



**The Actuarial Profession**

making financial sense of the future

Yorkshire Actuarial Society 8 February 2012



LPI market - LPI, fatal floors in BPA pricing

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Neil Snyman

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# Agenda

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1. History of LPI
2. Supply and Demand
3. Impact of LPI on BPA Pricing
4. Modelling LPI
5. LPI Alternatives
6. Other flavours of LPI
7. The rise of CPI

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# What is Inflation?

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Inflation is Rise in general level of Prices over a period of Time

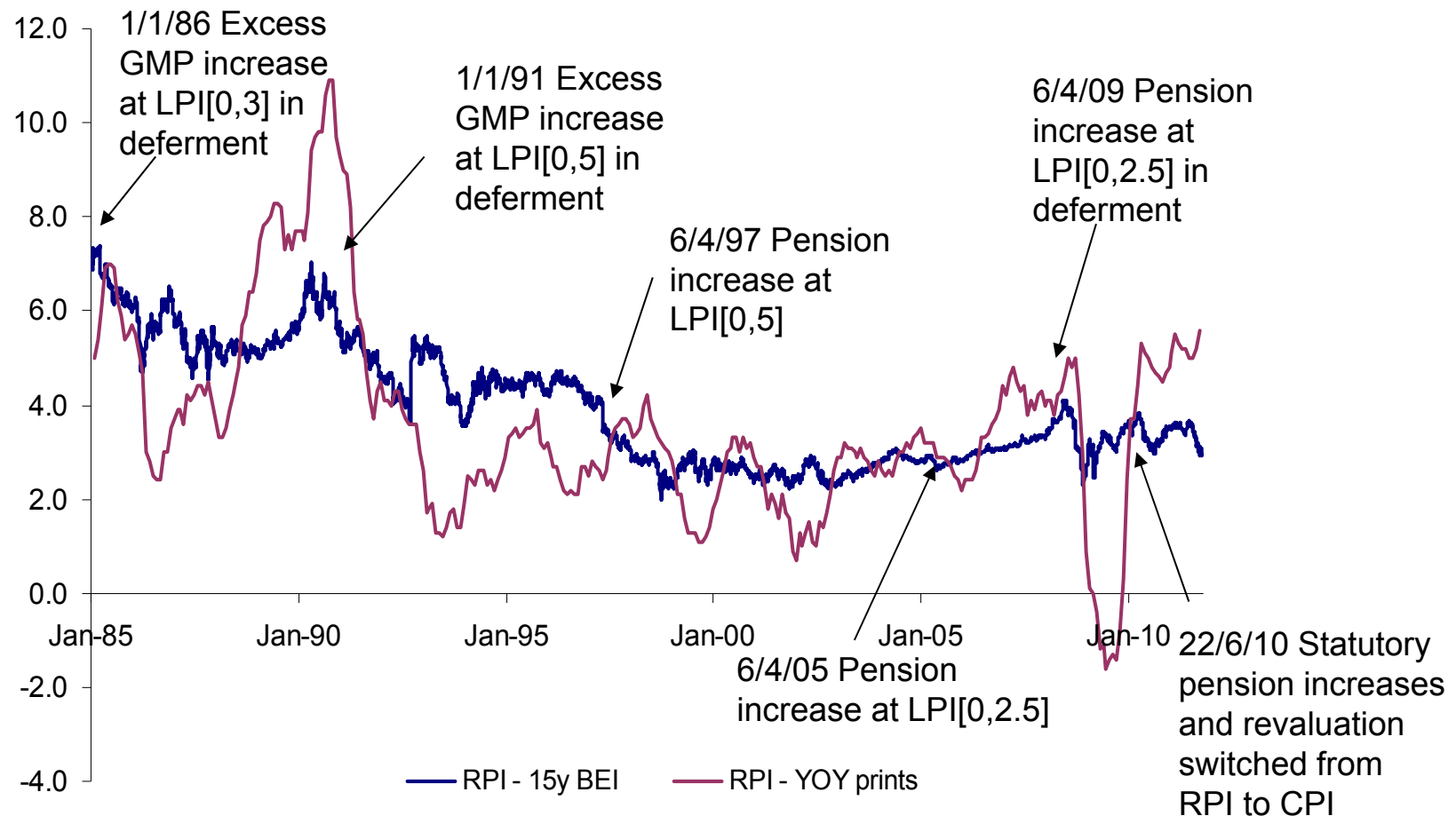
Retail Price Index (RPI) published monthly by ONS, first published in 1947

Basket of items bought by average family eg food transport communication, rent, council tax, housing costs, rebalanced every year via Family Expenditure Survey

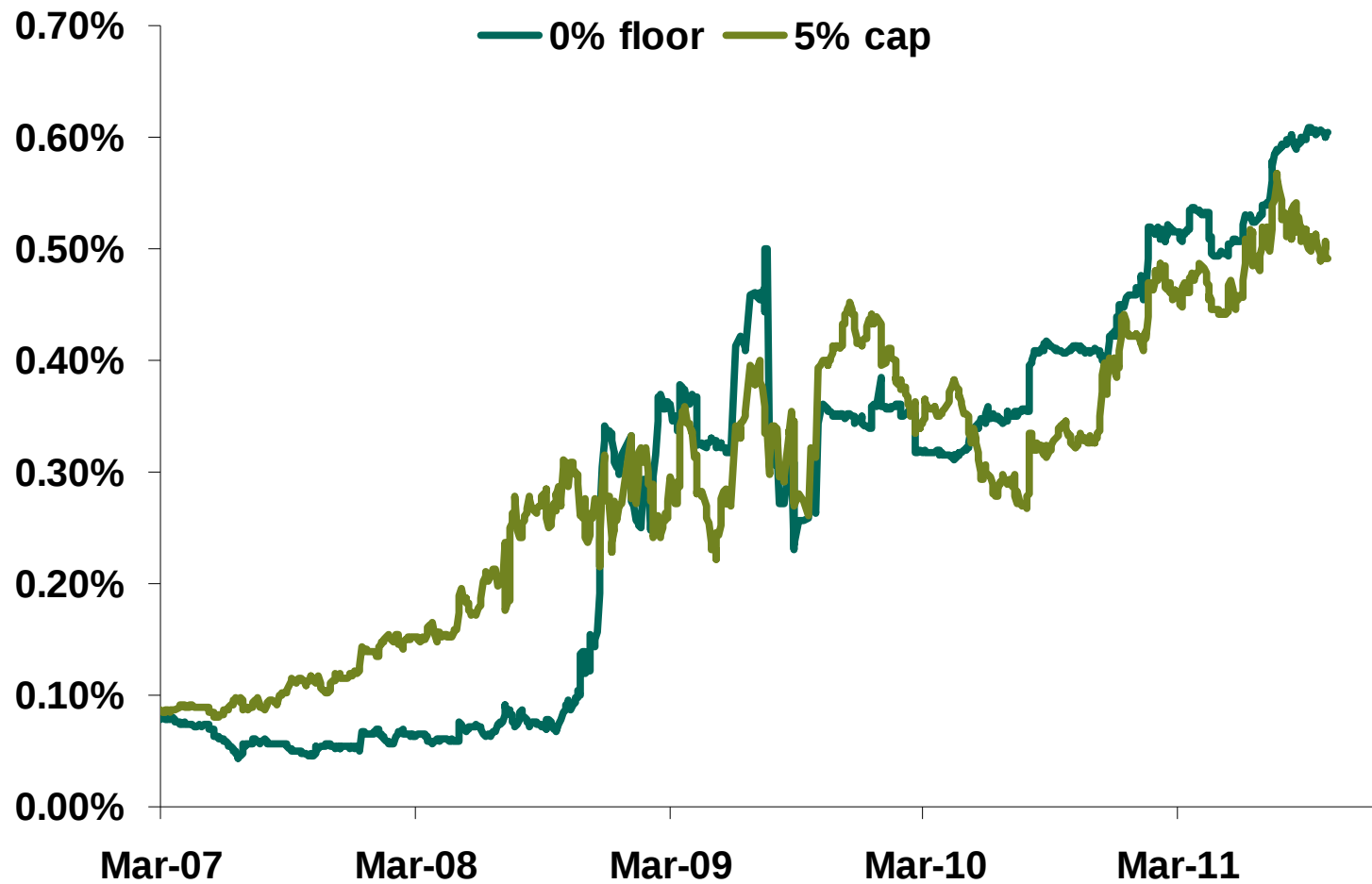
RPI Dec 2011 239.4 (rebased to 100 January 1987)

