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Adapting to the High Inflationary Environment: Stochastic Modelling Approaches and Challenges

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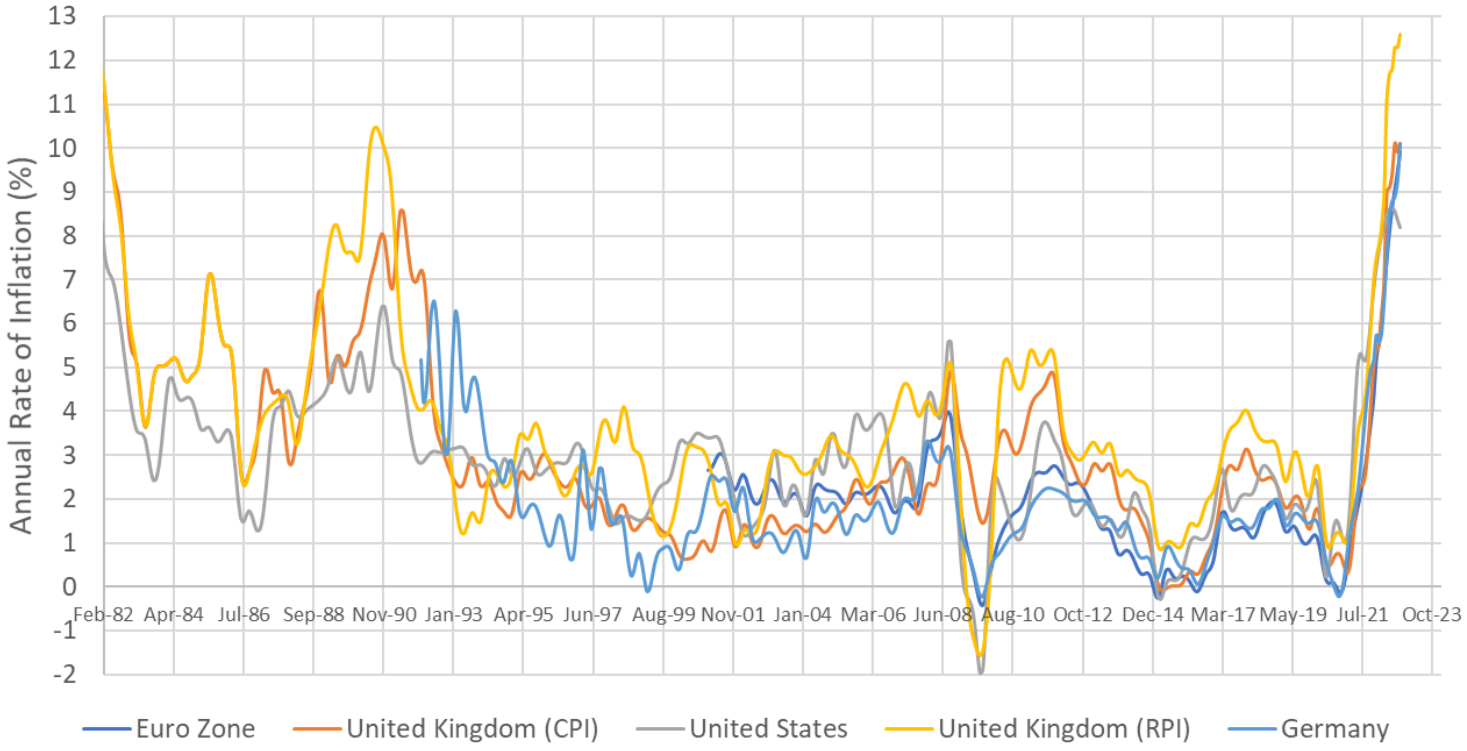
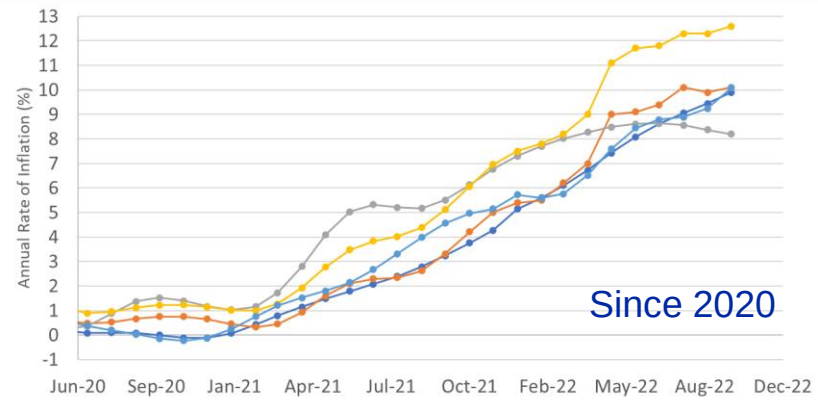
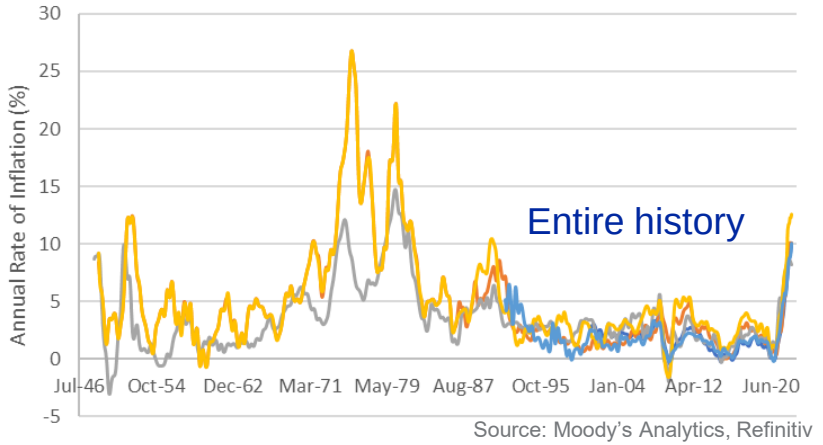
Agenda

- Current global inflation environment
- Structure of a stochastic inflation model
- Setting a target path for inflation
- Setting inflation distribution targets
- Validating stochastic inflation models
- Alternative inflation index modelling
- Stress testing inflation models

