Valuation, hedging and demand for ruin-contingent life annuities (RCLA)

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Joint work with M.A. Milevsky, H. Huang

September 10, 2009
AFIR colloquium, Munich
## Pensions Plans in Canada:
The Trend is Clear…

<table>
<thead>
<tr>
<th>% of Total Plans</th>
<th>Yr 2000</th>
<th>Yr 2007</th>
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<tr>
<td>Defined Benefit</td>
<td>53%</td>
<td></td>
</tr>
<tr>
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<td>22%</td>
<td></td>
</tr>
<tr>
<td>Hybrid, Flex &amp; other…</td>
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*Source: Towers Perrin Benefits Data Bank (BDB)*
Pensions Plans in Canada: The Trend is Clear…

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</tr>
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Source: Towers Perrin Benefits Data Bank (BDB)
Context

- Pension plan conversions from DB to DC mean that individuals shoulder more of the burden of ensuring sustainable income in retirement.
- Individuals must manage and understand their risks themselves.
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- Pension plan conversions from DB to DC mean that individuals shoulder more of the burden of ensuring sustainable income in retirement.
- Individuals must manage and understand their risks themselves.
- Longevity risk is critical, especially with declining mortality and a trend to early retirement. Retirement can last 25 or 35 years. There may be significant risk of outliving your money (due to long life or substandard returns).
Average Age of Retirement in Canada

# 5-Year Relative Survival Rates

<table>
<thead>
<tr>
<th>Year</th>
<th>All Cancers</th>
<th>Prostate Cancer</th>
<th>Female Breast Cancer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>50.0%</td>
<td>70.0%</td>
<td>75.2%</td>
</tr>
<tr>
<td>1987</td>
<td>55.6%</td>
<td>81.1%</td>
<td>83.3%</td>
</tr>
<tr>
<td>1997</td>
<td>64.7%</td>
<td>99.7%</td>
<td>88.4%</td>
</tr>
</tbody>
</table>

Source SEER Program, National Cancer Institute; Reported in National Underwriter, July 31, 2006
Heart disease deaths plummet ahead of 2010 goal

Mortality rates fall 25.8% in six years

By Steve Sternberg
USA TODAY

Heart disease deaths in the USA have fallen below the American Heart Association’s prevention goal for 2010, and deaths from strokes are nearing their own record low, the AHA said Tuesday.

But epidemics of diabetes, obesity and inactivity, along with widespread racial, economic and geographic differences in access to care, threaten those gains, AHA President Daniel Jones warns.

"Unless we can find a new strategy to stem diabetes and obesity, we can anticipate a new wave of cardiovascular disease deaths," Jones says. He notes that heart disease is still the nation's leading killer, and stroke ranks third.

New government data show that heart disease death rates dropped 25.8% between 1999 and 2005, from 195 to 144 deaths for every 100,000 people, surpassing the AHA’s 25% target reduction. Stroke deaths dropped 24.4%, from 61 to 47 deaths per 100,000.

That adds up to roughly 160,000 lives saved in 2005, Jones says. If the trend holds, the AHA projects that as many as 240,000 lives may be saved this year.

The analysis of data released by the National Center for Health Statistics doesn’t explain why death rates continue to fall. Studies suggest people are eating better, smoking less and getting better medical care than Americans of previous generations, says Paul Ridker of Brigham and Women’s Hospital in Boston. Ridker says improved methods of preventing and treating cardiovascular disease have paid off.

"Not only have they reduced the number of events, but when events occur, we’re more likely to survive them," he says.

These advances didn’t benefit everyone, AHA notes. The death rate for blacks dropped by 23.8%, compared with 25.6% for whites.

"While overall statistics look better for the U.S. as a whole," Ridker says, "a major portion of our population is not benefiting from this shift."

Heart disease death rates fell among women by 26.9%, and stroke deaths among women were down 23.7%.

Signs of trouble loom on the horizon, among them twin epidemics of diabetes and obesity in young people, says Daniel Levy of the National Heart, Lung, and Blood Institute’s Framingham study, a 50-year-old examination of heart disease in a Massachusetts community.

"We haven’t yet paid the full price in heart disease and stroke deaths for the obesity epidemic in our children that began 25 years ago," he says.
Traditional retirement savings vehicles

▶ SWiP (*systematic withdrawal plan*): Portfolio of investments, from which you withdraw to fund consumption. Carries market risk, longevity risk. But retains upside potential and preserves capital (eg bequest)
Traditional retirement savings vehicles

- **SWiP (systematic withdrawal plan):**
  Portfolio of investments, from which you withdraw to fund consumption.
  Carries market risk, longevity risk. But retains upside potential and preserves capital (e.g., bequest).

