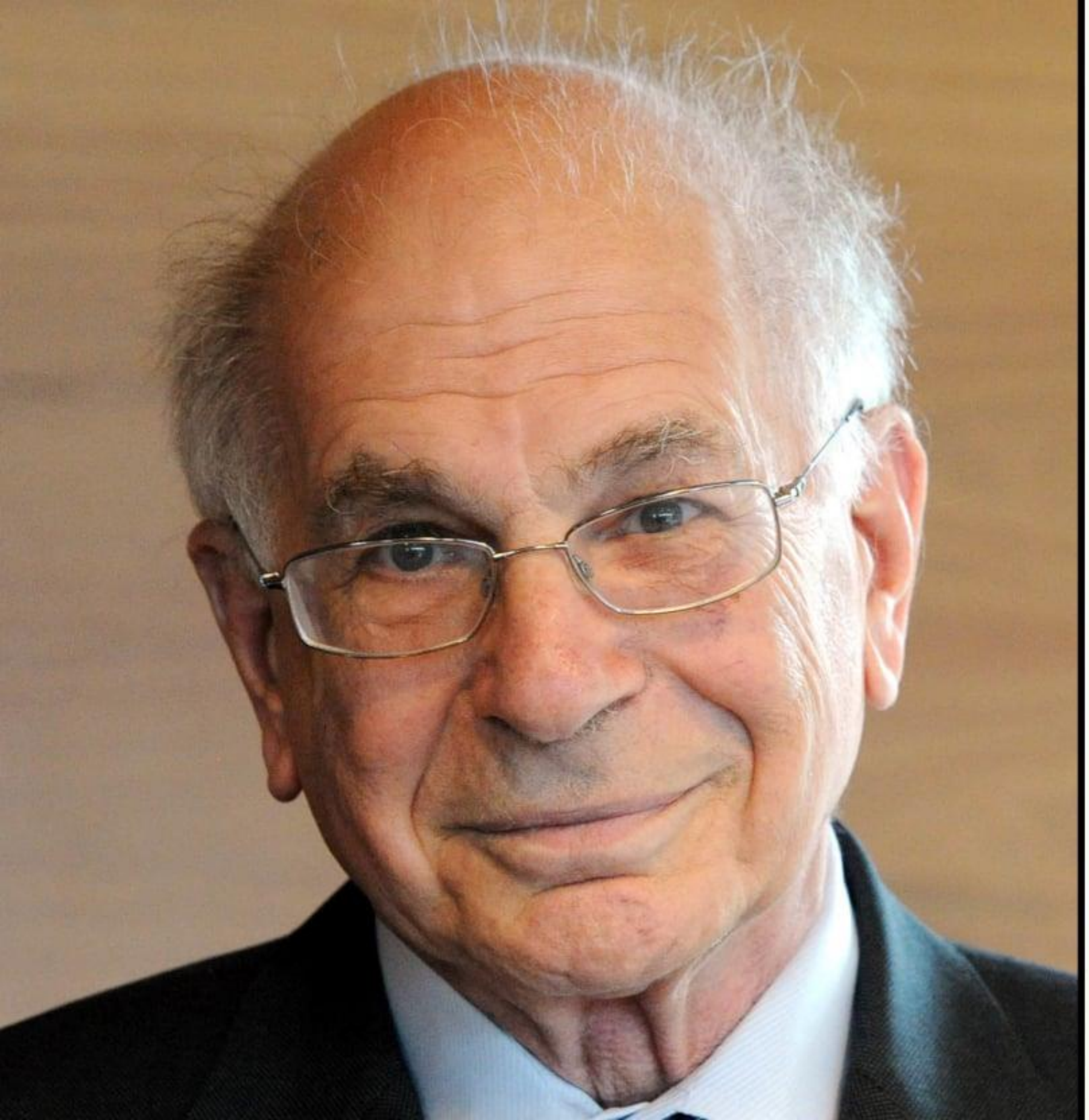
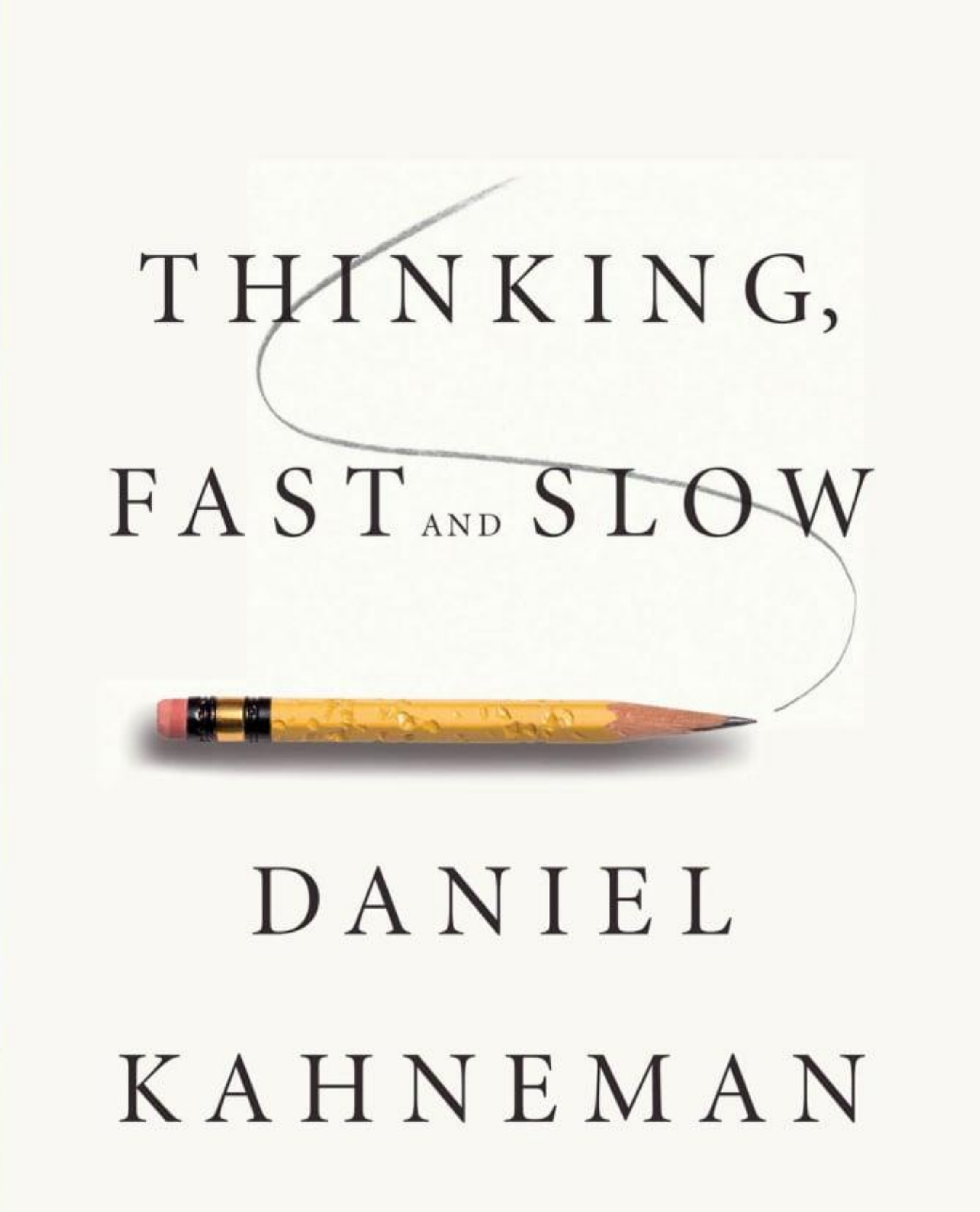
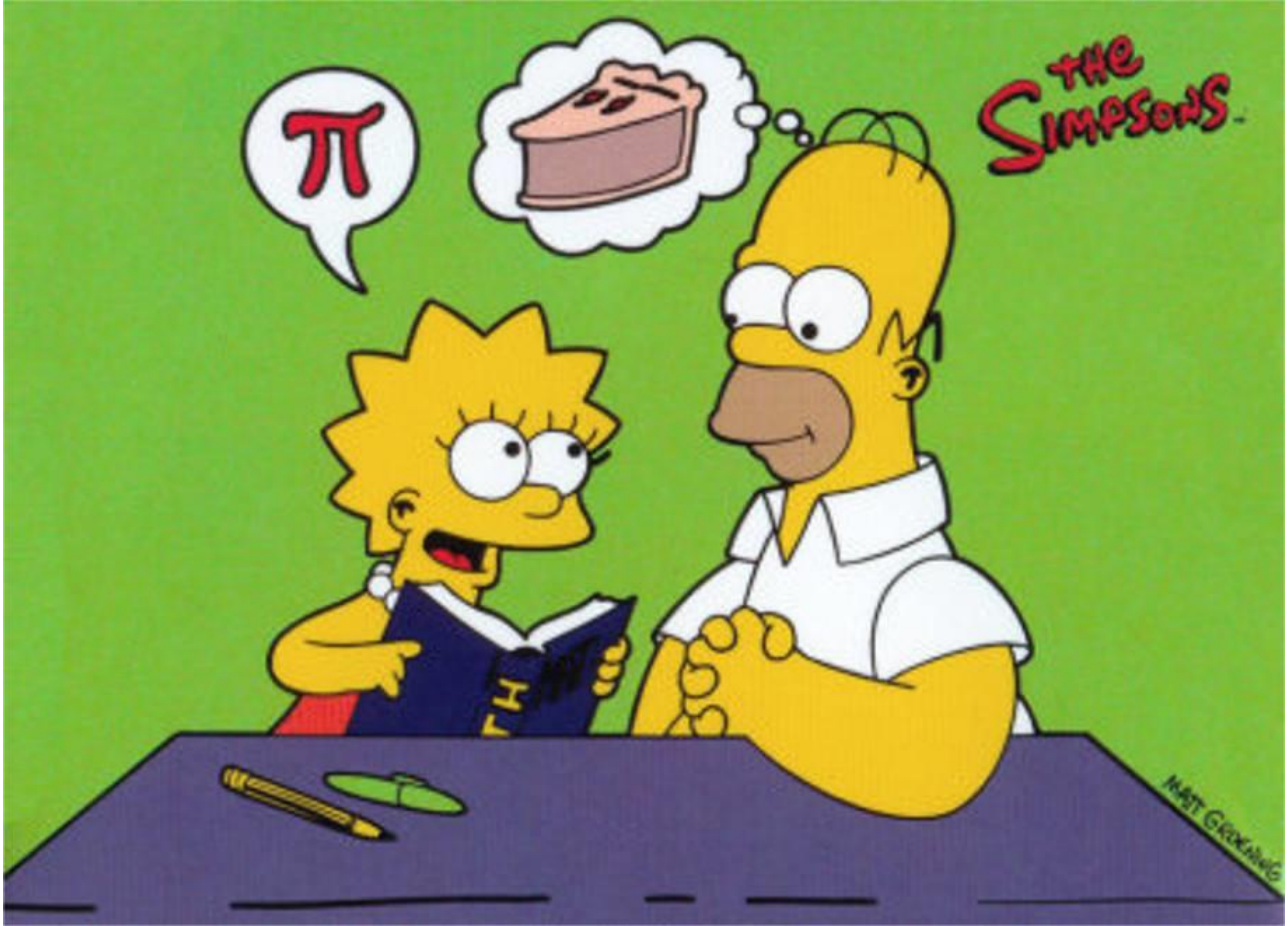
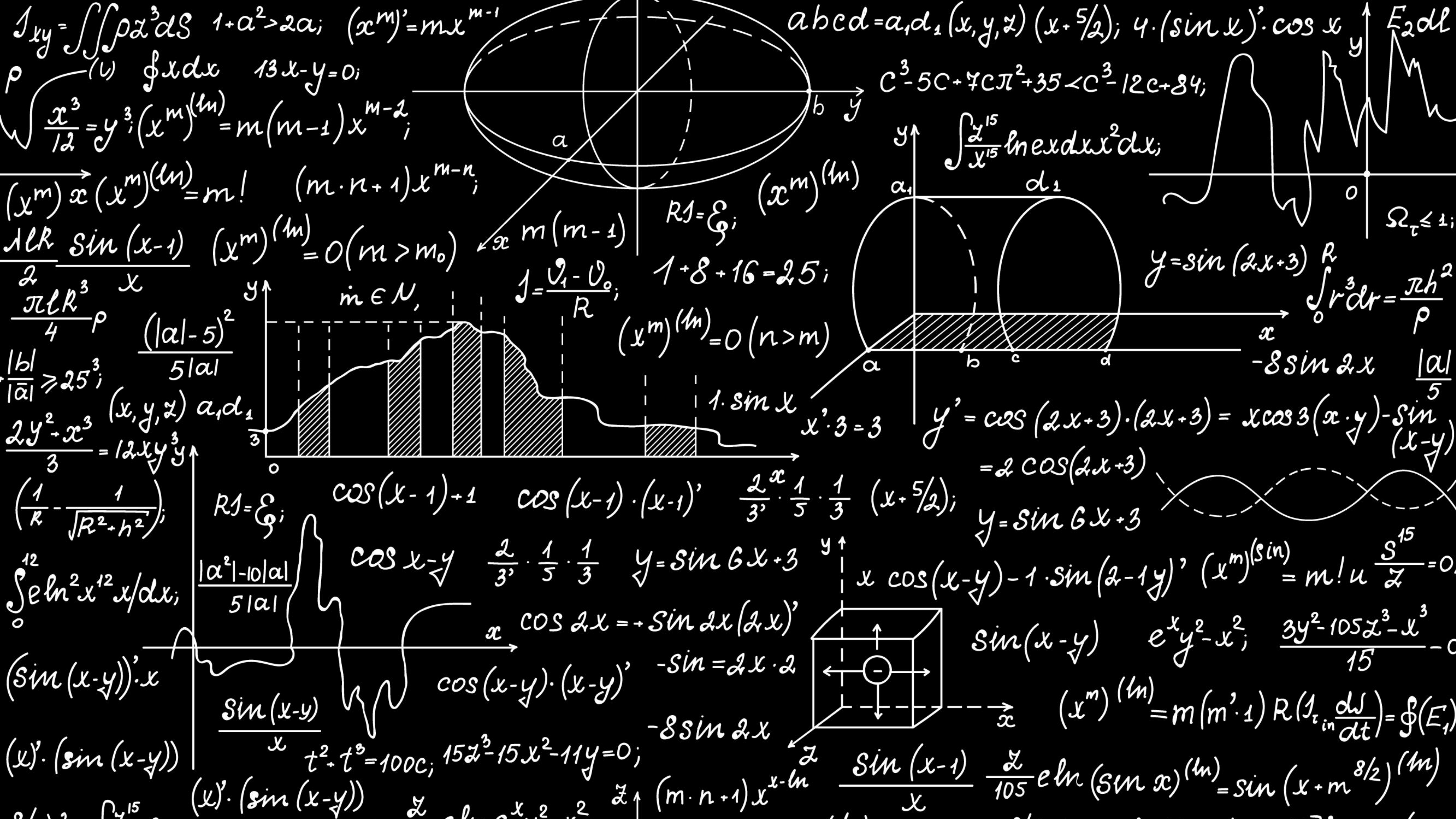
SAM Risk Margin Simplifications: How things can go wrong

