CAIM | CROWN AGENTS INVESTMENT MANAGEMENT

WEIGHTED BOOTSTRAPPING

MAKING MORE USE OF MORE RECENT DATA

OCTOBER 2025

INPUTS INTO SCENARIO GENERATION

- We've now covered Monte Carlo simulation and simple boot-strapping.

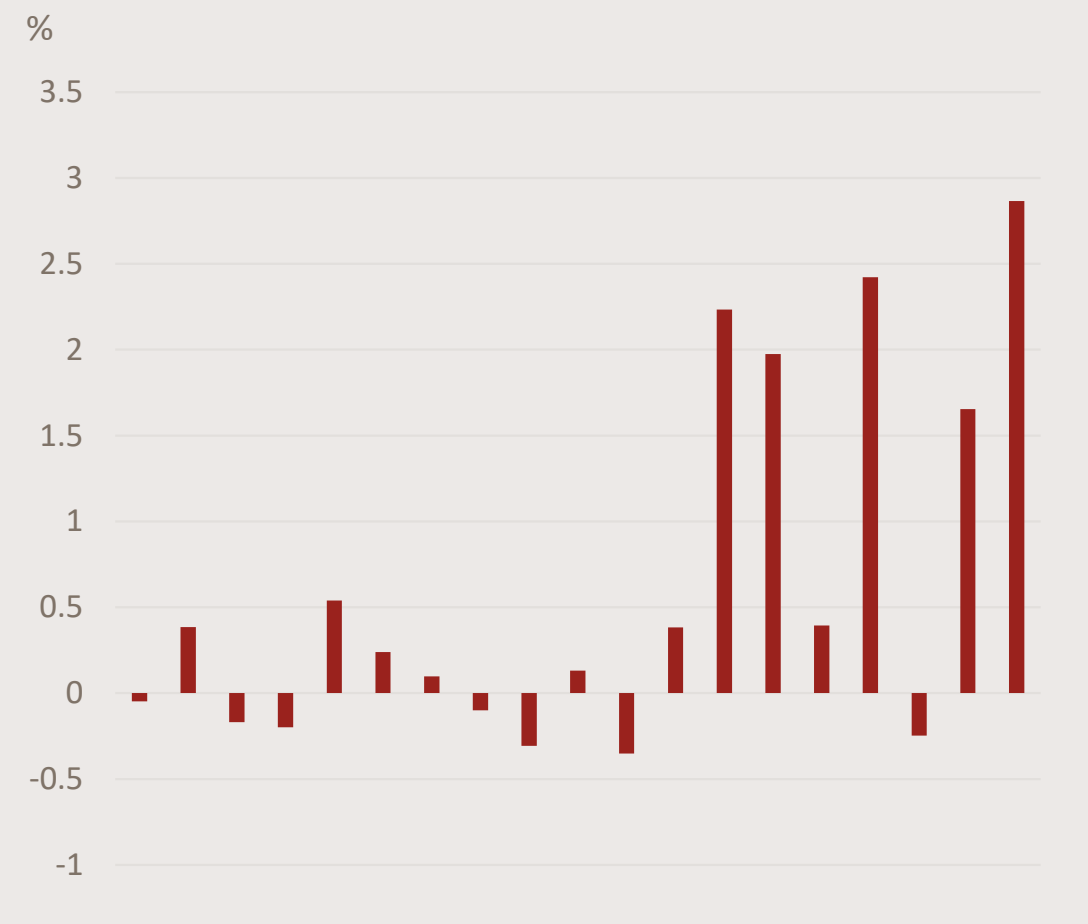
- We randomly selected several short periods from history and combined them to generate scenarios of our desired length.

- The short periods we choose are just as likely to come from the recent past as from long ago. Is that a good thing?

There's a never-ending trade-off between going back in time to get as much data as you can, and the fact that the world may have changed since then.