Limited Price Indexation (LPI) is RPI with CAPS and FLOORS

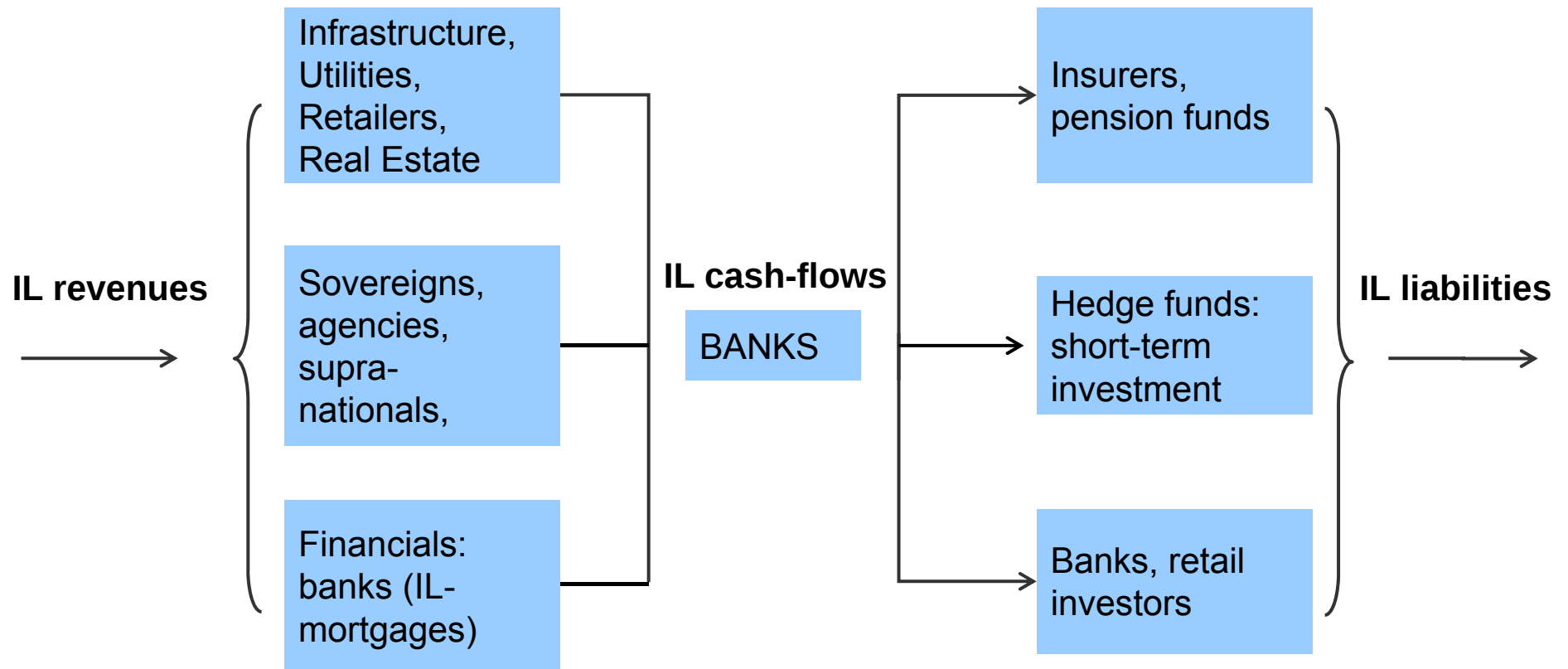
# History of Limited Price Indexation - LPI



# History of LPI – Historical Pricing



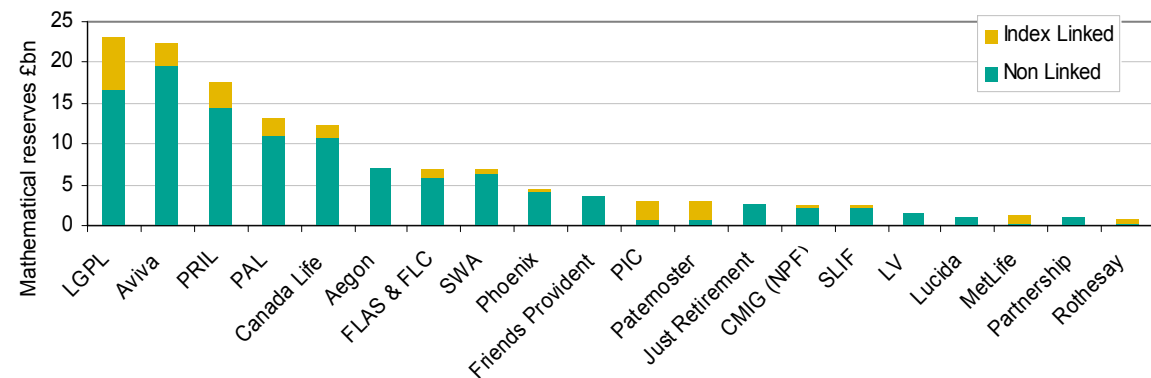
# LPI – The Players: Supply and Demand



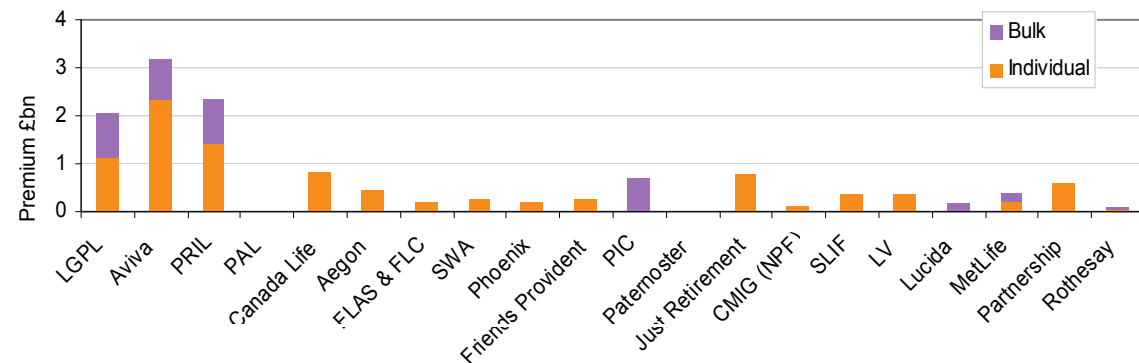
# Annuity liabilities

- Individual market is dominated by **L&G, Prudential and Aviva**
- **Just Retirement, Partnership and LV=** have all been active in the enhanced/impaired annuity space

Net mathematical reserves (End 2010)



New business premiums (2010)

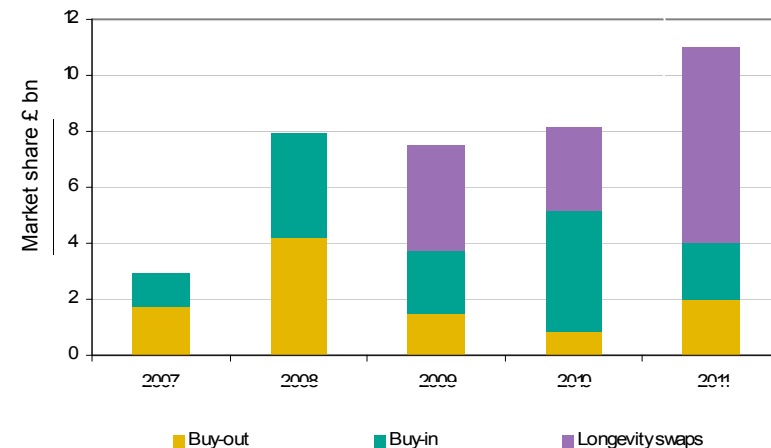


Source: RBS; FSA Returns 2010

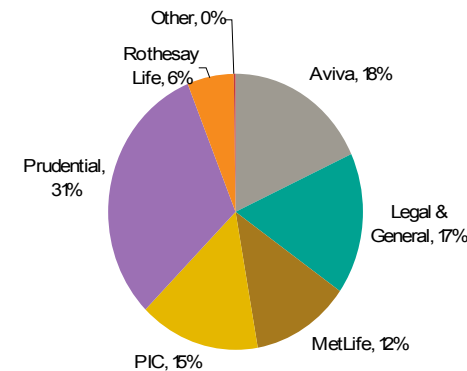
# Bulk annuity market in 2011

- The total deal volume in 2011 was over **£11bn** with significant activity coming in the **last quarter** of the year
- Over £7bn of the transactions were **longevity swaps** including Rolls Royce/Deutsche (£3bn), ITV/Credit Suisse (£1.7bn)
- In Oct 2011, L&G transacted the largest buy-out deal to date - £1.1bn with Turner and Newall