Peter Carswell, Nikhara Nirghin, Ross Farnaby




THINKING,
FAST AND SLOW
DANIEL
KAHNEMAN

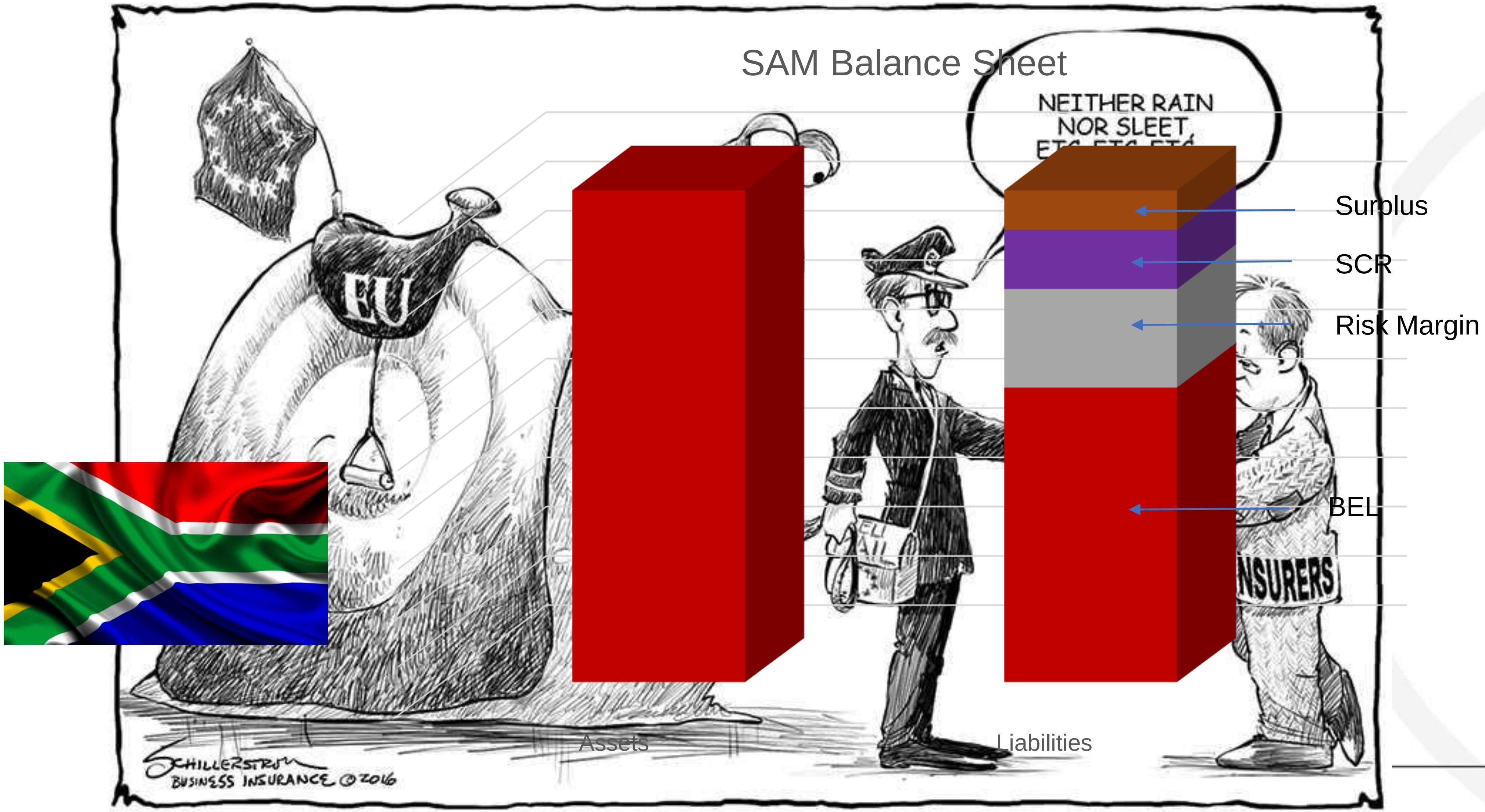

π
THE SIMPSONS
MATH
MATT GROENING



$I_{xy} = \iint \rho z^3 dS$
$1 + a^2 > 2a;$
$(x^m)' = mx^{m-1}$
$abcd = a_1 d_1 (x, y, z)\ (x + 5/2);\ 4 \cdot (\sin x)' \cdot \cos x$
$\oint x dx$
$13x - y = 0;$
$C^3 - 5C + 7C\pi^2 + 35 < C^3 - 12c + 84;$
$\frac{x^3}{12} = y^3; (x^m)^{(ln)} = m(m-1)x^{m-2};$
$\int \frac{z^{15}}{x^{15}} \ln e x dx x^2 dx;$
$(x^m)\, x\, (x^m)^{(ln)} = m!$
$(m \cdot n + 1)x^{m-n};$
$(x^m)^{(ln)}$
$RI = \mathcal{E};$
$\frac{\lambda l R}{2}$
$\frac{\sin (x-1)}{x}$
$(x^m)^{(ln)} = 0 (m > m_0)$
$m(m-1)$
$y = \sin (2x + 3)$
$\int_0^R r^3 dr = \frac{\pi h^2}{\rho}$
$\frac{\pi l R^3}{4} \rho$
$\frac{(|a| - 5)^2}{5|a|}$
$m \in N,$
$I = \frac{V_1 - V_0}{R};$
$1 + 8 + 16 = 25;$
$(x^m)^{(ln)} = 0 (n > m)$
$-8 \sin 2x$
$\frac{|a|}{5}$
$\frac{|b|}{|a|} \geqslant 25^3;$
$(x, y, z)\ a_1 d_1$
$1 \cdot \sin x$
$x' \cdot 3 = 3$
$y' = \cos (2x + 3) \cdot (2x + 3) = x \cos 3(x \cdot y) - \sin (x - y)$
$\frac{2y^2 + x^3}{3} = 12xy^3y$
$= 2 \cos(2x + 3)$
$\cos(x - 1) + 1$
$\cos (x-1) \cdot (x-1)'$
$\frac{2^x}{3^3} \cdot \frac{1}{5} \cdot \frac{1}{3}$
$(x + 5/2);$
$\left(\frac{1}{R} - \frac{1}{\sqrt{R^2 + h^2}}\right);$
$RI = \mathcal{E};$
$y = \sin 6x + 3$
$\cos x - y$
$\frac{2}{3^3} \cdot \frac{1}{5} \cdot \frac{1}{3}$
$y = \sin 6x + 3$
$x \cos(x - y) - 1 \cdot \sin (2 - 1y)'$
$(x^m)^{(\sin)} = m!u$
$\frac{S^{15}}{Z} = 0$
$\int_0^{12} e \ln^2 x^{12} x / dx;$
$\frac{|a^2| - 10|a|}{5|a|}$
$\cos 2x = -\sin 2x (2x)'$
$\sin(x - y)$
$e^x y^2 - x^2;$
$\frac{3y^2 - 105z^3 - x^3}{15}$
$(\sin (x - y))' \cdot x$
$-\sin = 2x \cdot 2$
$\cos(x - y) \cdot (x - y)'$
$(x^m)^{(ln)} = m(m' \cdot 1) R (I_{\tau in} \frac{dW}{dt}) = \oint(E_1)$
$\frac{\sin (x-y)}{x}$
$-8 \sin 2x$
$(x)' \cdot (\sin (x - y))$
$t^2 + t^3 = 100c;$
$15z^3 - 15x^2 - 11y = 0;$
$(m \cdot n + 1)x^{x - ln}$
$\frac{\sin (x-1)}{x}$
$\frac{z}{105} e \ln (\sin x)^{(ln)} = \sin (x + m^{8/2})^{(ln)}$
$(x)' \cdot (\sin (x - y))$

AGENDA

1. Background
2. Summary of results
3. Method
4. Results: Annuities
5. Results: Credit Life
6. Results: Whole Life Assurance
7. Proposed Solution
8. Conclusion


SAM Balance Sheet
NEITHER RAIN
NOR SLEET
Surplus
SCR
Risk Margin
BEL
EU
INSURERS
Assets
Liabilities
SCHILLERSTROM
BUSINESS INSURANCE © 2016

ANNUITIES

- The risk margin simplifications tend to underestimate the true risk margin

  …in some cases by up to 25%
- The bias is worse for longer guarantee periods and low benefit escalation rates
- We recommend a simple technique that gives a better estimator

CREDIT LIFE

- The risk margin simplification gives a reasonable approximation of the true risk margin
- The Best Estimate Liability is a poor driver and should be avoided

WHOLE OF LIFE ASSURANCES

- The risk margin simplifications tend to underestimate the true risk margin

  …in some cases by up to 40%
- The bias is worse for younger ages and higher escalation rates
- Best Estimate Liability is a poor driver and should be avoided
- We recommend a simple technique that gives a better estimator

And now… over to Nikhara

METHOD

ACTUARIAL SOCIETY OF SOUTH AFRICA

Annuities, credit life and whole life assurances

Expected Cash Flow Model

- BEL and risk margin were explicitly calculated for each of these products
- The risk margin was then recalculated under each level of the hierarchy of simplifications.
- A number of drivers were considered, only in places in which a driver approach was allowed for the simplification.
- Sensitivity testing was done for the difference between the risk margin calculated under the sensitivity and the risk margin calculated using the simplification – this gives a percentage error
- Sensitivity testing was performed on key policy inputs and key assumptions

Model points considered - Annuities

Table 1. Model points for annuity products

Factor	Values used
Policyholder Age at Balance Sheet	65 to 95 in 5 year intervals
Annuity Escalation Rate (Annual)	0% to 8% in 1% intervals
Guarantee Period remaining (Years)	0 to 10 years in 1 year intervals

Model points considered – Credit Life

Table 2. Model points for Credit Life products

Factor	Values Used
Policyholder Age at Balance Sheet	25 to 75 in 5 year intervals
Sum Assured at start of policy	R10 000, R100 000 and R2 000 000
Original Term (Years)	2 to 7 years in 1 year intervals
Duration inforce (Years)	0 to 5 years in 1 year intervals

Model points considered – Whole Life Assurances

Table 3. Model points for Whole Life Assurance products

Factor	Values Used
Policyholder Age at Balance Sheet	25 to 75 in 5 year intervals
Sum Assured at start of policy	R10 000, R100 000 and R2 000 000
Premium and Sum Assured Escalation Rate (Annual)	0% to 10% in 2% intervals
Duration inforce (Years)	0 to 35 years in 5 year intervals

- Life insurance underwriting risk:

Annuity Products	Risk Products
• Longevity • Expenses	• Mortality • Expenses • Lapses • Catastrophe

- Operational risk: 30% * BSCR

Assumption: Market risk = hedgeable

Assumptions

Mortality

- SA Life Table 85-90
- Longevity improvement = 1%
- Constant force of mortality was assumed throughout year

Expense, expense inflation and interest rate assumption

Risk	Value
Renewal expenses	R4,50 p.m.
Expense inflation (p.a.)	5,3%
Interest rate (p.a.)	8,2%

Calculations – Risk Margin

Calculations – Solvency Capital Requirements (2)

More on what drivers were used a bit later on!