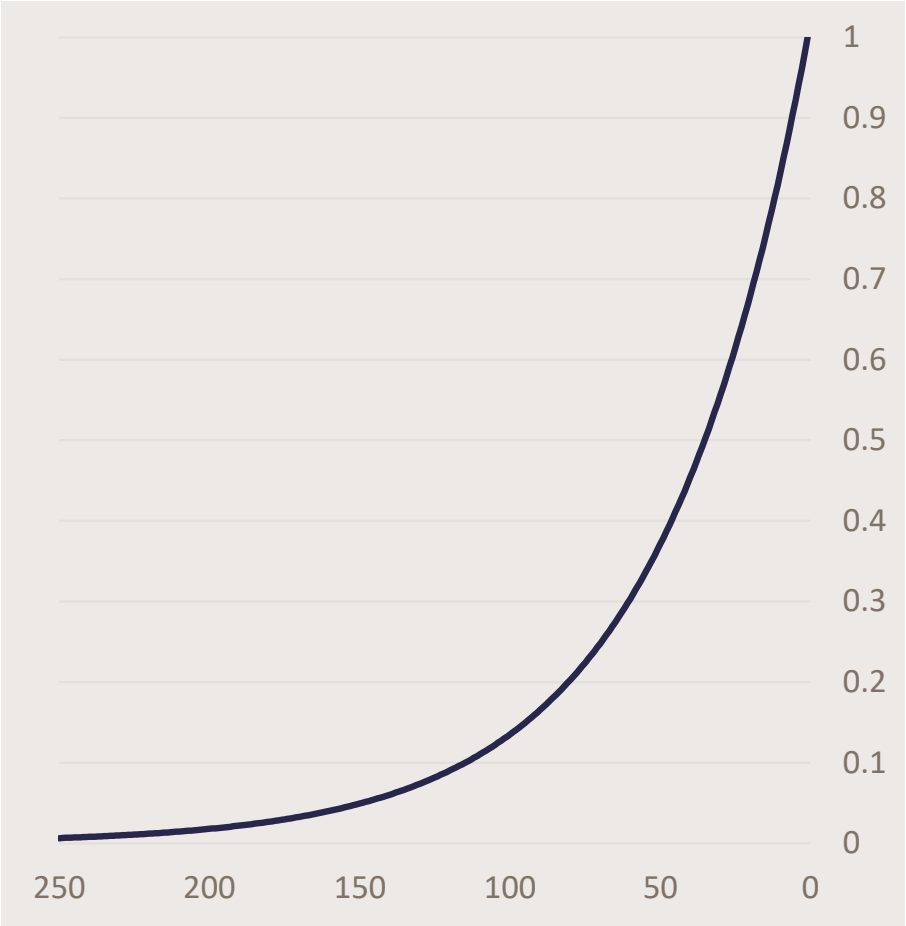
DEALING WITH CHANGE

- Consider the monthly returns of this asset.
- It looks as if something might have fundamentally changed about seven months ago.
- If so, do we really want to use data older than this? Should we throw it away?
- Time-weighting is a way of still using all the data, but attaching greater importance to more recent data.



