulting series of observations. Because of the iterative nature of the process, consecutive observations exhibit correlation – we do not get independent samples. In addition, depending on the initial starting point it may take some number of iterations to converge to the desired distribution. We can correct for auto-correlation by thinning the observations and for non-convergence by dropping observations from an initial burn-in period. Since this paper only considers means, we do not need to correct for auto-correlations. In addition, for simplicity the results do not discard any initial burn-in period (based on a visual inspection, the results quickly converge to the stationary distribution). Readers interested in further details can consult the extensive literature available on Gibbs sampling.

7 The inefficiency of the rejection method can reach rather extreme levels. The author encountered one situation involving a two-dimensional ratings transition matrix where the rejection method produced less than one valid result per million samples.

8 For 0, view this as the limit of the posterior distribution as alpha and beta go to zero.

9 The exact choice of a factor (or a prior distribution in general for Bayesian approaches) can present some problems beyond the scope of this article, but the illustrative 0.5 factor in this case has three desirable properties. First, in the extreme case of n=1 it produces defensible results. Second, for Bernoulli trials, a Beta distribution with parameters $\alpha = ½$ and $\beta = ½$ is the Jeffreys prior. As the Jeffreys prior, it has a certain invariance under re-parameterization. Third, it still results in a whole number of total observations, since 0.5 gets added to both the number of defaults and the number of non-defaults.

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A Sneak Preview of the Investment Section Program at the 2015 SOA Annual Meeting

By Peter Sun

The 2015 SOA Annual Meeting will be held Oct. 11 – 14 at the Austin Convention Center. The Investment Section Council is preparing a feast of programs for the attendees. As an Investment Section member, you have the privilege to get a sneak peek of what is to come. Should you find a topic that you are passionate about and would like to share your knowledge, please contact Peter Sun at *peter.sun@milliman.com* or Angelika Feng at *angelika.feng@aig.com* for speaking opportunities.

Let's start with the fun activities first.

The Investment Section Continental Breakfast will be on Wednesday, Oct. 14, 7:15 - 8:15 a.m., and it will be open to all with no charge. The Investment Section Council will report its work over the past year, and it will be a great forum for members to interact with the council members.

We also have two networking events. For chess lovers, the Fifth Thomas C. Barham III Speed Chess Networking Event is presented jointly by the Technology and Investment Sections on Tuesday, Oct. 13, 6:30 – 10:00 p.m. (open to all: M $10, NM $20). Participants will have a professional chess player to help sharpen their skills. If you prefer wine, a wine tasting event at Max's Wine Dive around the same time might be, well, just your cup of tea. The wine tasting event is jointly sponsored by the Entrepreneurial Actuaries and Investment Sections (open to all: M $15, NM $25).

SOA 2015

SOCIETY OF ACTUARIES

Annual Meeting & Exhibit

Now comes the heavy lifting. The Investment Section is involved in presenting nine sessions at the annual meeting. A brief description of the sessions is listed below, along with their time slots.

Monday, Oct. 12, 10:00 – 11:15 a.m. Session #19: "Use of Derivatives for Insurance Company Risk Management." This session will cover a survey of how insurance companies use derivatives for risk management and their rationale.

Tuesday, Oct. 13, 8:30 – 9:45 a.m. Session #75: "Insurance Company Asset Allocation Trends." In this session we plan on discussing asset allocation trends, how strategies vary by company size, asset classes insurance companies are increasing their allocations to, and other asset classes to consider for your portfolio.

Tuesday, Oct. 13, 10:15 – 11:30 a.m. Session #90: "Equity Investment for Life Insurers."

Life insurers have historically limited their exposure to equity investments for risk and capital reasons. Recent economic environment coupled with advancement in risk management and innovative product designs have made equity investment more attractive to life insurers. This session will explore various alternatives.

Tuesday, Oct. 13, 10:15 – 11:30 a.m. Session #93: "Measuring the Success of LDI." The presenters will consider potential approaches to assessing an investment strategy's effectiveness in a manner that reflects stakeholder priorities and objectives. Discussion topics will include how to assess performance given different investment strategies, ex-post risk metrics, and attribution of unexpected outcomes by risk source.

Tuesday, Oct. 13, 3:45 – 5:00 p.m. Session #123. "Risk Managed Funds: Principles and Applications." Managed volatility and managed risk strategies have experienced tremendous growth in recent years, and will play an increasingly important role in the retirement security system in the years to come. This session will cover the range of strategies currently in use, the historical growth of these strategies, their recent performance, challenges in benchmarking, and future developments.

Wednesday, Oct. 14, 8:30 – 9:45 a.m. Session #148: "Are We in Another Bubble?" This session will focus on the current equity and debt market valuation in light of the economic fundamentals. The presenters will provide a diverse range of views on the global economic state.

Wednesday, Oct. 14, 10:15 – 11:30 a.m. Session #166: "Stochastic Modeling of the Interaction of Asset and Non-Asset Risks." There has been a lot of effort by the industry in examining asset related risk when determining economic capital. However, there has been less focus on liability driven risk. In this session, we will demonstrate methods for quantifying the cost of non-economic risk in an economic capital framework.