Total bulk annuity market size

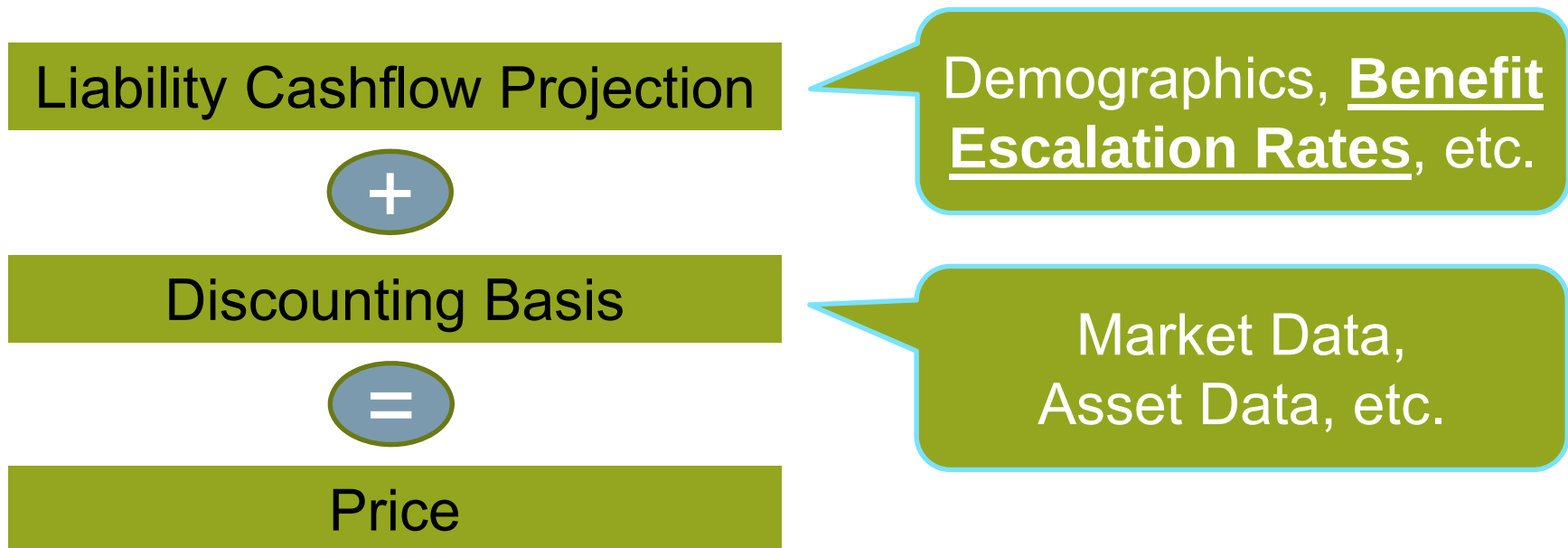


Buy-ins & Buy-outs: Year to Sept 2011



# LPI's Impact on BPA Pricing

BPA price calculated using a discounted cashflow approach

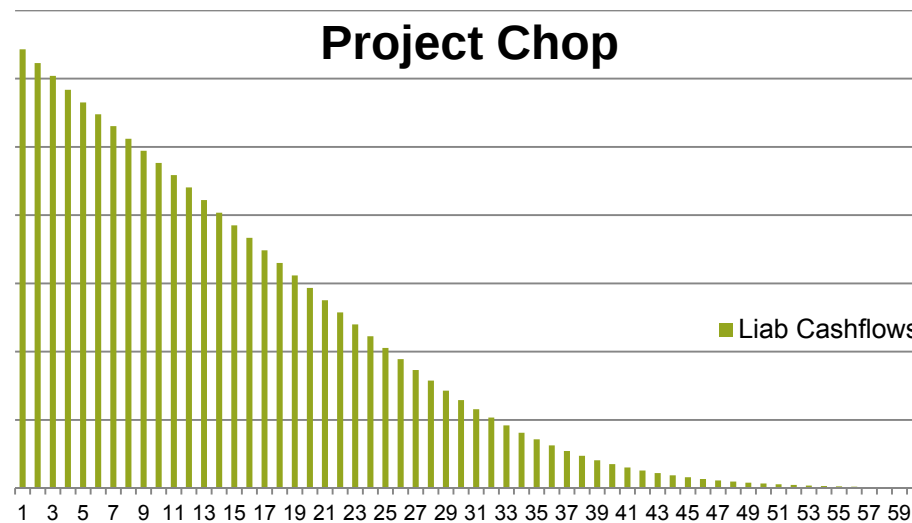


Escalation parameter is market consistent

How material is the impact of Escalation?

# Materiality of LPI on Pricing

Investigation of impact of 10bp increase in escalation (LPI) rate

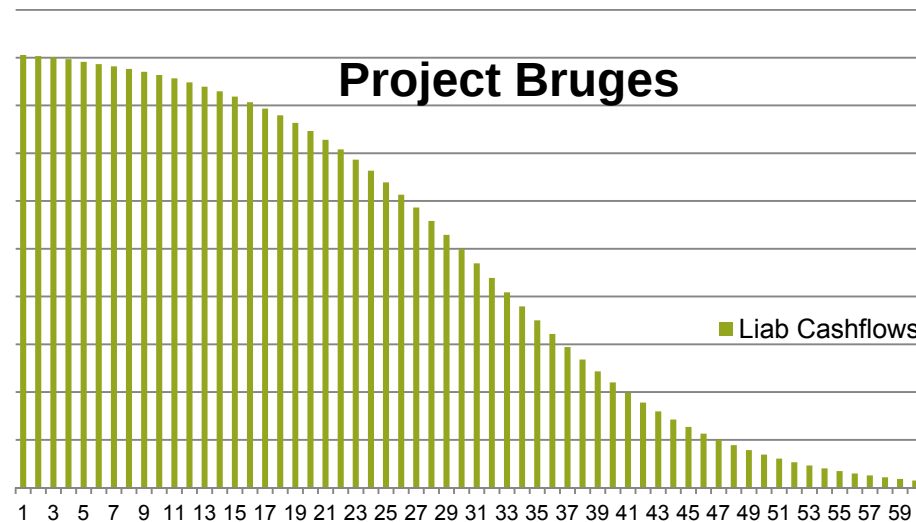


Duration ~ 14yrs

10bp increase in escalation rate results in pricing increase of 1.36%

# Materiality of LPI on Pricing

Investigation of impact of 10bp increase in escalation (LPI) rate

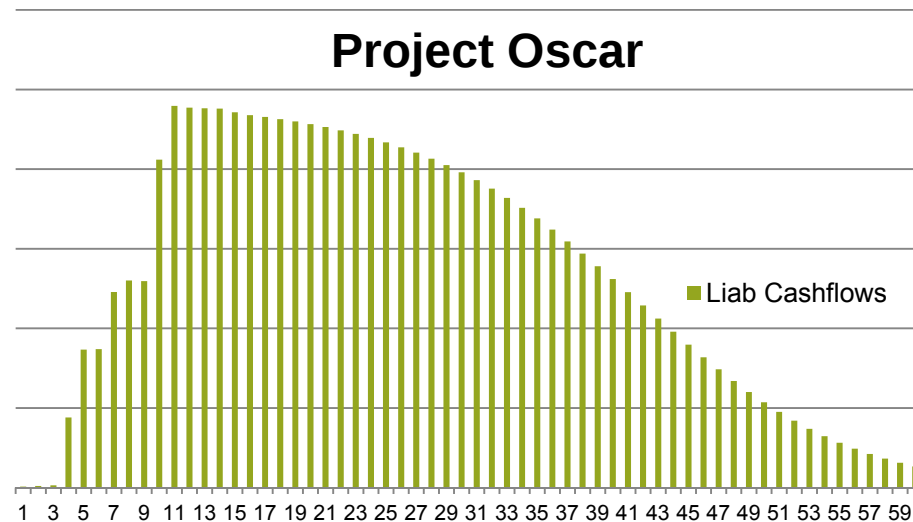


Duration ~ 19yrs

10bp increase in escalation rate results in pricing increase of 1.85%

# Materiality of LPI on Pricing

Investigation of impact of 10bp increase in escalation (LPI) rate



Duration ~ 27yrs

10bp increase in escalation rate results in pricing increase of 2.66%

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# Modelling of LPI

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Two most common forms of LPI

YoY :  $LPI_t = LPI_{t-1} * \min[\max[1 + \text{floor}\%, RPI_t / RPI_{t-1}], 1 + \text{cap}\%]$

Index :  $LPI_t = RPI_0 * \min[\max[(1 + \text{floor}\%)^t, RPI_t / RPI_0], (1 + \text{cap}\%)^t]$

The building blocks of the LPI derivatives market are zero coupon RPI swaps

Three forms of “standard” RPI options trade in the market

1. YoY RPI caps and floor
2. RPI Index caps and floors
3. LPI swaps

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# Modelling of LPI

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RPI options trade on price

RPI Index Options

Natural to use Black Scholes model

RPI YoY Options

Market convention is to assume the underlying yoy rate has a normal distribution

# Modelling of LPI

10 Curncy

11:49 UK ZC LPI COLLARED SWAP SPREAD PAGE 1 / 1

LPI Spreads quoted in bps running, with respect to the RPI ZCS rate  
Indicative mid for a delta neutral trade

| ZC LPI<br>Term |   | LPI[0,5]<br>MID TIME |   | LPI[0,inf]<br>MID TIME |   | LPI[0,3]<br>MID TIME |   | RPI<br>Refs |
|----------------|---|----------------------|---|------------------------|---|----------------------|---|-------------|
| 5 Year         | 1 | -1.5 8:54            | 9 | 28.2 8:54              | 7 | -65.2 8:54           | 5 | 3.07        |
| 10 Year        | 2 | 2.7 8:54             | 0 | 45.6 8:54              | 8 | -70.6 8:54           | 6 | 3.15        |
| 15 Year        | 3 | 7.2 8:54             | 1 | 54.1 8:54              | 9 | -75.1 8:54           | 7 | 3.25        |
| 20 Year        | 4 | 11.0 8:54            | 2 | 59.1 8:54              | 0 | -77.3 8:54           | 8 | 3.32        |
| 25 Year        | 5 | 15.9 8:54            | 3 | 63.5 8:54              | 1 | -77.3 8:54           | 9 | 3.36        |
| 30 Year        | 6 | 19.1 8:54            | 4 | 66.9 8:54              | 2 | -79.0 8:54           | 0 | 3.41        |
| 40 Year        | 7 | 23.6 8:54            | 5 | 70.4 8:54              | 3 | -76.6 8:54           | 1 | 3.41        |
| 50 Year        | 8 | 24.8 8:54            | 0 | 71.9 8:54              | 4 | -77.4 8:54           | 2 | 3.42        |

LPI base index follows standard RPI base  
Trading:  
Please see RPDS<GO> for example ZC LPI termsheet

Australia 61 2 9777 8600 Brazil 5511 3048 4500 Europe 44 20 7330 7500 Germany 49 69 9204 1210 Hong Kong 852 2977 6000  
Japan 81 3 3201 8900 Singapore 65 6212 1000 U.S. 1 212 318 2000  
SN 865425 GMT+0:00 H466-1-0 15-Nov-2011 11:49:32

