

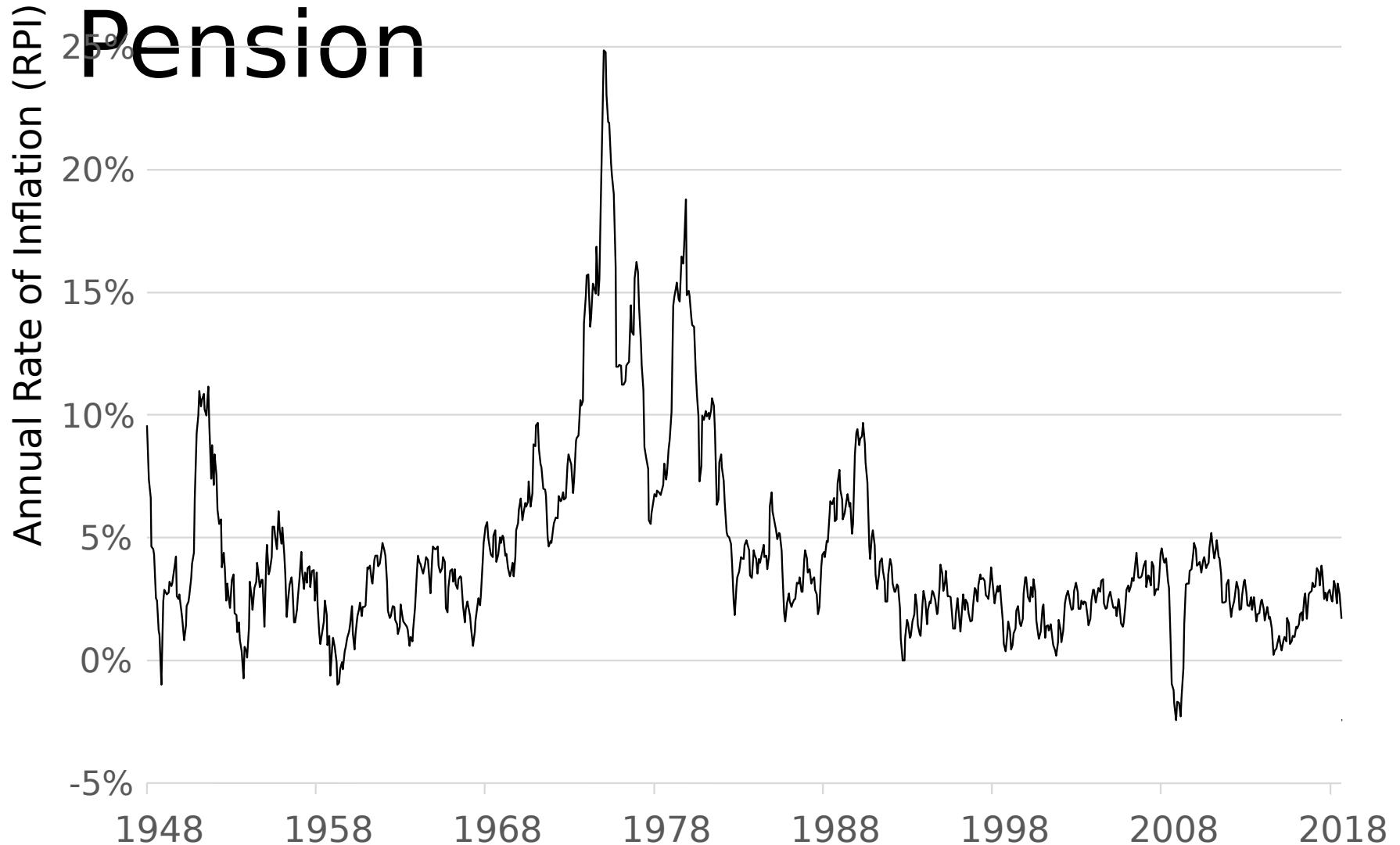
# Inflation Guarantees in Pensions

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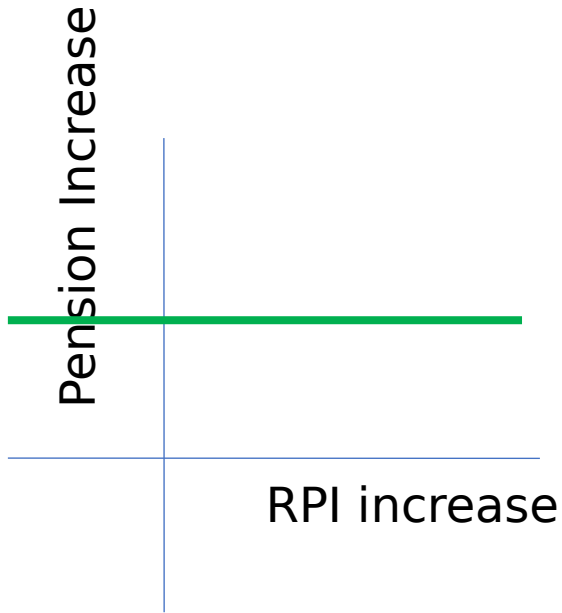
# Presentation Overview

- Types of inflation guarantees in pensions.
- Black (-Scholes) model.
- Historic burning cost.
- Four complicating issues:
  - Data limitations
  - Convexity effects
  - Volatility skew
  - Intra-year timings
- Conclusions

