INVESTIGATION OF **HEDGING STRATEGIES** BETWEEN **ASSURANCES AND ANNUITIES** FOR THE PURPOSE OF MITIGATING LONGEVITY RISK

F.F. Koning, FASSA, FIA

S.J. Bekker

DEPARTMENT OF MATHEMATICAL STATISTICS AND ACTUARIAL SCIENCE
UNIVERSITEIT VAN DIE VRYSTAAT • UNIVERSITY OF THE FREE STATE • YUNIVESITHI YA FREISTATA
Tel: 051 4012299 • e-mail: schallr@ufs.ac.za • www.ufs.ac.za

INTRODUCTION

- We all know that nowadays **people are living longer**, this could be celebrated
- **Mortality improvements are very difficult to model, in fact, is it not impossible?**
  They vary over time and in different age ranges, and can occur in jumps with medical advances, i.e. antibiotics, heart transplant/bypass, cure for cancer, cure for HIV/AIDS
- Many **drivers of longevity are complex** – obesity, electromagnetic waves(mobile phones), genetic engineering, pollution, global warming: will longevity slow down, stabilise, decrease?

PURPOSE OF THE PRESENTATION

The topic of this presentation is to try and find a way to hedge this type of risk, at least in the short term, no matter what!

INTERESTING FACTS AND PROJECTIONS

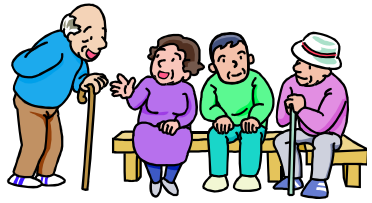
- Vaupel et al (2009) predicted that
  ½ of babies born in 2007 in Germany **will reach age 102**

- According to Institut National d'Etudes Démographiques (INED) **mortality for ages 40-70 reduced by ±50%** throughout Western Europe from 1952 to 2006

MORE - INTERESTING FACTS AND PROJECTIONS

- The # of **centenarians doubled every 10 years** from 1950 to 1990, i.e. in France there were more than 20,000 centenarians in 2008, compared to only 200 in 1950.

- The US Census Bureau (Kinsella and He 2009) projected that **by 2040** in Western Europe 28% of the population will be age 65+, so roughly **every 3rd person you see will be over age 65**



- The **disability-free life expectancy** is also important, where additional years of life are likely to be burdened by large medical and disability costs, a discussion for another day.

PREDICTING LONGEVITY – HOW DID YOUR CO. DO?

The below shows the **change in population mortality rates** for the 7 countries as an annual compound change in mortality rates, over the 18 years from 1990 to 2008, for ages 25 and 55

Country	Year	Age	${}_nq_x$	Change p.a.	Country	Year	Age	${}_nq_x$	Change p.a.
Australia	1990	25	0.00460		SA	1990	25	0.01746	
	2008	25	0.00293	-2.54%		2008	25	0.05516	6.19%
	1990	55	0.03524			1990	55	0.08081	
	2008	55	0.02063	-3.02%		2008	55	0.12480	2.39%
Brazil	1990	25	0.01096		China	1990	25	0.00781	
	2008	25	0.00847	-1.44%		2008	25	0.00436	-3.29%
	1990	55	0.06932			1990	55	0.06092	
	2008	55	0.04954	-1.88%		2008	55	0.04151	-2.15%
USA	1990	25	0.00623		Germany	1990	25	0.00396	
	2008	25	0.00491	-1.33%		2008	25	0.00215	-3.45%
	1990	55	0.04577			1990	55	0.04448	
	2008	55	0.03473	-1.55%		2008	55	0.02968	-2.27%
UK	1990	25	0.00339						
	2008	25	0.00273	-1.21%					
	1990	55	0.04197						
	2008	55	0.02790	-2.29%					

Source: World Health Statistics 2010

LONGEVITY – VERY REAL – HERE TO STAY

- **Threaten solvency** with even a small improvement in mortality that was not anticipated.
- Future changes in mortality are **very hard to predict** and have often been underestimated, resulting in **large losses**
- Due to aging populations worldwide the **potential annuity business, and risks, are increasing fast**

Declining large potential profits or find a solution?