Level 1 simplification:

- Individual sub-module risks were calculated using proportional approach:

$$Capital_{Risk}(t) = \frac{Capital_{Risk}(0)}{Driver_{Risk}(0)}(Driver_{Risk}(t))$$

- How were drivers selected?
  - Lowest possible error from full and comprehensive calculation
  - Lowest variance of errors
  - Behaviour when full and comprehensive risk margin increases
- BSCR calculated based on prescribed correlation matrix and factors

03 Calculations – Solvency Capital Requirements (3)

Level 2 simplification:

- Similar to Level 1 calculations
- The accuracy of the driver was tested when estimating the **full** SCR:

$$SCR(t) = \frac{SCR(0)}{DRV(0)}(DRV(t))$$

Calculations – Solvency Capital Requirements (4)

WHAT DRIVERS?

03 Sensitivity testing

- Importance of certain assumption on results calculated

Table 4. Sensitivity factors used

Factor	Up	Down
Mortality	+10%	–10%
Longevity Improvement Rate	+100%	Not Tested
Expenses	+1000%	–80%
Interest Rate	+200 Basis Point	-200 Basis Point


RESULTS

Results: Annuities – LEVEL 1 (1)

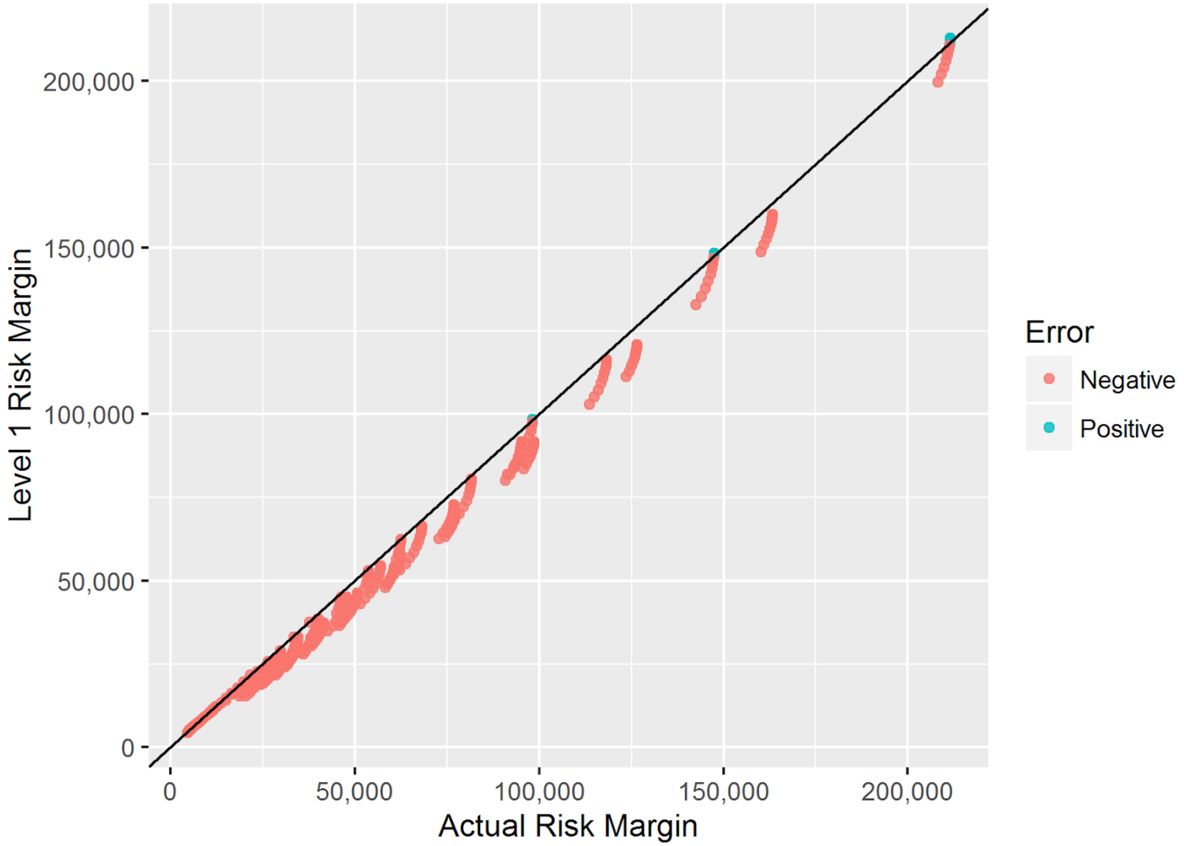


Figure 1. Level 1 Simplification against the full and comprehensive calculation of the risk margin

Results: Annuities – LEVEL 1 (2)

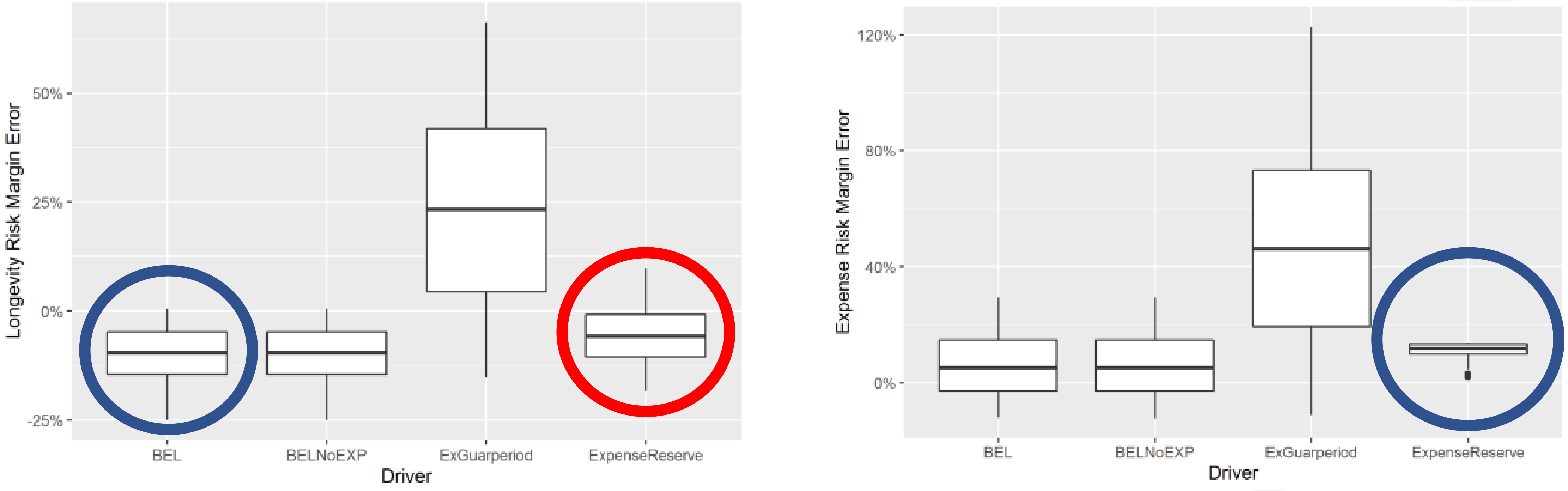


Figure 2 & 3. Longevity and expense risk margin errors for the annuity products considered under each driver

Results: Annuities – LEVEL 1 (3)

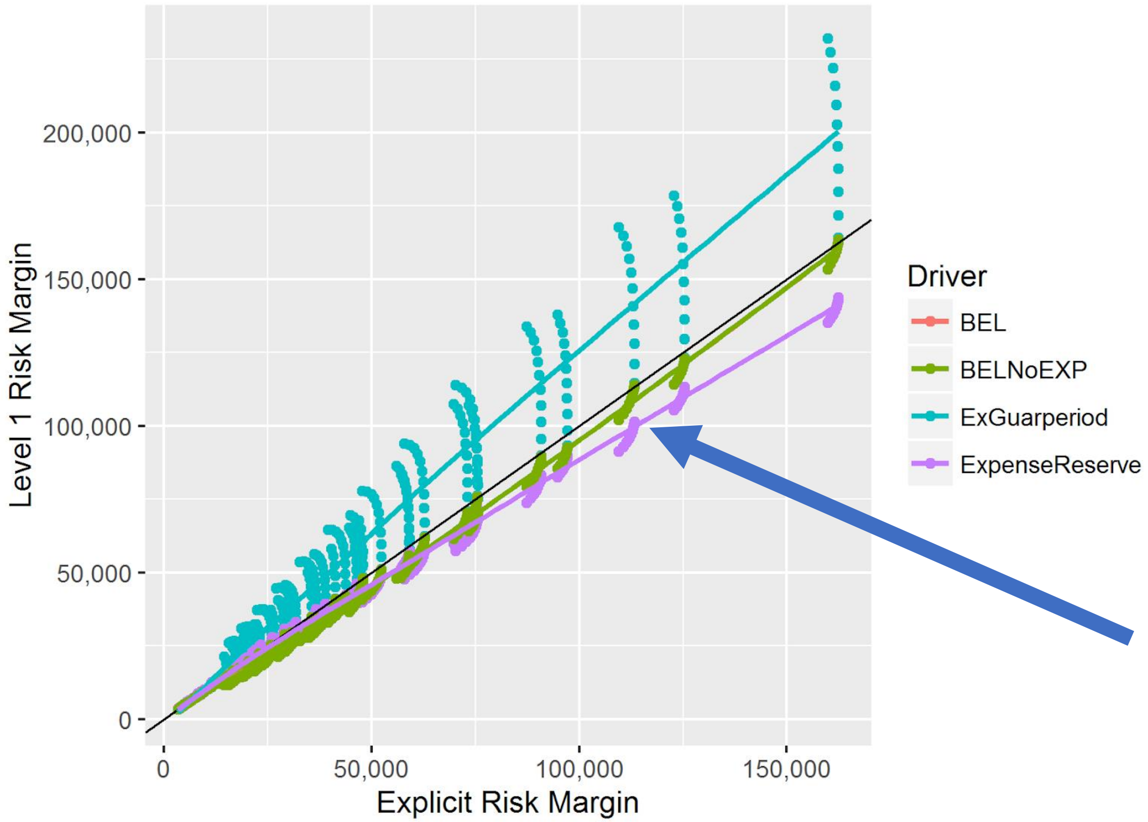


Figure 4. The longevity risk margin, using different drivers under the level 1 simplification, plotted against the full and comprehensive calculation of the risk margin

Results: Annuities Level 1 - Summary

Longevity Risk Margin

- Expense reserve = lowest variance and error but worsens severely as risk margin increases
- BEL was chosen as optimal driver

Expense Risk Margin

- Expense reserve = lowest variance and error
- Expense reserve was chosen as the driver

Overall

- Level 1 underestimates true risk margin consistently
- Error increases for longer guarantee periods
- Error decreases for higher escalation rates
- Error increases as policyholder age increases

Results: Annuities – LEVEL 2 (1)