Source:  
Bloomberg  
Nov 2011

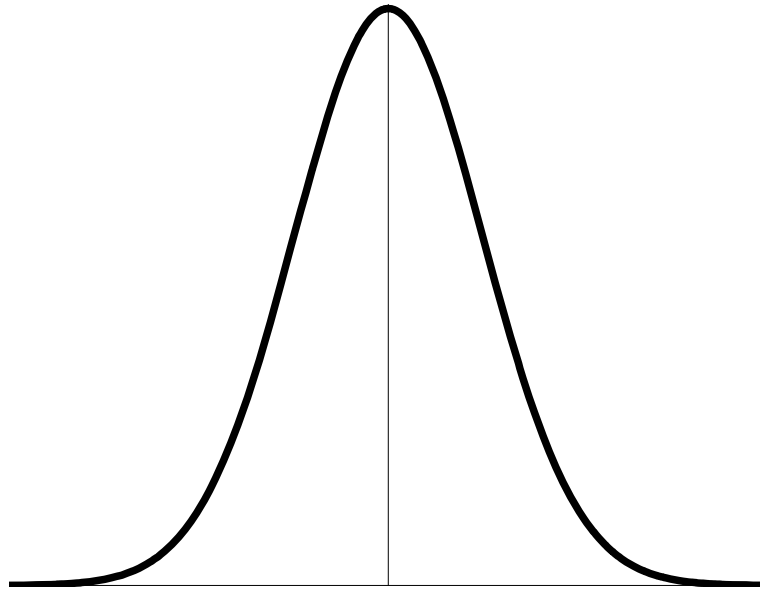
Screen prices do exist but for small size

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# Option Practicalities Recap

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Standard option pricing theory assumes a distribution for the underlying (RPI in our case today)

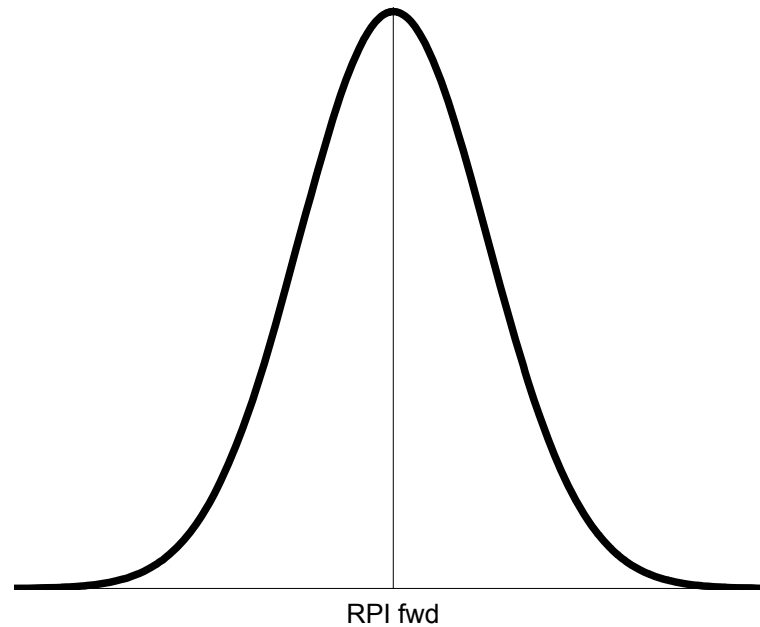


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# Option Practicalities Recap

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Market Consistent calibration requires the mean of the distribution to match forward prices

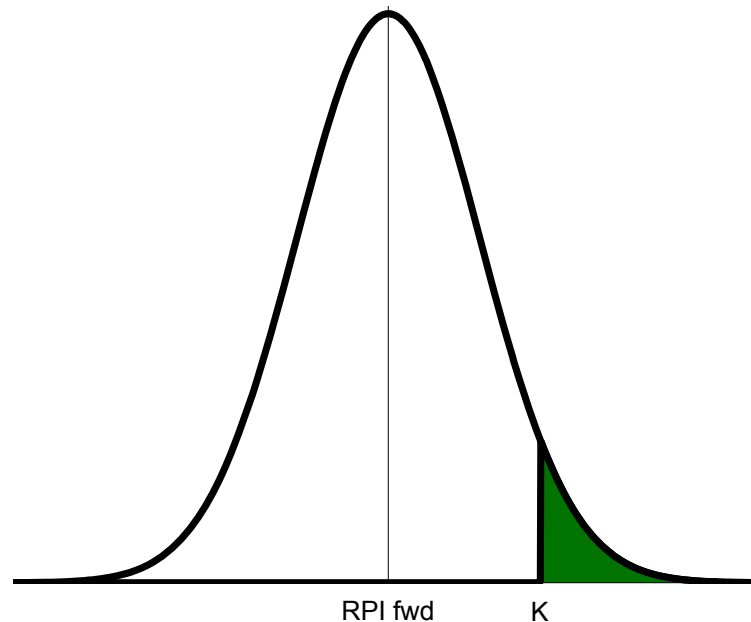


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# Option Practicalities Recap

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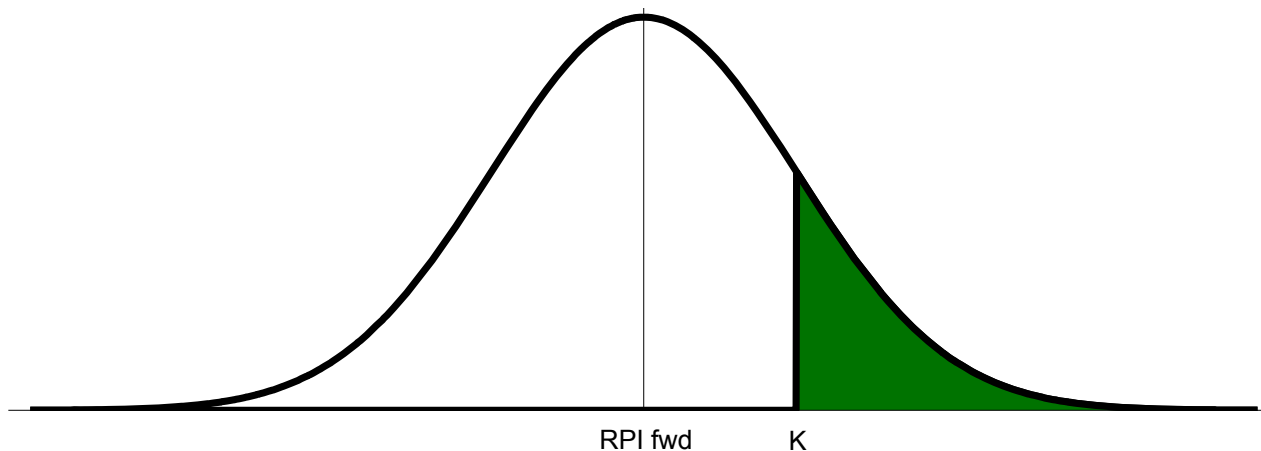
And the variance/std dev parameter is set so as to match observable option prices



Model price,  $cap_{model} = DF \int_K^{\infty} (x - K) f(x) dx$ , compared to market price and variance parameter set such as to make the two equal.