LONGEVITY – VERY REAL – HERE TO STAY

POSSIBLE SOLUTIONS:

- **Avoid the longevity risk**, many companies in South Africa are now selling annuities under the name of "**Living Annuity**", a pool of funds that can be depleted

- **Securitising** annuity portfolios and selling them on the **capital markets** have been met with limited success. Longevity risk, if accurate pricing is possible, can provide great **diversification to asset portfolios**, since this risk is not linked to the fuel crisis, war in the Middle East, or a sub-prime crisis.

- Maybe **reinsurance or co-insurance / swap agreements** could work…

THE NATURAL HEDGE

- Normally the natural hedge considers an annuity and life cover **TO THE SAME LIFE**, taking one of two common forms:
  - "cash-back annuities", with decreasing life cover to the annuitant
  - Deferred annuities, with life cover initially, followed by the annuity

- We propose to do this on **portfolio basis** as shown below, where the annuity holder and the person with life cover may be very different

- Mortality is comonotonic in the sense that a **single factor** affecting mortality would affect **all lives**, and in the **same direction**

NATURAL HEDGING – AN OPTION?

ANNUITIES	LIFE COVER
pays up to death	**receives** contributions **up to death**
risk of living longer	risk of living shorter
Longevity = larger PV	Longevity = smaller PV

DEFINITION OF NATURAL HEDGE:

OFFSET THE **LOSSES** /PROFITS **ON ANNUITIES WITH PROFITS** /LOSSES **ON LIFE COVER** DUE TO THE SAME CHANGE IN MORTALITY (OR OTHER FACTORS)

CAN SUCH A HEDGE WORK?

HEDGING LONGEVITY – CAN SUCH A HEDGE WORK?

- How often should it be rebalanced

- What factors affect the hedge

  - Changes in interest
  - Changes to the portfolio, more annuities sold, less life cover
  - Changes in longevity above 65 and less for ages below 65
  - Cross subsidies used, male-female, young-old
  - Not allowed to distinguish between young and old, male female

THE NATURAL HEDGE – we propose

- **Make use of changes in present values (PVs)**

annuities vs Assurances,

which are in opposite directions,

<u>similar to immunisation</u>

to hedge expected mortality and interest changes

ASSUMPTIONS

- The term structure of interest rates is flat at 6%
- Death benefits are paid at the end of the year of death
- Annuity payments are made at the beginning of every year until death
- PMA80 and PFA80 tables used when pricing annuities
- AM80 and AF80 tables used when pricing life assurances
- Mortality changes by a constant annual compound percentage over all lives

THE NATURAL HEDGE – EXAMPLE

❖Assume that after a certain unspecified improvement in mortality the change in the present value of an annuity is an increase of R0.35.

❖ For the same improvement in mortality the present value of a certain assurance reduced by R0.02. We propose to hedge as follows:

$$\text{Assurances Required} = \left|\frac{\Delta\, annuity\ \ PV}{\Delta\, Assurances\ \ PV}\right| = \left|\frac{0.35}{-0.02}\right| = 17.5$$

So R17.5 Assurances Required per R1 of annuities p.a.
i.e. 175000€ life cover on 25 year old hedges
10000€ pension to 65 year old – for the particular improvement

THE NATURAL HEDGE – IMMEDIATE CHANGE

A hedged portfolio is constructed for the **1% mortality reduction** using the ABOVE hedge ratio

The first two rows show the present values of the two products at time zero under the assumption of no change in the mortality rates. The third row shows the total present value of **the hedged portfolio consisting of 1 annuity and 24.286855 assurances**. This portfolio is hedged against a reduction in mortality of 1%, using the ratio calculated earlier.