Wednesday, Oct. 14, 12:00 – 1:15 p.m. Session #180: "New Developments in Pension Fund Investments." Pension fund investment is experiencing fundamental shifts with regulatory updates and introduction of new risk management techniques. This session will cover new developments in pension fund investments.

The Investment Section Council hopes you enjoy the programs and find them useful. Again, please let us know if you are interested in speaking at any of the sessions. We all look forward to seeing you in Austin in October. ■

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A Seminar in Beijing: Applications of Derivatives for Life Insurance Company Risk Management

By Peter Sun

In North America, Europe and Japan, derivatives have been a risk management tool for life insurance companies for a long time. In particular, the past decade saw an explosive growth of hedging in variable annuities and indexed annuities using derivatives. Corresponding to the growing number of applications for derivatives, there has also been a rapid evolution of regulatory, tax, audit, and reporting requirements. The process thus far has not been a smooth ride by any means, but insurance companies did learn some important lessons along the way.

Half way across the globe, China's economy is growing fast. Its economy is officially the second largest in nominal terms after the U.S., and some would even argue it is the largest on a purchasing power parity basis. China is also expanding its derivatives market to go with its burgeoning economy. The CSI 300 futures were the first financial derivatives launched on April 16, 2010 in the Chinese market. Since then, the Chinese derivative market has been growing at the so-called "China speed."

CSI 300 futures are seeing large increases in average daily volume (ADV) and open interest, and 30-day ADV in notional now exceeds that of S&P 500 & Eurostoxx 50 futures combined. On high volume days in early Dec. 2014, CSI 300 futures were trading more than two million contracts per day, and the notional dollars traded in this single contract exceeded that in every other equity index futures contract combined globally. On average, daily volumes for Chinese equity index futures are much larger than western markets though open interest is lower. 2015 also witnessed the launch of equity options based on the SSE 502 and other financial and commodity derivatives.

Given this background, there is keen interest in the Chinese life insurance community to learn from what the developed economies have done and eventually grow its own ability to use derivatives for risk management purposes. The regulatory body, China Insurance Regulatory Commission (CIRC) recently asked the Chicago Mercantile Exchange (CME) to host a seminar on this topic. The seminar was held on April 28 in Beijing, where delegates from Milliman spoke along with local Chinese fund managers.

The seminar was a great success with more than 50 regulators, fund managers, and insurance company representatives in the audience. The speakers also represented the wide area of expertise needed in derivative usage, including actuarial, portfolio management, and trading. The speakers were also able to visit many Chinese companies before and after the seminar.

I left China with several deep impressions about this vibrant market.

Quantitative investment is very popular in Chinese fund management companies. With the rapid growth of China's economy, mutual fund management techniques are also becoming increasingly sophisticated. Using advanced financial mathematics as investment guidance is gradually winning over methods that rely purely on analysts' subjective opinions. A typical Chinese quantitative investment team is very much like the quant teams in the U.S. whose members are generally math-whizzes with an affection for partial differential equations.

The methods being used in China are similar to what are used in the West as well. The Chinese quantitative analysts are very well versed in dynamic derivative replication, volatility

CONTINUED ON PAGE 30

The Chinese derivatives market is dominated by individual investors.

projection, CPPI, etc. In fact, some of the funds being offered already incorporate synthetic options for downside protections.

However, all is not always smooth when East meets West. There are many challenges facing the application of derivatives for risk management purposes. To begin with, many of the underpinning assumptions for modern financial mathematics are not met in the current day Chinese market. For example, the general investor seems to exhibit risk-seeking as opposed to risk-averse behavior, and markets are not as efficient as the theoretical ideal calls for due to regulations. To apply what has been taken for granted in the West, the young Chinese quants have to resort to many, often "messy," adjustments.

There are also quite some differences in terms of the market's composition. One key characteristic of the Chinese derivatives market is that it is dominated by individual investors, whereas the derivatives market in the U.S. is dominated by institutional investors. Also, a market rally in the U.S. is usually preceded by a period of low volatility, whereas in China, a period of extraordinary high volatility is often a harbinger of a huge bull market which is unfolding in China today.

What have I learned from my brief trip to China? I have gained some ground zero experience for the roaring Chinese economy leading to its tremendous growth in the derivatives market. We, as investment actuaries, can indeed play a huge role in that market to manage life insurance company risks using derivatives. However, I feel the road to that success is bound to be rocky as we adapt the western quantitative investment theories and practices to the unique realities in China. ■

ENDNOTES

1 The CSI 300 is a capitalization-weighted stock market index designed to replicate the performance of 300 stocks traded in the Shanghai and Shenzhen stock exchanges. The index is compiled by the China Securities Index Company, Ltd.

