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Longevity Bonds: Construction, Valuation and Use

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Introduction

- Longevity risk: risk that members of reference population live on average longer than anticipated
- Longevity risk (LR) is one of the largest sources of risk faced by life companies and pension funds
  - Life expectancy for men aged 60 is 5 years longer in 2005 than anticipated in mortality tables made in 1980s
  - Amounts at risk £2520 bn (about $4424 bn) (UK Pensions Commission Report) or £40k ($70k) per person in UK
- This paper looks at Longevity bonds

Main Features of Swiss Re Bond

- Bond is hedge to issuer; issuer gains if *S*(*t*) very low
  - Hence, bond is hedge against portfolio dominated by life insurance
- Bond is *short-term* bond to protect issuer against *extreme* deterioration in mortality
- *S*(*t*) is average of 5 national mortality indices
- Does not involve complicated credit problems
- Bond is coupon-plus-principal bond, but only principal is at risk due to LR
- Spread over LIBOR compensates for principal-at-risk

EIB/BNP Bond

- Announced in late 2004, to be issued by EIB

Main Features of EIB/BNP Bond

- Hedge to holder; issuer gains if $S(t)$ lower than anticipated
- Bond is hedge against portfolio dominated by annuity issues
- Bond is *long-term* bond designed to protect holder against *any* unanticipated improvement in mortality
- $S(t)$ involves a single national survivor index
- Bond involves (quite) complex credit issues
- Bond is annuity-type bond and all coupon payments at risk

Types of Longevity Bond

- Bond might be issued or held as a hedge
- Type of portfolio hedged by bond (i.e., life or annuities)
- Type of bond: coupon-plus-principal, annuity bond, etc.
- Survivor/mortality index used
- Credit risks involved
- Nature of payment function and how it is contingent on $S(t)$
- LBs can vary across many dimensions

Other Types of Longevity Bond

- Zero LBs: equivalent to conventional zeros, make single payment contingent on $S(t)$
- Open-ended LBs: continue to make payments for as long as members of ref pop are alive
- Principal-at-risk LBs: coupon payments conventional
- Inverse LBs: payments are inverse functions of $S(t)$
  - Comparable to conventional inverse floaters
- Collateralized longevity obligations (CLOs) comparable to CDOs
  - Synthetic equivalents, synthetic CLOs etc.

Constructing Longevity Bonds

- Decomposition method
  - Deconstruct existing govt bonds
  - Use govt. bonds assuming minimal credit risks
- Construction using longevity swaps
  - Supplements govt bond with longevity swap

Decomposition Method

- Put conventional govt bond into SPV
- Sell conventional LB as claim on SPV
- Sell residual claims as ILB
- In this case, ILB produced as by-product of LB
- Trivial credit risk problems

Swap Method

- Combine conventional govt bond and longevity swap (LS)
- LS is a swap involving at least one longevity-dependent payment leg, e.g.,
- Floating payment might be $S(t)$
- Fixed payment might be $(1+\pi)H(t)$, $H(t)$ based on mortality tables, π is the swap premium set to make both legs same value
- Bank puts bond and LS into SPV, SPV provides LB

Constructing Different LBs

- Conventional bond + pay-fixed LS produces LB with long expsoure to *S*(*t*)
- Conventional bond + pay-floating LS produces inverse LB
- Conventional bond + one payment pay-fixed LB produces zero LB
- Annuity bond + zero LB for terminal payment produces principal-at-risk LB, etc.

Complications [1]

- Availability of govt bonds of sufficiently long maturity
  - Need these to financially engineer LBs
- 25 years is too short
  - A lot of risk arises from people living well into 90s
- French, UK governments starting to issue ultra-long bonds (50 years)
- If price stability lasts, might expect to see bonds of up to 100 years' maturity

Complications [2]

- Credit risk complications
- Relatively straightforward if LBs constructed using SPVs
- Can be more complicated if LBs are constructed using longevity swaps
- Swaps can create complex credit exposures
- Example is EIB/BNP bond

Complications [2], cont

- Investors exposed to (AAA) EIB
- Swap means that EIB exposed to (AA) BNP, and BNP exposed to EIB
- Reinsurance means that BNP also exposed to (AA) Partner Re
- Parties involved might also choose further credit enhancement

Complications [3]

- Survivor index problems
- Index must reflect payments due if bond is to provide a good hedge
- But if there are too many different indices there can be liquidity problems
- $\Rightarrow$ Need to balance hedging and liquidity

Complications [3], cont.