	Type	Change	Mortality Age	PV Age	PV	Change in PV
1	Assurance	Original	25	25	0.072481	
2	Annuity	Original	65	65	9.639131	
3	Total	Original	25 & 65	25 & 65	11.399426	
4	Assurance	1% Improvement	25	25	0.059952	-0.012529
5	Annuity	1% Improvement	65	65	9.943421	0.30429
6	Total	1% Improvement	25 & 65	25 & 65	11.399426	

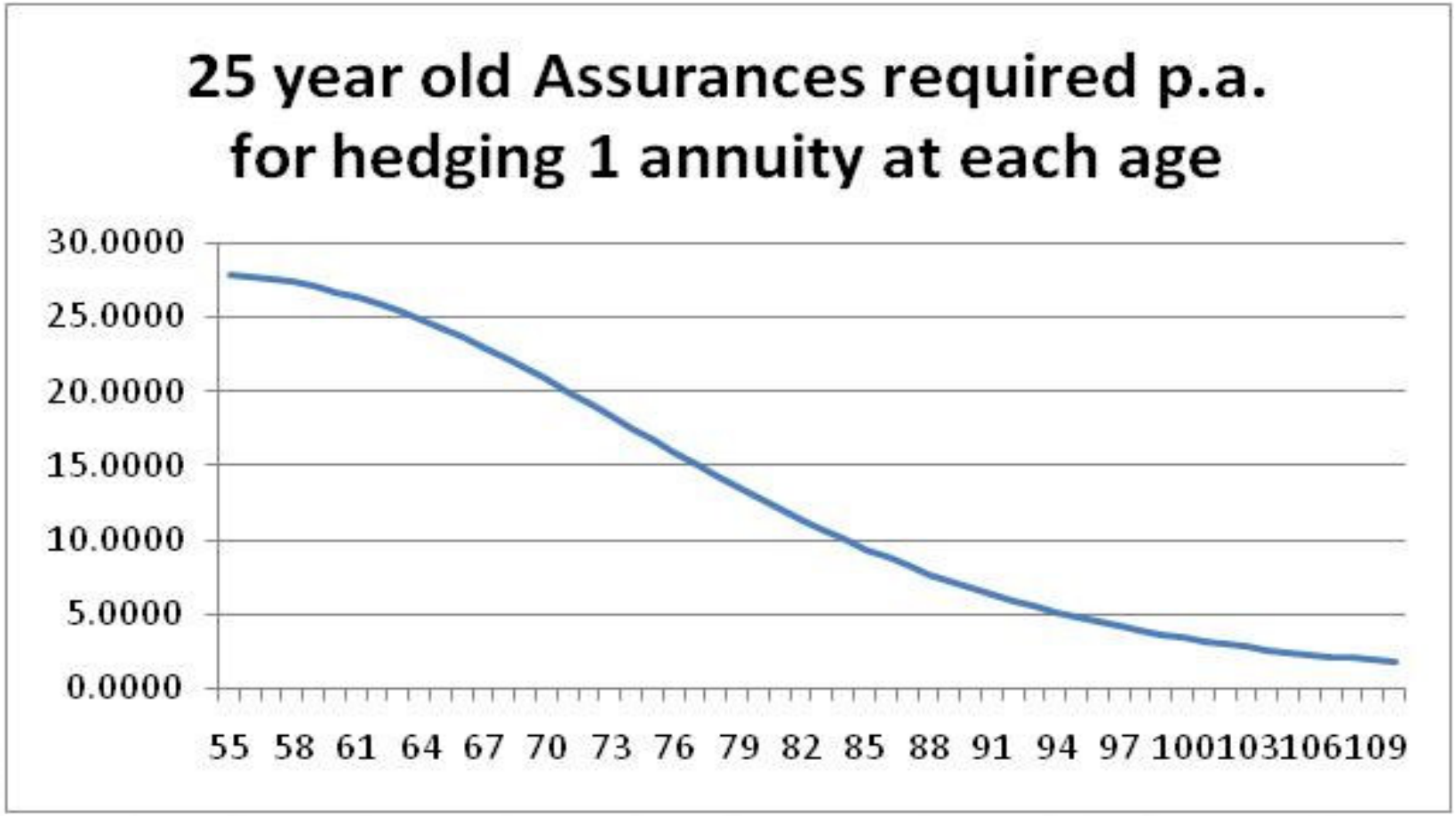
Even for a 2% reduction, the hedge requires a ratio of 1:25.781 of annuities to assurances