EXPONENTIAL WEIGHTING

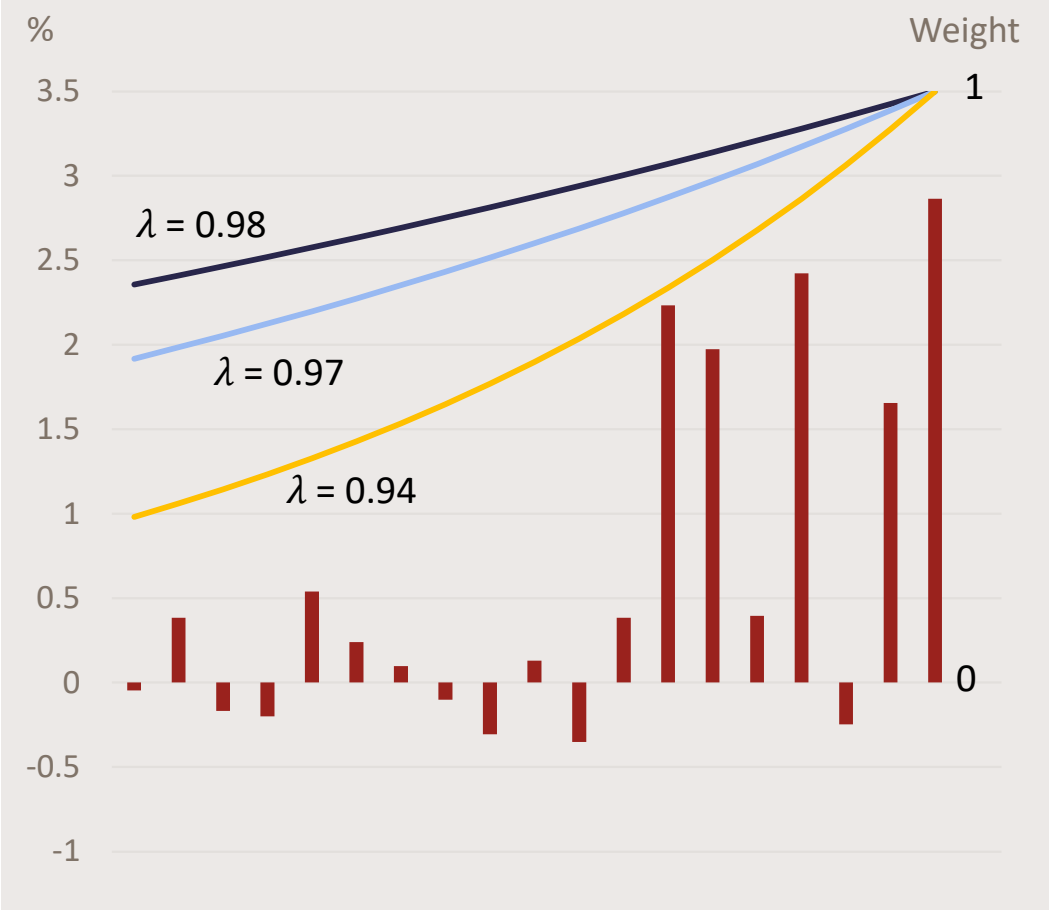
- Suppose we say we'll attach "full weight" to our most recent observation.
- However, for the previous month's observation, we'll attach a little less weight. Say, 98% of the most recent.
- And for the month before that we'll give that a weight of 98% of the succeeding month.
- And so on.
- If we denote our decay factor, here of 98%, as λ, then the weight attached to the n^{th} oldest observation is λ^{n-1}.