Current Inflation Dynamics: comparison to history







Source: Moody's Analytics, Refinitiv

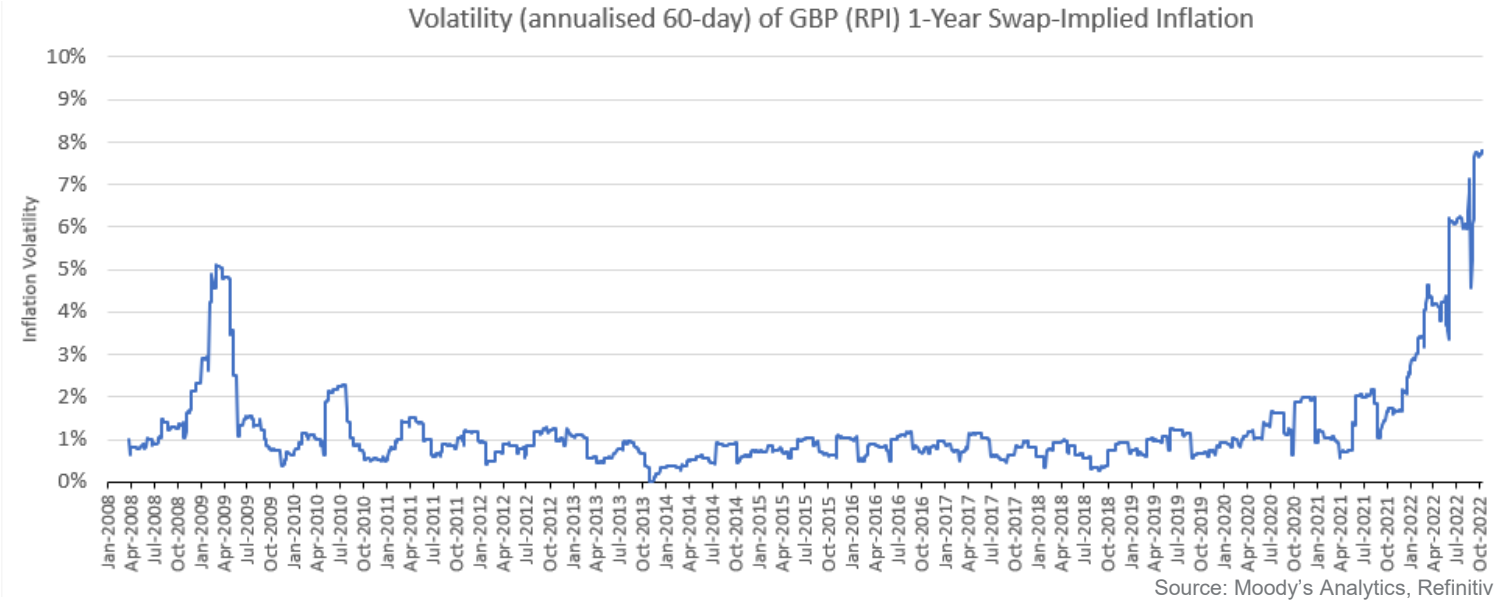
The recent dramatic increase in inflation is a very rare event:

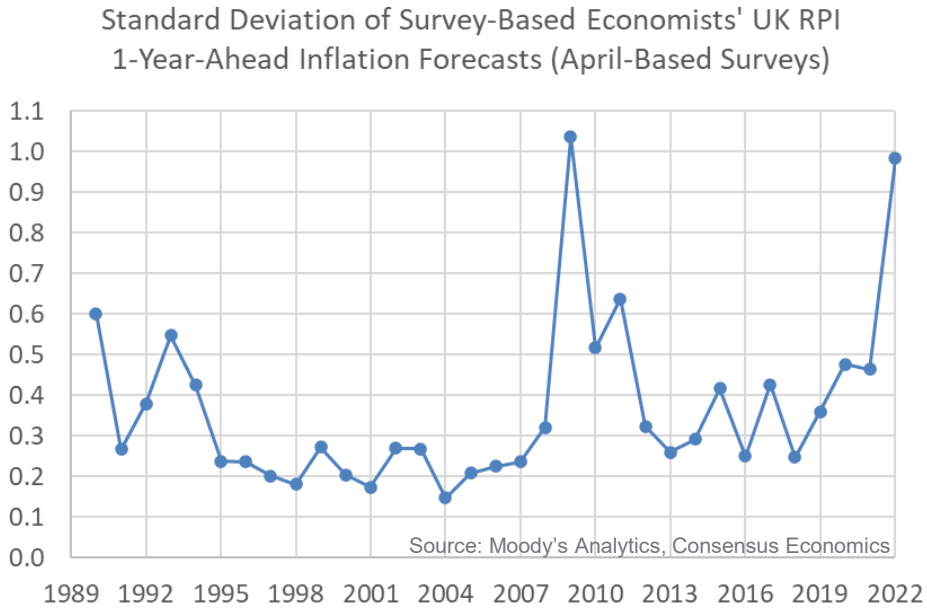
- An annual upward jump with a magnitude greater than those in recent months not observed in over 40 years in most major economies.
- No. of larger jumps over entire history: UK CPI (30/879), UK RPI (22/879), US (7/885). Most in 1950s and 1970s.
- No. of proportionally larger upward jumps over entire history: UK CPI (5/879), UK RPI (4/879), US (13/885), Germany (3/357).

Future Inflation Uncertainty is Current Very High

» Future inflation uncertainty can be measured using various types of data/methods including:

- **Economists' forecasts (survey-based)**: e.g. standard deviation of 1-year ahead forecasts.
- **Market data-derived volatility:** e.g. standard deviation of historic 1-month inflation swaps.





» Important that insurers' stochastic inflation model/s reflect both:

- The current high-**level** of inflation and the expected high-**levels** of inflation over the next few years.
- The current high-degree of **uncertainty** about near-future inflation.

Inflation Model Structure

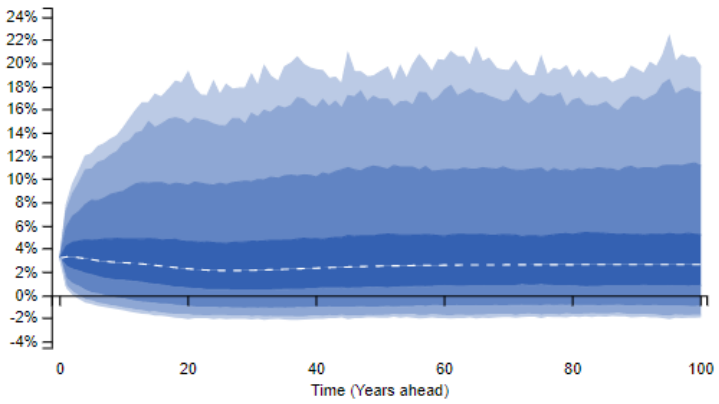
Inflation Model Structure (part 1): modelling ‘expected’ inflation

» Fisher Equation:

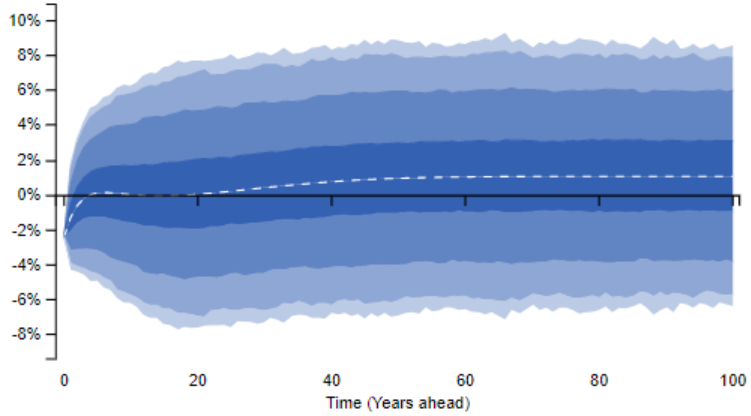
nominal 1Y rate (t) = real 1Y rate (t) + expected 1Y inflation (t)

» Typically 1-year nominal and real rates are explicitly modelled (possibly with different models) and 1-year expected inflation is ‘backed-out’.

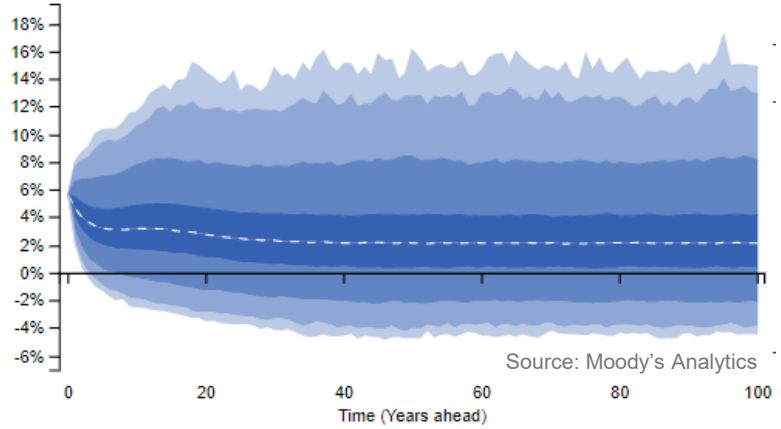
– End-Oct 2022 UK Example:



1Y nominal rate (modelled directly)



1Y real rate (modelled directly)



1Y expected inflation (modelled indirectly)

» The distribution of the derived variable (i.e. 1-year expected inflation) is dependent on:

– The **modelled distribution** of 1-year nominal and 1-year real rates.