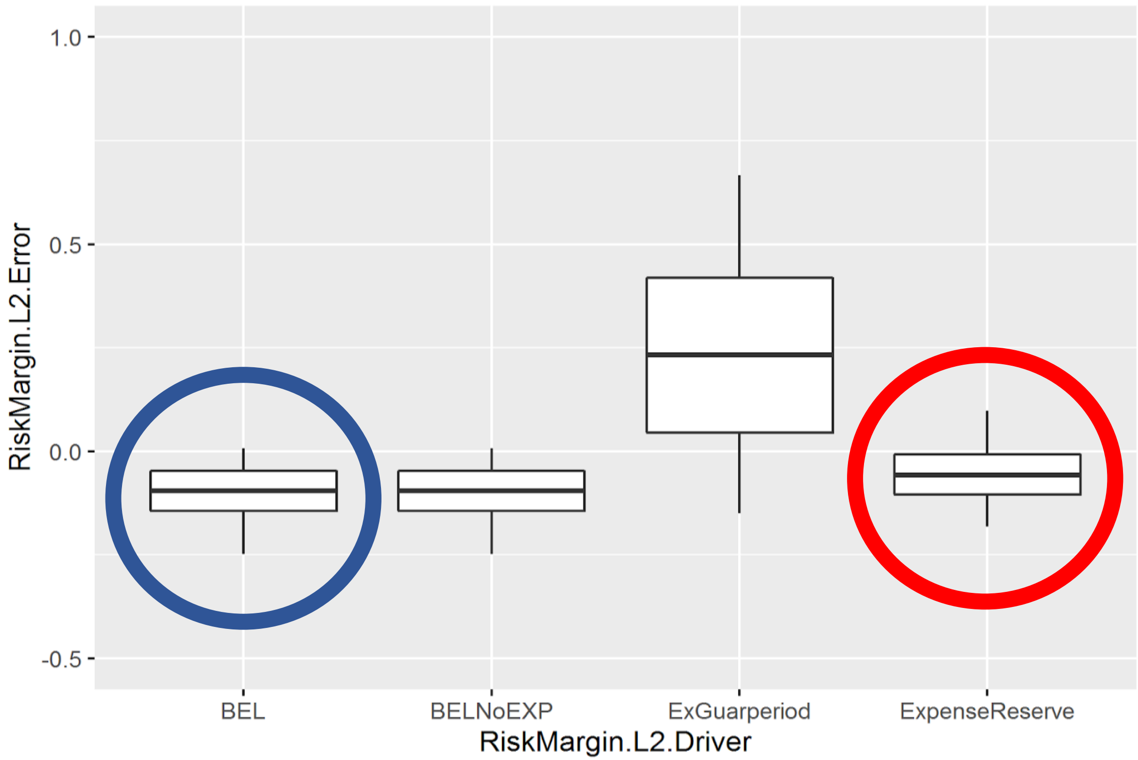


Figure 9. Box plots for risk margin errors using each driver to estimate the full risk margin

Results: Annuities – LEVEL 2 (2)

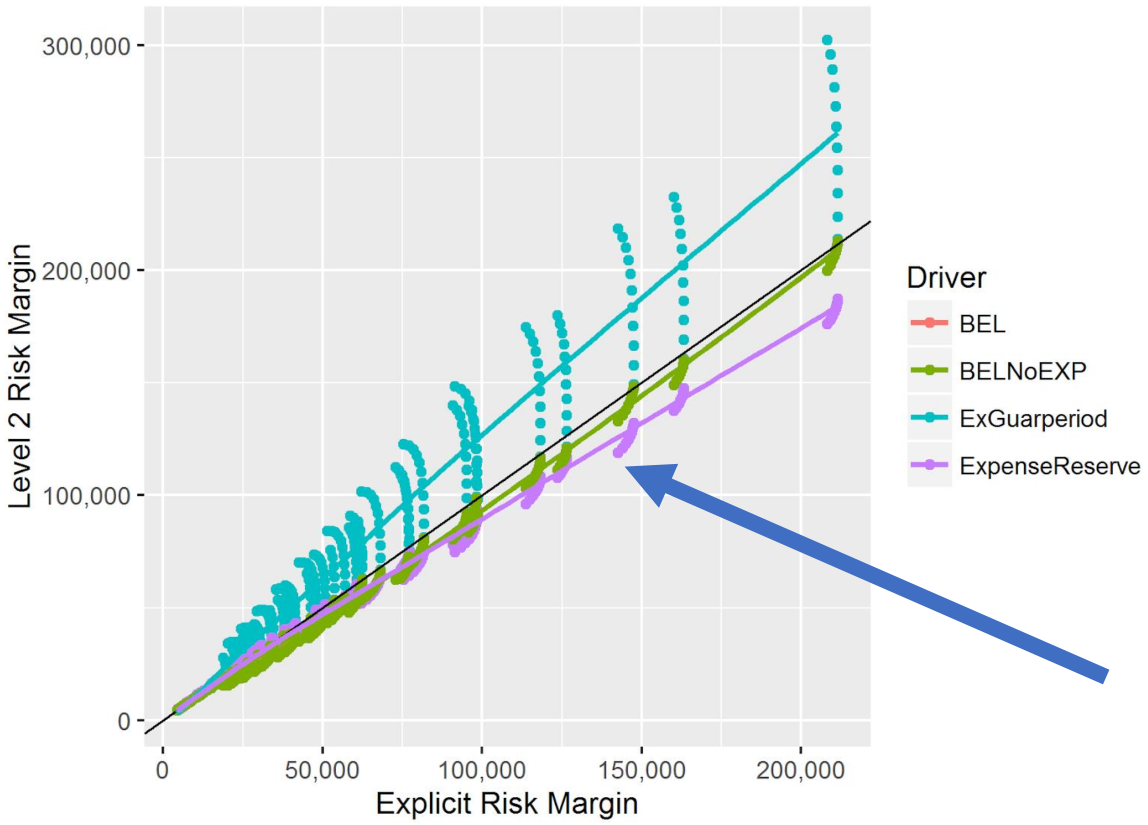


Figure 10. The estimated risk margin under level 2, using different drivers, plotted against the full and comprehensive calculation of the risk margin

Results: Annuities Level 2 - Summary

Overall

- Expense reserve = lowest variance and error but worsens severely as risk margin increases
- BEL is chosen as the optimal driver for estimating the full risk margin
- Level 2 underestimates true risk margin

Similar relationships to key variables as level 1

- Error increases for longer guarantee periods
- Error decreases for higher escalation rates
- Error increases as policyholder age increases

Results: Annuities – Sensitivity testing

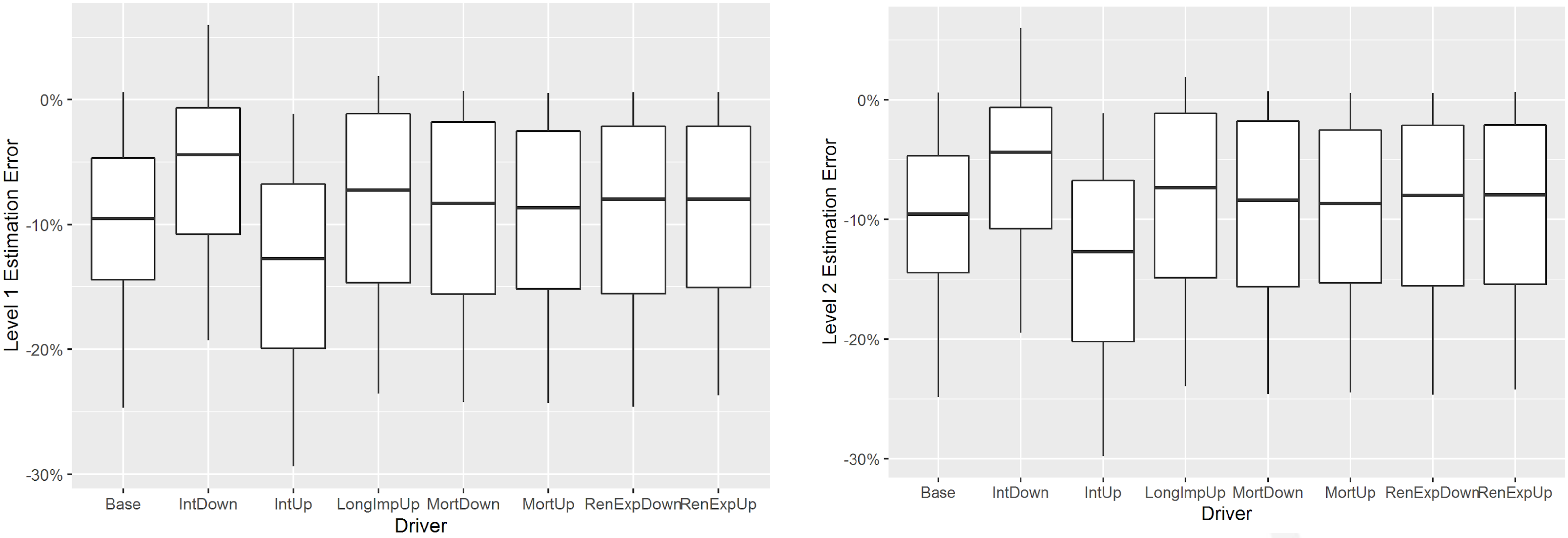


Figure 11 & 12. Box plots for risk margin errors under Level 1 and 2, when this simplification is exposed to various sensitivities

Results: Annuities Level 2 - Summary

Overall

- Level 1 errors actually improve (lessen) but variance increases
- Level 2 errors actually improve (lessen) but variance increases

Don’t despair! Proposed solution!

And now... Ross

Whole Life and Credit Life Insurance

Whole Life assurances:

- Benefit payable on death only
- Premium and Sum assured escalate at same rate
- Comparable to a Funeral Insurance Product in the market
- Priced for a 10% expected profit margin

Credit Life Insurance:

- Death only cover that pays the outstanding balance of the loan
- Short term of up to 6 years.
- Often seen in products backing up unsecured lending or Vehicle Financing
- Priced for a 25% expected profit margin

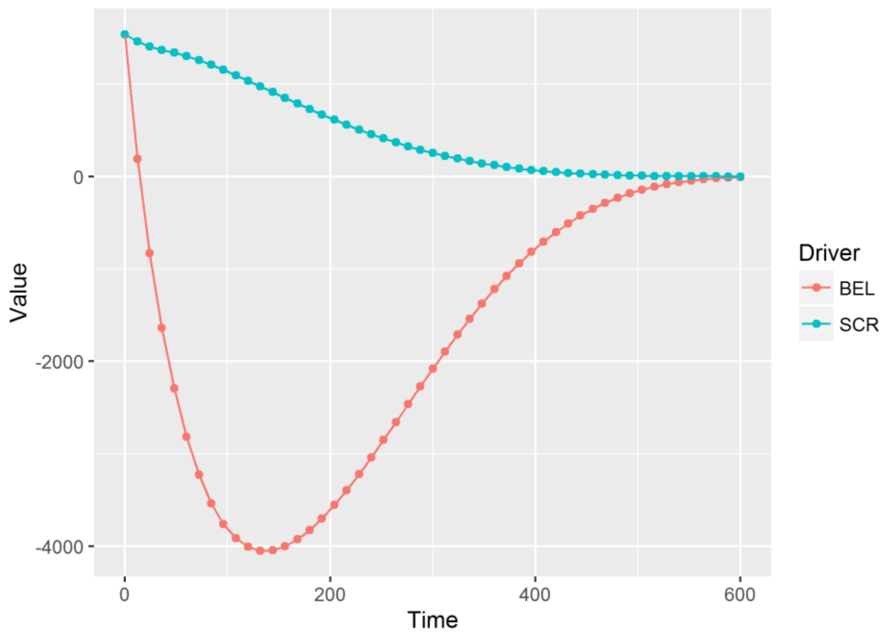
ACTUARIAL SOCIETY OF SOUTH AFRICA

Drivers Analyzed

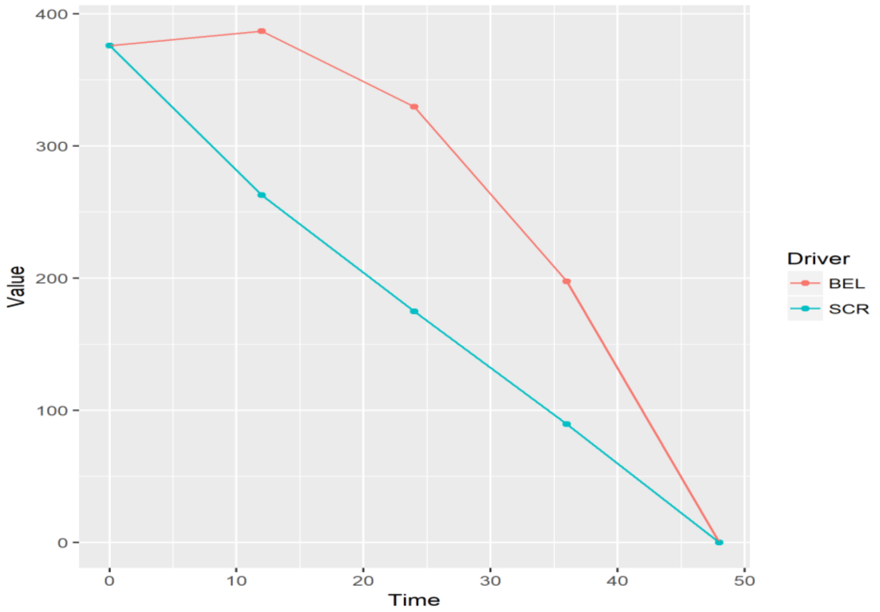
- Best Estimate Liability (BEL)
- Expected Present Value of Premiums
- Expected Present Value of Benefits paid
- Expense Reserve
- Expected Death Outgo in the Next Month
- Minimum of Bel and Zero