- **LPIA (Lifetime payout income annuity)**
  Risk: No growth, loss of capital, no bequest.
  But fully hedges longevity risk, and earns significant mortality premiums. A perfect product if all you care about is sustainable income in retirement.
The Annuity Market is “thin”…

“…It is a well known fact that annuity contracts, other than in the form of group insurance through pension systems are extremely rare…It is still ill-understood…”

Franco Modigliani,
December 1985, Stockholm
Guaranteed Living Benefits (GLiB: GMIB, GMLB, ..)

- Financial innovation to provide income protection while preserving some liquidity and upside potential.
- In the U.S. variable annuities are tax-sheltered retirement savings plans, and represent substantial face value and a respectable portion of the retirement savings market.
- Popular in the US, Japan, UK. Now sold in Canada. In 1 year, after launching in October 2006, Manulife’s Income Plus generated over $2B in sales (a huge amount in the small Canadian market).
- Current downturn ⇒ guarantees are now in the money: Good for clients (as long as the vendors remain solvent)
Sales of Annuities in Year 2007: approximately $220 Billion U.S.D.

Source: National Underwriter (16 March 2008)
<table>
<thead>
<tr>
<th>Insurer</th>
<th>New Sales (2006)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIAA-CREF</td>
<td>$13.8 B.</td>
</tr>
<tr>
<td>MetLife Co.</td>
<td>$13.4 B.</td>
</tr>
<tr>
<td>AXA Financial</td>
<td>$12.9 B.</td>
</tr>
<tr>
<td>Hartford Life Co.</td>
<td>$12.2 B.</td>
</tr>
<tr>
<td>Lincoln National</td>
<td>$10.3 B.</td>
</tr>
<tr>
<td>Prudential / Allstate</td>
<td>$10.2 B.</td>
</tr>
<tr>
<td>Pacific Life</td>
<td>$9.5 B.</td>
</tr>
<tr>
<td>RiverSource</td>
<td>$9.4 B.</td>
</tr>
<tr>
<td>John Hancock Life</td>
<td>$9.1 B.</td>
</tr>
<tr>
<td>AIG / SunAmerica</td>
<td>$8.8 B.</td>
</tr>
</tbody>
</table>

Source: National Underwriter
US: GLiB Sales in 2007

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>New deferred variable annuity (VA) sales:</td>
<td>$141.3 b</td>
</tr>
<tr>
<td>% of sold VA contracts that <em>offer</em> a GLiB rider:</td>
<td>91% or $128.4 b</td>
</tr>
<tr>
<td>% of sold VA contracts with a <em>elected</em> GLiB rider:</td>
<td>77% or $98.8 b</td>
</tr>
</tbody>
</table>

Source: LIMRA int'l; reported by National Underwriter, April 7, 2008
# The Galaxy of Annuity Riders

<table>
<thead>
<tr>
<th>What is it Called?</th>
<th>Clunky Acronym</th>
<th>What Exactly Does it Do?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income Benefit</td>
<td><strong>GMIB</strong></td>
<td>Provides the ability to convert the “best” or “most favorable” policy value into lifetime income at a guaranteed rate by annuitizing</td>
</tr>
<tr>
<td>Withdrawal Benefit</td>
<td><strong>GLWB</strong></td>
<td>Allows for a systematic withdrawal plan that guarantees a minimal income for a fixed period of time (e.g. 10 to 25 years) or in some case, for life</td>
</tr>
<tr>
<td>Accumulation Benefit</td>
<td><strong>GMAB</strong></td>
<td>Guarantees to return “at least” your entire original investment back, if not more, at some predetermined horizon (e.g. 10 years) or age.</td>
</tr>
<tr>
<td>Longevity Benefit</td>
<td><strong>ALDA</strong></td>
<td>Provides lifetime income that starts at advanced ages (e.g. 85) in exchange for a small insurance premium that you pay up-front or over time</td>
</tr>
</tbody>
</table>

Source: Moshe Milevsky and The IFID Centre, 2008
GLiB Elected in 2007 (U.S.)