2 The SSE Composite Index (Chinese: 上海证券交易所综合股价指, 简称上证综指) is a stock market index of all stocks (A shares and B shares) that are traded at the Shanghai Stock Exchange. The SSE 50 Index selects the 50 largest stocks of good liquidity and representativeness from the Shanghai security market by scientific and objective methods. The objective is to reflect the complete picture of those good quality large enterprises, which are most influential in the Shanghai security market. The index is compiled by the China Securities Index Company, Ltd.

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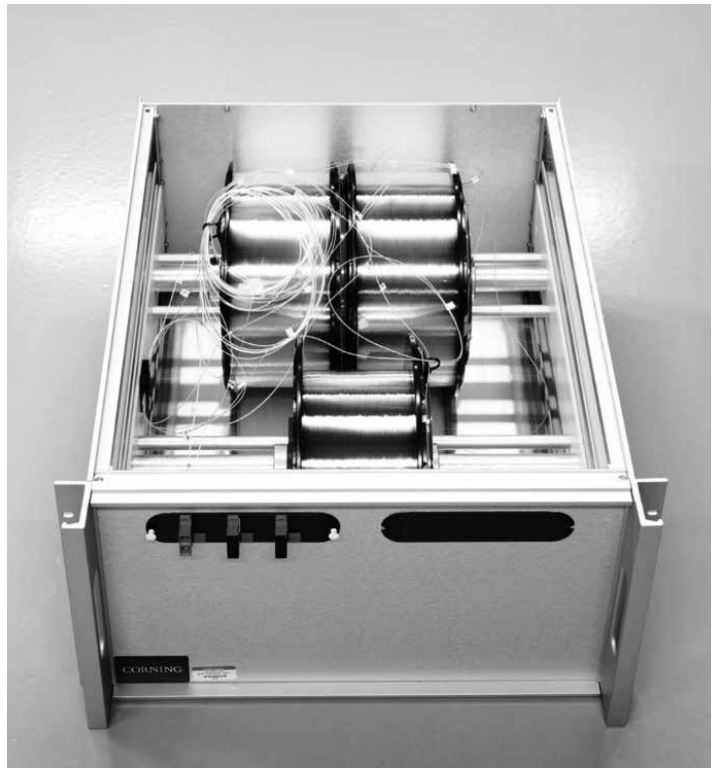
High Speed Refereeing—How IEX Put The Brakes On High Frequency Traders

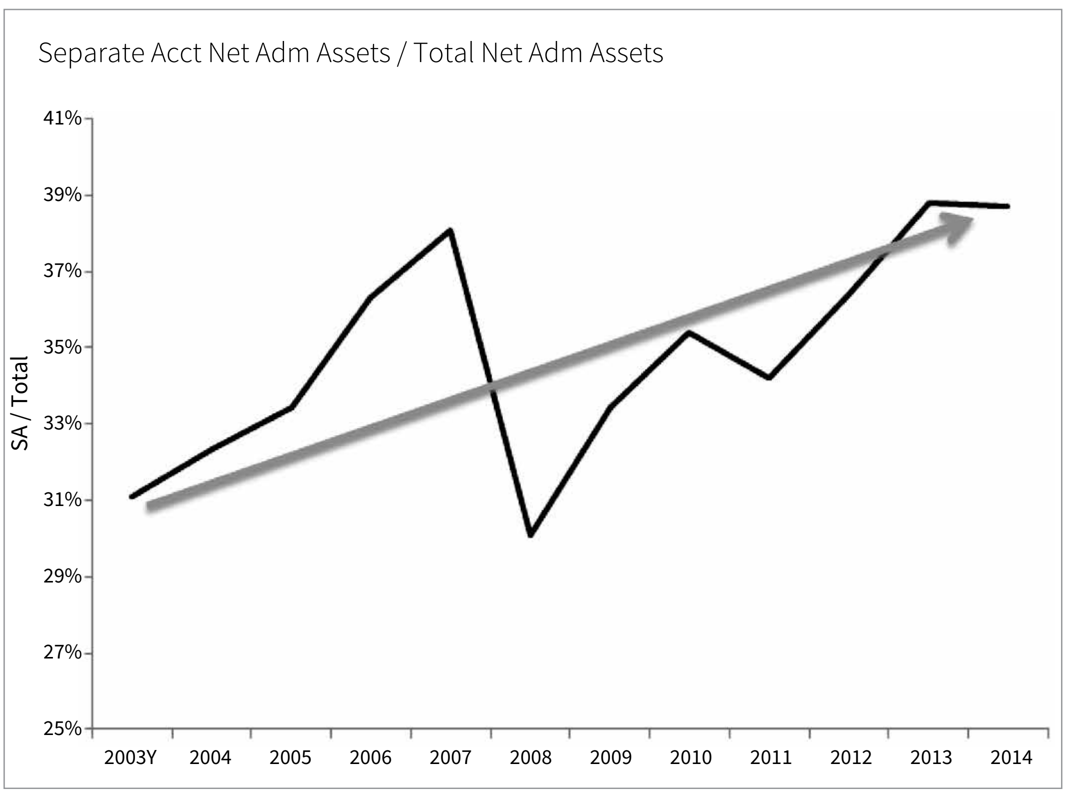
By Warren Manners



The SOA Investment Section had the privilege of sponsoring two sessions at this year's Life & Annuity Symposium: Session 33: "High Speed Refereeing," and Session 61: "Economic Scenario Generators: Risk-Neutral Applications in Life Insurance and Annuities." The focus of Session 33 was around so called "high frequency traders" and the influence they have had on equity markets, some of it good, some of it not so good.