# Option Practicalities Recap

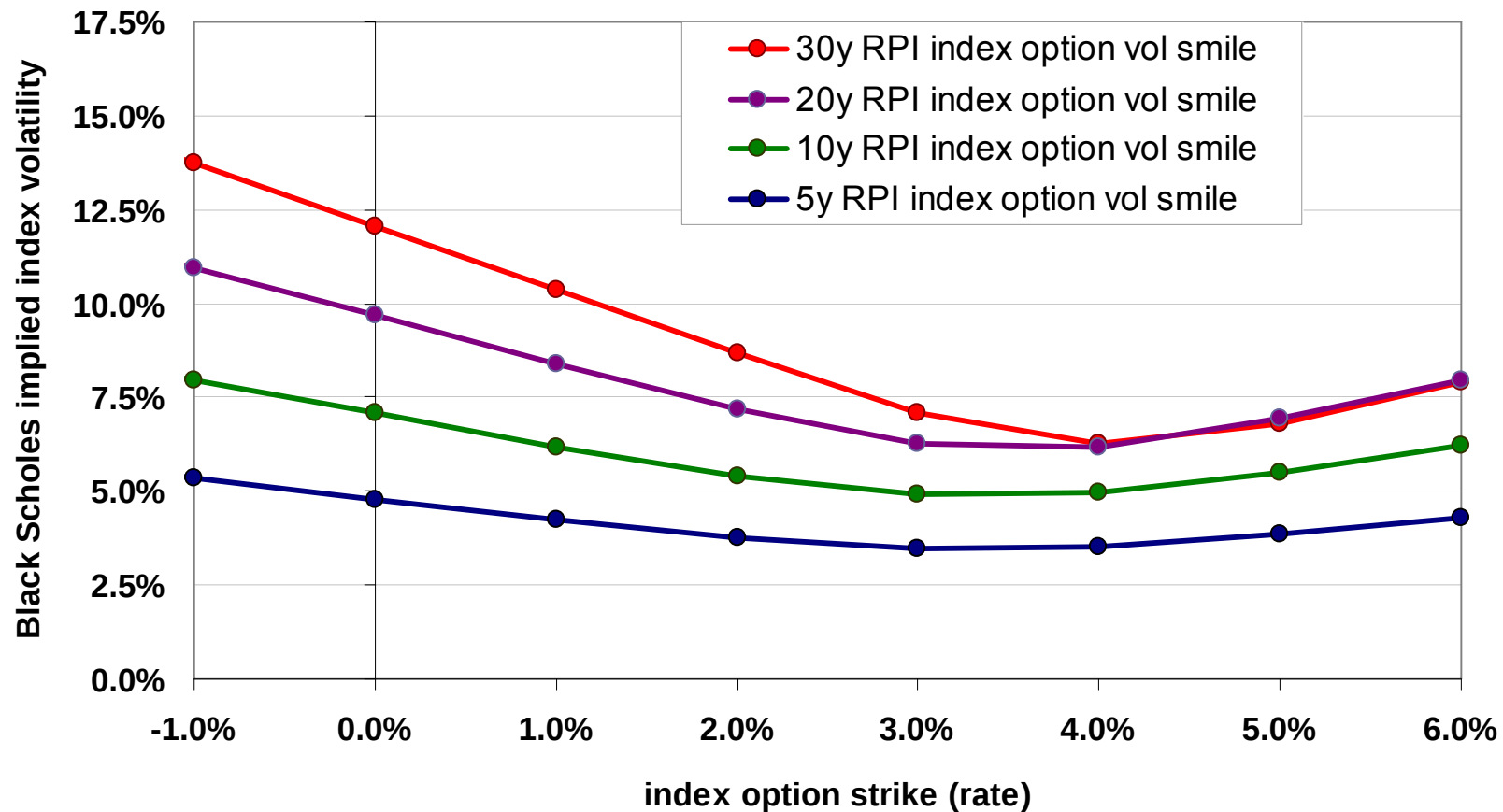
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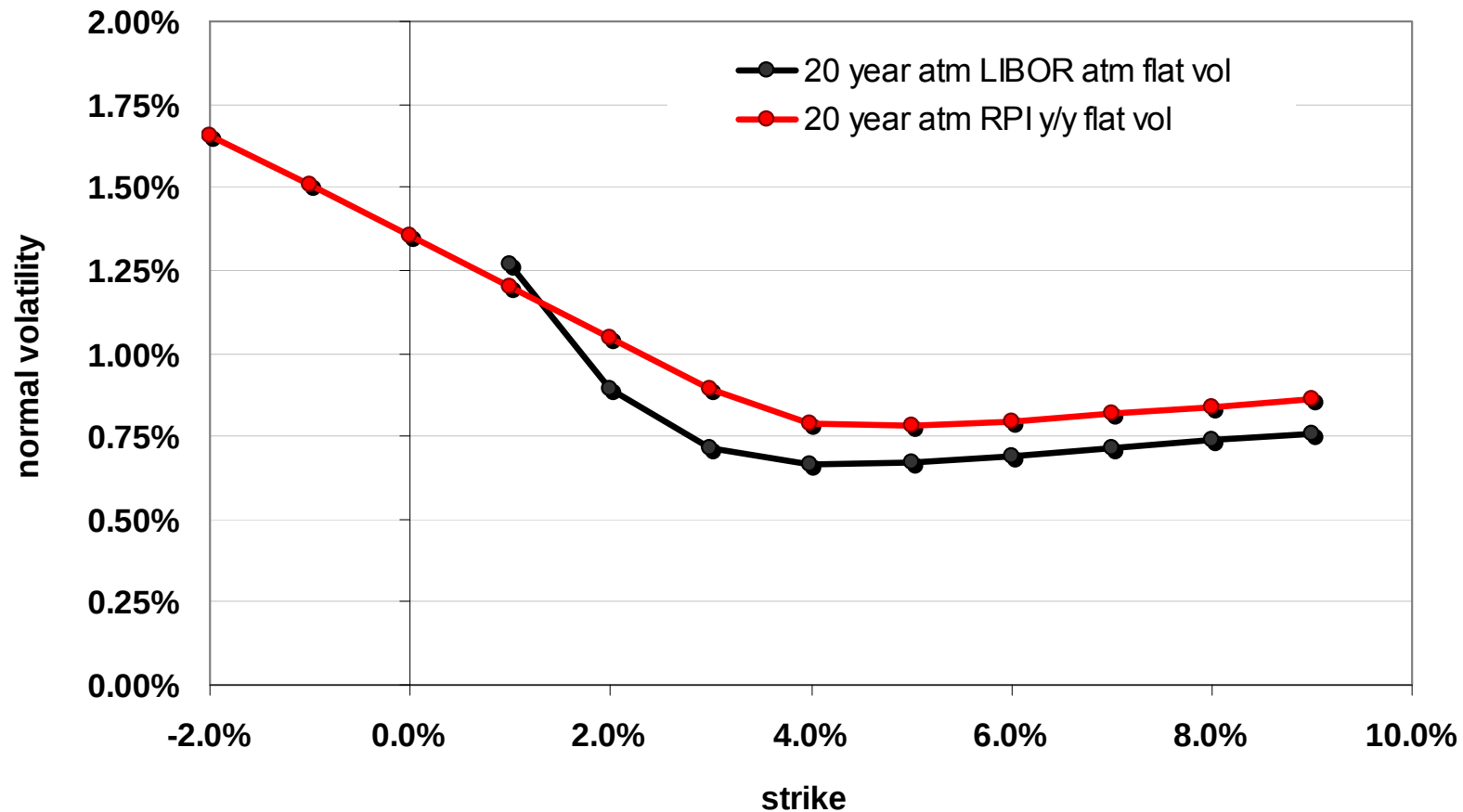
# Modelling of LPI

## Skew graph of RPI Index



# Modelling of LPI

## Skew graph of RPI YoY



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# Modelling of LPI

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Historically the implied volatility smile first appeared in the equity option markets

Techniques developed for equities have subsequently been used in interest rate and inflation markets

SABR model is the market standard for fitting the implied volatility smile

$$\begin{aligned}dF_t &= \alpha_t F_t^\beta dW_t^1, & F_0 &= f \\d\alpha_t &= \nu \alpha_t dW_t^2, & \alpha_0 &= \alpha\end{aligned}$$

Advantage is that equivalent lognormal implied volatility can be approximated analytically

For extreme parameter values and strikes far away-from-the-money, these approximations break down

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# Alternatives to matching LPI exposure

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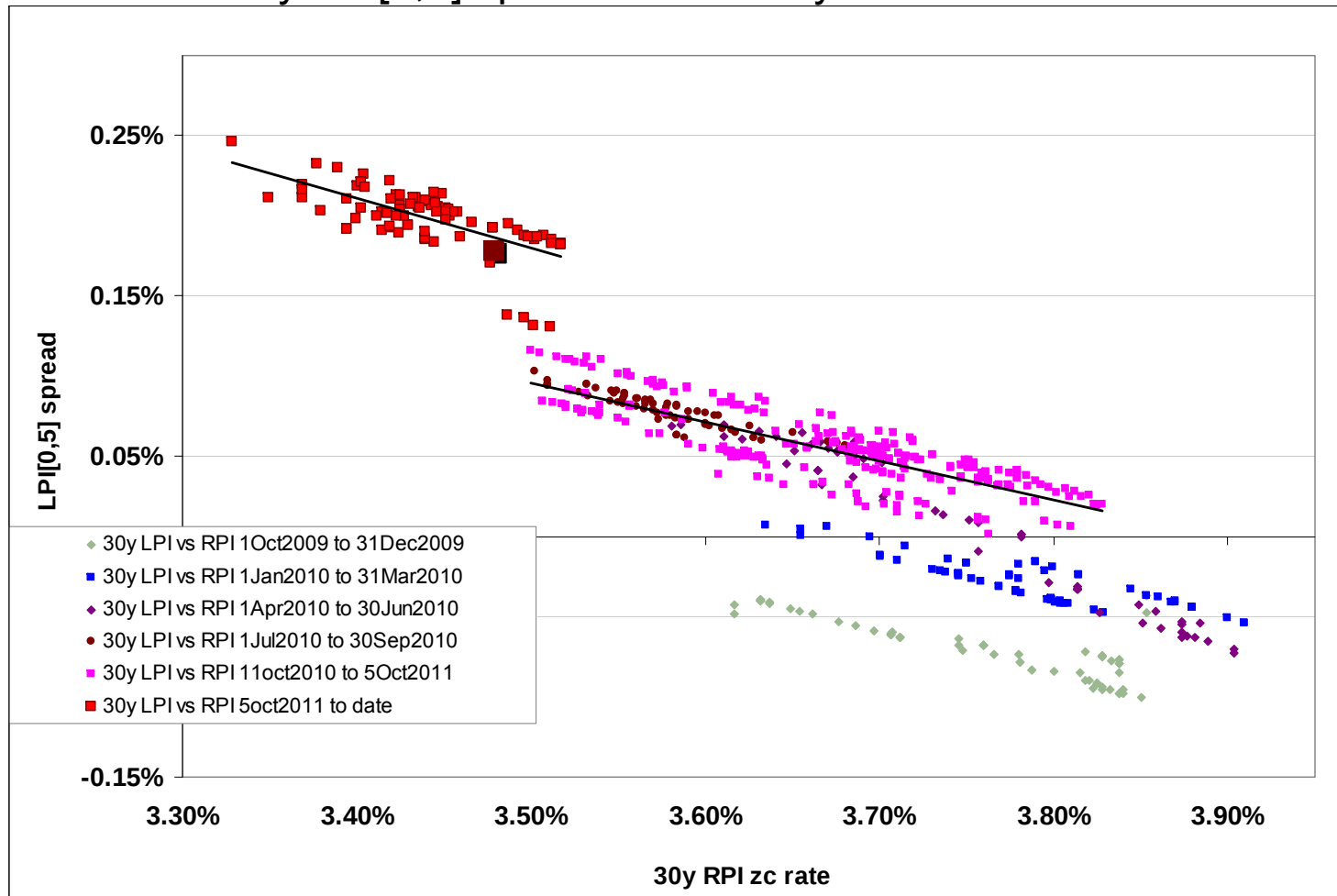
RPI volatility skew has been getting worse

Implied vol at the 0% floor is 66% higher than at the money

Valuing a 0% RPI YoY floor using at the money vol results in a fixed coupon of ~50bps less, which would have a significant impact on BPA pricing

# Alternatives to matching LPI exposure

30y LPI[0,5] spread versus 30y RPI Rate



# Alternatives to matching LPI exposure

These calculations can now be done on Swap Manager

GRAB CurncySWPM

90) Actions 91) Swaps & Options 92) Str. Notes 93) Data & Settings 94) Help Swap Manager