Source: LIMRA int'l; reported by National Underwriter, April 7, 2008
Guaranteed Minimum Lifetime Benefit: An insurance rider within a variable annuity (US)
GMLB = SWiP + income guarantee:
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▶ While account value > 0 you can continue to withdraw, close out account and draw capital out, pass it on at death, etc.
▶ But if systematic withdrawals drive account to = 0 then the insurance company steps in and funds those “withdrawals” for life.
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- While account value > 0 you can continue to withdraw, close out account and draw capital out, pass it on at death, etc.
- But if systematic withdrawals drive account to = 0 then the insurance company steps in and funds those “withdrawals” for life.
- Pay for the guarantee through periodic management fees, usually as a yearly percentage of guaranteed base.
Basic question today

- How much does the guarantee cost to hedge, when markets are complete?
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- We call the embedded option an RCLA (ruin contingent life annuity). Acts as an insurance policy on your SWiP: if it gets ruined, the RCLA kicks in and pays you for life.
- Not sold this way (yet), but we think it should be.
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  Acts as an insurance policy on your SWiP: if it gets ruined, the RCLA kicks in and pays you for life.
- Not sold this way (yet), but we think it should be.
- Question: What would it cost to buy this up front? (rather than by installments @ 80 b.p. per year)
Put another way: stand-alone portfolio insurance

- GLiB offers longevity insurance for portfolios.
Put another way: stand-alone portfolio insurance

- GLiB offers longevity insurance for portfolios.
- Why can’t we buy the insurance without also having to buy asset management?
- Instead, why not manage your own assets as a SWiP, but also insure against the crash of some generic portfolio with specified withdrawals.

See Huang, Milevsky, Salisbury, J. Wealth Man. (2009)
Put another way: stand-alone portfolio insurance

- GLiB offers longevity insurance for portfolios.
- Why can’t we buy the insurance without also having to buy asset management?
- Instead, why not manage your own assets as a SWiP, but also insure against the crash of some generic portfolio with specified withdrawals.
- Pays off if 2 things happen – long life, sustained bear market.
- See Huang, Milevsky, Salisbury, *J. Wealth Man.* (2009)
We insure an account $W_t$ invested in a mutual fund $S_t$ with initial $W_0 = 100$.

Simplest dynamics: continuous withdrawals as a simple proportion $g$ of the initial investment. So

$$dS_t = \mu S_t \, dt + \sigma S_t \, dB_t$$

and

$$dW_t = [\mu W_t - gW_0] \, dt + \sigma W_t \, dB_t.$$
Simple RCLA Model

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  \]

- But this type of GMLB induces people to lapse (reset the guarantee) when the account value gets high relative to the guaranteed amount.

RCLA Model with stepup

- So GMLB’s usually are sold with a *ratchet* or *stepup* provision. That is the version of an RCLA that we analyze. This allows consumption to increase if markets do well, and builds in a level of protection against inflation.
RCLA Model with stepup

- So GMLB’s usually are sold with a ratchet or stepup provision. That is the version of an RCLA that we analyze. This allows consumption to increase if markets do well, and builds in a level of protection against inflation.
- Let $M_t = \max_{s \leq t} W_s$. Continuous withdrawals are taken as a fixed proportion of $M_t$. 
  
  \[
  dW_t = [\mu W_t - gM_t] \, dt + \sigma W_t \, dB_t.
  \]
  
  (And as before, $dS_t = \mu S_t \, dt + \sigma S_t \, dB_t$ and $dR_t = rR_t \, dt$)
- Ruin time $R = \text{first time } W_t \text{ hits 0}$. RCLA pays $gM_R \, dt$ from time $R$ till death at time $\tau$. 

We diversify mortality risk by selling a very large number $N$ of accounts, with independent $\tau$’s. By LOLN, total cash flow = \( \int_{\tau}^{\infty} Np_t \times gM_t \, dt \) where \( p_t = \) (real) survival probability.
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So the cash flow per account is = \( \int_R^\infty p_t gM_t \, dt \) . The same procedure as before shows that if \( V_t \) is the hedging portfolio per account, then

\[
dV_t = rV_t \, dt + dU_t - 1_{\{t > R\}} p_t gM_t \, dt
\]

where \( U_t \) is a \( Q \)-martingale.

And \( V_0 \) can be found as a risk-neutral expectation: \( V_0 = E_Q[\int_0^\infty e^{-rt} 1_{\{t > R\}} p_t gM_t \, dt] \).
Variable reduction

- A scaling argument shows that we can write $V_t = M_t u(t, Y_t)$ where $Y_t = W_t / M_t$ is the moneyness of the account.

- Then $0 \leq Y_t \leq 1$, and in fact
  
  \[ dY_t = (r Y_t - g) dt + \sigma Y_t \, d\tilde{B}_t - dL_t, \]

  where $L_t$ is the local time of $Y$ at 1. Also get $dM_t = M_t \, dL_t$.