The session presenter was Jay Fraser who is head of Business Development at IEX, an investor-owned equity trading platform created by Brad Katsuyama in December 2013. Brad is the main protagonist in Michael Lewis' latest Wall Street expose', "Flash Boys," and IEX was his brainchild in response to the market distortions created by high frequency trading (HFT) firms. The goal of IEX was to eliminate these distortions and bring fairness back into equity trading markets.

Jay began the session by pointing out that while equities make up less than 1 percent of general account assets for U.S. Life insurers, equity exposure through policyholder separate account assets has grown substantially over the last decade. Performance guarantees on these funds offered through Variable products (e.g., Variable Annuity GMWBs) has created material downside risk to shareholders. Any bias or friction in the equity market place that systematically erodes fund value for these policyholders also increases the cost to life insurers providing these guarantees.



Jay then walked the audience through the evolution and mechanics of the U.S. equity exchanges and how the introduction of electronic trading completely changed the landscape and heuristics of equity trading. HFT firms at the vanguard of this new universe were able to create value for investors by reducing transaction costs, but some (not all) were also guilty of rigging the system to be skewed in their favor. In many cases these firms were making money on all but a few days per year, and taking little to no risk, rarely if ever ending a day with an open equity position.

The most notorious transgression was something known as front-running whereby HFT firms would obtain trade data from one exchange, literally microseconds before the rest of the market, and then "front-run" via fiber optic cables to an alternate exchange and bid up the price before the rest of the trade arrived. This was done multiple times a day over thousands of trades. IEX's solution? Slow down the trades … everyone's trades … HFT firm or not. In essence, level the playing field so all traders were obtaining the same information at the same time. Jay then flashed a slide of the now-famous magic shoebox which is nothing more than a large spool of fiber optic cable over which all trades must travel before reaching the IEX exchange. This shoebox lengthens the amount of time a trade takes to reach the market, eliminating any advantage the HFT firms were exploiting.

The presentation ran for 45 minutes followed by a very interactive Q&A session that ran for 30 minutes, but could have run longer. The presentation was a refreshing change from the more traditional sessions and we expect more provocative offerings from IEX in the future. Look for Jay and his colleagues to present again in October at the 2015 SOA Annual Meeting in Austin, Texas. ■

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Liability Driven Investing Seminar Held In New York

SOA Investment Section Jointly Sponsors LDI Seminar in NYC with Quant Group

By Jeff Passmore

On February 23, the Investment Section jointly sponsored a seminar on Liability Driven Investing for pension plans with the New York Society of Quantitative Analysts (SQA). There were two formal presentations made to a group of around 50 people including seven actuaries.

Through our sponsorship of this seminar, the Investment Section was able to provide some useful information, provide professional development credits for attendees, and increase awareness of actuaries as professionals contributing to the body of investment knowledge. We were also able to network with an organization that has goals and interests that overlap with the Investment Section. Both groups considered the seminar a success.

The seminar included two presentations by two speakers. The SQA provided one speaker and the Investment Section provided the other.

Jeff Passmore presented for the Investment Council. Passmore's presentation was titled *"LDI from an Investment Actuarial Point of View."* It covered some LDI basics like the definition of financial risk in an LDI context, why LDI has become the predominant approach to corporate pension investing in the U.S. and how LDI glidepaths are used to de-risk pension plans.

It also included some new research done as part of an upcoming whitepaper that quantifies the sources of pension financial risk and shows how this can vary based on type of pension benefit. Finally, it concluded with a quantitative structure for analyzing pension risk budgets.

Prashant Lamba's presentation was titled, *"The 'I' of LDI: Ideas."* Prashant began with some discussion of pension risk asymmetry and how this affected plans sponsor risk appetite; he then showed a graphic representation of the relationship that exists between the pension fund and the plan sponsor and the impact of this relationship on the sponsor's cash flow statement, income statement and balance sheet. He then presented a sample pension plan and showed how the asset allocation and risk metrics would change as the plan became better funded and began to reduce risk. He finished with a discussion of how derivatives can be used in

Passmore describes de-risking using glidepaths.

What is the SQA?

The Society of Quantitative Analysts (SQA) is a not-for-profit organization based in New York City that focuses on education and communication to support members of the quantitative investment practitioner community. The SQA was founded in 1972 and continues to be a pioneer in the use of quantitative investment techniques. SQA membership spans the United States and numbers more than 250 individuals.