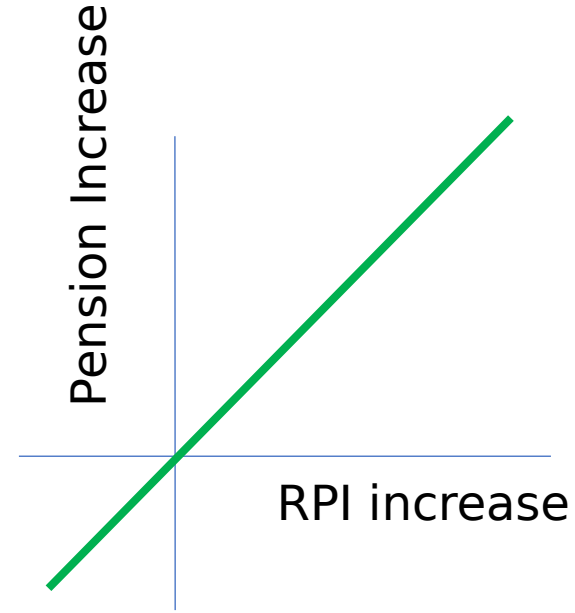
# Inflation can Erode your Pension



# Forms of Inflation Guarantee

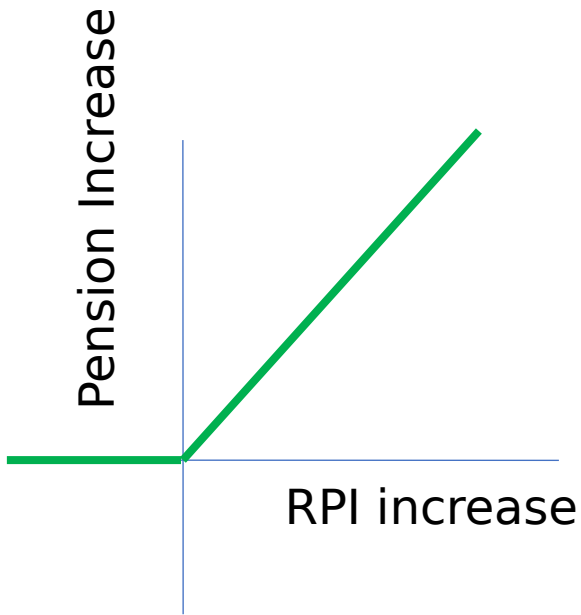


Fixed Pension

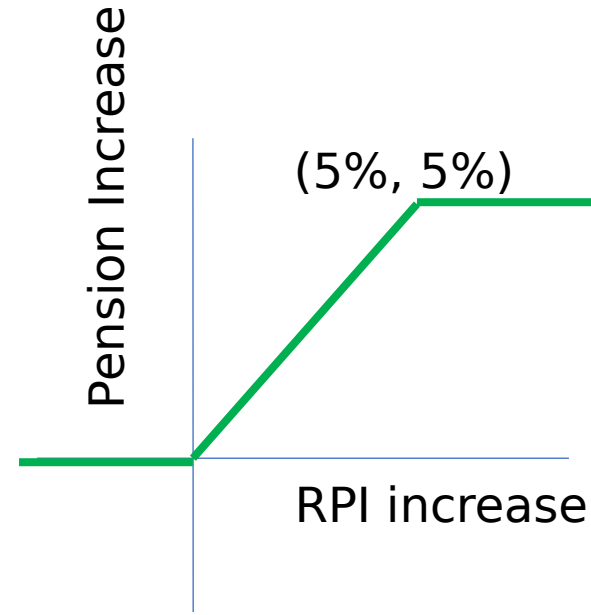


RPI—linked Pension

# Limited Price Indexation

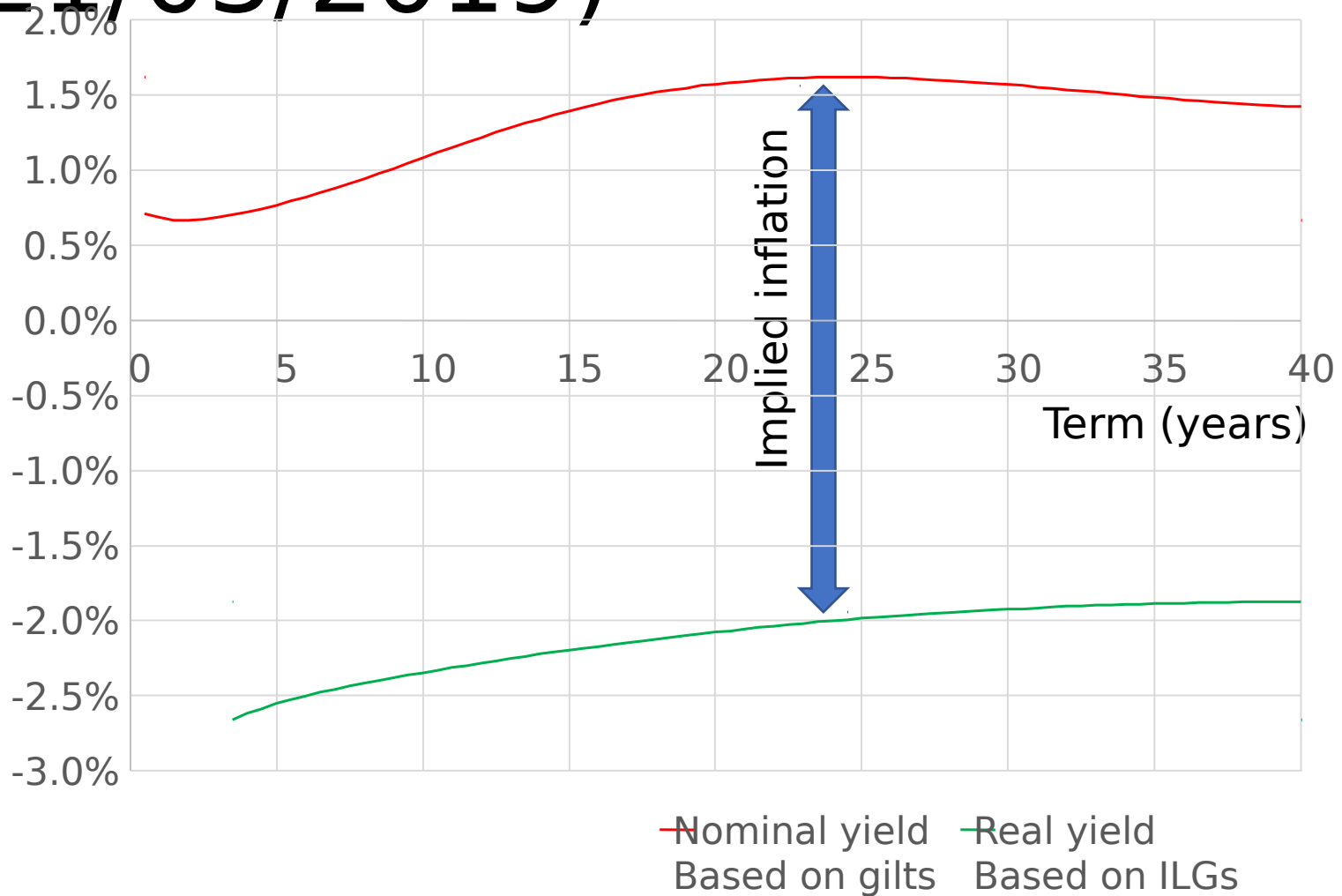


LPI  $[0, \infty]$



LPI  $[0, 5]$

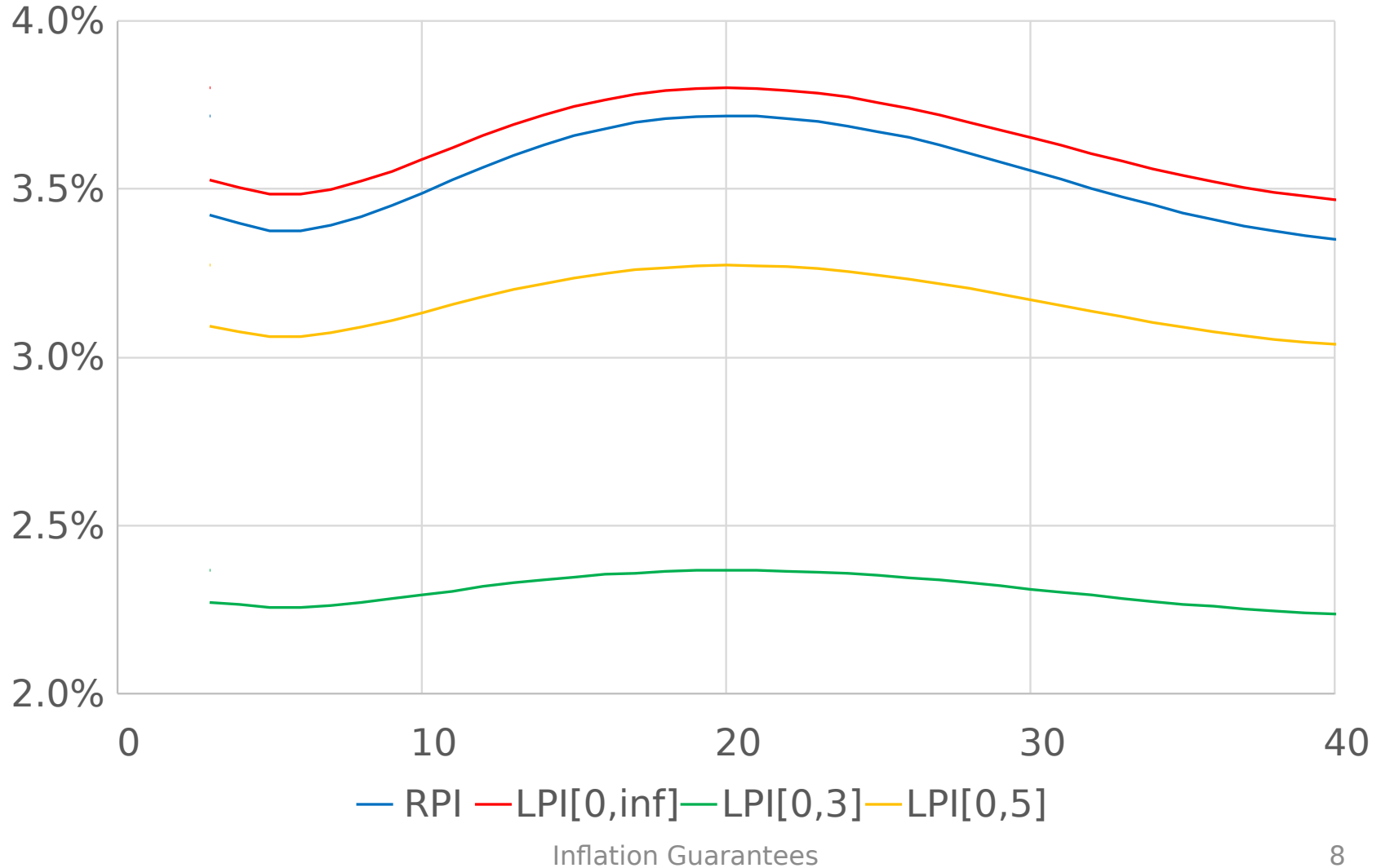
# Market Yields (at 21/03/2019)



# Valuing LPI: Black's Model

- Idea: future annual  $1 + \text{inflation}$  is a series of independent lognormal random variables with
  - Common parameter  $\sigma$  (we used 2.5%)
  - Mean as implied by initial yield curves
- To find expected LPI increase, apply cap and floor and recompute expectations for each future year.
- Cumulate to get expected future LPI index
- Take  $n^{\text{th}}$  root and subtract 1 to get annualised rate