<- Back in time

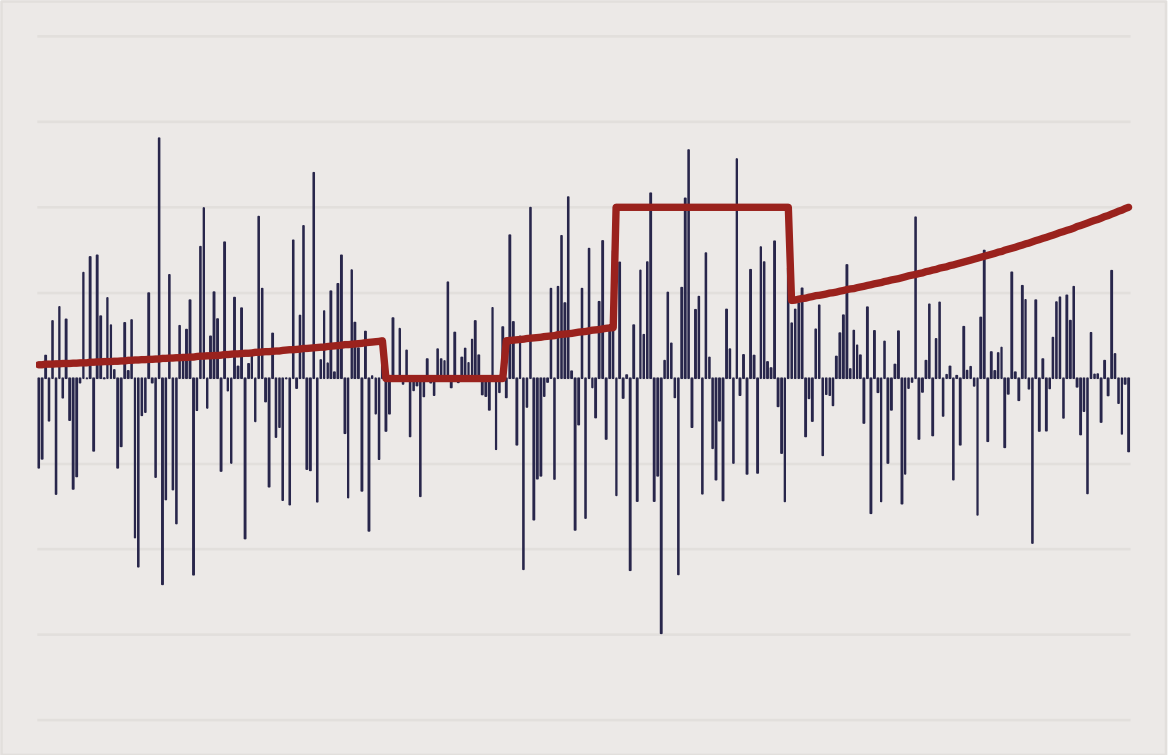
HALF-LIVES

- The weight of an observation never falls to zero. Instead, as with radioactivity, the speed of decay is normally measured in terms of the "half-life": the time it takes for the weight to fall by half.
- For our 98% monthly decay the half-life is just under 35 months: λ^{35} = 0.493. This means that the most recent three years of history will account for roughly half of what happens in our simulations.
- Other half-lives, as no. of periods:
  - if λ = 0.97, half-life c. 23
  - if λ = 0.94, half-life c. 12



VARIATIONS ON EXPONENTIAL WEIGHTING

- Other weighting schemes are available, and it could be useful to mix schemes.
- For example, it could be that a historical period of heightened volatility is of concern, so given a full weight.
- Another period that is unlikely to recur could be given a zero weight to exclude it from our scenarios.



- Is it better to optimise over a single set of scenarios with different weights like this, or is it better to split the scenarios into different sets and – for example – come up with a portfolio that does well in one “most likely” set, but doesn’t blow up if another set turns out be closer to reality?

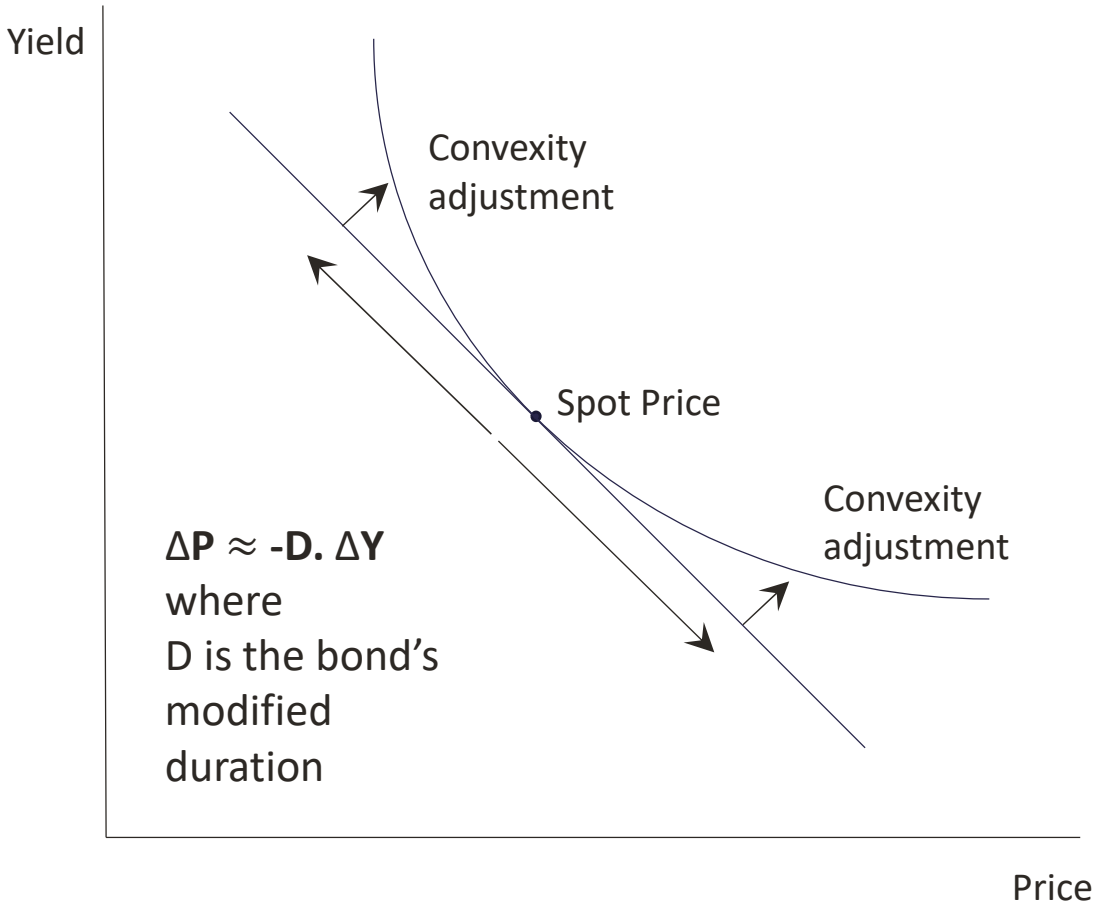
IS THIS GETTING TOO COMPLICATED?