The principal mission of the SQA is to encourage the dissemination and discussion of leading-edge ideas and innovations related to the work of the quantitatively-oriented investment professional, including analytical techniques and technologies for investment research and management. These include:

- Practical applications by investment practitioners;
- Academic presentations of theories in finance and economics;
- Concepts from other disciplines that might provide inspiration to the investment practitioner; and
- Regulatory issues that can impact investment practice. ■

pension plans to improve risk/reward trade-offs.

The audience was very engaged during both presentations, asking several detailed questions about the analyses presented and suggesting alternative approaches.

There was time reserved for networking before the presentations began and again once the presentations had been completed. During the networking time, the groups mingled easily and the questions and answers continued informally during the post-presentation networking.

Special thanks go to Tom Egan the treasurer of the Investment Section Council for attending the seminar, helping with logistics associated with the professional development credits and asking some good questions.

Lamba illustrates pension risk asymmetry.

Networking before and after the presentations permitted the actuaries and quants a chance to get to know each other and permitted time for informal follow-up.

The Investment Section is currently planning a similar seminar in Toronto. This Canadian LDI seminar will be jointly sponsored with the CFA Society of Toronto. Details will be provided once logistics have been confirmed.

We are also looking for other opportunities to partner with groups who have professional interests that are well aligned with those of the Investment Section and in venues that offer the opportunity to participate for a significant number of Investment Section members. If you have suggestions, please forward them to David Schraub at *dschraub@soa.org*. ■

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What Else Makes an Economic Scenario Generator "Realistic"?

By Jon Mossman

In his article in the August 2014 issue of Risk and Rewards, Bahram Mirzai covered two risk factors modeled in economic scenario generation that are intended to produce realistic (real-world) distributions: specifically equity returns and risk-free interest rates. This article expands on Mirzai's comments around non-normal distributions as well as factors to consider when modeling credit spreads, inflation and exchange rate risks.

In his discussion of equity modelling, Mirzai states, "the choice of stochastic residual distribution must account for the observed tails of returns for both market booms and market crashes." While it is true that the non-normal distribution of equity returns can be captured by using non-normal residuals, there are other methods that could also be used. A well-known regime switching log-normal model developed by Dr. Mary Hardy at the University of Waterloo is available for research purposes on the Society of Actuaries website. More complex models that use a combination of log-normal residuals plus discrete, asymmetric jumps have been developed as well. These models are also able to capture the fat-tails of equity return distributions.

Credit ratings communicate the level of credit risk inherent in a debt security and are issued by several credit rating agencies. Credit spreads correspond closely with these credit ratings and measure the additional yield an investor receives for the additional risk of purchasing a fixed income security from an issuer who is not risk-free. Similar to risk-free rates, spreads have a term structure that varies by maturity. A realistic economic scenario generator (ESG) should capture different levels of credit risk as well as the term structure of the spreads. Using a simplified distribution of credit ratings, an ESG might rank different securities, from AAA, AA, A, continuing to CCC, with seven distinct credit ratings, where AAA is the best rated (least risky) and has the lowest spread and CCC has much more credit risk and very high credit spreads. The model might capture the entire term structure of spreads or should at least reflect the risk difference between short and long maturities which can be very significant.

Because companies evolve over time, corporate bond ratings can and do change which has a significant impact on the price of the bond. The probabilities of securities being upgraded or downgraded or even defaulting can be measured over time and summarized in a "transition matrix." A realistic ESG should also capture this possibility of upgrade, downgrade and default and reflect these transitions on the bond's return. An even more sophisticated model would coherently incorporate both stochastic credit spreads and stochastic transition and default probabilities, with the spreads and the probabilities reflecting the inherent level of risk of each scenario at each point in time. For example, in a complex model, a scenario where credit spreads are well above their historical average would also have higher than average probabilities of downgrade and default. Finally, consideration should be given to the relationship between credit markets and equity markets; a negative jump in equity returns (a market correction) as described above would realistically translate into a spike in credit spreads.

When modelling realized price inflation in an ESG, it is important to capture real-world dynamics. It is particularly important for asset-liability modelling where liabilities are linked to inflation, as in the case of auto insurance claims or pension benefits with cost of living adjustments. Price inflation and short-term interest rates are highly dependent because in most developed economies, the central bank will use short-term rates as a lever to target price inflation or keep it within a desired range. This interdependence could be modelled using a correlation factor, or a stricter relationship could be captured by directly linking these two series within the model in a cascade approach (where the output from one model becomes input, or cascades into a second model). In addition to this relationship, other key factors need to be considered in a real world inflation model. For instance, experienced inflation can be negative even if this does not happen frequently and typically it does not remain negative for an extended period of time. Also, since inflation can historically be observed as having different regimes, for example a normal regime and a hyperinflation regime, these variations could be captured using a regime shifting model where the probability of switching between regimes is a model input. Finally, because central banks tend to have an inflation target, it makes sense to use an inflation model that reverts over time, on average, to this target, known as a mean reverting model.

Most asset-liability models will need to reflect credit spreads and inflation and … exchange rate risks.