THE NATURAL HEDGE – OVER TIME

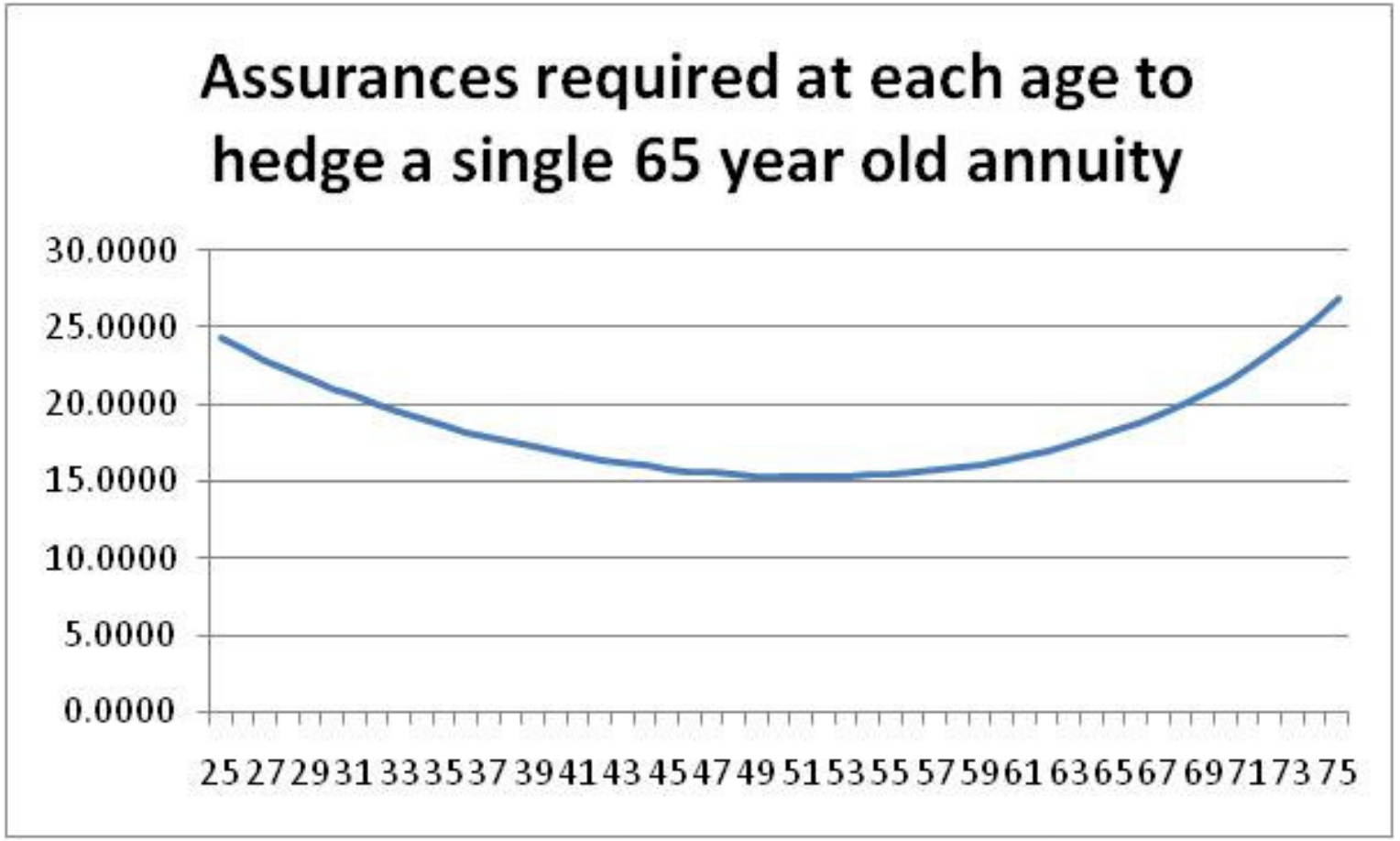
	Type	Change	Mortality Age	PV Age	PV	Assurances required to restore hedge
7	Total	Original	25 & 65	26 & 66	11.201403	
8	Total	1% Improvement	25 & 65	26 & 66	11.206053	0.350
9	Total	Original	25 & 65	27 & 67	11.007780	
10	Total	1% Improvement	25 & 65	27 & 67	11.016502	0.61952
11	Total	Original	25 & 65	28 & 68	10.819575	
12	Total	1% Improvement	25 & 65	28 & 68	10.831616	0.80731
13	Total	Original	25 & 65	29 & 69	10.637858	
14	Total	1% Improvement	25 & 65	29 & 69	10.652288	0.91335
15	Total	Original	25 & 65	30 & 70	10.463678	
16	Total	1% Improvement	25 & 65	30 & 70	10.479380	0.93852