05 Don’t Use BEL as a Driver!

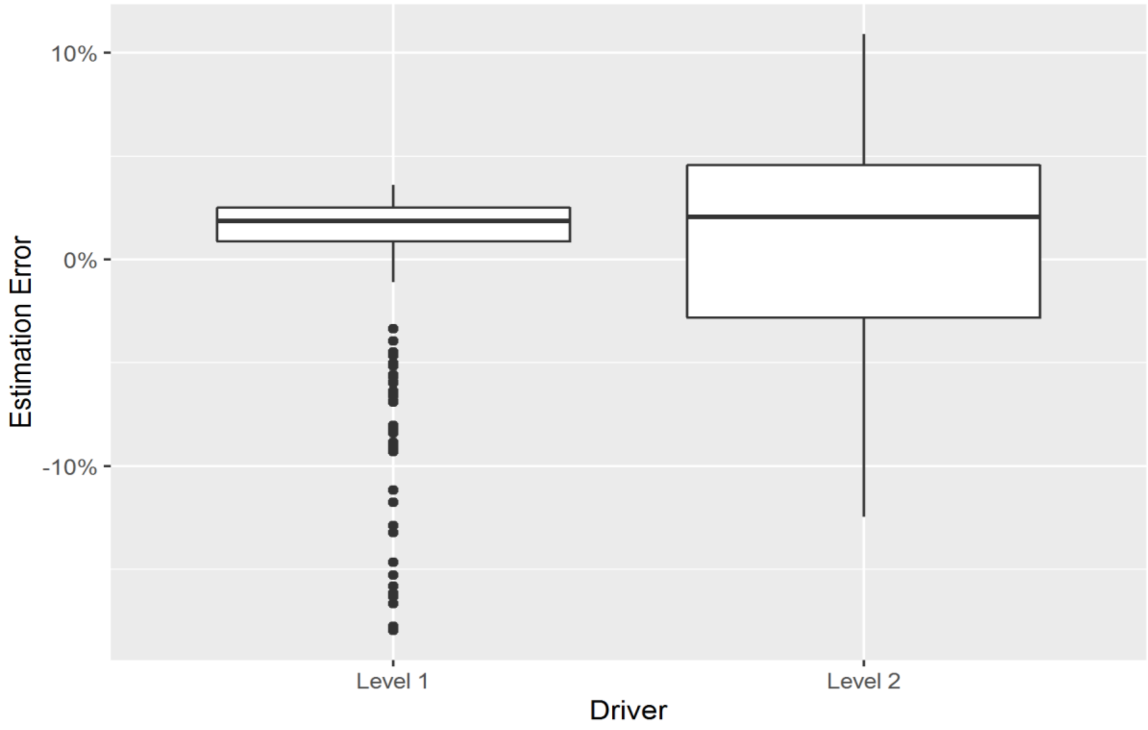
Whole Life Assurance



Credit Life Insurance



- Best Estimate Liability does not work as a driver
- Even when credit life policies, where positive reserves are not generated, a problem still exists



Level 1:

- PV Benefit Outgo for Mortality
- Expense reserve for expenses
- PV prem for Lapse Down & Life Catastrophe
- Min (BEL & 0) for Mass Lapse

Level 2

- Expense Reserve

- Reasonable for Level 1 and Level 2
- Level One shows some promise for a viable solution

ACTUARIAL SOCIETY OF SOUTH AFRICA

Where it works well

- Best fits are at lower ages and duration in force
- Shorter terms leads to better fits
- Important as these are the areas that pricing of products occur in

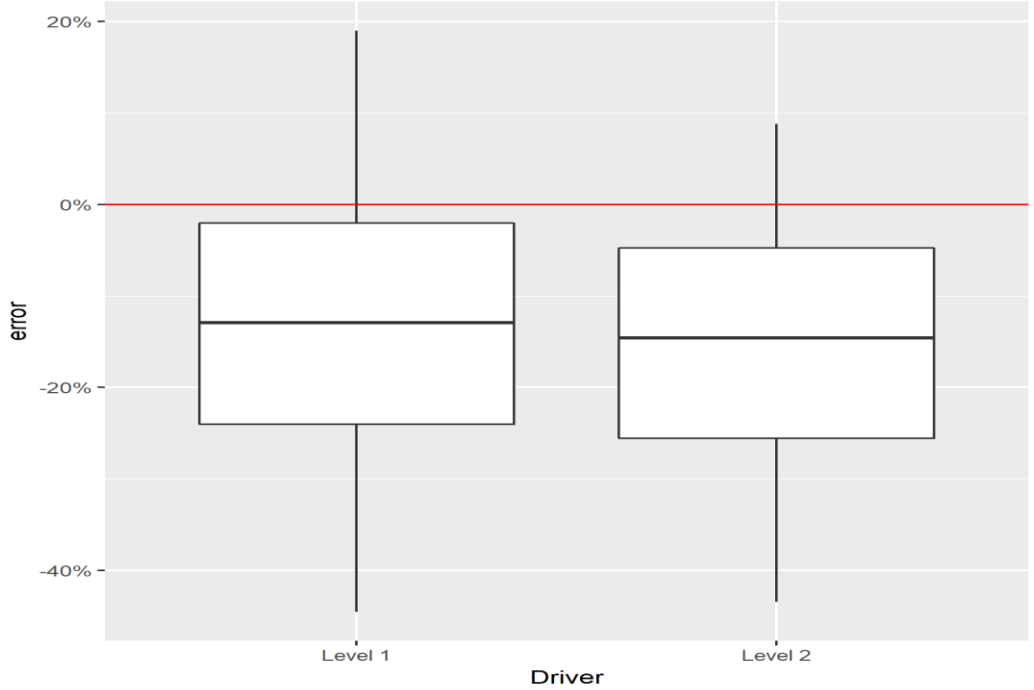
Where it falls apart

- Can't ignore the outliers in the graph!
- Caused by older policyholders of longer term products, in the last 2 years of their policy
- These are less common cases

05 In Summary for Credit Life.

ACTUARIAL SOCIETY OF SOUTH AFRICA

1. Level 1 is a reasonable approximation of the risk margin.
2. Level 2 is not too bad either.
3. Both are more accurate when you want them to be accurate.
4. Overall it's hard to fault using the simplifications if they are applied correctly, for the policies we tested.



Level 1:
- PV Benefit Outgo for Mortality
- Expense reserve for expenses
- PV prem for Lapse Down/Up & Life Catastrophe
- Min BEL & 0 for Mass Lapse

Level 2
- PV Premiums

- We have an underestimation issue again
- Very similar drivers to those used in Credit Life

Where it works well.

- Not very often.
- Older ages and higher duration in force leads to a better match.
- These are the areas that often contain the least policies.

Where it falls apart.

- Higher escalation rate for the premium and sum assured worsens the result.
- Estimation is at its worst at policy inception, which is what pricing will be based off.

06

In Summary for Whole Life Assurances.

ACTUARIAL SOCIETY OF SOUTH AFRICA

1. Level 1 or Level 2 both produce an underestimation of the risk margin.
2. Both are worse in the areas where it is most vital to be accurate.
3. Thus a better solution to the problem is needed.