Suddenly, we have some choices to make

- What is the “right” time-weighting to use? What about daily versus monthly data?
- Maybe looking at more than one time-weighting makes sense, but then there’s the risk of being swamped by too much information. Particularly as we shouldn’t look just at tracking error and neglect other risk measures.
- Wouldn’t it be better to focus on a simpler risk measure that’s more familiar? Such as?

DURATION

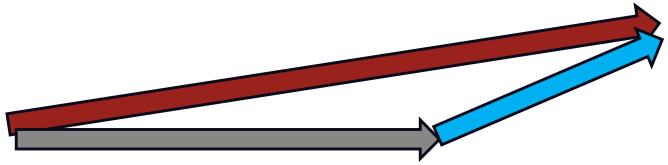
The instantaneous price-yield relationship



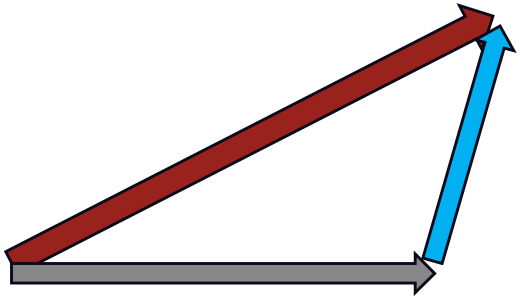
- Duration is the sensitivity of a bond or bond portfolio's value to a change in yield
- Here we're looking at how the price and yield of a bond move together at a single moment in time.
- Using duration enables the easy comparison of risks between strategies both today and over time: it is often used by PMs for risk-budgeting purposes.
- Maybe we should just use duration and forget all about tracking error?

BUT DURATION ALONE IS NOT ENOUGH

Visualising adding the risks of two trades (in grey and blue) to get the risk of a portfolio (in red)



When the trades are closely related



When less closely related

- Suppose we have two trades in our portfolio, each with a 3m duration exposure. If the trades are in assets of different volatility their risks in tracking error terms, as signified by the length of the arrows, will be different.

- Depending on how closely related the trades are the final tracking error of the portfolio can vary considerably.

- If the two trades were independent the portfolio risk could be calculated using Pythagoras' theorem.

CONSTANT DURATION DOES NOT MEAN CONSTANT RISK

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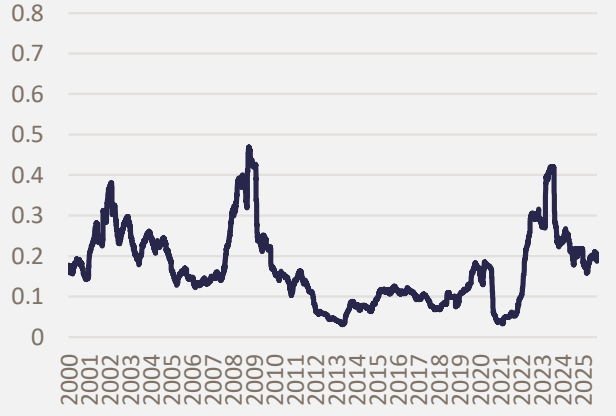
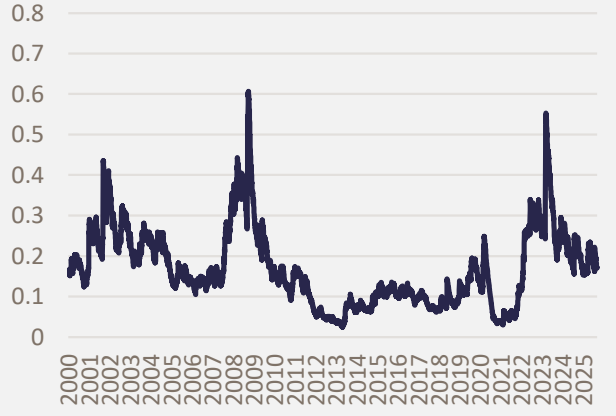
Tracking errors over time for constant 3m exposures in 2y and 10y USTs calculated using different daily time decays