Inflation Swap Cpty SWAP CNTRPARTY CCP OTC Ticker / YOY Series Deal ID 21) Detail

31) Load 32) Save 34) Send 36) Share 37) Ticket

Leg 1 Receive Inflation Arrears Leg 2 Pay Fixed

|            |              |               |          |            |            |
|------------|--------------|---------------|----------|------------|------------|
| Notional   | 10MM         | Index         | UKRPI    | Notional   | 10MM       |
| Country    | GB           | Lag           | 2 Months | Currency   | GBP        |
| Effective  | 11/14/2011   | Interpolation | Monthly  | Effective  | 11/14/2011 |
| Maturity   | 11/14/2031   | Leverage      | 1.00000  | Maturity   | 11/14/2031 |
| Reset Freq | Annual       | Spread        | 0.00 bp  | Pay Freq   | Annual     |
| Pay Freq   | Annual       | Day Count     | ACT/ACT  | Coupon     | 3.330142 % |
| Cap        | 4.20000 %    |               |          | Calc Basis | Money Mkt  |
| Floor      | 1.50000 %    |               |          | Day Count  | ACT/ACT    |
| MV         | 5,035,168.82 | Accrued       | 0.00     | Unwind Cpn | 2.982228 % |
| Premium    | 50.35        | DV01          | 5,254.22 |            |            |

Market Seasonality Conv Adj Jarrow-Yildin

|              |            |           |                        |              |    |     |               |
|--------------|------------|-----------|------------------------|--------------|----|-----|---------------|
| Dscent Curve | 22         | Mid       | British Pound          | Dscent Curve | 22 | Mid | British Pound |
| Fwd Curve    | IL         | Mid       | UKRPI                  |              |    |     |               |
| Inflat. Vol  | SWIL       | Mid       | Inflation Vol. Surface |              |    |     |               |
| Curve Date   | 11/11/2011 | Valuation | 11/14/2011             |              |    |     |               |

Valuation

|              |          |                |              |                |           |
|--------------|----------|----------------|--------------|----------------|-----------|
| Par Cpn      | 3.330142 | Calculate      | Leg2: Coupon | PV01           | 15,119.98 |
| Principal    | 0.00     | Unwind Annuity | 0.347913     | DV01           | 209.77    |
| Accrued      | 0.00     | Unwind PV      | -526,044.46  | Inflation DV01 | 4,846.20  |
| Market Value | 0.00     | Premium        | 0.000000     | Vega (1bp)     | -1,281.87 |

3) Main 4) Curves 5) Cashflow 7) Leg Detail 10) Reset Rates 13) Scenario

Australia 61 2 9777 8600 Brazil 5511 3048 4500 Europe 44 20 7330 7500 Germany 49 69 9204 1210 Hong Kong 852 2977 6000  
 Japan 81 3 3201 8900 Singapore 65 6212 1000 U.S. 1 212 318 2000 Copyright 2011 Bloomberg Finance L.P.  
 SN 314146 H715-86-2 13-Nov-11 17:09:53 GMT+0:00

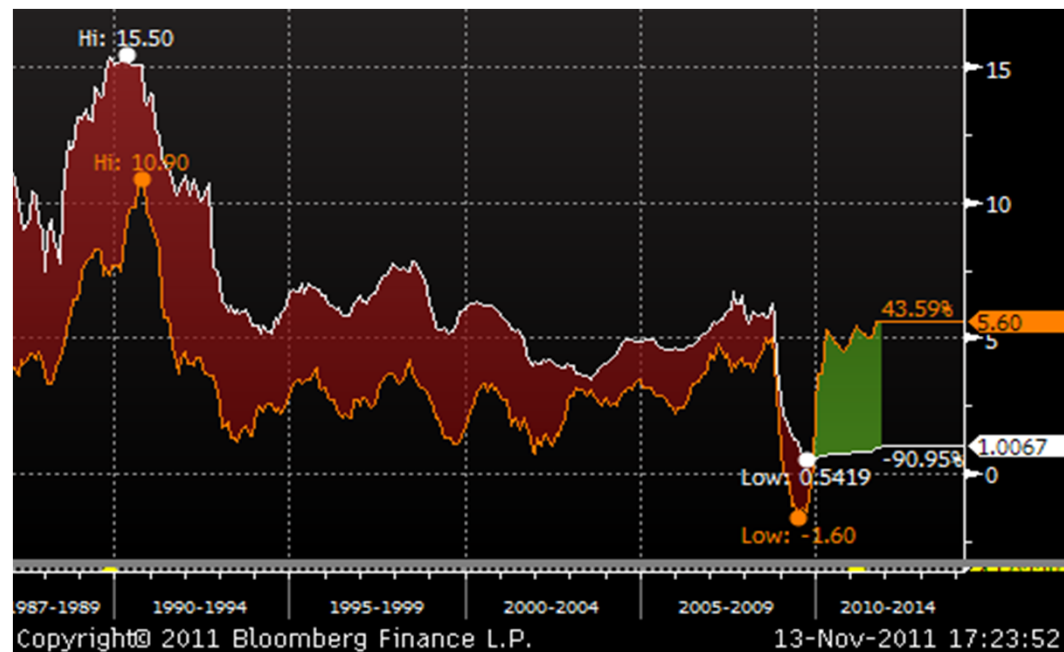
# Alternatives to matching LPI exposure

## Macro Hedge

The correlation between RPI & 3m Libor over the period of data is 75%

During the recent period of negative RPI, 3month Libor averaged 1.2% and an appropriately struck Libor floor would have provided a good hedge

By hedging the RPI floor embedded in your BPA liability on a more macro basis there is potential to release efficiency savings



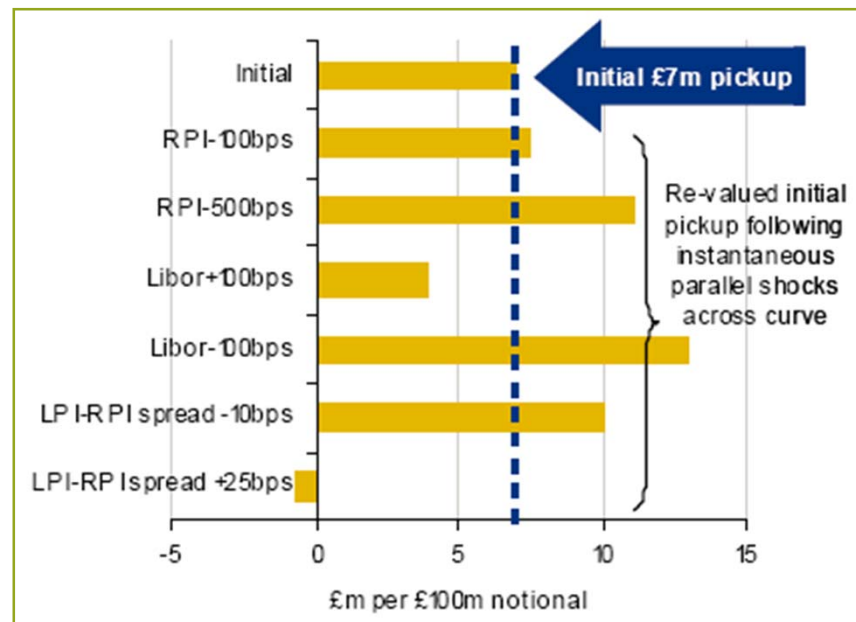
# Alternatives to matching LPI exposure

## Macro Hedge

We consider the example of hedging a 0% YoY RPI floor with a 2% Libor floor and 0% cumulative RPI floor

Macro hedge with an upfront gain which works against major shocks

- Performs under severe RPI movements
- Sensitive to interest rates
- Exposed to LPI-RPI spread widening
- Gains if the spread normalises



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# Alternatives to matching LPI exposure

## Delta Manage

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Similar to how many WP funds hedge the embedded options in the Cost of Guarantees