Back to Peter

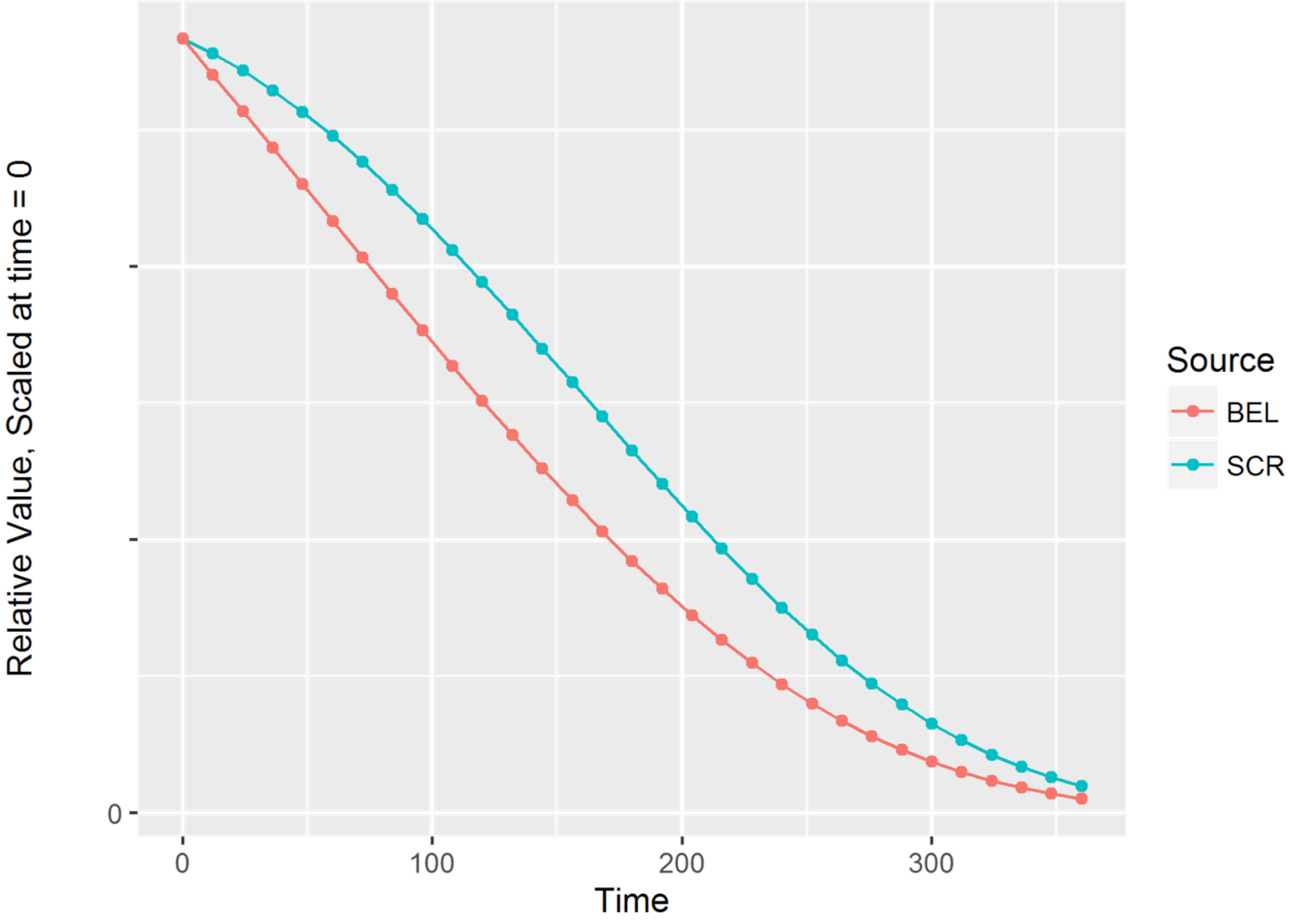
OBJECTIVE

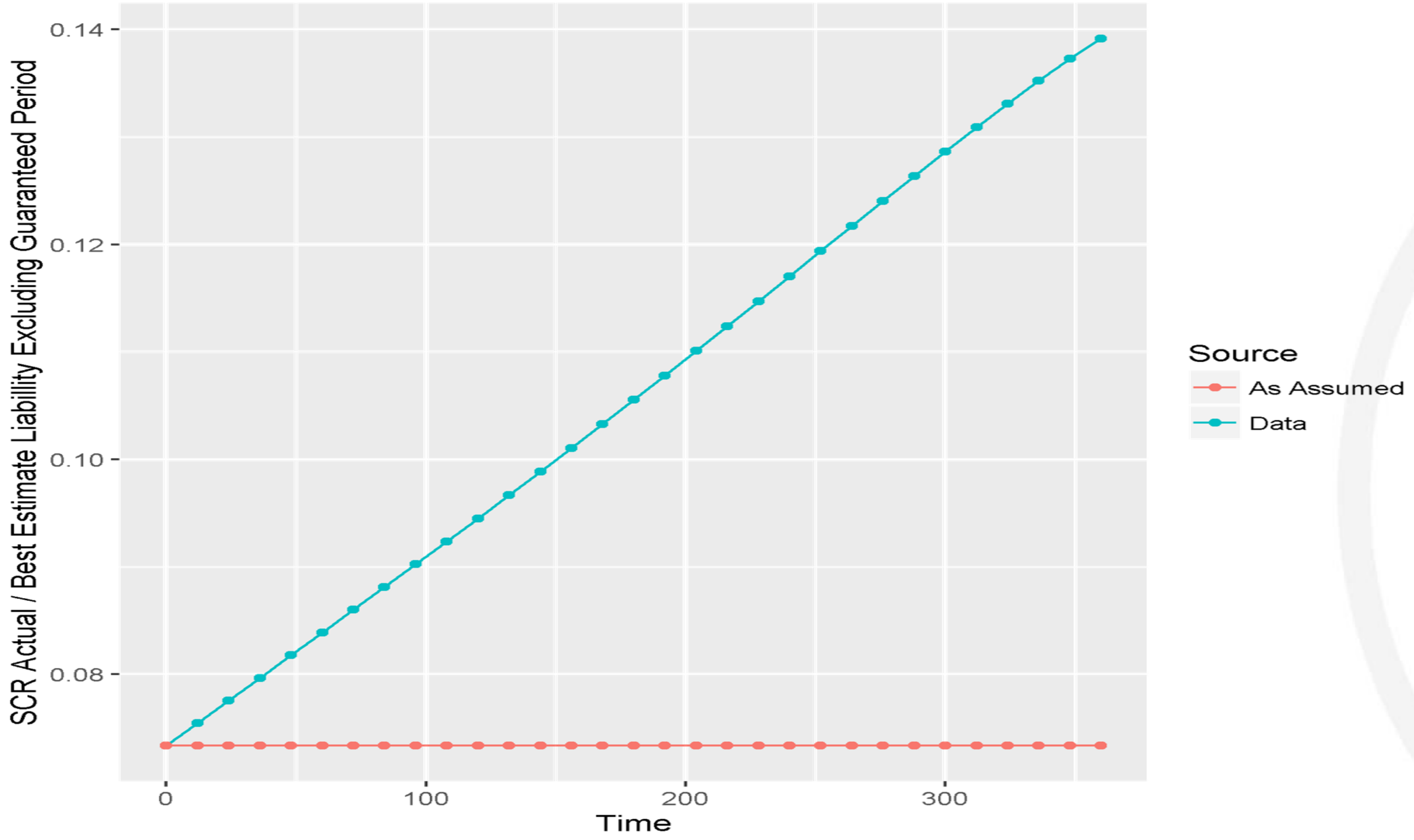
- Find a more accurate estimate for the future SCRs
- Use those estimates to calculate the risk margin

OTHER AREAS OF USE

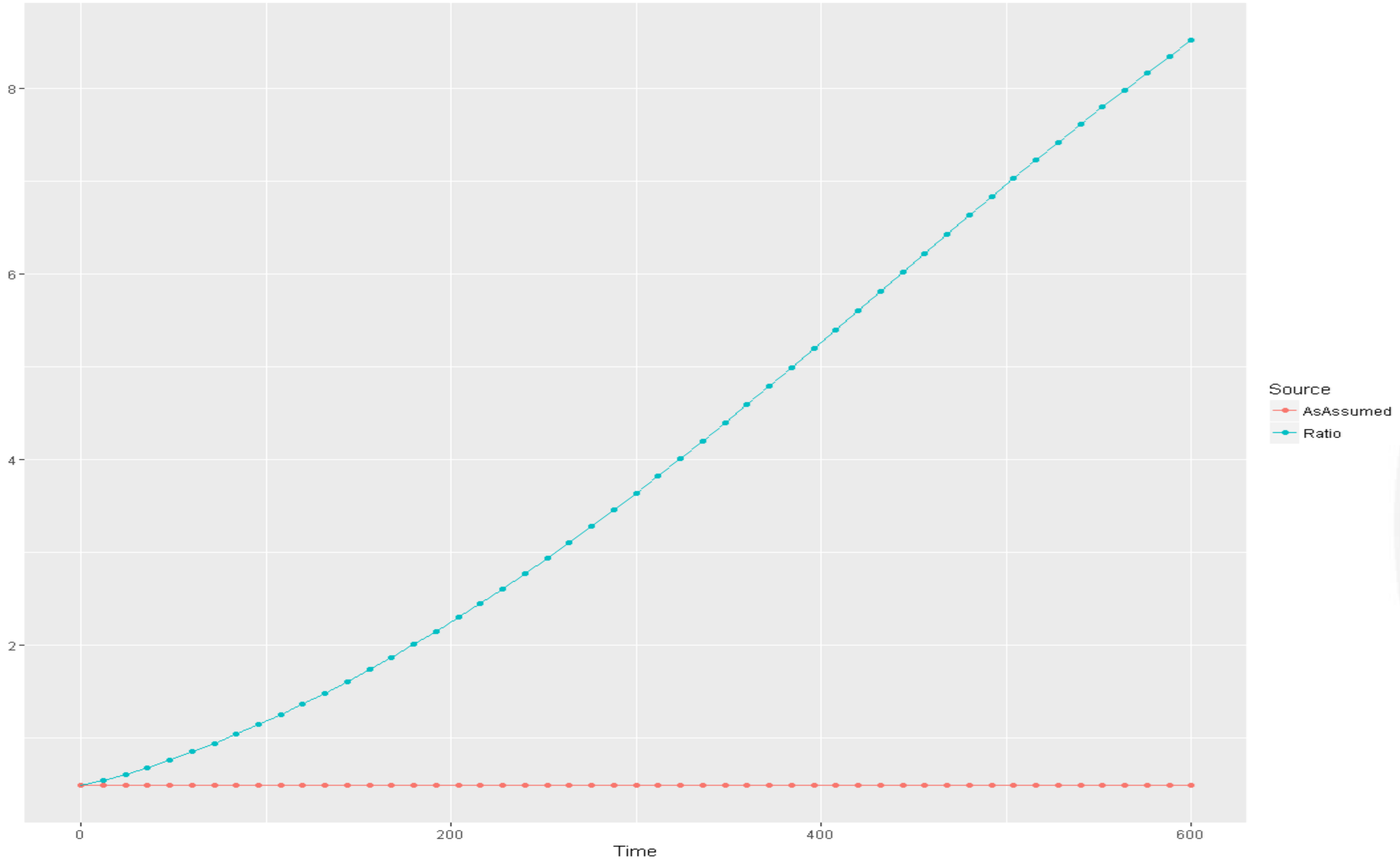
- Business Case
- Pricing
- Business Planning
- Embedded Value
- IFRS 17 Unit of Measure

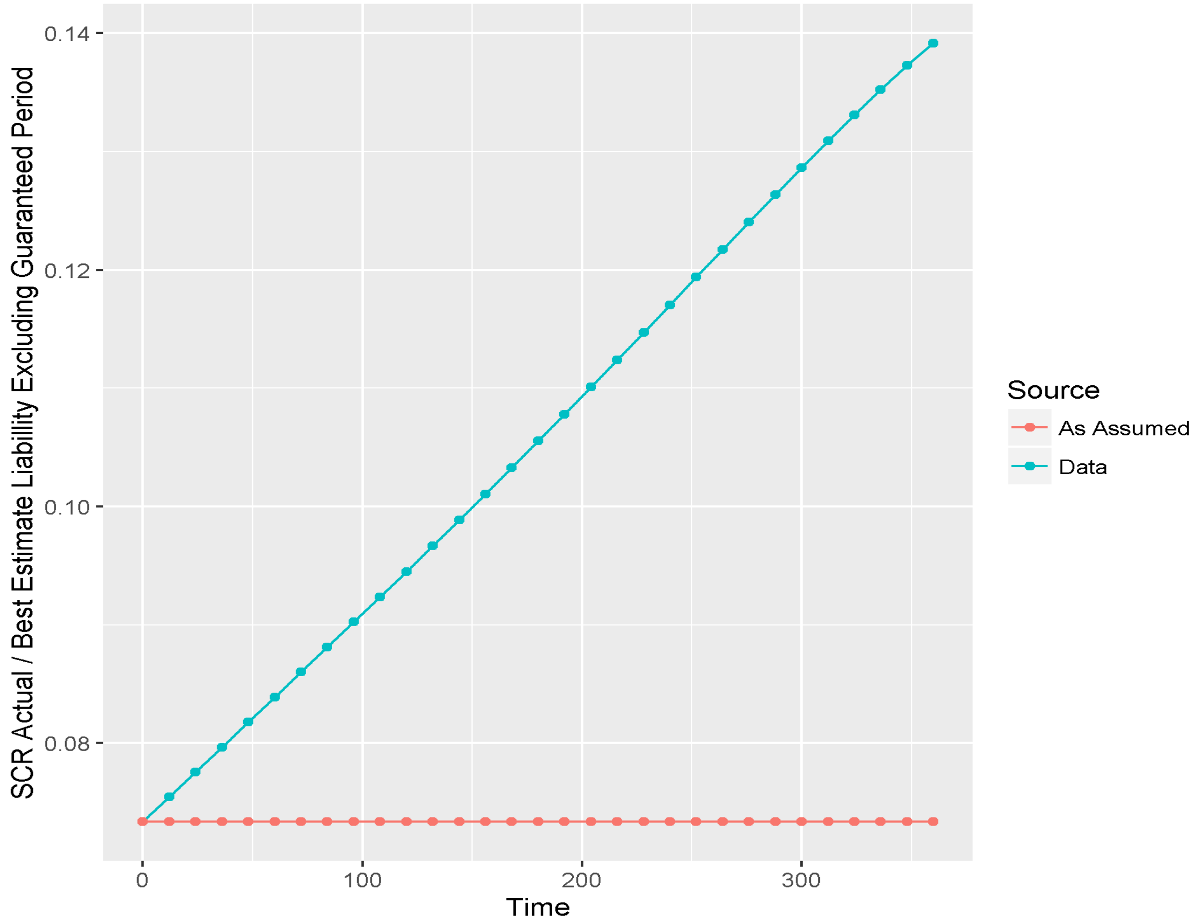
ACTUARIAL SOCIETY OF SOUTH AFRICA





SCR Actual / Best Estimate Liability Excluding Guaranteed Period
0.14
0.12
0.10
0.08
0
100
200
300
Time
Source
As Assumed
Data


8
6
4
2
0
200
400
600
Time
Source
AsAssumed
Ratio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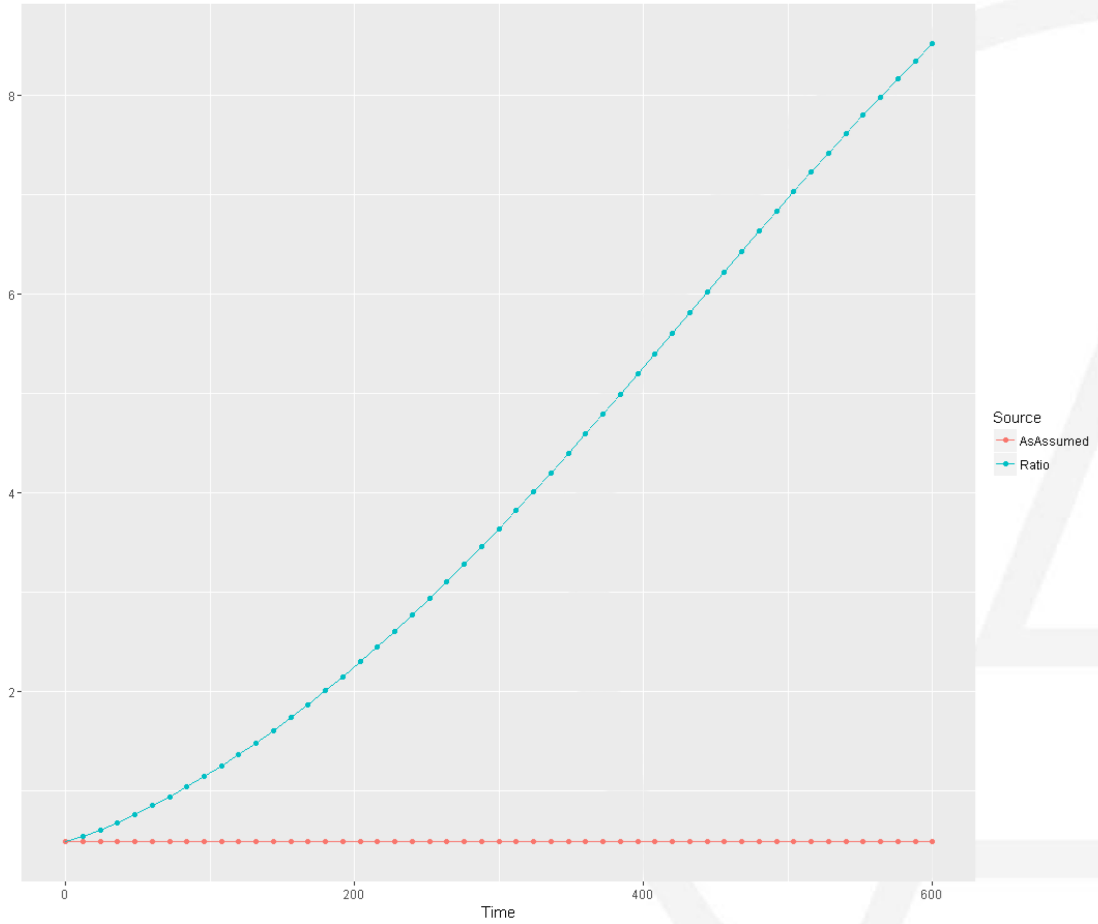