# LPI Curves according to Black

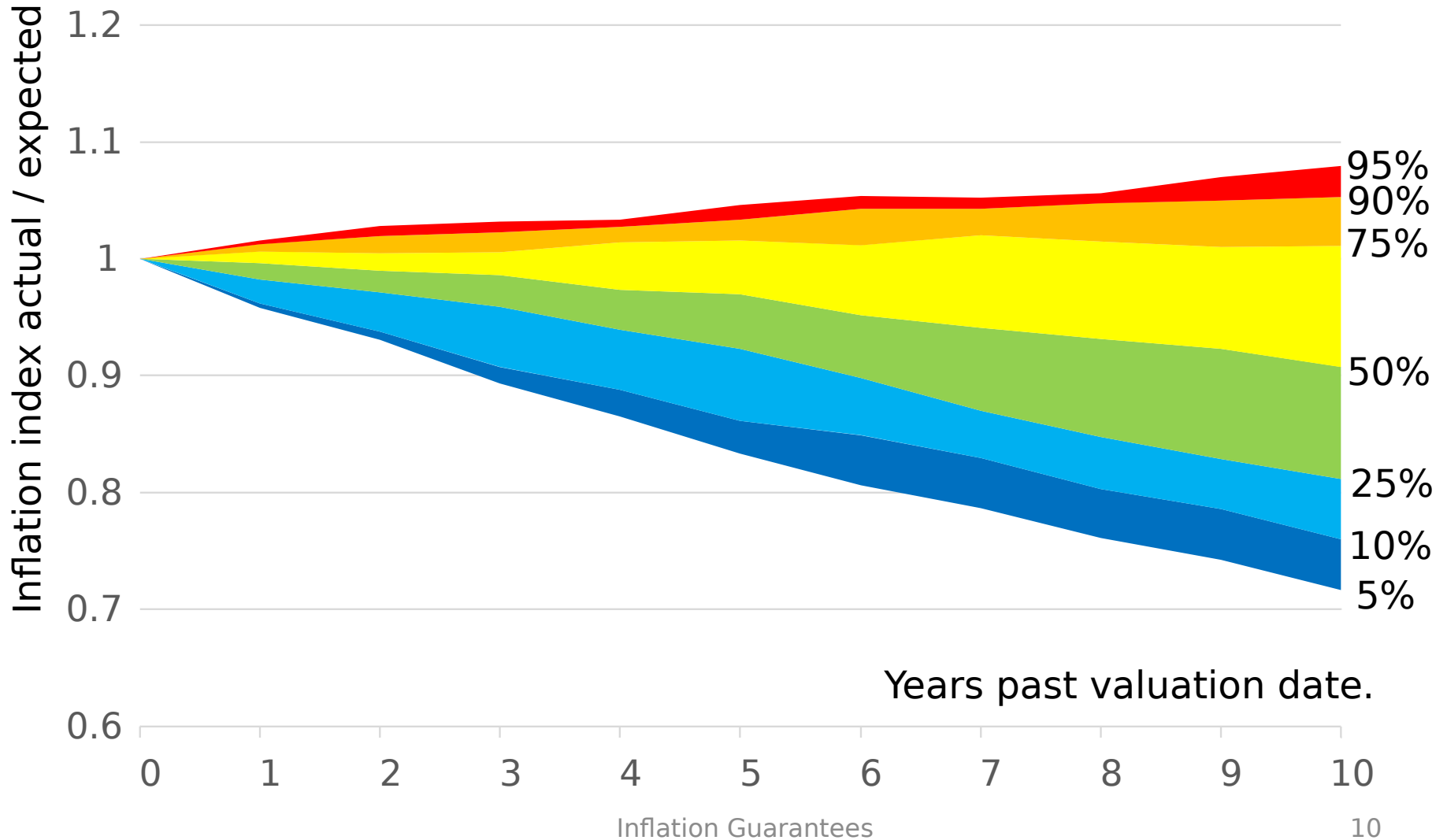




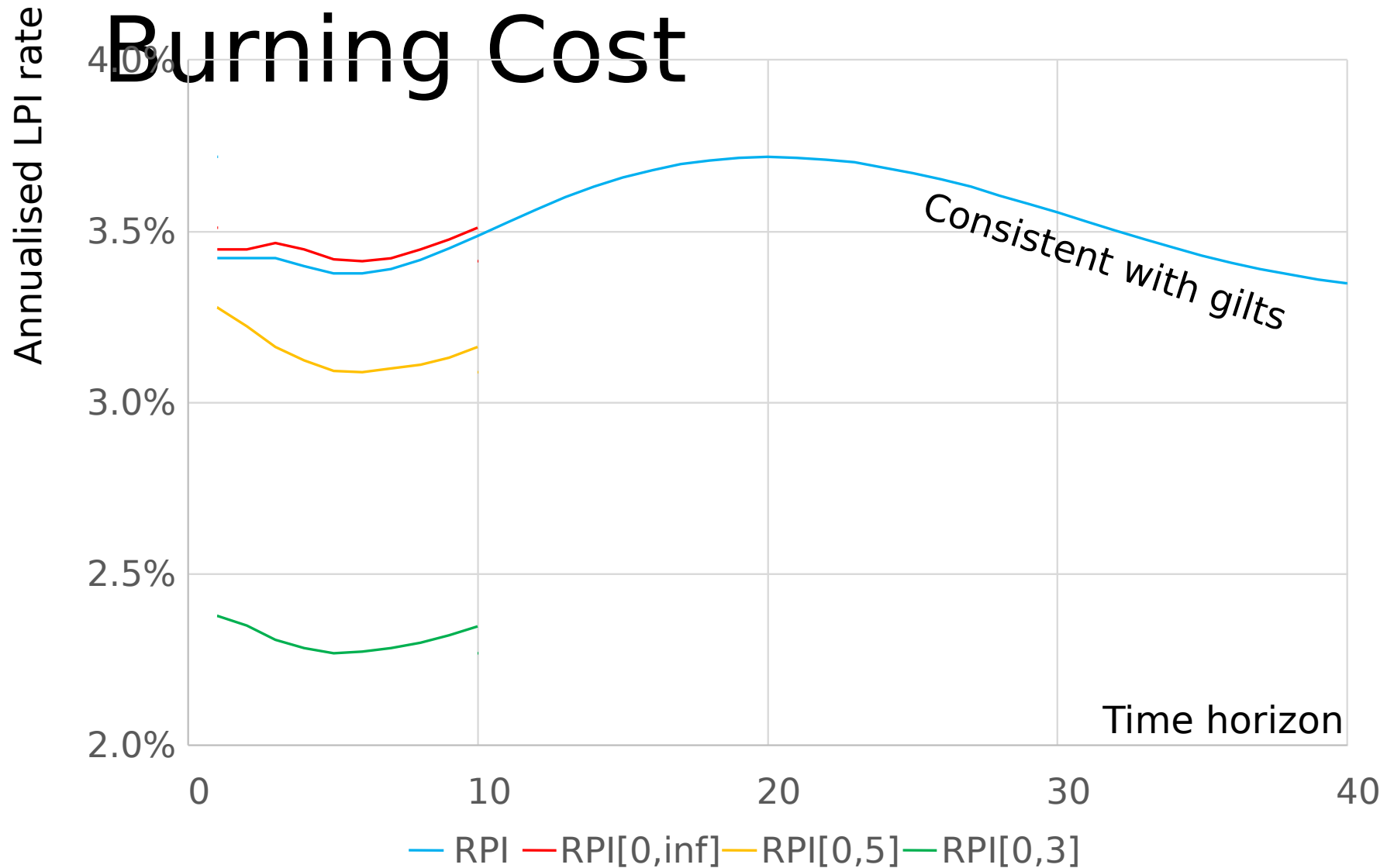
# Burning Cost Analysis

- What would LPI be if historic inflation repeated itself?
- We can re-run history, but this is not much use for pricing because
  - market implied future inflation is different to average historic inflation
  - The “what if history repeated itself” method does not even price ILGs correctly today.
  - Also, we want conditional forecasts given where we are now, not a collection of historic paths from different starting points.
- So instead, look at historic inflation outcome (unexpected inflation) relative to what was implied in gilt / ILG markets, and scale to replicate current gilt / ILG prices.