– The **modelled correlation** between 1-year nominal and 1-year real rates.

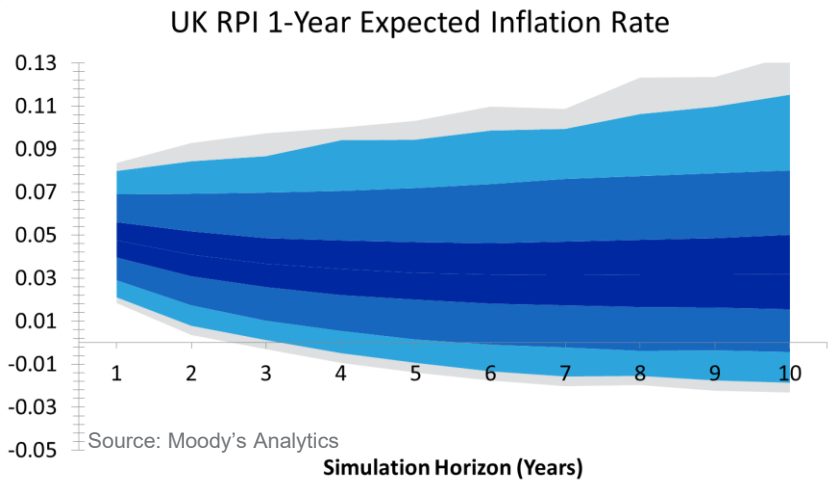
Inflation Model Structure (part 2): modelling ‘realised’ inflation

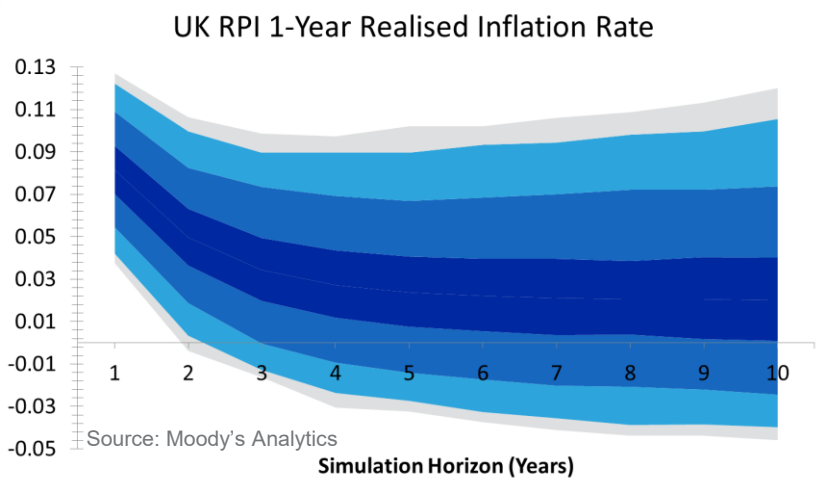
- The modelled inflation rate outputted from a stochastic simulation does not have to equal the modelled 1-year ‘expected’ inflation.
- The modelled 1-year ‘expected’ inflation can be adjusted to give modelled ‘realised inflation’. This could allow modelled inflation to:
  - Follow a target path of future inflation on average. We may want this to differ from market-implied inflation.
  - Exhibit an ‘unexpected inflation shock’. We may want the distribution of modelled inflation to be different to expected inflation.
- Structure of modelled ‘realised inflation’ model

$$\textit{realised inflation}(t) = [\ \textit{expected 1Y inflation}(t-1) + x(t)\ ] + \textit{stochastic shock}(t)$$

Can be chosen to capture a target path for average modelled inflation

The magnitude of this can be chosen to capture a target for the size of unexpected inflation shocks

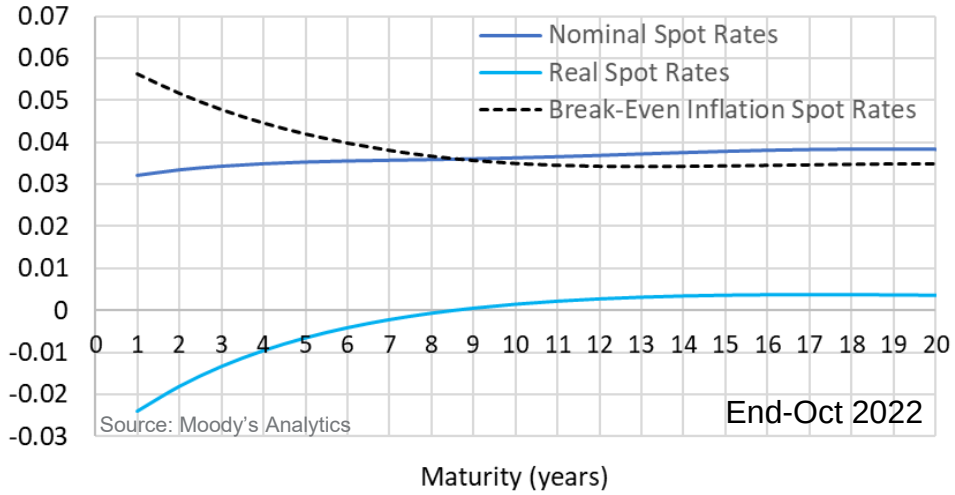




Setting an Inflation Target Path

Setting an Inflation Target Path: could break-even inflation be used?

» The break-even inflation curve = nominal yield curve – real yield curve

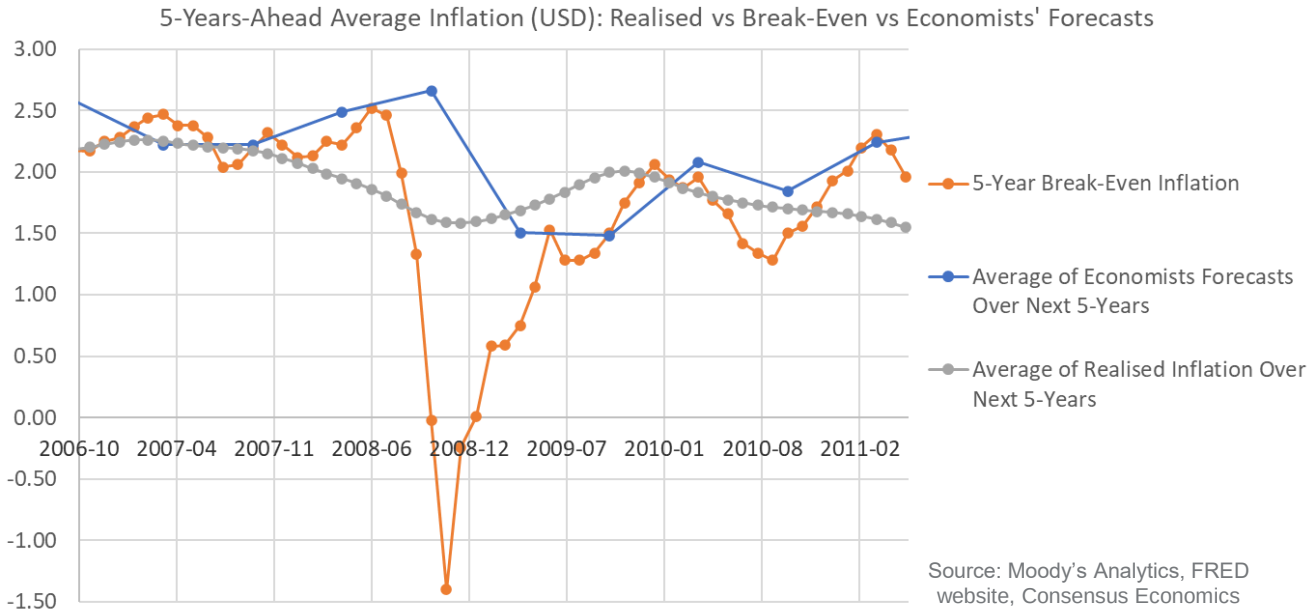


The *X*-year maturity break-even inflation spot rate = The market's prediction of average annual inflation over the next *X* years

Is break-even inflation a good predictor of future inflation?