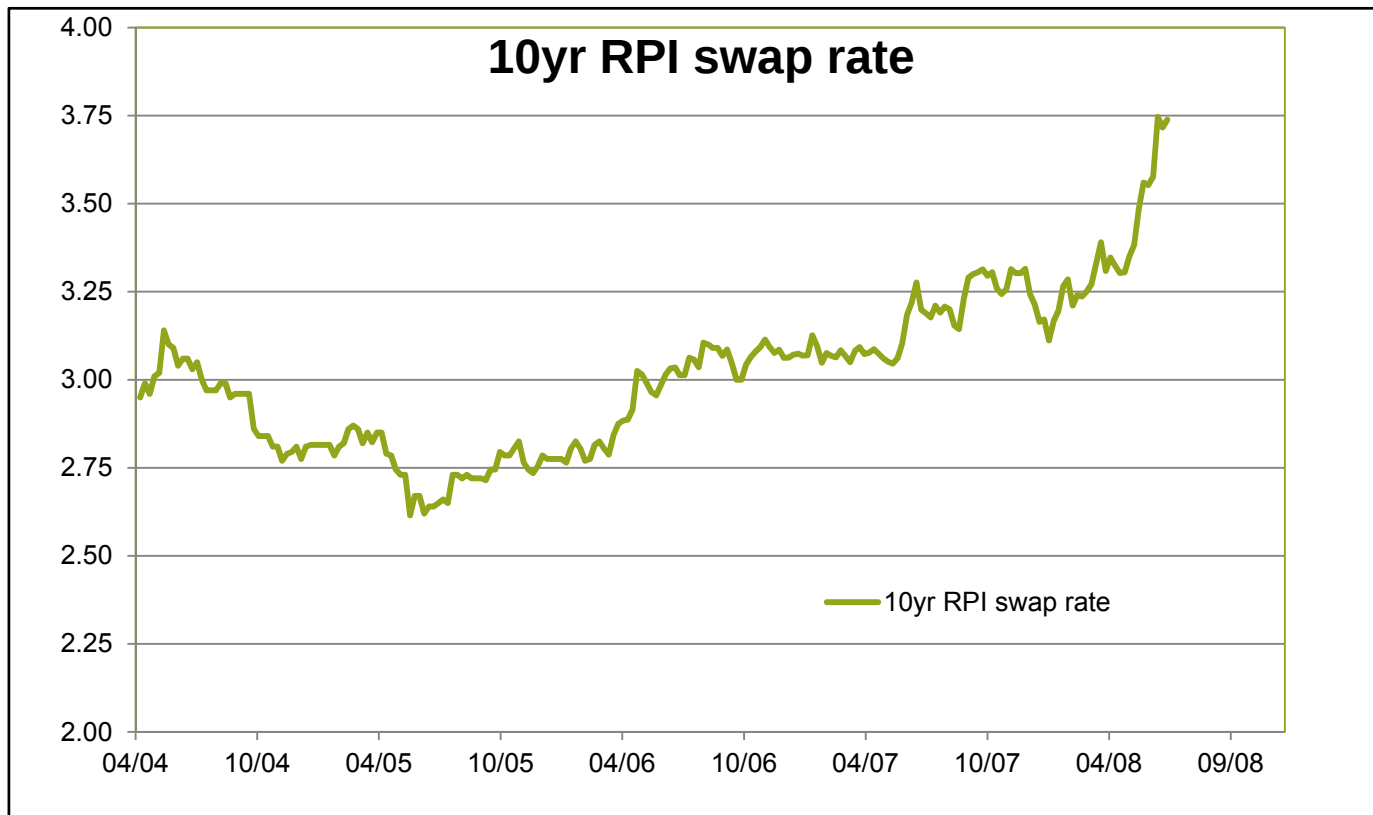
Significant potential value (banks are still doing it!)

Risks as with any option replication

- Model risk (we discussed the perturbation issue with SABR model)
- Transaction costs (ZC RPI swaps are the building blocks)
- Gamma Trap

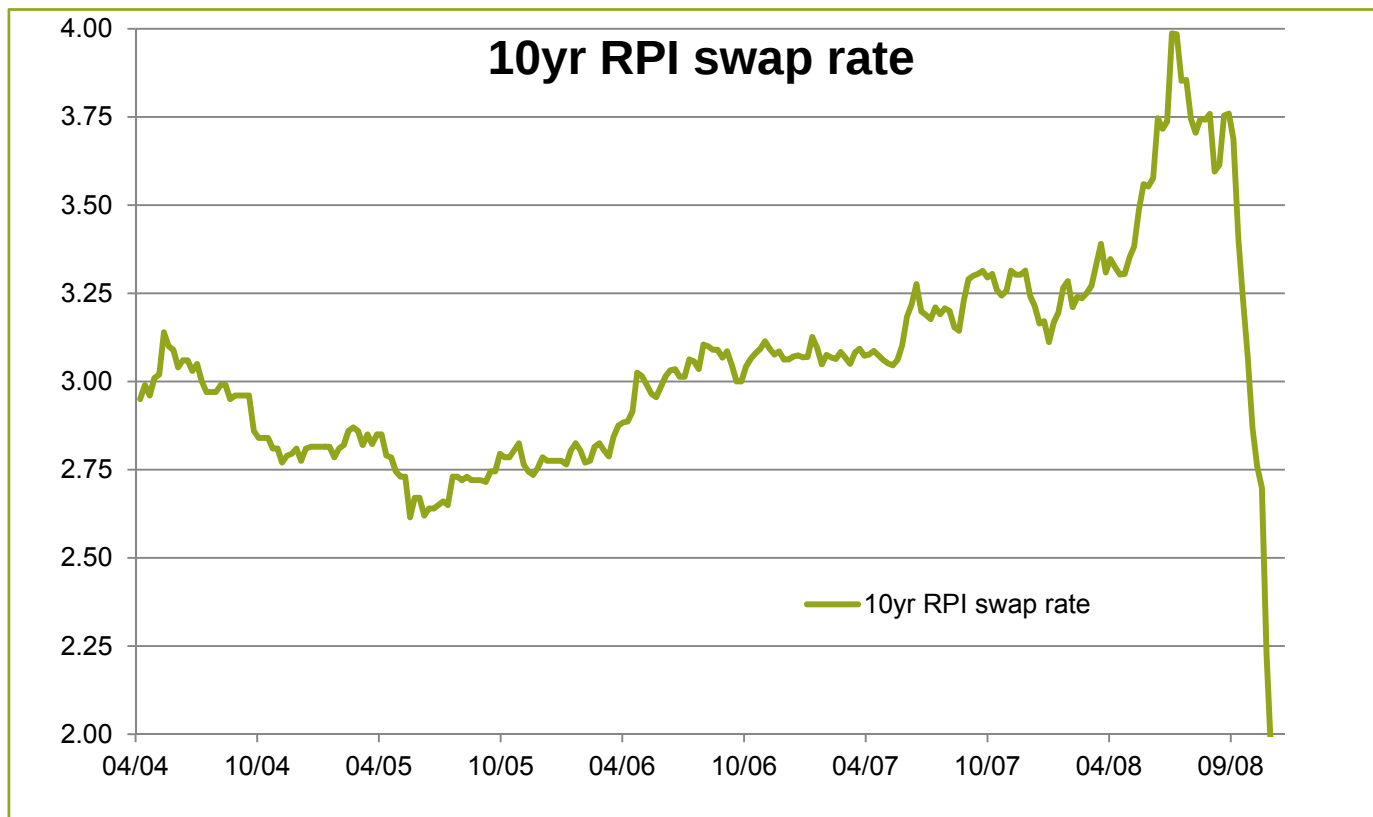
# Alternatives to matching LPI exposure

## Delta Manage



# Alternatives to matching LPI exposure

## Delta Manage



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# Alternatives to matching LPI exposure

## Do nothing

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Do nothing

This has the benefit of simplicity and is a widely used technique

Not very suitable for insurers given the requirement to consider and hold capital against a 1 in 200 yr event

Has not worked well as LPI has not normalised but become even more expensive

## Other flavours of LPI

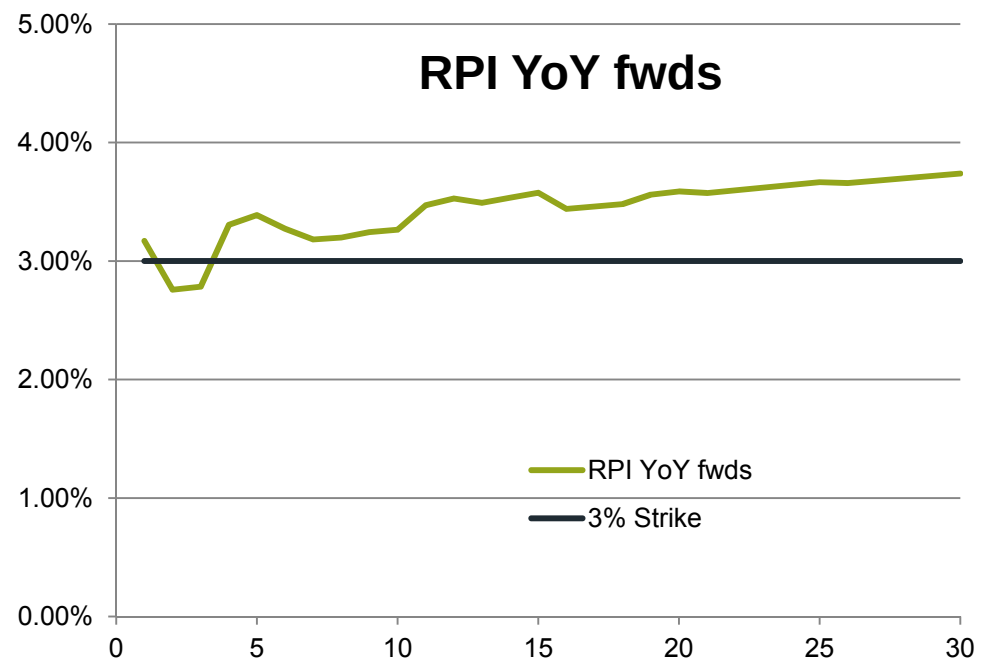
LPI[0,2.5], LPI[0,3], LPI[3,5] are more common 'exotic' variants

Strikes more ATM so issues with high gamma more relevant

Interdealer market trades [0,5], [0,3] and [0,∞]

More exotic benefit escalation magnifies the issues:

- Fewer sources
- No comfort from visible levels
- No market to transfer risk



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## The rise of CPI – Timeline

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22<sup>nd</sup> June 2010 – Public Sector indexation moved from RPI to CPI for all public sector pensions

8<sup>th</sup> July 2010 – Pension Minister announces intention to legislate so that all private sector pensions also CPI

8<sup>th</sup> December 2010 – DWP announces consultation and backtracks on claim all linkage will be CPI

16<sup>th</sup> June 2011 – DWP response, result is no rule changes so RPI linked benefits must stay RPI

29<sup>th</sup> June 2011 – DMO announced consultation on issuing CPI linked bonds