To be on the safe side, hedge with 1:25, and rebalance from time to time

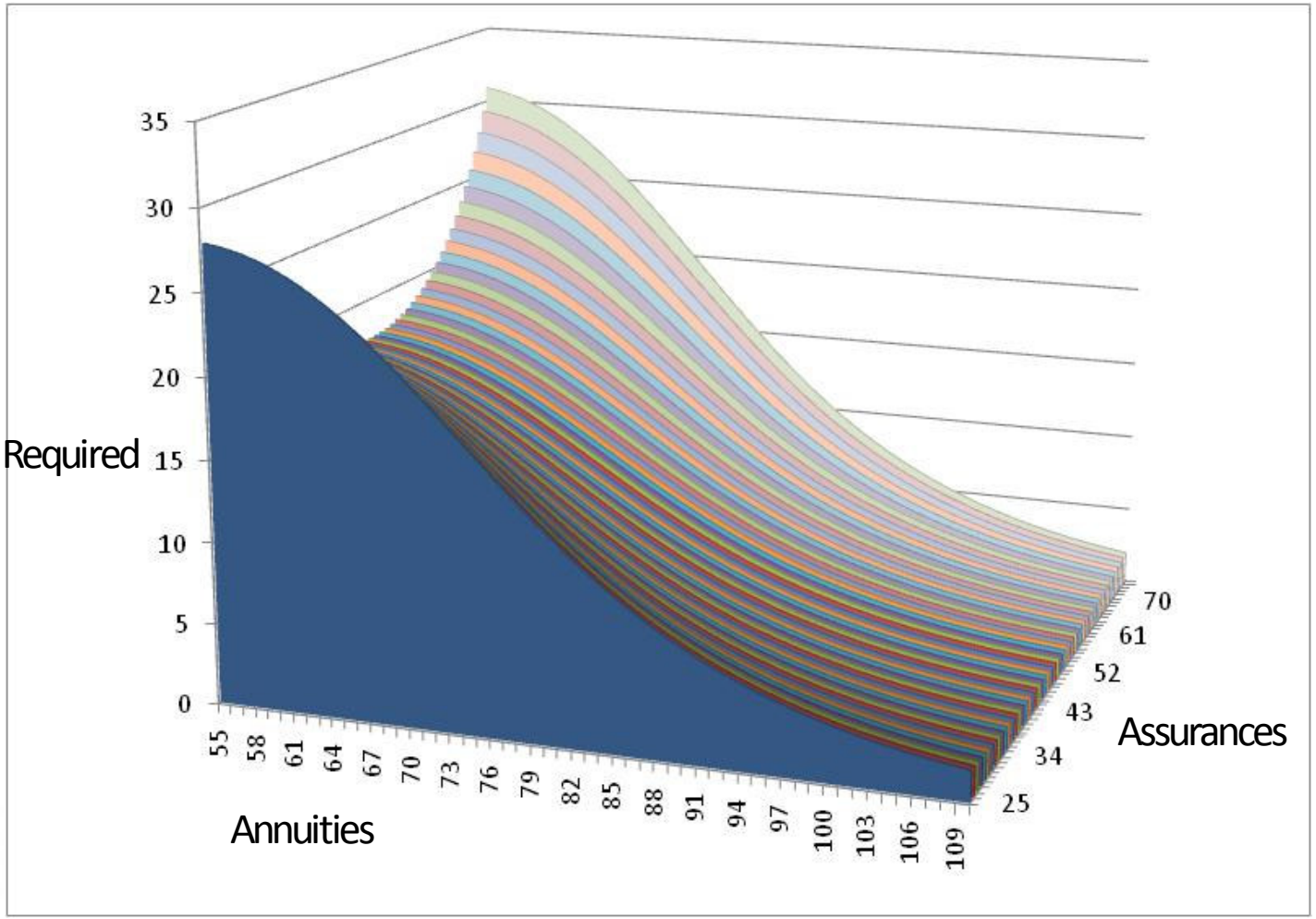
THE NATURAL HEDGE – Mortality Δ^S at 1% improvement