It should be noted that the above is referring to experienced inflation, such as CPI or the increases observed on a basket of goods. This contrasts with the forward looking "break-even" inflation defined as the market observable difference between the yield on nominal bond and the yield on an inflation linked bond of the same maturity. Break-even inflation would have a different set of dynamics.

As for the modelling of exchange rate risk, there are two important economic theories that need to be considered. Purchasing Power Parity (PPP) states that have an identical good in two countries should have the same price when expressed in the same currency. While reflecting perfect PPP in an ESG would not be considered realistic, historical exchange rates display weak to moderate PPP and an ESG should capture this. As discussed above, a realistic projection of nation-specific inflation should revert to the central bank's inflation target for each country being modelled. Since each country's central bank will likely have a different inflation target, exchange rate projections would exhibit a trend due to the difference in inflation targets and the effect these different levels of inflation will have on relative prices for goods between the two countries. The second economic theory to consider in exchange rate modelling is Interest Rate Parity which states that the differential in the risk-free rate between two countries will be equal to the difference in the forward exchange rate and the spot exchange rate. Interest Rate Parity is more important in short term exchange rate projections because if it does not hold, an immediate arbitrage opportunity exists. Of course the assumption must be made that the countries for which the exchange rates are being modelled actually have risk-free rates.

The goal of a real-world economic scenario generator is to capture realistic distributions of various risk factors as well as interrelationships between these factors. While no model can perfectly capture all risk factors and dependencies, most asset-liability models will need to reflect credit spreads and inflation and may also need to capture exchange rate risks. This paper was intended to outline some considerations when developing or reviewing an economic scenario generator that will provide input into an asset-liability model. ■

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The 2015 Investment Section Asset Allocation Contest is On!

By George Eknaian

The 2015 version of the Asset Allocation Contest for Section members began in earnest in April. The contest covers the six month period from April 1 to September 30. Participants needed to choose an initial allocation among 10 exchange traded funds which represented a broad range of asset classes, including equities, fixed income, real estate, and commodities. In a twist to this year's contest, participants also had to choose whether to automatically rebalance to their initial allocation on a monthly basis, or to deterministically change their asset allocation at two time steps during the contest—June 30 and July 31. As in past years, prizes will be awarded for highest return, lowest risk measured by annualized standard deviation, and best return-to-risk ratio. Tie-breakers for each prize will be determined on how well the participants predicted what their returns and risk would actually be (how could we have a contest with actuaries without asking for predictions?).

Just fewer than 100 folks are participating in this year's contest. There are some interesting results when reviewing the submissions:

1. 30 percent of the participants chose only one ETF, which may make predictions very important for determining the prize winner. The most popular single asset choice was U.S. equities, followed by commodities;
2. 22 percent of the participants chose five or more ETFs—some differing views on the benefits (or lack thereof) of diversifying asset classes; and
3. 70 percent of the participants chose to manually make a decision to reallocate, rather than automatically rebalance. It will be interesting to test whether automatic rebalancing is a help or a hurt during this time period.

Through the end of May, the name of the game is volatility. Emerging markets and commodities both experienced great Aprils and poor Mays. Commodities and international equities are just about the same in overall performance over the time period. It will be interesting to follow as the summer unfolds.

Prizes will be awarded at the Annual Meeting, so stay tuned and good luck to those that are participating! ■

George Eknaian, FSA, CERA, MAAA, the section vice chairperson, is a consulting actuary with experience in all sectors of the life insurance business. He may be reached at *george.eknaian@comcast.net*

Inflation vs. Deflation (U.S. vs. Europe/Japan)

By Allan Levin

As part of this year's investment symposium, I spoke at a session: "Inflation vs. Deflation (U.S. vs. Europe/Japan)" which centered on whether the recent short-term drop in oil prices and USD strength is only temporarily preventing U.S. inflation from rising, or if Europe and Japan could instead drag the U.S. into a deflationary spiral.

I was very fortunate to be joined by two esteemed speakers from Vanguard: Senior Portfolio Manager, Gemma Wright-Casparius, and Investment Analyst and Strategist, Andrew Patterson. I thought that it might be of interest to report on some of the key items mentioned as well as my conclusions based on the discussion.

GLOBAL ECONOMY

Over the last few decades, global economies have become more integrated, and central banks more consistent in their actions—accordingly, there has been a long-term convergence of global inflation rates—for the most part, lower. However, in efforts to drive inflation and inflation expectations nearer their stated targets, global monetary policies in developed markets are beginning to diverge. In the current environment, disinflation and deflation remain global risks, but more so in those regions that have implemented more aggressive easing measures, namely Japan and the EuroZone.

Even within the EU, the North is experiencing higher core inflation than Southern Europe—a reflection of their relative economic performance and a likely by-product of aggressive internal devaluations (austerity and structural policies) in the south. In the United States and Britain, the time for beginning to once again raise policy rates is approaching.