- Ito’s lemma gives an expression of the form
  
  \[ dM_t u(t, Y_t) = \text{drift} \, dt + \text{vol} \, d\tilde{B}_t + \text{refl’n} \, dL_t. \]

  Now compare with the expression for $dV_t$ and equate terms.
Matching the $dt$ terms gives a PDE:
\[ u_t + (ry - g)u_y + \frac{1}{2}\sigma^2 y^2 u_{yy} - ru = 0. \]
Matching the $dL_t$ terms gives a boundary condition
\[ u(t, 1) = u_y(t, 1). \]
When $Y_t$ hits 0, we basically have a LPIA.
Or matching coefficients, as above, an ODE $v_t = rv - gp_t$.
Solving yields a boundary condition
\[ u(t, 0) = g \int_t^\infty e^{-r(s-t)} p_s \, ds. \]
Now solve numerically for $V_0 = W_0 u(0, 1)$. 
<table>
<thead>
<tr>
<th>Initial age</th>
<th>Initial spending rate</th>
<th>$r = 3.0%$</th>
<th>$r = 5.0%$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age = 57</td>
<td>$g = 10.0%$</td>
<td>$102.03$</td>
<td>$66.80$</td>
</tr>
<tr>
<td></td>
<td>$g = 7.0%$</td>
<td>$54.03$</td>
<td>$31.26$</td>
</tr>
<tr>
<td></td>
<td>$g = 5.5%$</td>
<td>$32.12$</td>
<td>$16.42$</td>
</tr>
<tr>
<td></td>
<td>$g = 4.0%$</td>
<td>$13.98$</td>
<td>$5.77$</td>
</tr>
<tr>
<td>Age = 65</td>
<td>$g = 10.0%$</td>
<td>$66.98$</td>
<td>$44.76$</td>
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<tr>
<td></td>
<td>$g = 7.0%$</td>
<td>$31.67$</td>
<td>$18.34$</td>
</tr>
<tr>
<td></td>
<td>$g = 5.5%$</td>
<td>$16.99$</td>
<td>$8.58$</td>
</tr>
<tr>
<td></td>
<td>$g = 4.0%$</td>
<td>$6.30$</td>
<td>$2.54$</td>
</tr>
<tr>
<td>Age = 75</td>
<td>$g = 10.0%$</td>
<td>$28.58$</td>
<td>$19.17$</td>
</tr>
<tr>
<td></td>
<td>$g = 7.0%$</td>
<td>$10.66$</td>
<td>$6.02$</td>
</tr>
<tr>
<td></td>
<td>$g = 5.5%$</td>
<td>$4.70$</td>
<td>$2.28$</td>
</tr>
<tr>
<td></td>
<td>$g = 4.0%$</td>
<td>$1.30$</td>
<td>$0.50$</td>
</tr>
</tbody>
</table>
hedging cost of a one-time premium RCLA.

RCLA insures a SWiP account with initial deposit $100, invested in a medium volatility mutual fund ($\sigma = 17\%$ volatility).

Withdrawals occur continuously at an annual rate of $g\%$ of the maximum observed account value.

Mortality is assumed Gompertz with parameters $\lambda = 0$, $m = 86.3$ and $b = 9.5$.

Mean remaining life is 25.0 years (age 57), 18.4 years (age 65), 11.1 years (age 90)
Conclusions

- At high withdrawal rates, these products are prohibitively expensive to hedge.
- At lower withdrawal rates, costs are not as extreme, particularly when sold to older individuals.
- Current GMLB’s are financed through periodic fees (80 basis points per year is typical). Hedging costs can be worked out in that context too, but the up-front RCLA charge is particularly instructive. In neither case does the actual charge come close to what is required for hedging.
- The model is idealized, but note that more realistic assumptions (e.g., stochastic volatility) should increase costs.
Lapsation

- Low fees are driven by generous assumptions about clients lapsing before the guarantees come into effect.
- It remains to be seen if clients will behave more rationally during the current downturn, and hold onto their (valuable) guarantees. If so, underwriters will have serious liabilities to contend with. Already, many North American insurers have substantially increased cash reserves because of marking to market inadequate hedges for these products. Have seen no insolvency problems yet, but firms are phasing out expensive features and raising fees.
- This point was made back in 2005 (Milevsky, Salisbury IME 2006), and picked up in a Moody’s special comment at the time (focused on arbitraging lapse assumptions).
Complete markets pricing is only the first step:

- Really an incomplete market – can’t fully diversify mortality. Y. Wang studied unhedged mortality risk via quantile hedging.
- Q. Yun uses indifference pricing to see at what level of continuous fees does a GMLB add economic value to clients?
- Asset allocation: There is usually a choice of asset classes within a VA. The associated stochastic control problem quantifies how much more equity risk clients should take on in the presence of a (bond like) guarantee.
Company A: N=170,462

- % invested in high and medium risk assets (HMR)
  - GLiB Selected
  - No GLiB Selected

Age:
- <=40
- 41-45
- 46-50
- 51-55
- 56-60
- 61-65
- 66-70
- 71-75
- 76-80
- >80
Other questions

- Lapsation modeling is a key issue (Boyle et al)
- Product allocation: how much of your nest egg should be protected by such guarantees? Put another way what is the tradeoff between you vs. the kids?
- For QWeMA (Quantitative Wealth Management Analytics Group) we’ve modeled this in terms of a tradeoff between RSQ – Retirement Sustainability Quotient and EDB – Expected discounted bequest. Individuals can use this information to choose an appropriate point on their efficient frontier.
The RSQ vs. EDB Frontier: Age 62

[Graph showing Retirement Sustainability Quotient vs. Expected Discounted Bequest for different spending rates (4.80%, 5.20%, 5.50%, 5.80%, 4.80%) across various Retirement Sustainability Quotient (RSQ) levels (75%, 80%, 85%, 90%, 95%, 100%)]

- Spend 4.80%
- Spend 5.20%
- Spend 5.50%
- Spend 5.80%
- Spend 4.80%

The graph illustrates the trade-off between spending rates and the expected discounted bequest for different Retirement Sustainability Quotient levels.
Hedging and solvency

- Hedging these guarantees is expensive. The insurance industry is more used to reserving than hedging. And hedging more than your competitors puts you at a competitive disadvantage.
- Too few firms have fully hedged equity guarantees. As a result, many have recently required large injections of capital.
- Consumer fears about credit worthiness of firms underwriting the guarantees impacts on the sustainability of these products – people want to buy security, not credit risk. Stability and good risk management is essential to ensure continued sales.
“Despite management’s concerns about hedging practices (high costs, ineffectiveness), management acknowledged that all NEW variable annuity sales are being hedged. Despite the profitable long-term outlook of VA products, management is implementing pricing and product design changes going forward to reduce volatility and protect profitability.”

– Credit Suisse’s Jim Bantis, referring to the experience of one large Canadian firm, that had earlier made a policy of reserving rather than hedging.
Brokers Fear Many Insurers Are Ignorant of Annuity Risks

By Leslie Scism

More than 70% of financial advisers in a recent survey said they were concerned about the risks insurers have taken on with guaranteed-minimum variable annuities—and nearly a third said they doubted the insurers themselves understood those risks.

These are among the key findings of the fourth annual survey of Merrill Lynch advisers, conducted in February by analysts at what is now Banc of America Securities-Merrill Lynch, a unit of Bank of America Corp. Merrill has long been one of the largest distributors of retirement-advantaged form of investing in mutual funds. In a competitive frenzy that began about five years ago and was continuing even as the market began its slide last year, insurers sold increasingly generous guarantees. The most basic ones promise that investors won’t lose their original investment, while the more-generous ones promise annual increases of 7% or more in the guaranteed amount.

The Merrill survey suggests increasing wariness among advisers for whom the annuities are a significant portion of their business about “the risk profiles” of the insurers creating the products, according to the survey authors, Edward Spehar and Roman Leal. Some 71% said they thought the insurers had taken on greater risk...
Brokers Fear Many Insurers Are Ignorant of Annuity Risks

Leslie Scism -- Wall Street Journal, Apr 6, 2009

“More than 70% of financial advisers in a recent survey said they were concerned about the risks insurers have taken on with guaranteed-minimum variable annuities – and nearly a third said they doubted the insurers themselves understood those risks.”

...The advisers were polled amid a steady drumbeat of ratings downgrades for some of the biggest names in the U.S. life-insurance industry. About two dozen insurers saw their financial-strength ratings fall one or two notches during the first quarter, although most remain at least for now in categories denoting capitalization that is “strong” to “very strong.” The ratings firms assigned a negative outlook to many of the insurers for the next 12 to 18 months and put some on watch for possible additional downgrade over the next few months.
The more things change . . .

The risks of variable annuities come home to roost for insurers (Washington Post)

“As the bull market faded, the financial products have left insurers with huge exposures”, writes Ellen Kelleher.
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The issue was the total lack of hedging of GMDB’s going into the bear market of 2000-2002

We’re doing better this time.
And the need for solid hedging can’t be ignored in future.