8
6
4
2
0
200
400
600
Time
Source
AsAssumed
Ratio

CALCULATE TWO POINTS

- SCR at time zero and future time *f*
- Driver at time zero and future time *f*
- We chose *f* to be 15 years for the annuities and 10 years for the whole of life assurances; drivers were BEL and PV Prem

FIT THE LINE

- $y = m\,x + c$
- Use the fitted line to predict the future SCR values

ACTUARIAL SOCIETY OF SOUTH AFRICA

STEP 1: Key metrics at months 0 and 180

Month	SCR	BEL	SCR/BEL
0	4,000	55,000	0.073
180	1,800	17,000	0.106

STEP 2: Fit the Line

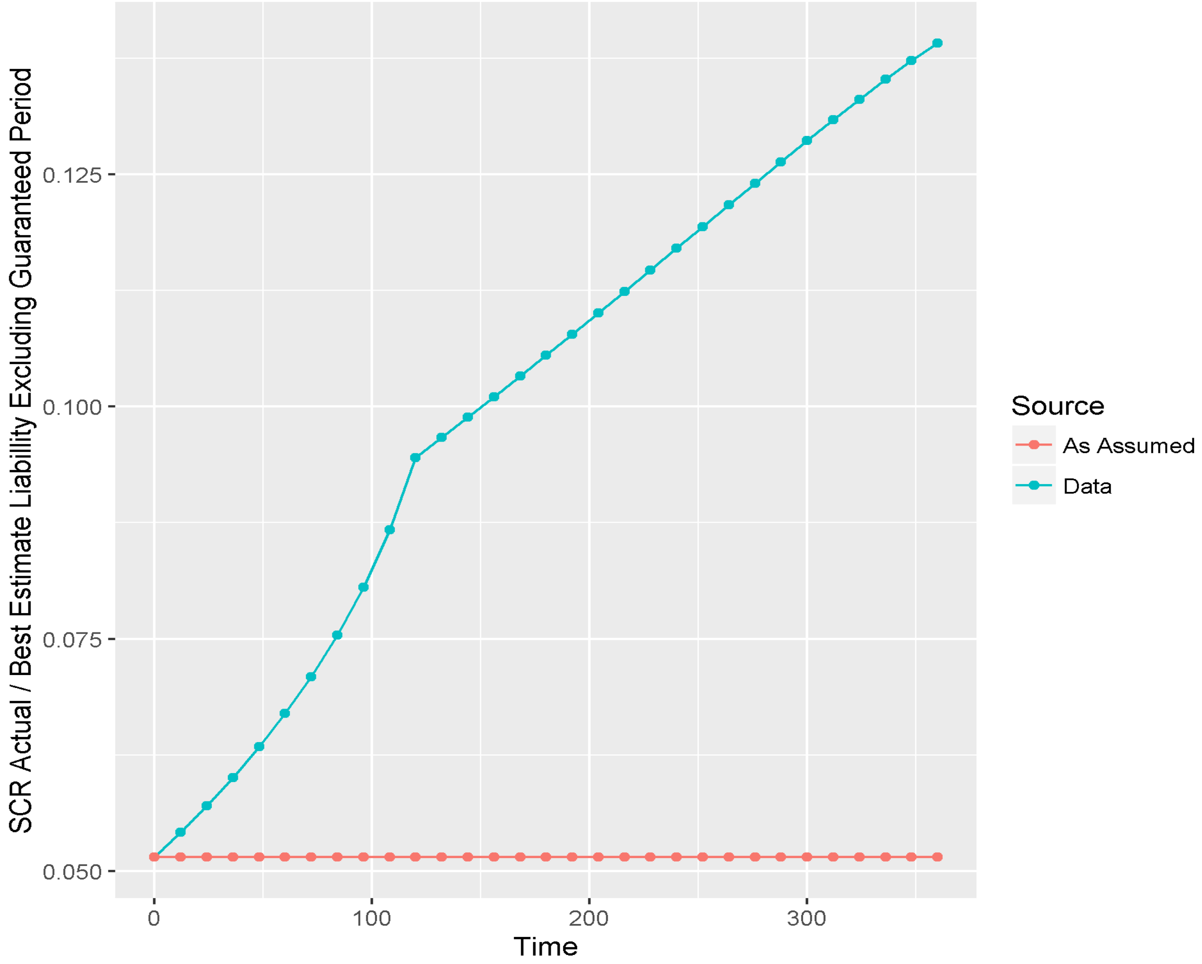
- *[SCR/BEL] = m x [Month] + c*
- $m = 1.84 \times 10^{-4}$ $c = 0.073$

ACTUARIAL SOCIETY OF SOUTH AFRICA

STEP 3: Calculate all future SCR(t) given the known future BEL(t)

Month	BEL		SCR/BEL	SCR
0	55,000		0.073	4,000
12	52,500		0.075	3,940
24	49,900		0.077	3,840
36	47,400		0.079	3,740
48	44,900		0.082	3,680
60	42,300		0.084	3,550

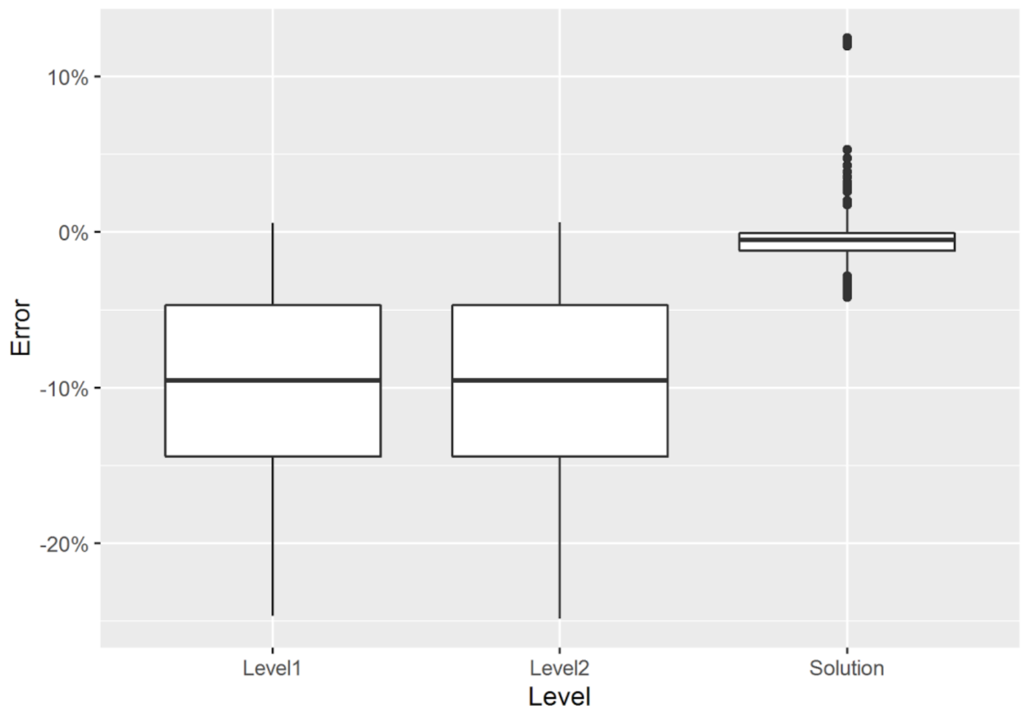
STEP 4: Use the SCR vector to calculate your Risk Margin