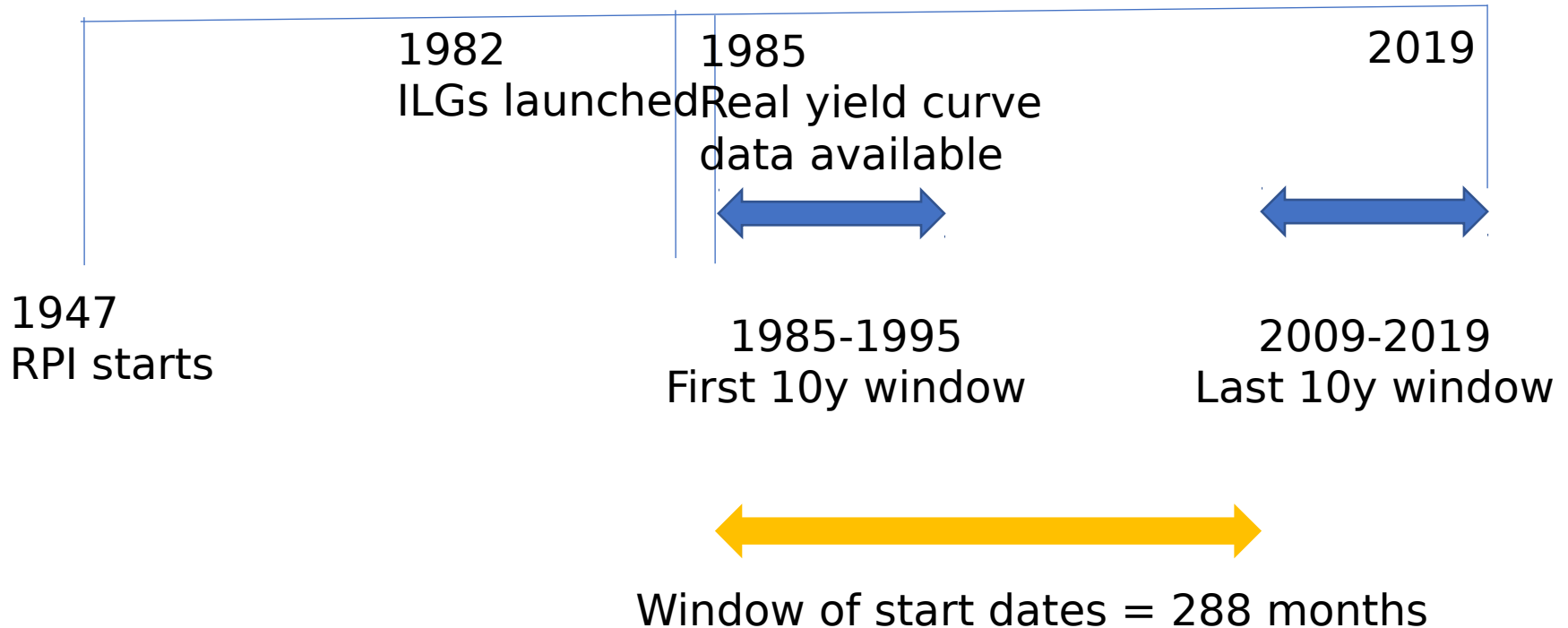
# Unexpected Inflation: Historic



# LPI Curves: Historic Burning Cost

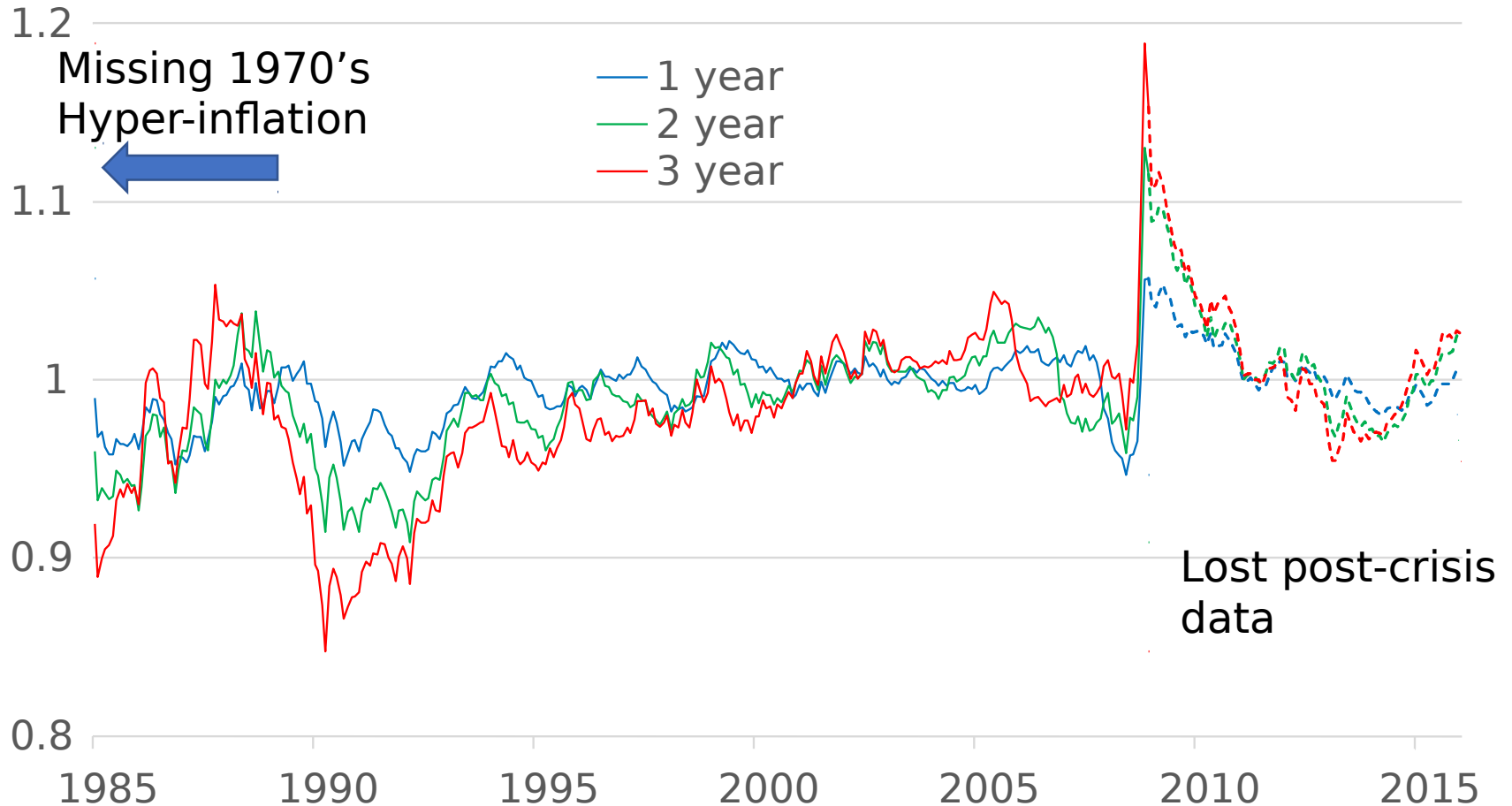


# Issue 1: Data Limitations



# What Data are we Missing?

Unexplained Inflation Index by Origin and Delay

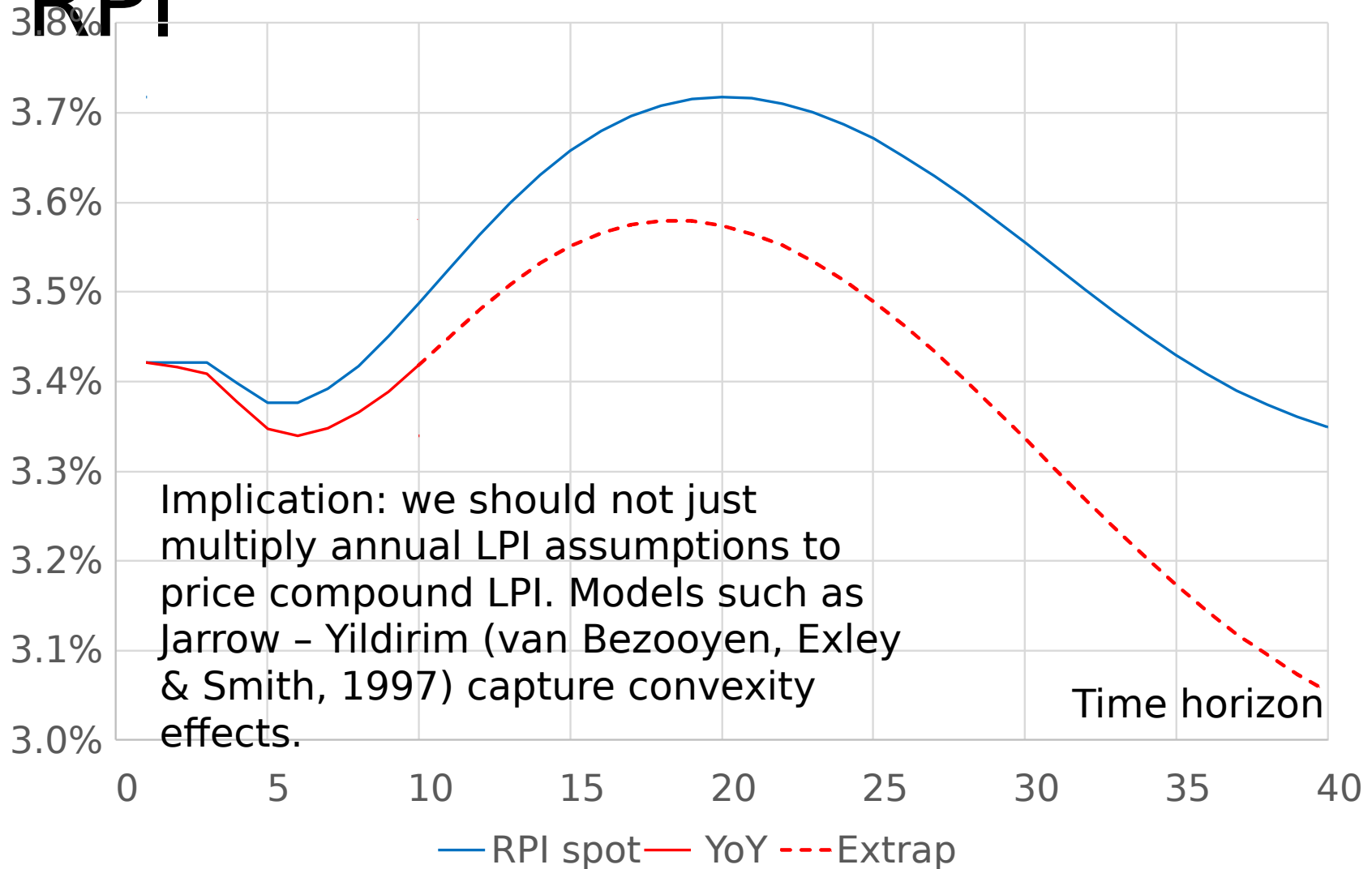


# Issue 2: Convexity

- Compare two instruments depending on RPI
  - A cumulative RPI payment, that depends on a future RPI index level.
  - A year-on-year RPI flow, that pays the RPI increase on a fixed amount over the year before payment.
- Should follow the same implied inflation, right?
  - Wrong – the cumulative payment has higher implied RPI
  - Because the year-on-year increases are positively correlated.
  - Expected product  $>$  product of expectations.

# Effect of Convexity on Spot RPI

Annualised RPI assumption