» Risk premia in government and index-linked bond curves can distort the market-participants inflation expectations.
  – 'Flight-to-quality' in crises magnify this effect.

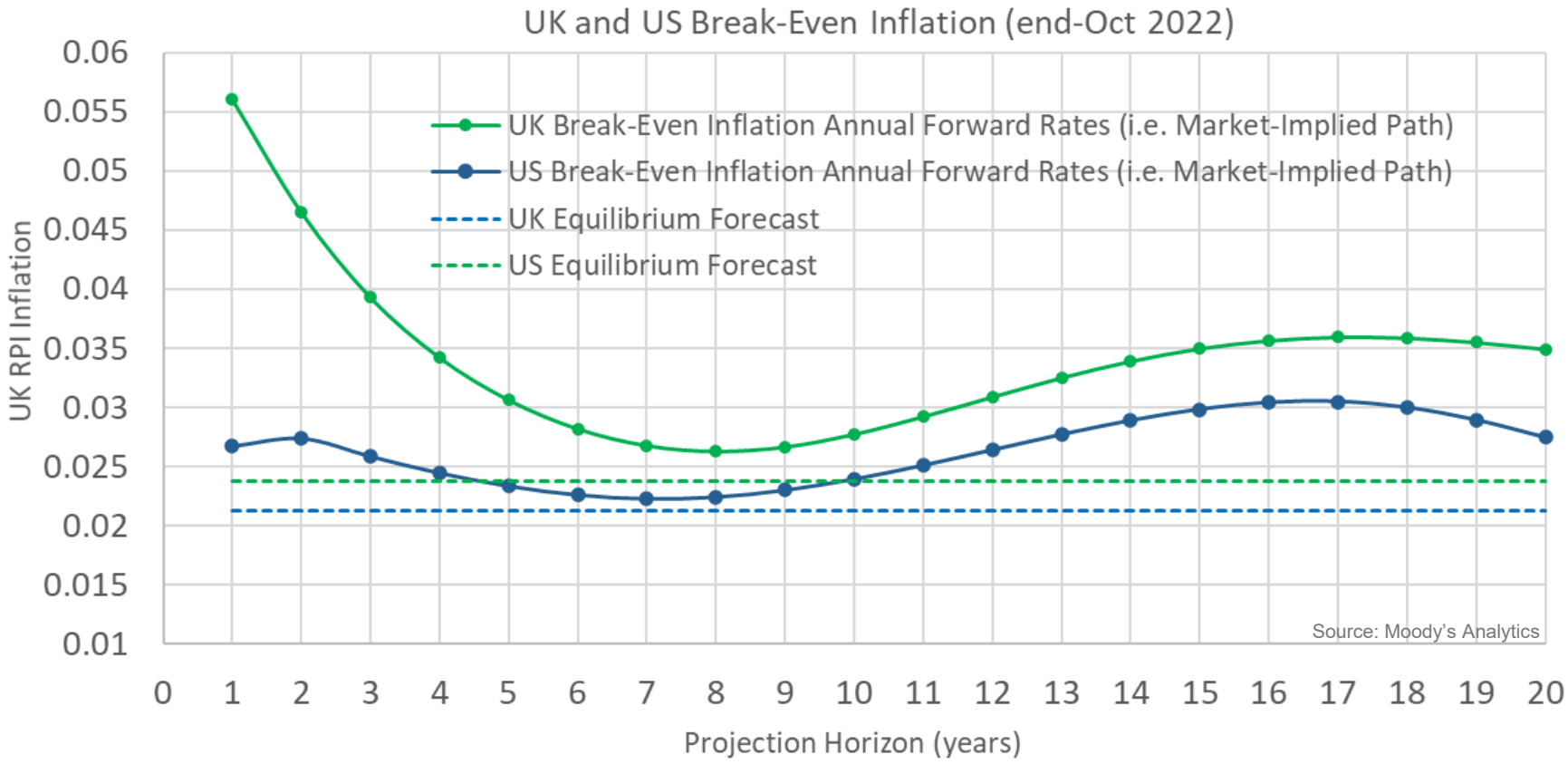
» Market-implied inflation in US 2008 suggested inflation over the next 5 years would be negative on average.
  – Economists' believed it would be between 1.5–2.6%.
  – Realised inflation average 2008-2013: about 1.5%



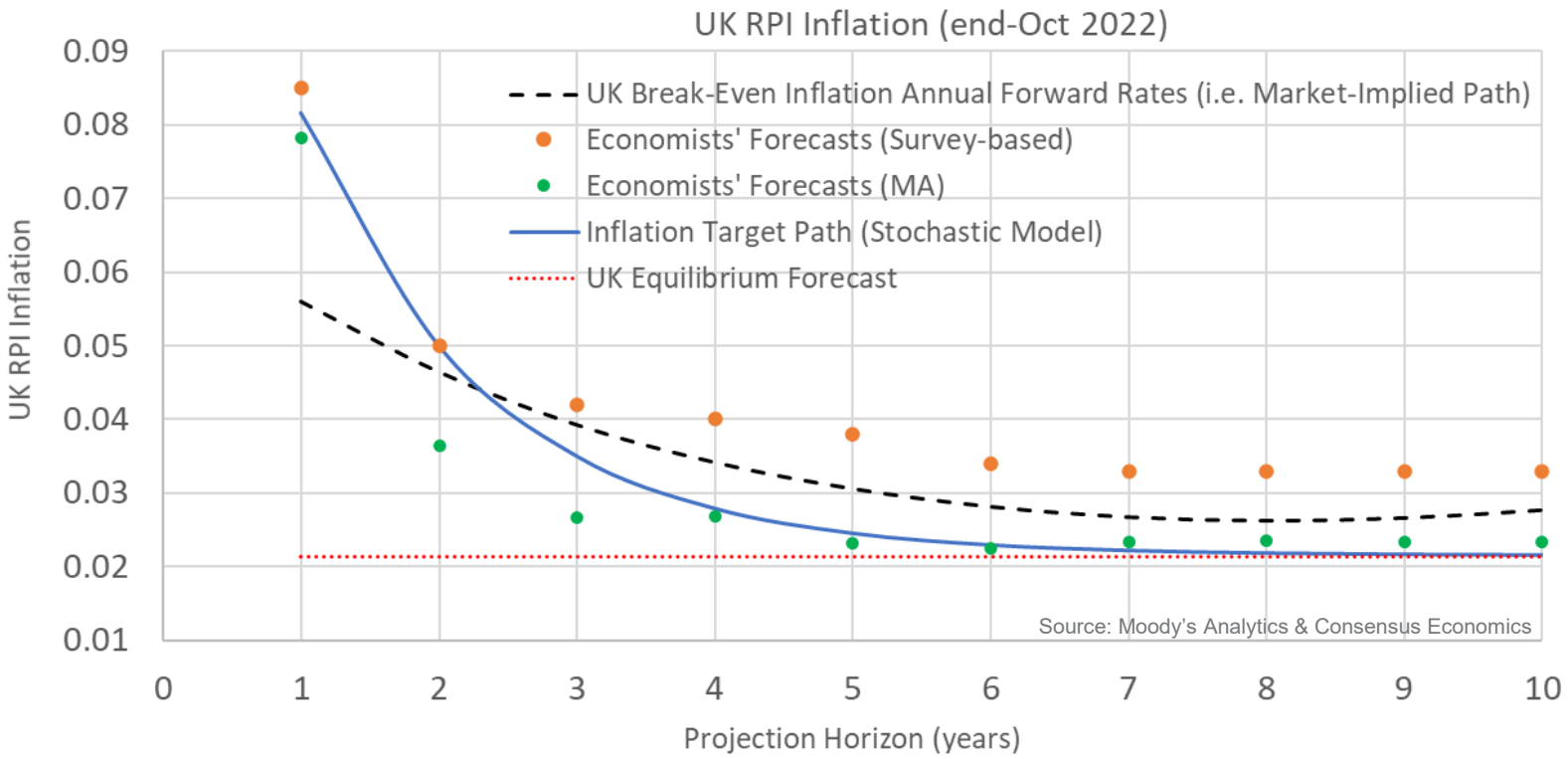
Inflation forecasts are likely to be better predictors of inflation over the next few years than market-implied inflation