- Indices constructed from infrequently reported data subject to IBNR problems
- Issues of smoothing methodologies – changes in methodology produce uncertainty
- Reliance on projections and associated model and parameter risk
- Moral hazard and data integrity problems

First-Order Sensitivities

- Interested in first-order sensitivities to shocks in force of mortality μ and *r*
- These give approximations to their hedging qualities
- Hence, can use them to design hedges against both IR and Longevity Risk
- Can measure sensitivities using elasticities

Elasticities

- Mortality elasticity is

$$\eta(\mu,T) = (\Delta P/P)/(\Delta\mu/\mu)|T$$

- IR elasticity is

$$\eta(r,T) = (\Delta P/P)/(\Delta r/r)|T$$

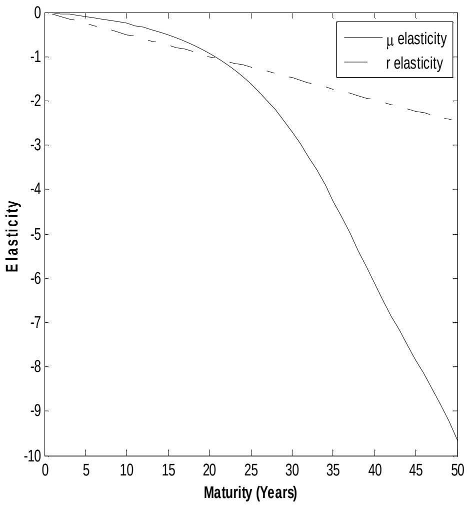
- Interested in these for illustrative positions for T=1 to 50

Illustrative Positions

- Zero-coupon LBs, coupons equal to *S*(*t*)
- Classical LBs paying *S*(*t*) for *t*=1 to 50
- Principal-at-risk LBs where principal is *S*(*t*) and coupon floats with market *r*
- Principal-at-risk fixed coupon LBs where principal is *S*(*t*)
- + 'inverse' equivalents

Elasticities for Zero LBs

- Zero LB is long LR and short IR risk
- Implies zero LB is a good hedge for position that is short LR and long IR risk
- Note large elasticities esp. for high *T*

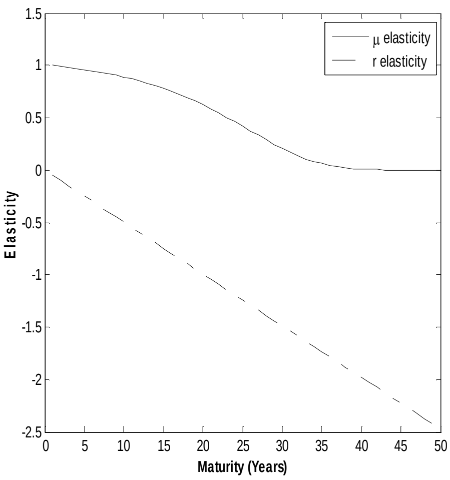


Zero LB Example

- Life company might be short LR and long IR risk
- If two risk exposures have similar magnitude, might consider hedging both simultaneously using zero LB with 20 year maturity
- Or might use an LB to hedge LR and a conventional hedge for remaining IR risk

Elasticities for Inverse Zero LBs

- Inverse zero LB is good hedge for position that is long LR and long IR risk
- Would want short to medium term maturity



Inverse Zero LB Example

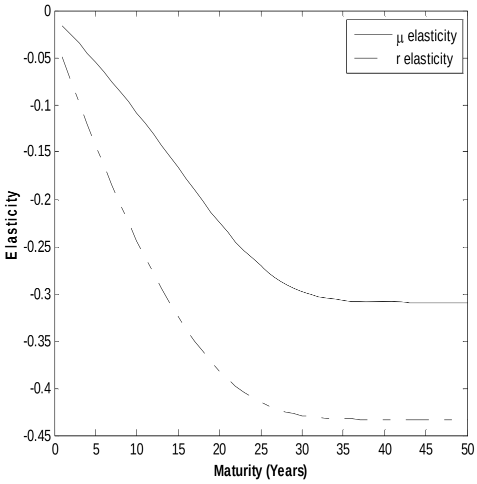
- Annuity provider might be long IR risk and long LR risk
- If LR exposure a little bigger than IR exposure, might use zero ILB with maturity of 15 years
- Or might use an ILB to hedge LR and a conventional hedge for remaining IR risk

A General Lesson

- The *type* of security we should consider as a hedge depends on nature of LR and (possibly) IR risk exposures
- *Maturity* of hedge instrument depends on the relative sizes of these exposures

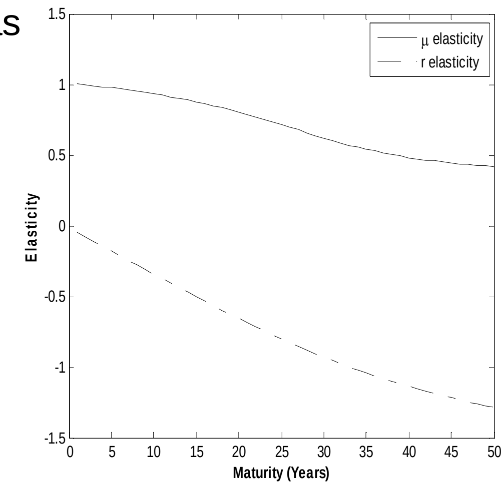
Elasticities for Classical LBs

- Similar properties as zeros
- Elasticities generally not so large
- Less leverage than zeros