Implication: we should not just multiply annual LPI assumptions to price compound LPI. Models such as Jarrow - Yildirim (van Bezooyen, Exley & Smith, 1997) capture convexity effects.

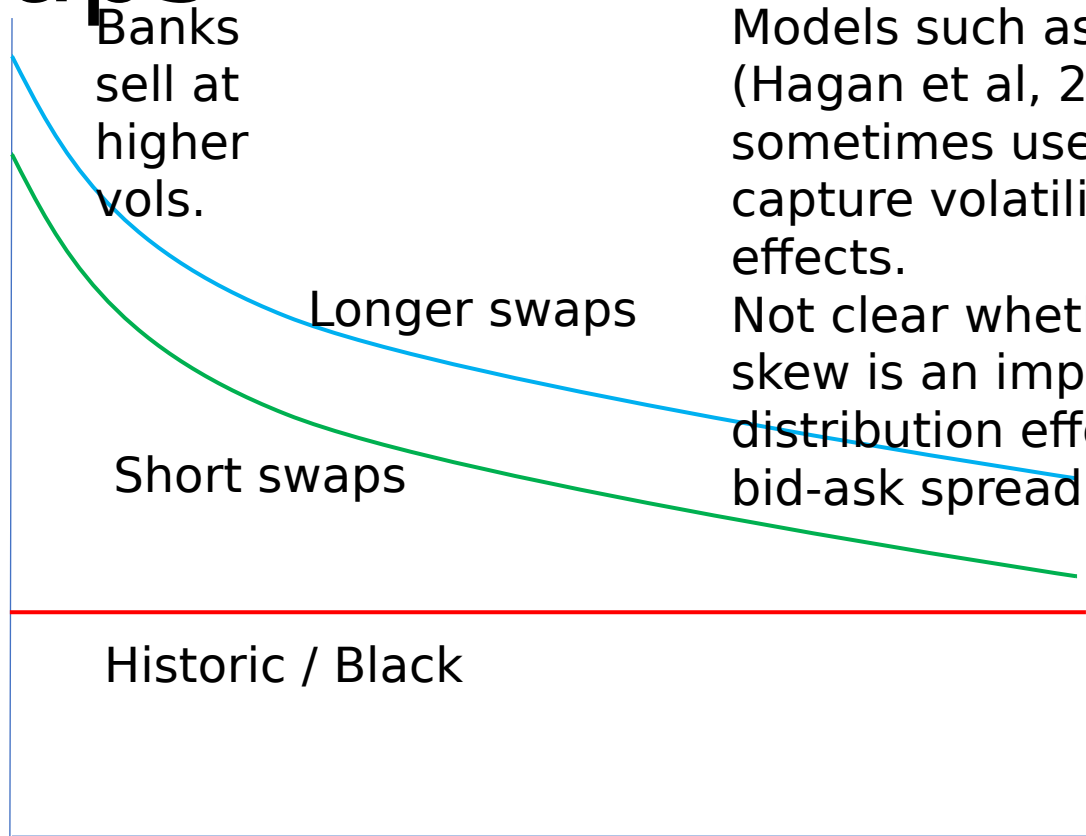
# Issue 3: Inflation Swaps

- In addition to gilts and ILGs there are also over-the-counter derivatives depending on inflation.
- Inflation swaps, and also swaps based on LPI[0,inf], LPI[0,5] and LPI[0,3]
- This market was much more liquid prior to the financial crises; now very few active banks and infrequent trades.
  - Nevertheless, data vendors offer survey data.
- Question as to whether pension schemes should use these data to value liabilities.



# Volatility Skew in LPI Swaps

Implied vol (illustrative)



Banks sell at higher vols.

Longer swaps

Short swaps

Historic / Black

Models such as SABR (Hagan et al, 2002) are sometimes used to capture volatility skew effects.

Not clear whether the skew is an implied distribution effect or a bid-ask spread effect.