Setting an Inflation Target Path: could break-even inflation be used?

- The break-even inflation curve is likely to be a poor predictor of inflation at long time horizons (10+ years).
  - Risk/term premia embedded with nominal and index-linked bonds can become significant for long-maturity instruments.

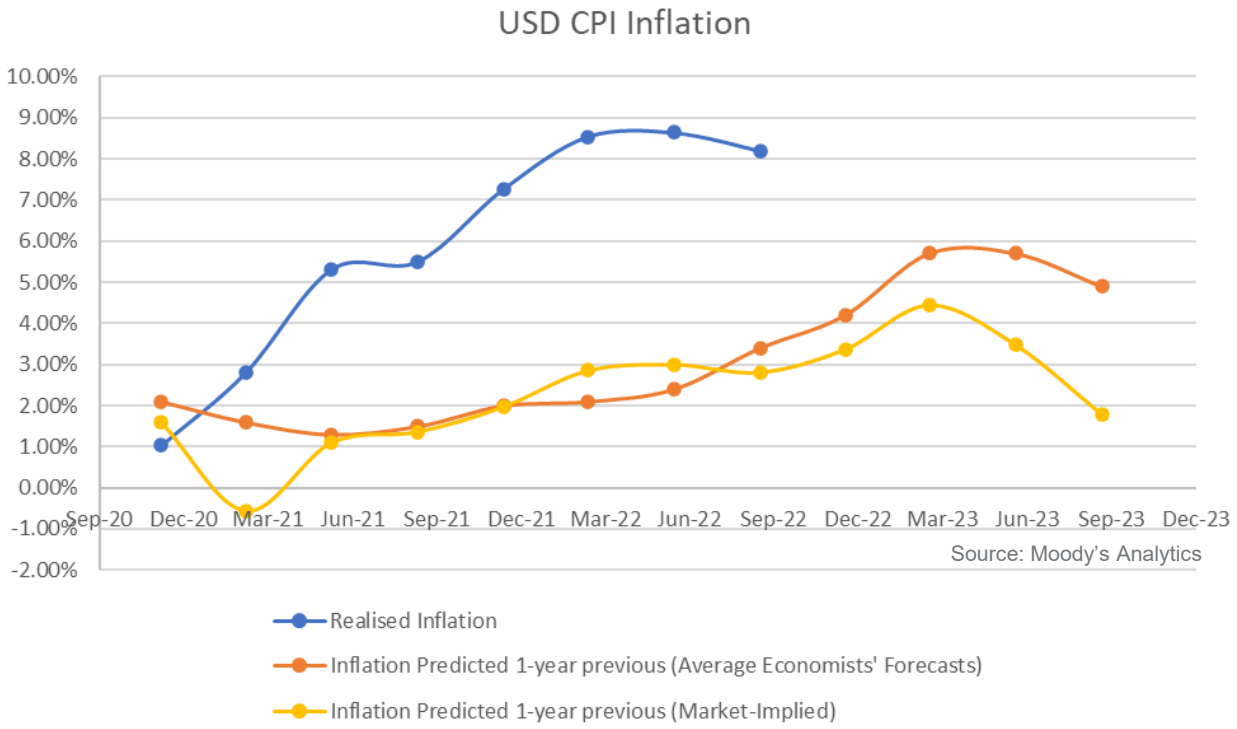


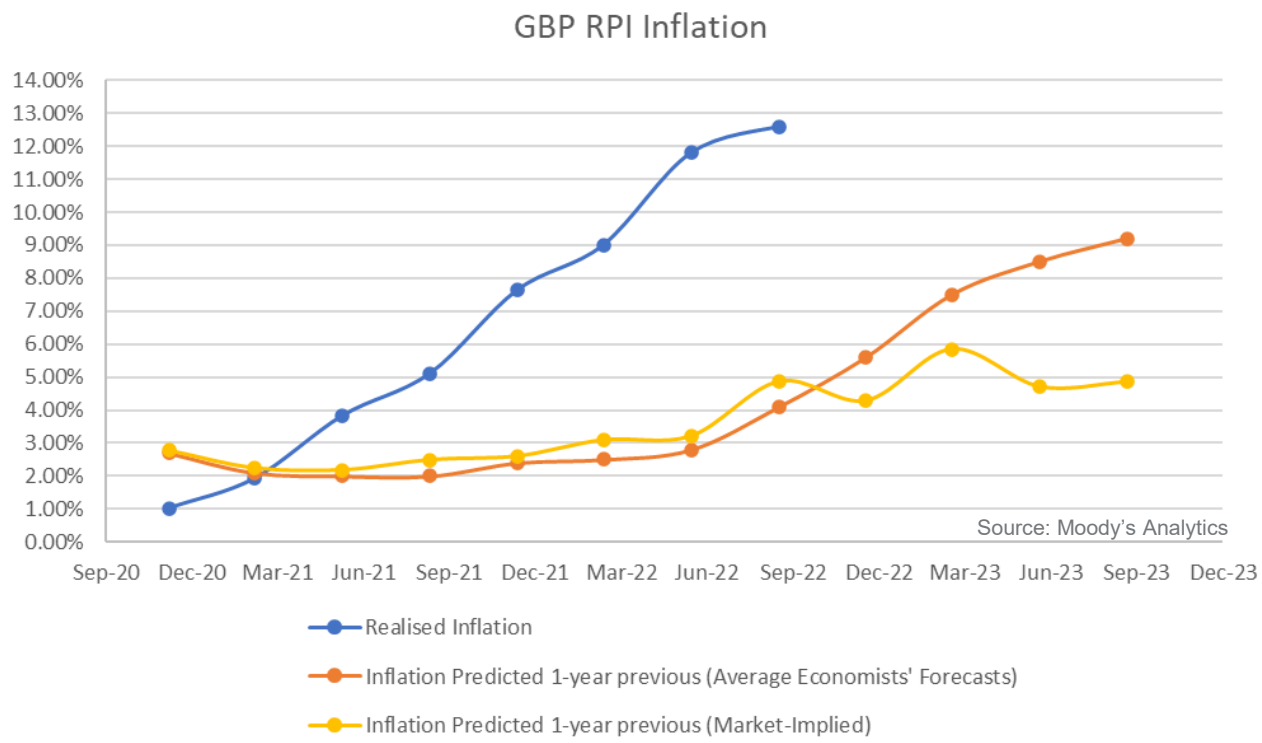
Setting an Inflation Target Path: using economists' forecasts



- One approach to setting a target path for inflation is to fit a smooth function to a range of forecasts.
  - This allows any differences in forecast dates (and approaches) to be smoothed out.
- In this example the Rebonato function (blue curve) is fitted to:
  - Average of survey-based forecasts from Consensus Economics (orange circles).
  - Econometric model-based forecasts from Moody's Analytics (green circles).