Recent comparisons between different economies has been distorted by the recent drop in oil prices. Core inflation, which strips out energy and food prices, has been more consistent globally. More importantly, the oil price drop is likely a net positive for the world—and the resultant economic stimulation could ultimately spur wage inflation.

The overall conclusion was that the recovering U.S. economy will create wage pressures, and thus higher inflation in due course. This is less clearly the case in Europe, where the recovering is being slowed due to sovereign crises in the southern countries; and Japan where the verdict is still out on whether Abenomics is going to succeed.

INFLATION MARKETS

Global inflation-linked bond issuance continues to grow, in both developed and emerging economies—with the U.S. being the largest market. In addition, there is an active market in Inflation derivatives—which tends to use the same measure of CPI as the corresponding bond markets.

However, when comparing countries, it is important to factor in differences in both weightings and seasonal patterns of domestic consumer inflation.

It should be noted that asset performance depends on both inflation and real growth.

While investors often assume the market-implied expected inflation level as the inflation rate of indifference between Nominal and Real rate (e.g., Treasury Yield less Real Yield of similar maturity TIPS issue), known as the breakeven Inflation rate. The reality is that this measure also encompasses an inflation risk premium and a liquidity premium. It tends to be difficult to disentangle these factors in day-to-day market moves.

Nevertheless, the key market drivers are:

- Macroeconomic events;
- Monetary policy;
- Actual inflation (i.e., wages); and
- Unanticipated changes to inflation expectations (due to commodities, currency exchange rates, shifts in risky assets, Fed balance sheet, reported inflation surprises).

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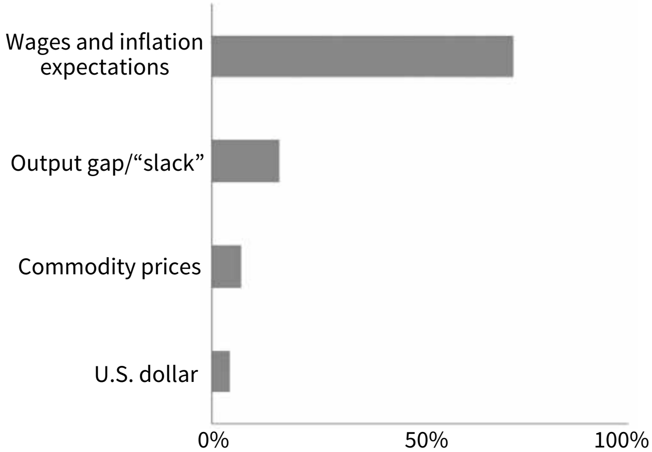
Secular Shift

Real Growth	Low/Falling	High/Rising
High/Rising	Best: Stocks Mixed: Commodities and nominal bonds Worst: TIPS	Best: Commodities Mixed: Stocks and TIPS Worst: Nominal bonds
Low/Falling	Best: Nominal bonds Mixed: Stocks and TIPS Worst: Commodities	Best: TIPS Mixed: Commodities and nominal bonds Worst: Stocks

Source: PIMCO Institute, Presentation on "An introduction to Inflation-Related Investing" by Bob Greer, September 24, 2010

Decomposition of variance of U.S. core inflation, 1983-2013



Note: Chart based on inflation-variance decomposition described in Vanguard research (Davis, 2007).

Sources: Vanguard, based on data from U.S. Bureau of Labor Statistics, Federal Reserve Board, Bridge/Commodity Research Bureau, and Federal Reserve Bank of Philadelphia.

Breakeven Inflation is cyclic, and we should anticipated an upward move in a growing economy.

Financial markets are increasingly interconnected, and global capital flows are strengthening correlations. Notwithstanding this, ultimately inflation-linked bond markets reflect domestic economies.

PARTICIPATION BY INSURANCE COMPANIES AND PENSION FUNDS

Insurance companies and Pension funds are large players in the inflation market—either for purposes of asset-liability management, or to benefit from diversification.

There are annuity and long-term care products that have payments directly linked to CPI. In addition, P&C policy claims inflation has been highly correlated with large moves in CPI. As a result, not only have insurance companies invested in Iinflation-linked bonds, but there are examples of large hedging programs using inflation derivatives—both inflation swaps, and inflation options.

On an absolute basis, the U.S. is the largest inflation-linked market; however, countries like the U.K. and Canada, have much longer average durations of outstanding bonds—this reflects even stronger participation by pension funds in these markets on a relative basis. Often the participation is influenced by regulations and taxes. This is true for a number of countries in continental Europe as well, such as the Netherlands and in Scandinavia. In Japan, the issuance of inflation-linked bonds initially faltered due to a lack of protection against deflation in the design of these securities. However, more recent inflation-linked bonds have incorporated a deflation floor, and there has been much greater participation in these issues.

IN CONCLUSION

The underlying U.S. economic recovery has not yet been reflected in reported inflation due to the drop in oil prices, U.S. dollar strength, and remaining slack in the labor market. However, all of these factors should pass, and we may witness wage inflation that will translate into increases in consumer prices. This will further translate into higher market inflation expectations as reflected in breakeven inflation; as well as greater demand for inflation protection, including within insurance contracts and retirement savings.