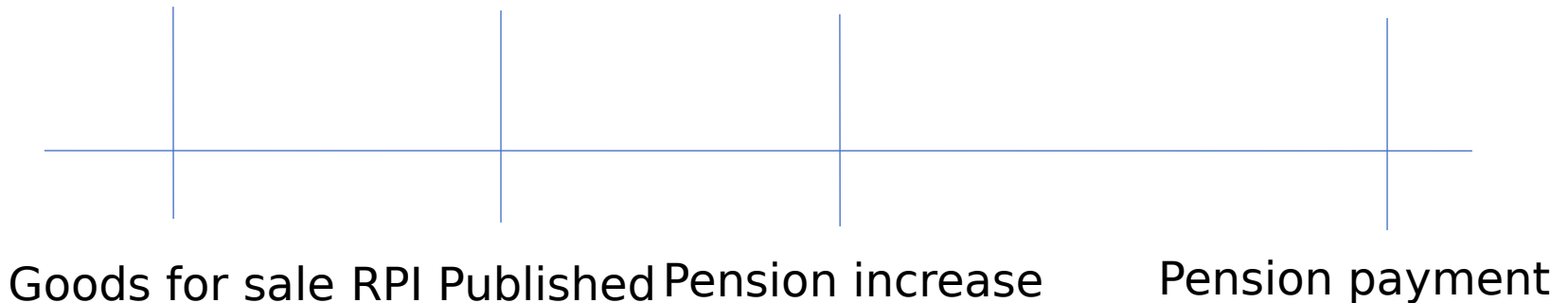
Banks buy at close to historic.