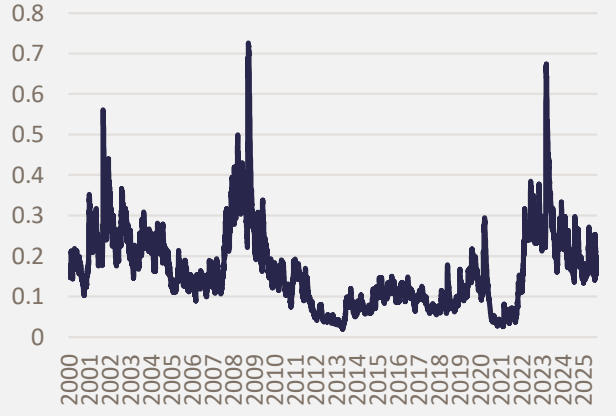
2y UST, λ = 1



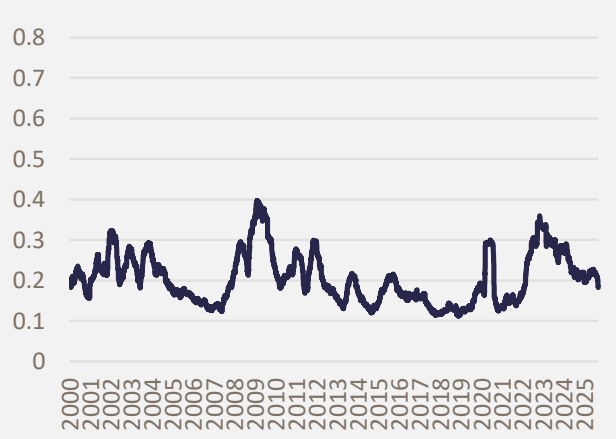
2y UST, λ = 0.97



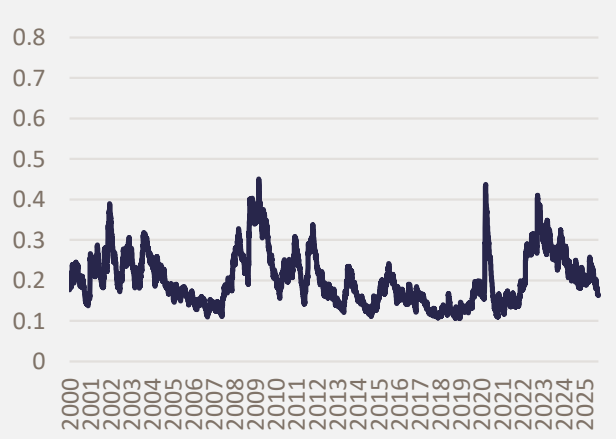
2y UST, λ = 0.94



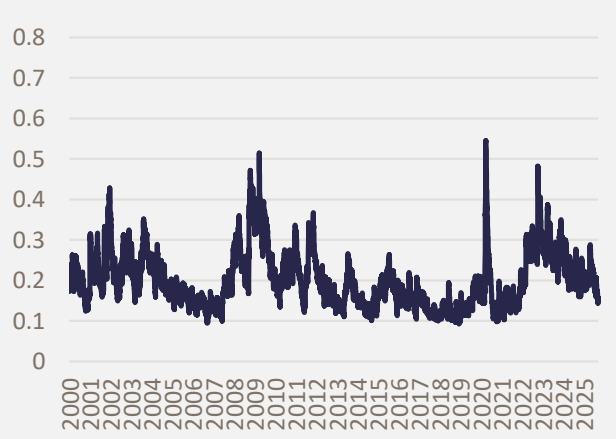
10y UST, λ = 1



10y UST, λ = 0.97



10y UST, λ = 0.94



Source: CAIM, ICE, September 2025

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