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# The rise of CPI

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## Overall effect

As there is no government override for private pension scheme inflation linkage

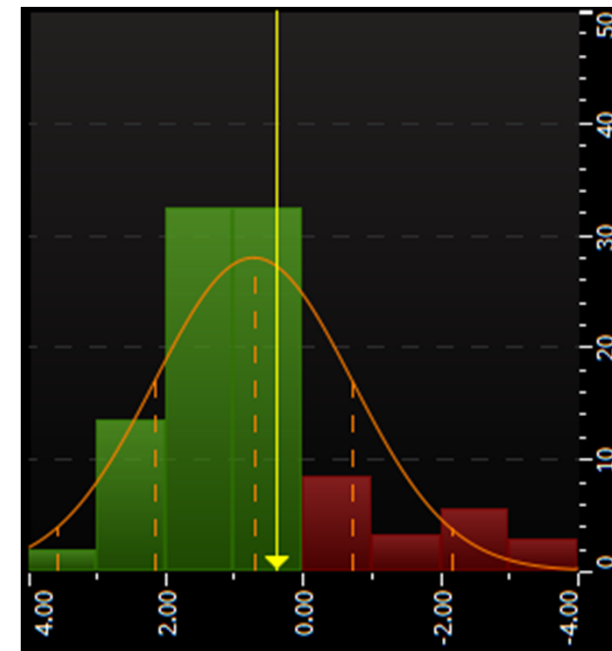
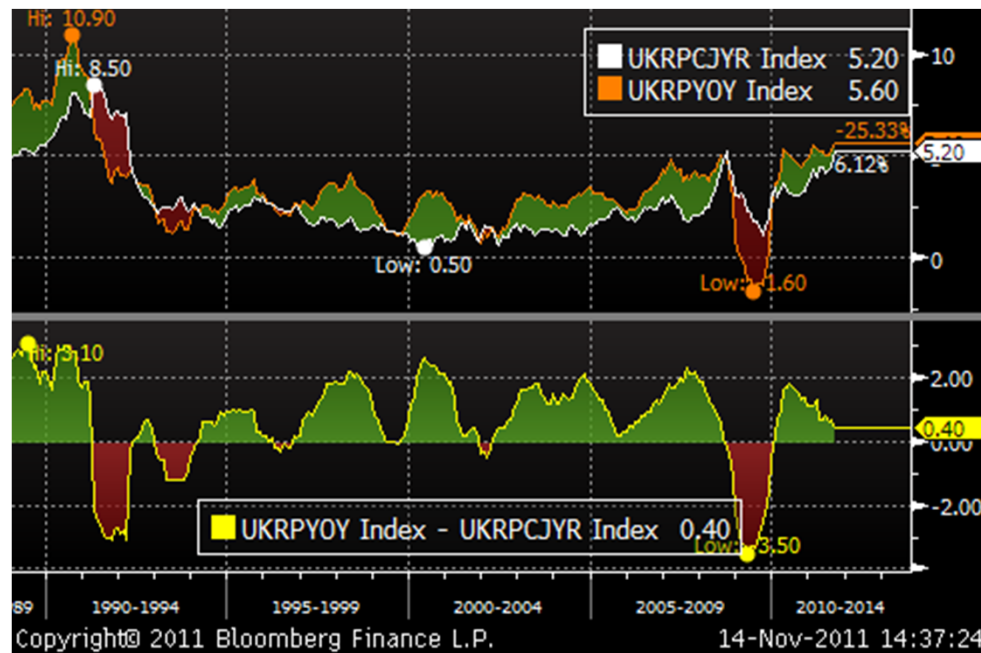
The overall effect is:

- For pension in payment – 80% RPI linked, 20% CPI linked
- For increases in deferment – 20% RPI linked, 80% CPI linked

So CPI linkage will be highest in the 10-25y maturity and RPI will be highest 25y plus

# CPI linked liabilities

Also evident from historical data that CPI is less volatile than RPI



# The rise of CPI

## Analysis of CPI and RPI Since 1989

CPI Average 2.79%  
SD 1.84%

RPI Average 3.49%  
SD 2.18%

## Trading

Bid offers for CPI are 40 bps versus 5bps for RPI. Possible to execute regular large RPI trades not possible for CPI

## CPI Pricing Screen

02

Currency **RILS**

9:19 **UK CPI**

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| Term        | Price |         | Size (MM) |     | Time  |
|-------------|-------|---------|-----------|-----|-------|
|             | Bid   | Ask     | Bid       | Ask |       |
| 1) 2 Year   | 1.774 | / 2.174 | 25 X      | 25  | 11/04 |
| 2) 5 Year   | 2.248 | / 2.648 | 25 X      | 25  | 11/04 |
| 3) 7 Year   | 2.323 | / 2.723 | 25 X      | 25  | 11/04 |
| 4) 10 Year  | 2.418 | / 2.818 | 25 X      | 25  | 11/04 |
| 5) 12 Year  | 2.478 | / 2.878 | 15 X      | 15  | 11/04 |
| 6) 15 Year  | 2.602 | / 3.002 | 15 X      | 15  | 11/04 |
| 7) 20 Year  | 2.710 | / 3.110 | 15 X      | 15  | 11/04 |
| 8) 25 Year  | 2.753 | / 3.153 | 15 X      | 15  | 11/04 |
| 9) 30 Year  | 2.809 | / 3.209 | 15 X      | 15  | 11/04 |
| 10) 40 Year | 2.805 | / 3.205 | 15 X      | 15  | 11/04 |
| 11) 50 Year | 2.808 | / 3.208 | 15 X      | 15  | 11/04 |

Zero Coupon- SEP FIX

|            |                   |                |                                      |
|------------|-------------------|----------------|--------------------------------------|
| Trading    | : 44 207 085 4684 | Euro Inflation | ->{ <a href="#">RBSE&lt;GO&gt;</a> } |
| Sales      | : 44 207 085 1211 | UK Inflation   | ->{ <a href="#">RBSK&lt;GO&gt;</a> } |
| Inter-Bank | : 44 207 085 1837 | Main Menu      | ->{ <a href="#">RBSX&lt;GO&gt;</a> } |


  
 The Royal Bank of Scotland

rbsm.com

Australia 61 2 9777 8600 Brazil 5511 3048 4500 Europe 44 20 7330 7500 Germany 49 69 9204 1210 Hong Kong 852 2577 6000  
 Japan 81 3 3201 8900 Singapore 65 6212 1000 U.S. 1 212 318 2000 Copyright 2011 Bloomberg Finance L.P.  
 SN 865425 GMT+0:00 H466-10-0 07-Nov-2011 09:19:28

# The rise of CPI v RPI

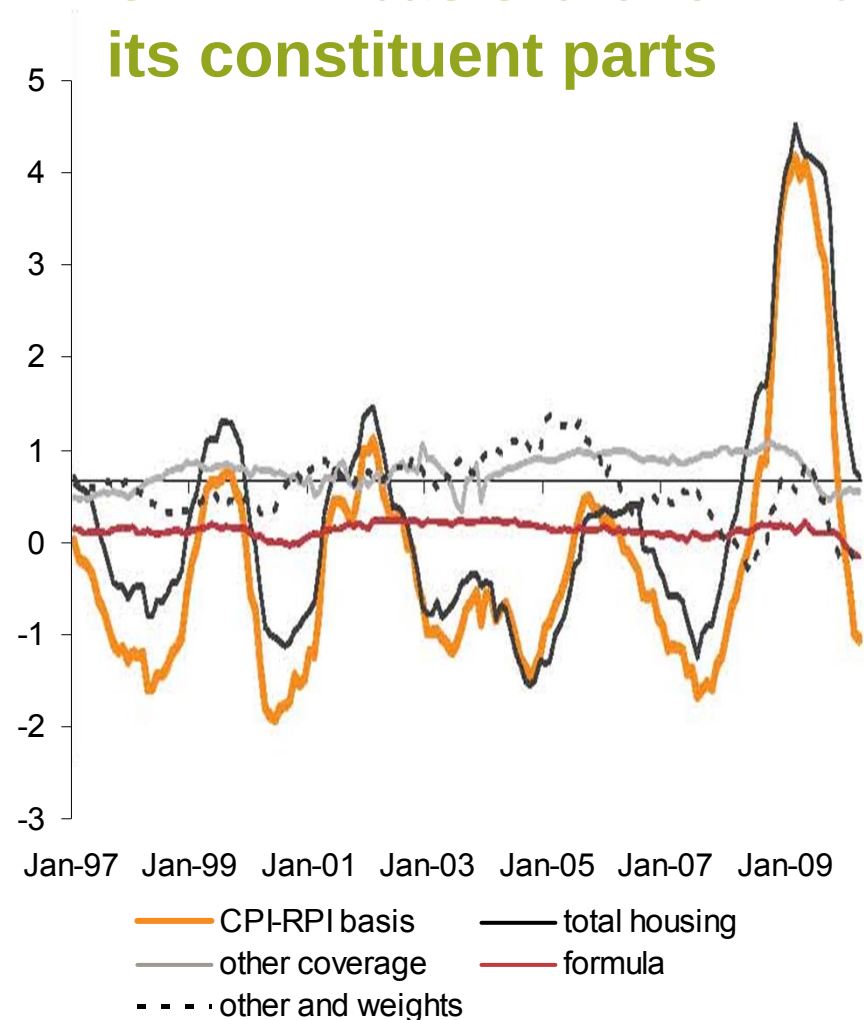
## Analysis of CPI and RPI

Driver of monthly volatility is housing in RPI which is not (currently) in CPI.

The chart also shows that the so called “formula” effect is the main cause of CPI tending to be lower than RPI

Eurostat looking to include housing in next 2 yrs

## CPI-RPI basis broken into its constituent parts



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# Questions or comments?

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Expressions of individual views by members of The Actuarial Profession and its staff are encouraged.

The views expressed in this presentation are those of the presenters.