THE NATURAL HEDGE – Mortality Δ^S at 1% improvement



THE NATURAL HEDGE – Mortality Δ^S at 1% – Combined



THE NATURAL HEDGE – INTEREST Δ^S

WE ALSO NEED TO CONSIDER THE POSSIBILITY THAT **INTEREST** MAY CHANGE DURING THE TERM

Recall at an interest rate of 6% p.a. the company required 24.28686 assurances for each 1 annuity. (24.29 : 1)

NOW INCREASE INTEREST TO 7% p.a.- Recalculate:
The company will now require (27.62637 : 1) to obtain a natural hedge.

After 5 years the company will only require 0.86909 extra assurances to restore the hedge

THE NATURAL HEDGE – INTEREST Δ^S

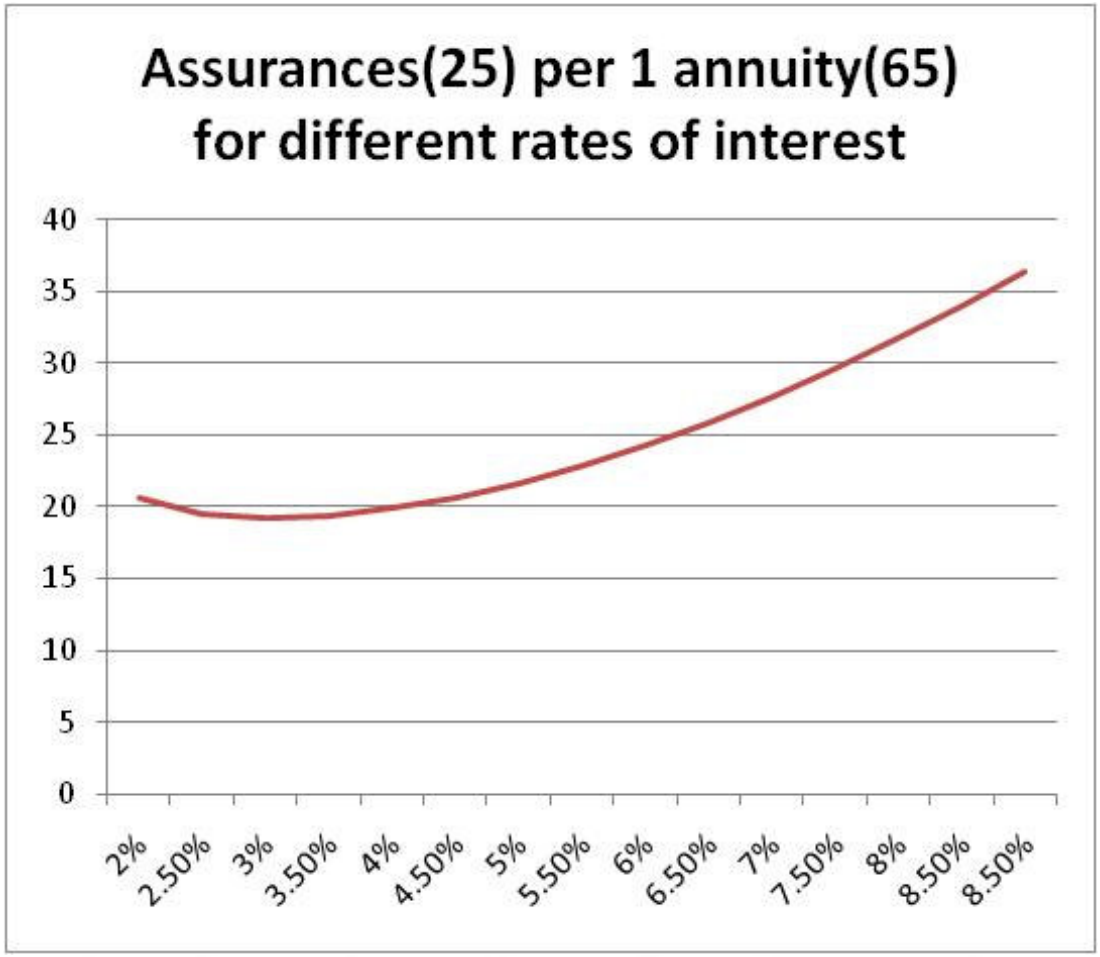
Recall at an interest rate of 6% p.a. the company required 24.28686 assurances for each 1 annuity. (24.29 : 1)

At an interest rate of 5% p.a. the company will require (21.6755 : 1) assurances for each annuity to set up the initial hedge.