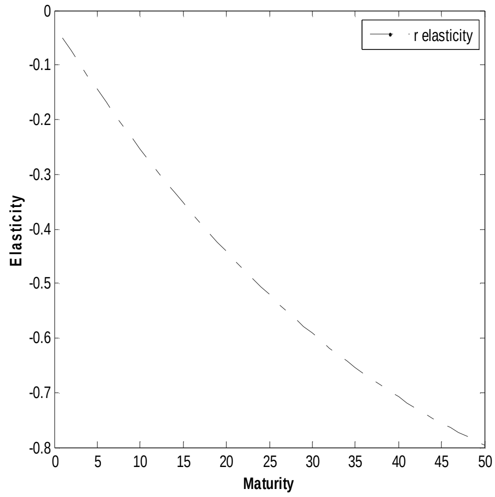
Elasticities for Classical ILBs

- Similar properties as inverse zeros



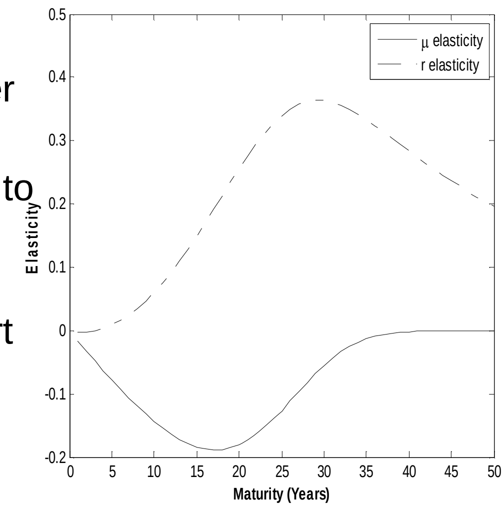
Elasticities for Conventional AB

- Interesting to note that conventional annuity bonds have much greater IR sensitivity



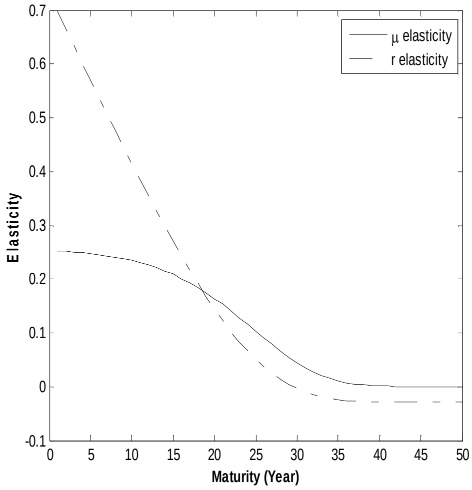
Floating coupon PAR LBs

- These are very different from earlier ones
- Peaks/troughs due to offsetting effects
- Would hedge a position that is short both risks



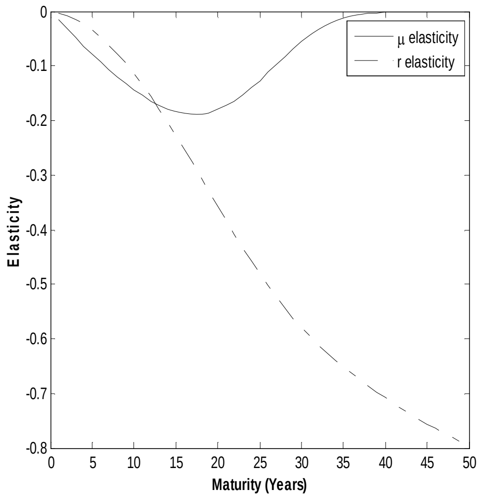
Floating coupon PAR ILBs

- No peaks/troughs!
- Would hedge a position that is long LR and short IR risk



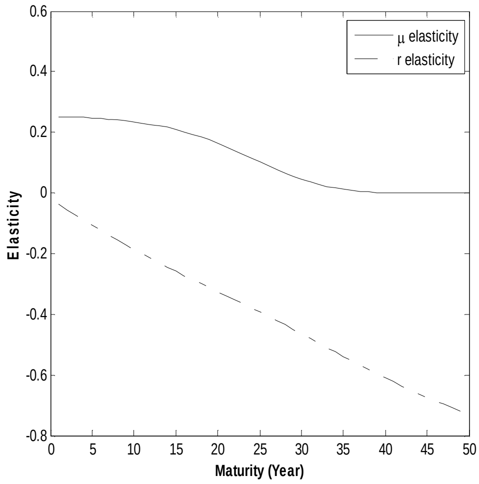
Fixed coupon PAR LBs

- Change of coupon makes no difference to μ curve but makes a big different to *r* curve
- Qualitatively similar to zeros



Fixed coupon PAR ILBs

- Again, change of coupon makes no difference to μ curve but makes a big different to *r* curve
- Qualitatively similar to inverse zeros



Conclusions

- LBs involve challenging problems, e.g.,
- Valuation problems due to market incompleteness
- Hampered by dearth of ultra long bonds
- Credit risk management problems
- Index problems
- Contract design problems

Conclusions

- But LBs also very promising, e.g.,
- Very versatile and flexible
- Can accommodate different mixes of LR and IR risk exposure
- Can accommodate desired leverage
- Attractions as low-beta investment opportunities