Recent Inflation Spike: anticipated by economists or the markets?





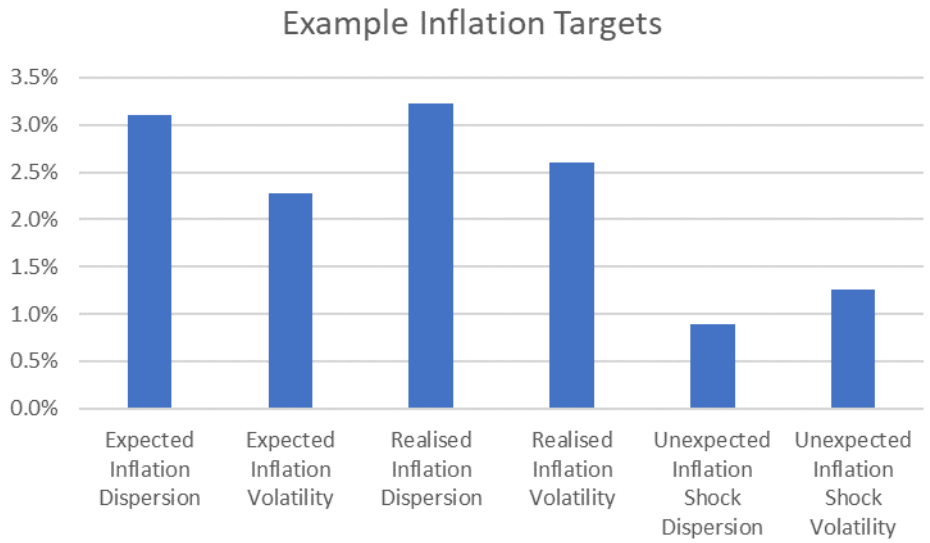
- 1-year-ahead market-implied and economists' forecasts significantly underestimated/missed the recent dramatic inflation increase.
  - Illustrates that the energy crisis and Ukraine/Russian war and its impact were unexpected (an economic 'tail event').
- We should expect recent stochastic inflation model projections to have captured the recent spike in the upper tail of their distribution.

- How can inflation models be calibrated to capture a reasonable level of risk?

Modelling Inflation Distributions

Setting Targets for the Distribution of Inflation

- It is reasonable to set distributional targets for inflation using historical data. Several considerations:
  - What length of history of should be used?
  - Should all periods of history be included?
  - Should all points in history be weighted equally?
  - Should index-specific or global targets be set?
  - Targets for ‘expected’ and ‘realised’ inflation may need to be set (dependent on model structure).
  - Targets based on the ‘volatility’ and ‘dispersion’ of inflation should be considered.
    - Definitions: standard deviation of level (i.e. the dispersion’) and in change in the inflation rate (i.e. volatility).



Example targets:

- All available history used: maximises information used.
- All periods of history used: difficult to justify what to remove/keep.
- Exponentially-weight history: more recent history weighted higher.
- Global targets: maximises information; rare events in one economy’s history may be possible in others; limited history available for some economies.

Calibrating an Inflation Model to Distribution Targets

$$realised\ inflation(t) = [\ expected\ 1Y\ inflation(t-1) + x(t)\ ] + stochastic\ shock(t)$$

Modelled correlation between nominal and real rates models could be calibrated to capture **expected inflation** targets

Standard deviation of this could be calibrated to better capture **realised inflation** targets or **unexpected inflation shock** targets

Considerations:

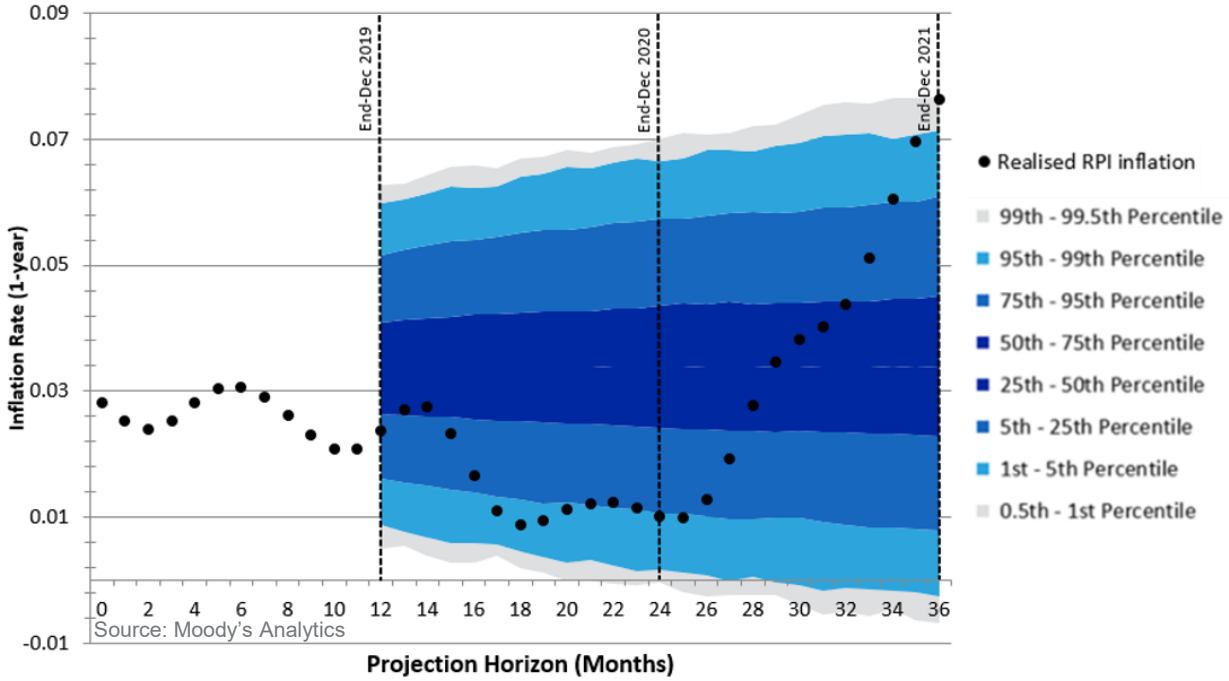
- All targets may not be perfectly captured – decision on which targets to best capture may depend on application/projection horizon.
- Expected inflation targets could be captured by adjusting nominal/real rate calibrations - may lead to sacrificing fit to related targets.
- Can conditionality be introduced?
  - If nominal rate model exhibits a realistic rate level/volatility relationship then this will feed into the expected inflation distribution.
  - If the standard deviation of the stochastic shock could vary through time it could be initialised at current inflation volatility levels.

- How could conditional volatility targets be set?
  - Utilise the distribution of 1-year horizon inflation forecasts from economists. Challenge: limited data; not available for all economies.
  - Measure historic data (weighting more recent most heavily). Challenge: backward looking; weighting scheme/window size is subjective.