Strike

↑  
Banks selling

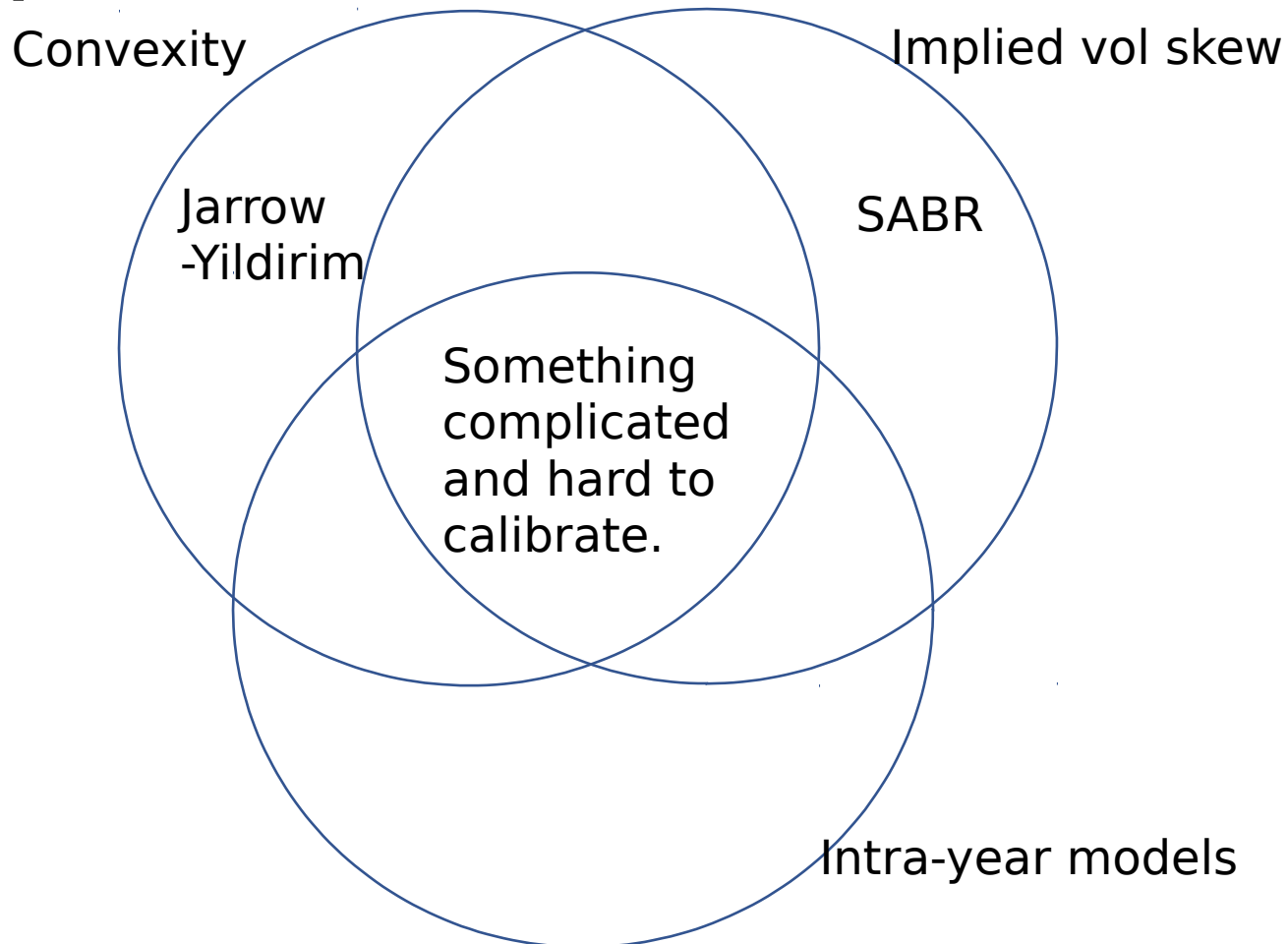
↑  
Banks buying

# Issue 4: Cash Flow Timing

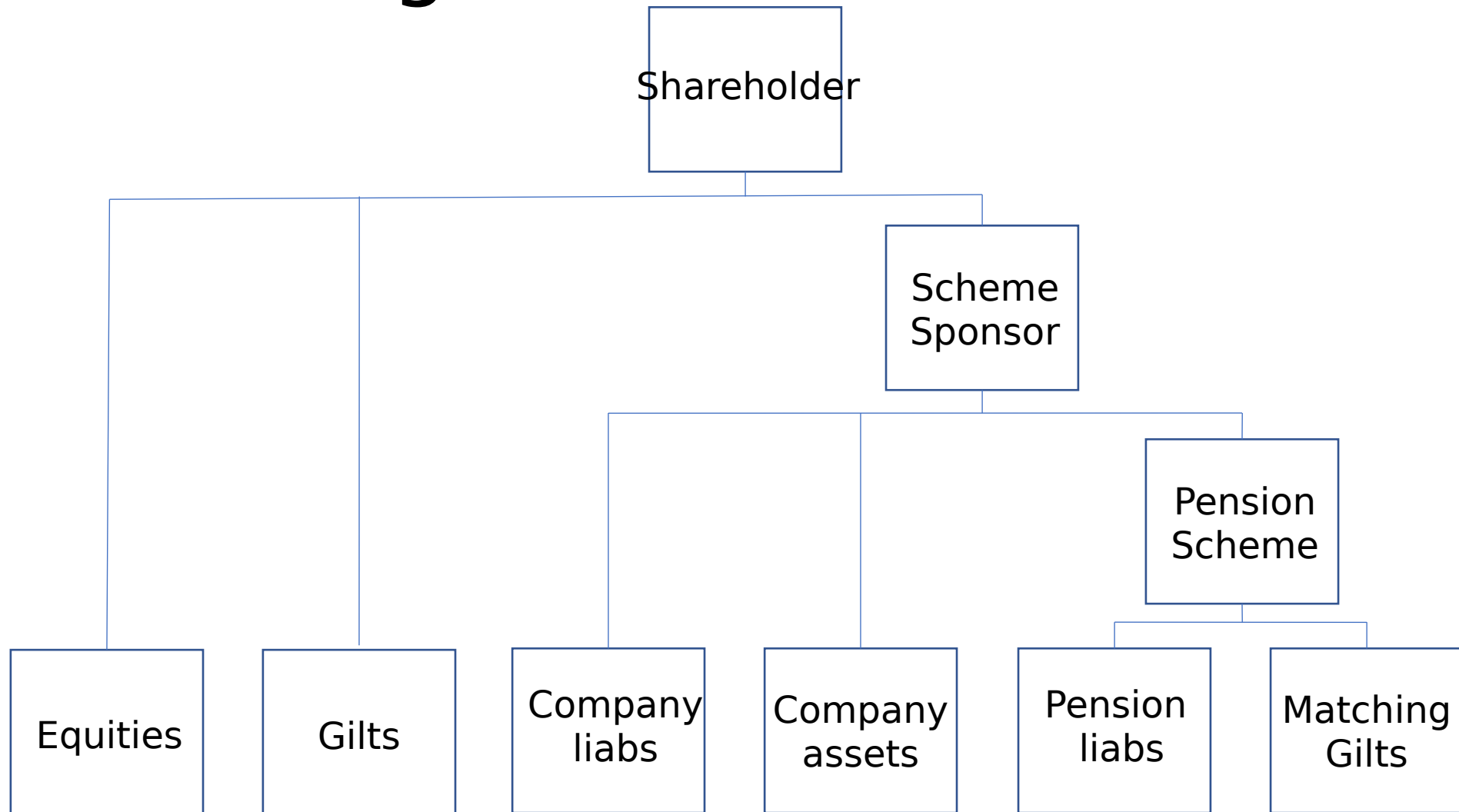


The details of intra-year timings are not always material for valuing LPI. But they can be important for calculating sensitivities that feed into hedge calculations and investment management benchmarks. Hedge sensitivities are discontinuous on the day (once a year) of the RPI publication that precedes the pension increase calculation.

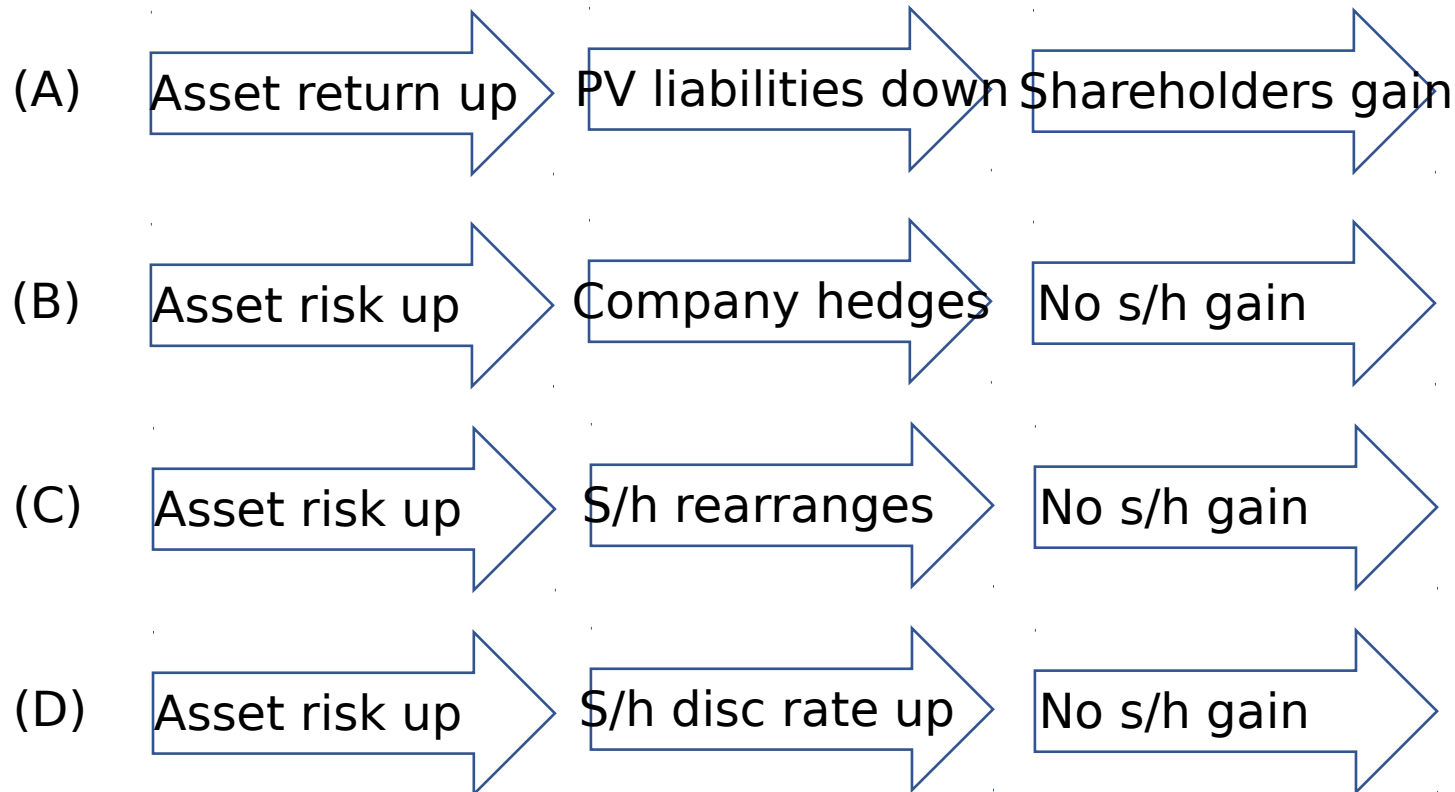
# Choice of Models: Properties



# Valuing Matched Pensions



# Risky Assets and Discount Rates



Which argument will you believe? We go for (B), (C) or (D).

# Conclusions

- Some actuaries have been applying option pricing methods to LPI for at least 30 years.
- Several interested parties (trustees, scheme actuary, sponsor, investment consultant, asset manager) need access to LPI models.
- RPI and ILG histories now long enough to construct non-parametric historic burning cost estimates from public data.
- Inflation derivatives provide more data, for a fee, and with questions about reliability.

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