After 5-years the company will now need to add an extra 0.99184 assurances to restore the hedge

LARGE INTEREST CHANGES MAY REQUIRE MORE FREQUENT REBALANCING

THE NATURAL HEDGE – INTEREST Δ^S



At low interest rates changes to interest have little effect on the hedge

THE HEDGE PROCESS - APPLIED

- Sort both portfolios from young to old, or from large policies to small
- Calculate the PV hedge tables as below for benefits at each age for both portfolios you want to hedge, according to the parameters expected

Females : Females Summarized hedging annuities with assurances

Annuity Age \ Assurance Age	27	32	37	42	47	52	57	62	67	72
57	30.2671	26.0326	22.7886	20.3747	18.6807	17.6469	17.2690	17.6130	18.8460	21.2946
62	30.3698	26.1209	22.8659	20.4437	18.7441	17.7068	17.3276	17.6727	18.9099	21.3668
67	28.7543	24.7314	21.6496	19.3563	17.7470	16.7649	16.4059	16.7327	17.9041	20.2303
72	25.5939	22.0132	19.2701	17.2289	15.7965	14.9223	14.6027	14.8936	15.9362	18.0068
77	21.3016	18.3214	16.0383	14.3394	13.1472	12.4197	12.1537	12.3958	13.2636	14.9869
82	16.7589	14.4142	12.6180	11.2814	10.3435	9.7711	9.5618	9.7523	10.4350	11.7908
87	12.7986	11.0080	9.6362	8.6155	7.8992	7.4621	7.3023	7.4477	7.9691	9.0045
92	9.7584	8.3931	7.3472	6.5690	6.0228	5.6895	5.5677	5.6786	6.0761	6.8656
97	7.4310	6.3914	5.5949	5.0023	4.5864	4.3326	4.2398	4.3242	4.6270	5.2281
102	5.5076	4.7371	4.1468	3.7075	3.3993	3.2112	3.1424	3.2050	3.4294	3.8749
107	3.9696	3.4142	2.9888	2.6722	2.4500	2.3144	2.2649	2.3100	2.4717	2.7928

THE HEDGE PROCESS

- Now start with the first age of annuities (or smallest/largest policies)
- Hedge it with assurances until fully hedged in terms of the table quantities
- If only part assurance is used, it remains for the next age of annuities (this assumes that sufficient quantity of policies exist so that dependence is negligible)
- Continue until all annuities are covered and some assurances are left or until no more assurances are left
- The leftover portion can be reinsured, co-insured (swap agreement), or left open

IN CONCLUSION

- This method is very **effective and easy** to understand and apply
- It proves to be **relatively stable** for changes in mortality and small changes in interest over a short period of time of around 5 years
- It does **not require excessive rebalancing**, although easy to do
- The method can be applied on policy by policy basis or grouped together by age or even age intervals – large **flexibility** in application
- **Great opportunity** for swap agreements and reinsurance sales
- Unfortunately does not reduce reserving requirements as yet

FURTHER RESEARCH

- **Stochastic approach** around similar lines, considering variances and probability calculations
- The effect of **dependencies**, like one large assurance hedging several annuities,
- calculating **optimal numbers** (minimum) of annuities/assurances, portfolio structures
- **Optimal methods** of hedging, including
  - Start young and work up, or work downwards
  - Start with annuities, match with assurances
  - Start with small annuities, or the larger ones first
  - Cap annuities or assurances on individual lives, reinsure or swap
- **Securitize** the hedged portfolio (sell as a 5-year product)
- Methods of **measuring risks** of such a hedged portfolio

THANK YOU

Questions?

PLEASE CONTACT ME ON

koningf@ufs.ac.za