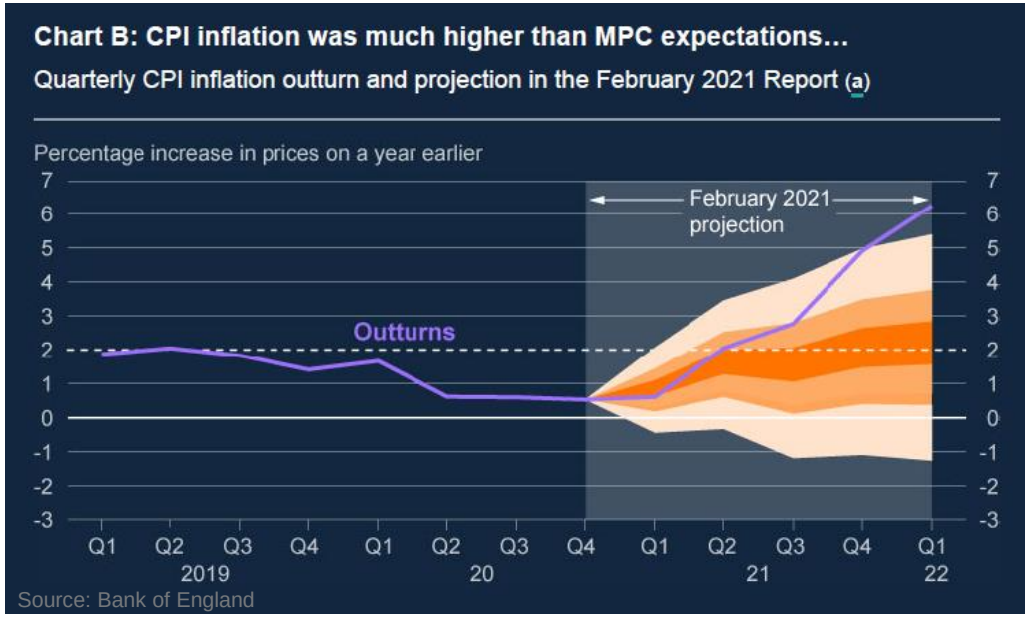
Validating Inflation Models

Inflation Modelling Validation: backtesting

- Model can be calibrated/initialised at a historic date to see if it captures realised rare/tail events.
- Considerations:
  - At what point in time before a tail event should the model be initialised? Assigned model probability likely to be dependent on this.
  - Where in the tail should tail events sit? May be difficult to justify given limited history of data.
- Backtesting can be a good qualitative sense-check of model suitability but can be difficult to draw strong quantitative conclusions from.
- Example: UK RPI end-Dec 2018 projection.

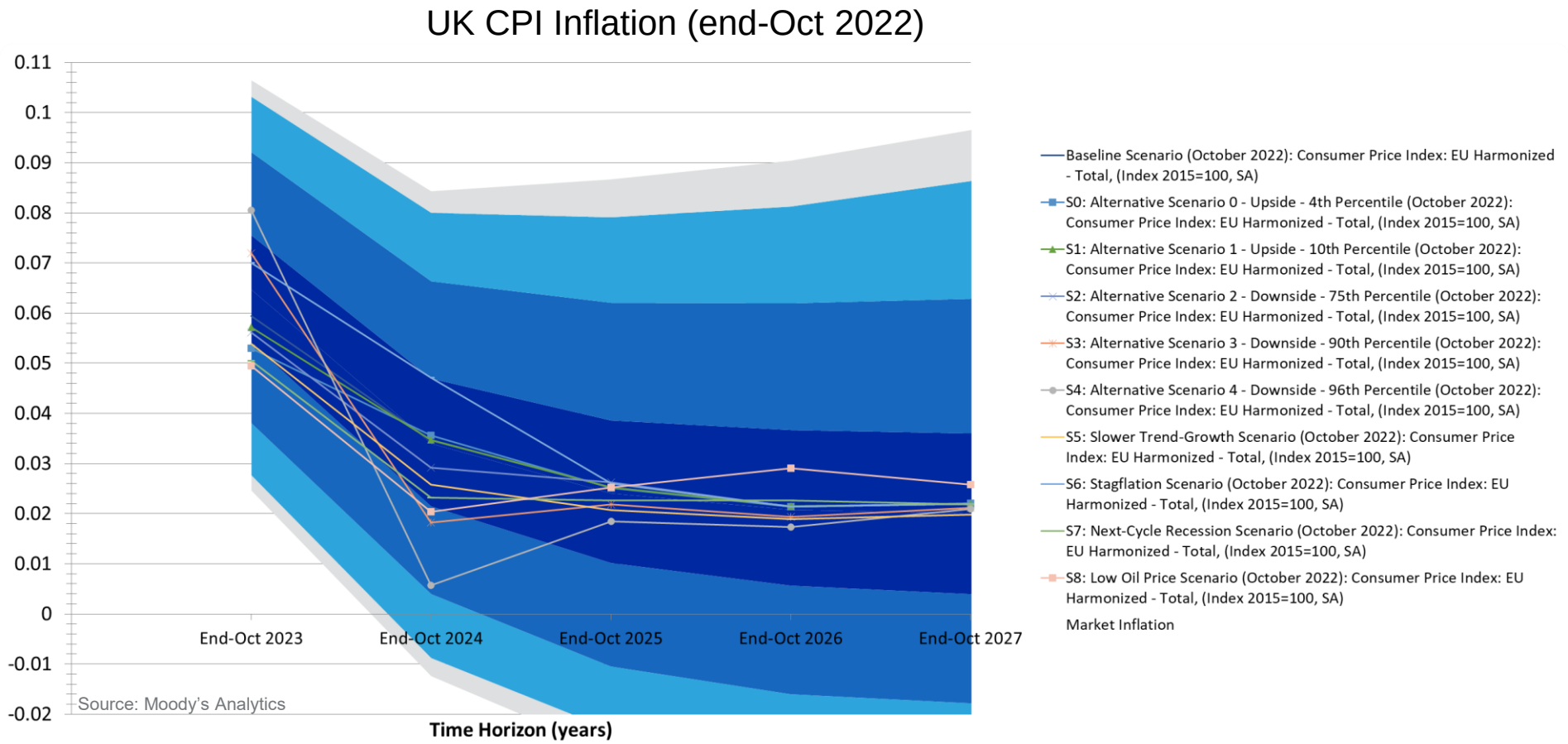


- The Bank of England often publish backtesting results:



Inflation Modelling Validation: using economists' narrative scenarios

» Forward-looking validation analysis could be performed using a range of current narrative forecasts from economists.



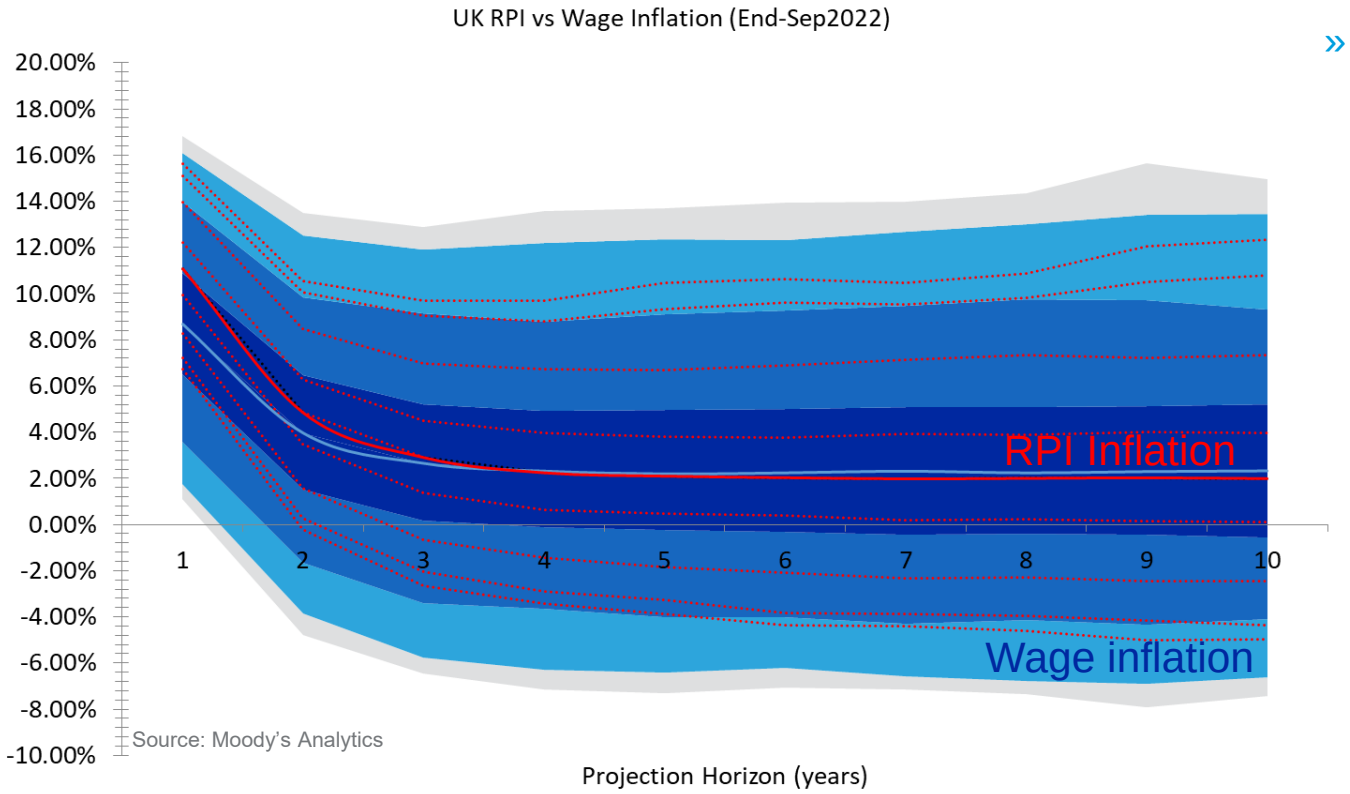
» Another good qualitative sense-check: does the median/mean align with baseline narrative? Does the distribution capture all narratives?