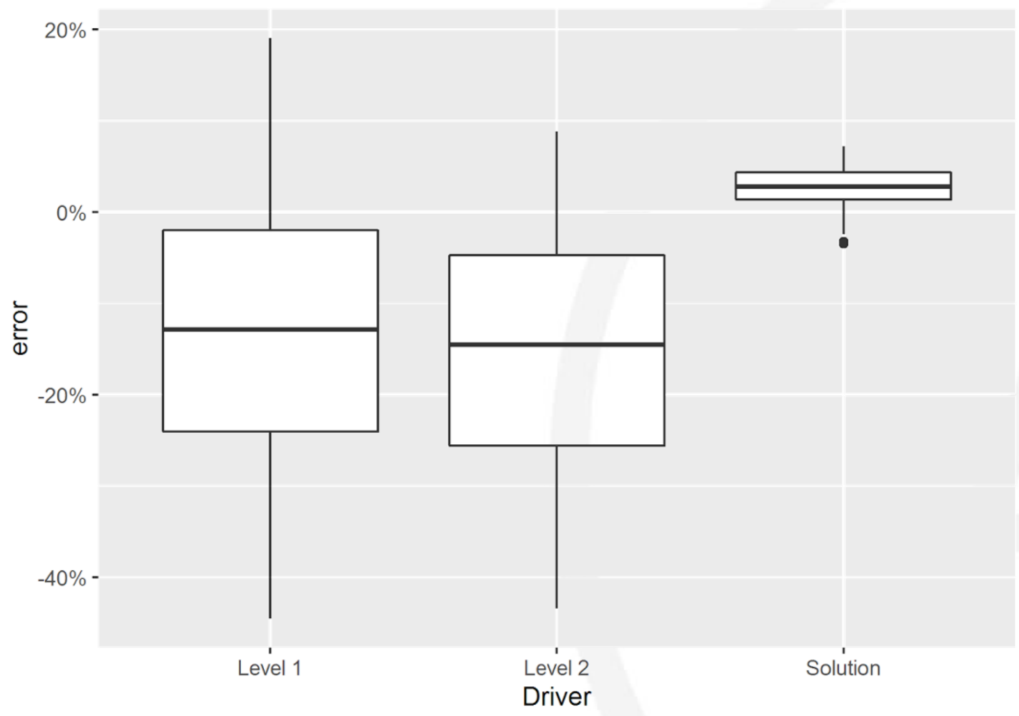
ANNUITIES WITH GUARANTEE PERIODS

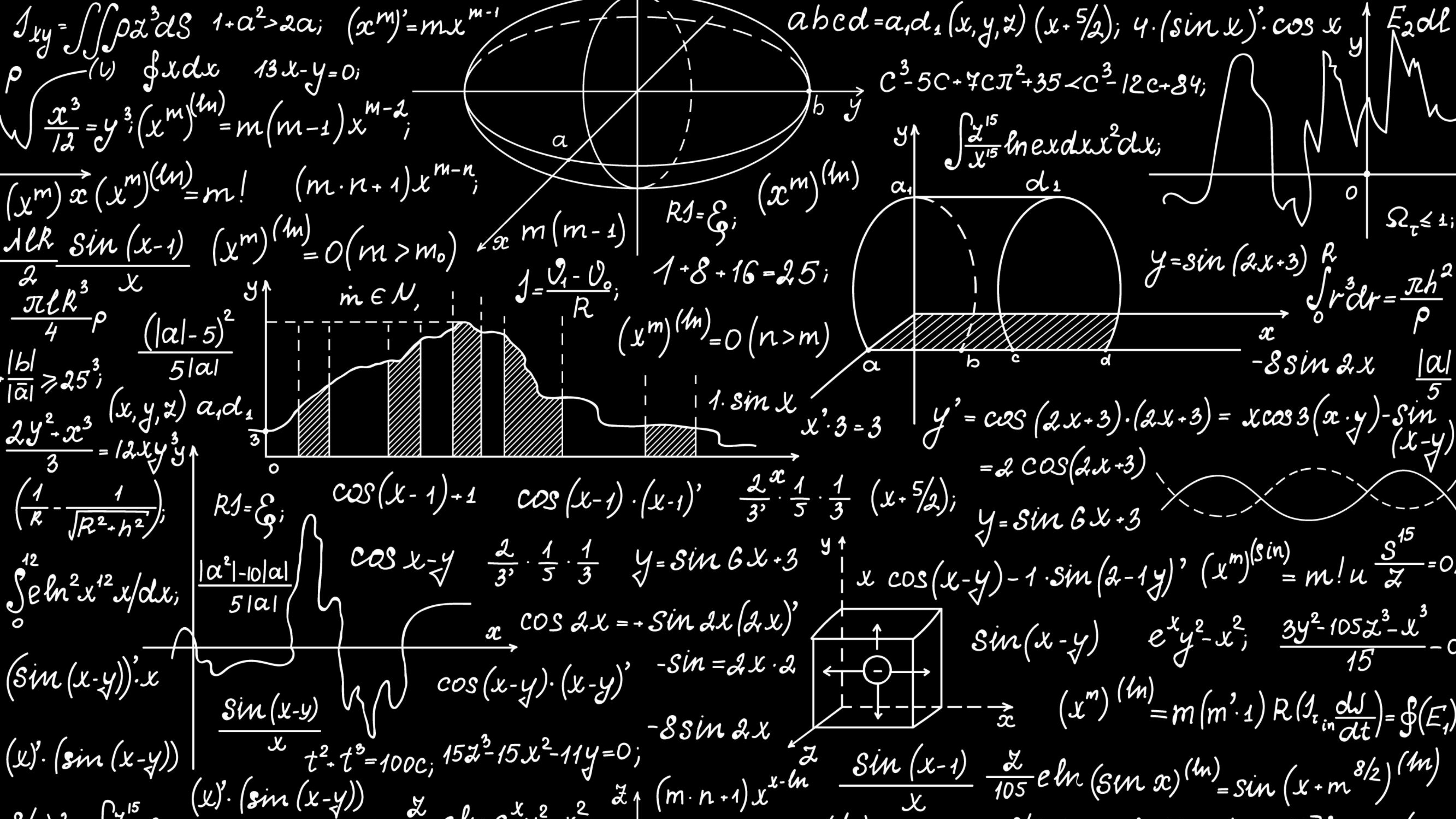
- There is a point of inflection at the end of the guarantee period
- Pricing actuaries should model the three points
- For other purposes you are choosing points across the portfolio so two should be adequate, but this is a limitation

ANNUITIES



WHOLE OF LIFE ASSURANCE





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x'·3 = 3
-8 sin 2x
= 2 cos(2x+3)
y = sin 6x + 3
cos(x-1)+1
cos(x-1)·(x-1)'
cos x-y
x cos(x-y) - 1 · sin(2-1y)'
cos 2x = - sin 2x(2x)'
-sin = 2x · 2
cos(x-y)·(x-y)'
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sin(x-y) / x
(x)'·(sin(x-y))
t² + t³ = 100c;
15z³ - 15x² - 11y = 0;
sin(x-1) / x

CONCLUSION

RISK MARGINS

- are necessary, but can be computationally expensive
- can be estimated using simplifications

SIMPLIFICATIONS

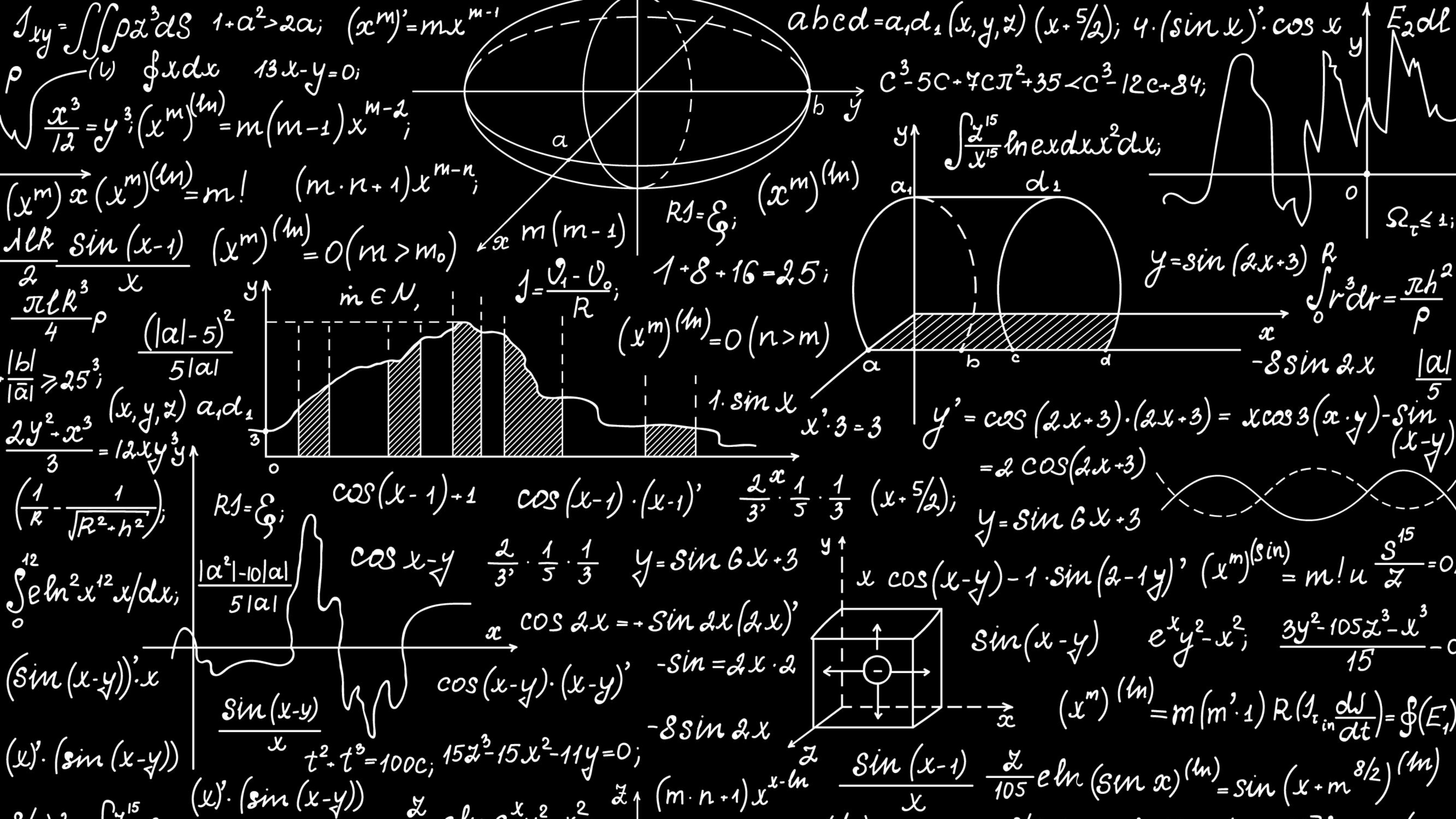
- generally underestimate the risk margin for annuities
- are pretty good for credit life
- under-estimate the risk margin for whole of life assurances

ACTUARIAL SOCIETY OF SOUTH AFRICA

WE HAVE

- Considered a restricted set of policies
- Confirmed that BEL is a bad driver for credit life and whole of life assurances
- found a reasonably linear relationship between SCR / Driver

.. that can be used to predict the future SCRs for your Risk Margin calculation



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(x^m)x(x^m)^(ln) = m!
(m·n+1)x^(m-n);
(x^m)^(ln)
RI = E;
m(m-1)
(x^m)^(ln) = 0(m > m₀)
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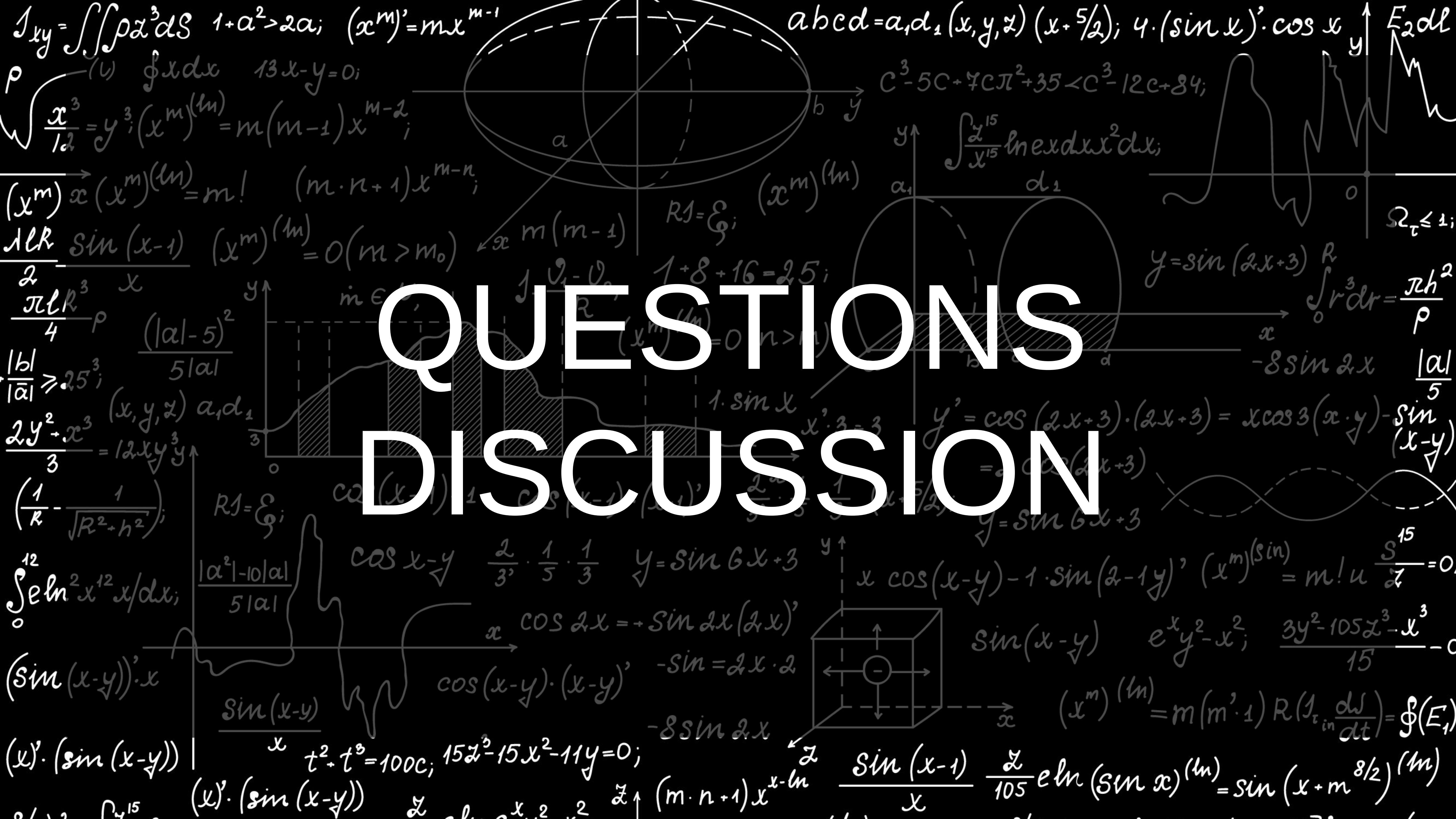
m ∈ N,
(|a| - 5)²/5|a|
(x^m)^(ln) = 0(n > m)
y = sin(2x+3)
1·sin x
x'·3 = 3
y' = cos(2x+3)·(2x+3) = xcos3(x·y) - sin(x-y)
-8sin 2x
= 2cos(2x+3)
(x, y, z) a₁d₁
cos(x-1)+1
cos(x-1)·(x-1)'
2^x/3'·1/5·1/3
(x+5/2);
y = sin 6x+3
cos x-y
2/3'·1/5·1/3
y = sin 6x+3
x cos(x-y) - 1·sin(2-1y)'
(x^m)^(sin) = m!u
|a²| - 10|a| / 5|a|
∫₀¹² eln²x¹²x/dx;
cos 2x = -sin 2x(2x)'
sin(x-y)
e^x y² - x²;
(3y² - 105z³ - x³)/15
(sin(x-y))'·x
-sin = 2x·2
cos(x-y)·(x-y)'
(x^m)^(ln) = m(m'·1)R(I_in dU/dt) = ∮(E₁
sin(x-y)/x
-8sin 2x
(x)'·(sin(x-y))
t² + t³ = 100c;
15z³ - 15x² - 11y = 0;
sin(x-1)/x
z/105 eln(sin x)^(ln) = sin(x+m^(8/2))^(ln)
(m·n+1)x^(x-ln)



QUESTIONS
DISCUSSION