The session presentations are available on the conference website (investmentsymposium.org). If you have any questions or thoughts, please feel free to contact me. ■

Allan Levin, FSA, CFA, FRM is a senior financial services executive who specializes in the intersection between banking and insurance, including inflation markets, derivatives, structured index development and ETFs. He can be reached at *(allan.levin@gmail.com).*

RISKS & REWARDS CROSSWORD PUZZLE

Never Underestimate the Power of Inertia

By Warren Manners

This issue's crossword puzzle contains circled letters that, when read in a clockwise direction, spells out the name of the person quoted in the puzzle title. The solution to this issue's puzzle will be provided in the next issue of Risks & Rewards along with the names of those who were able to complete the puzzle. Submissions should be made to warren_manners@swissre.com by Nov. 30, 2015. For submissions are received before the posted dedline and 100 percent correct, a winner will be selected at random and awarded a $25 Amazon gift certificate. The solution to last issue's puzzle can be found below along with the names of those who were able to successfully complete it. ■

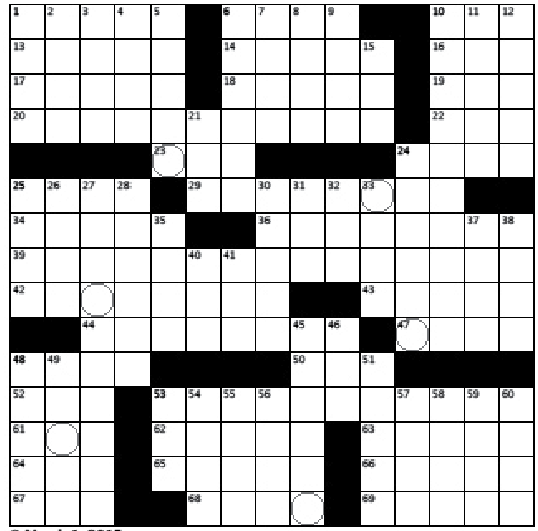
100% perfect: N/A
Nearly perfect: Bob Lemke

SOLUTION TO THE MARCH CROSSWORD PUZZLE

H	O	P	E	S		R	A	V	E	L		R	I	M
A	R	O	M	A		E	M	O	T	E		A	R	I
T	R	A	M	P		C	A	U	C	A	S	I	A	N
			Y	O	U	T	H	S			A	N	N	E
S	S	W		T	P	A		S	M	O	G			
N	E	A	R	E	R		S	O	A	R		M	A	S
O	S	L	O				A	I	R	C	R	A	F	T
B	E	R	M	U	D	A	T	R	I	A	N	G	L	E
B	L	U	S	T	E	R	Y				A	N	O	A
Y	I	S		A	C	E	R		C	A	S	U	A	L
			C	H	O	C		A	P	R		M	T	S
A	F	R	O			A	E	R	I	E	S			
Q	U	A	N	T	O	N	G	S		N	O	R	T	H
U	N	I		Y	O	U	G	O		A	M	U	S	E
A	D	D		R	A	T	O	N		S	E	E	K	S

ACROSS
1. Crinkly fabric
6. See 53 across
10. Easy as 1, 2, 3
13. Purplish
14. Lower deck
16. Big cheese
17. Internet letters
18. Natural cleaner
19. River west of University of Cambridge
20. With 10 down, elementary bookkeeping?
22. Self starter
23. Norse god of war
24. Relish
25. 4th and 6th in scale
29. >
34. "What ____ am I!": Hamlet
36. Disquiet
39. Ranch hand conduct?
42. Drum site
43. With 11 down, fiber-rich side dish
44. Abalone
47. "It's _____"; a lot of fun
48. Diagram used in many presentations
50. Corrode
52. Business mag
53. With 6 across, backing someone who knew it all along?
61. I. M. _____
62. Jerry MaGuire
63. Bathsheba's husband
64. Ratite
65. Russian novelist Maxim
66. Thingy
67. Butt
68. Signet
69. Fall flower

DOWN
1. G or F
2. N. Z. tree
3. Panache
4. Made square
5. Panache
6. Latin dance
7. Ore lead
8. Graham's number
9. Kind of bed
10. See 20 across
11. See 43 across
12. Rosetta's mission
15. Friend
21. Manga mag
24. Riga's country
25. Clock part
26. Wild ox
27. Synthetic chemical element with atomic number 103
28. Depth charge, slangily
30. 100 kopeks
31. Organic chemistry suffix
32. ACTH relative
33. Homonym with surname of 63 across
35. Cauterize
37. Samll Indian water pot
38. Greek Cupid
40. ER figures
41. Doo-_____
45. Soup seed
46. Kid
48. Sporty Dodge
49. Inside job?
51. Conifer tree
53. Tote
54. Vanity cases?
55. "Present" for the teacher
56. "_____ dinka doo", Durante song
57. See-through item
58. Crux
59. Harness part
60. Younger brother of 23 across



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