» Difficult to draw qualitative conclusions unless the narrative scenarios have associated probabilities.

Alternative Index Inflation Modelling

Modelling Granular / Alternative Inflation Measures

- Wage, construction, medical, legal inflation etc. could be modelled using a simple stochastic ‘wedge’/spread model above core inflation.
- Distributional qualities of the ‘wedge’ model could be determined by analysing the history of the index relative to core inflation.
  - For example can establish ‘excess’ inflation volatility, long-term level and mean reversion speed to calibrate a simple 1-factor model.
- Initialisation of wedge model determined from current level of specific inflation index.

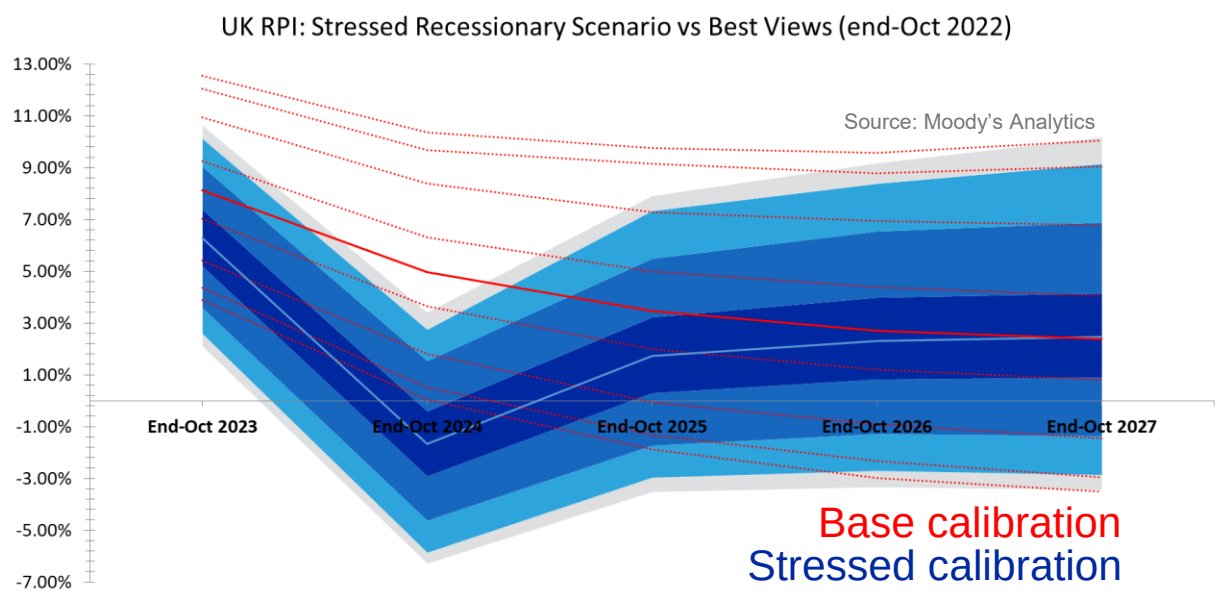


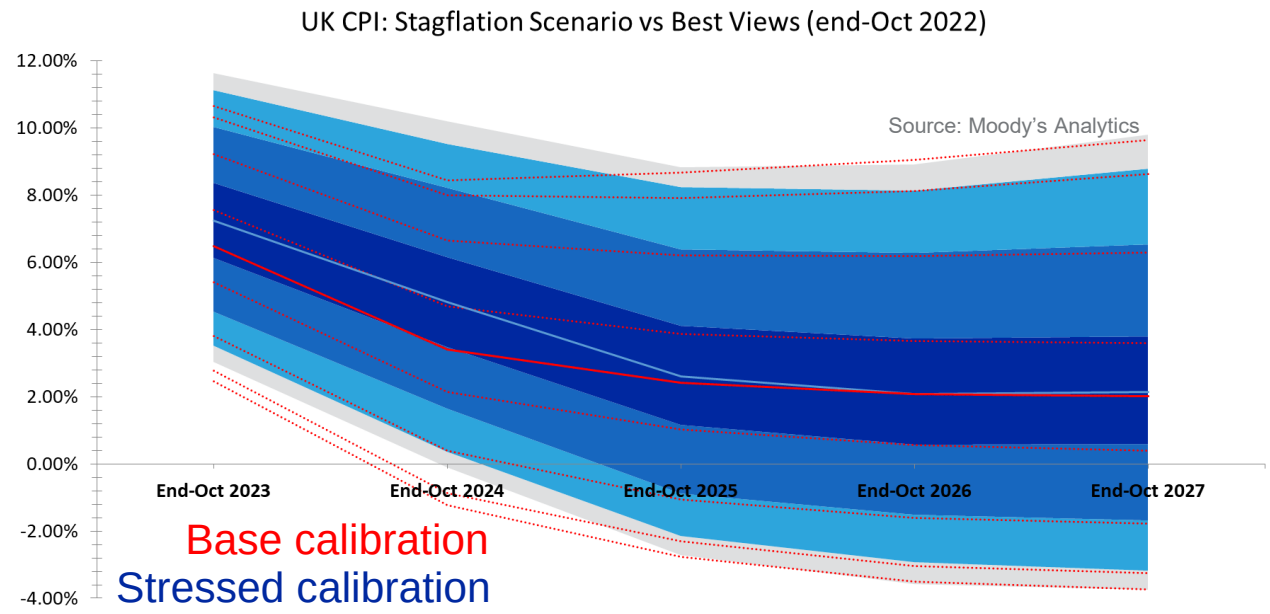
- It may be challenging to set a target inflation path for the alternative index, however if a path is set then this could be captured by:
  - Allowing the wedge model to have time-varying parameters (e.g. mean reversion level) and calibrating these appropriately.
  - A separate inflation model altogether (derived using an index-specific real yield curve) could be used.

Stress-Testing Inflation Models

Stressing Inflation Using Economists' Narrative Scenarios

- The central path of inflation (and other economic variables) can be calibrated to extreme deterministic narrative paths from economists.
- More justifiable stressing approach than arbitrarily increasing/decreasing inflation levels.





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