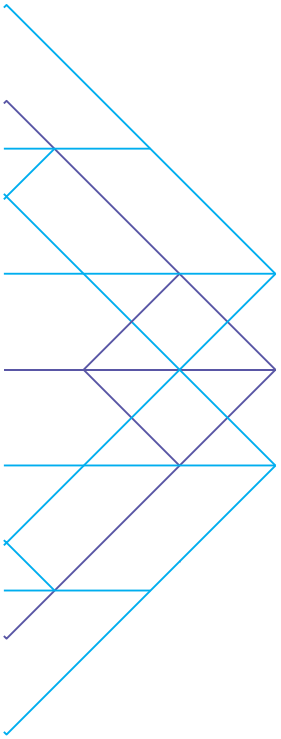
October 2025

Bond Market Focus: Yield Curves and Mean Reverting Rate Expectations

Understanding Return Expectations, Part 9



Executive Summary

Unlike in equity markets, where investors and analysts tend to extrapolate returns even at long horizons, in bond markets investors and economists exhibit mean-reverting rate expectations. There has been a decades-long debate on whether the evolving yield curve shape mainly reflects the market's rate expectations or time-varying term premia. The answer is shifting towards rate expectations, even if those expectations were wrong for decades—predicting rising rates which did not materialize. The new debate is whether those rate expectations were irrational or reflected rational learning when investors faced repeated one-way surprises.

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Introduction

The previous paper in our *Understanding Return Expectations* series turned from equity markets to a bond market focus, and drilled into the key determinants of 10-year Treasury yields with the help of survey data. This paper focuses on the determinants of the yield curve. Yield curve steepness or slope is often proxied by the yield difference between the 10-year Treasury and a short-term (say, 3-month) Treasury bill.

The yield curve (YC) reflects some mix of the market's expectations of future changes in interest rates and required term premia (also called bond risk premia, duration premia, or maturity premia). The YC is steep if the market expects rising short-term rates and/or requires a large compensation for bearing interest rate risk. The YC is inverted if the market expects rate declines and/or is prepared to pay a negative term premium (for example, because long bonds are exceptional safe-haven assets or are required to match pension funds' long-duration liabilities). In practice, the YC tends to be upward sloping but its slope varies over time and sometimes is inverted for prolonged periods.

Investors and academics have long debated and tried to estimate how much the YC reflects rate expectations versus term premia. The mix likely varies over time, but for decades central bankers and investors talked as if the YC was only driven by rate expectations (the pure expectations hypothesis). Yet, empirical research in the 1980s and beyond suggested that evolving YC shape reflects time-varying term premia (which would imply random-walk rate expectations, and thus unchanged rates as the base case).

This conclusion deserves a reassessment. Survey data give us direct estimates of interest rate expectations and they can differ meaningfully from unchanged rate forecasts. Economists' consensus predicted in vain rising rates through several decades of falling rates since the early 1980s and the zero-rate era of 2010s. These persistent forecast errors look foolish in hindsight but were not exclusive to economists; the market (YC shape) and some investor surveys made similar errors. These forecast errors in turn boosted the YC's ability to predict future bond returns besides any time-varying term premia.

I will show evidence that the time-variation in the slope and sign of the YC is largely explained by mean-reverting rate expectations: steep YC amid low short rates (say, 2010s) and inverted YC amid high short rates (say, 2023). The expectations were often correct in capturing predictably countercyclical monetary policy, but they missed the secular decline in rates.

The next question is whether the forecasters were irrational or whether they can be partly excused by the abnormal phase of truly surprising rate declines, one decade after another. I suggested this interpretation in my books, and new academic research confirms that a rational Bayesian learner would have made similar forecasts (and errors). I conclude by arguing that while both equity and bond investors have made persistent forecast errors in recent decades, it seems likely that the former errors will continue, while the latter won't.

This series has highlighted the extrapolative nature of equity investors' and analysts' return and growth expectations, and Part 3 contrasted this pattern with the contrarian nature of mean-reverting rate expectations in bonds.[1] This paper explores the latter story, while enhancing our

[1] I proposed *salience* as a key reason for this difference in expectations formation patterns across the two asset classes. Bonds are quoted in yields, making forward-looking and mildly contrarian mindset more natural, whereas stocks are quoted in prices and mainly discussed in terms of realized

understanding of the key drivers of YC steepness. Part 8 described our best understanding of the yield *level's* drivers by decomposing yields with the help of survey data (separation of rate expectations and required term premia as well as separation of inflation and real rate expectations).

What Drives the Yield Curve? Alternative Theories

The Appendix covers some simple bond math on bond yields and yield curves. The crux of it is that the yield curve reflects market's rate expectations and required bond risk premia—and there's been a decades-long debate on how much of each. That is, which of the two components has a larger influence on the YC shape? To interpret the YC, one can usefully contrast two hypotheses:

- The classic **pure expectations hypothesis** (PEH) makes the extreme assumption that bond risk premia are zero and is consistent with the idea of investors' risk-neutrality. One can then virtually read the market's rate expectations off the YC. According to the PEH, a particularly steep YC indicates that the market expects short rates and bond yields to rise sharply (to exactly offset longer bonds' initial yield advantage; thus, all bond investments have the same expected return).
- The **random walk hypothesis** makes the opposite extreme assumption, that an upward-sloping yield curve only reflects required compensation for bearing duration risk and does not contain any information about the market's rate expectations.

Empirical Evidence on the Yield Curve's Predictive Ability

Since both the market's rate expectations and required risk premia are unobservable, economists have long debated the relative importance of the two components. For decades, investors and central bankers seemed to take the PEH as a given, equating YC shape with market's rate expectations, despite accumulating contrary evidence. Yet, when empirical studies in the 1980s (e.g., Fama-Bliss (1987)) ran direct horseraces between the two hypotheses, the results were clearly in favor of the random walk hypothesis: an upward-sloping YC predicts empirically high future excess bond returns rather than rising yields.[2]

Empirical patterns may have weakened over time, but newer analysis confirms that the YC predicts near-term excess bond returns rather than near-term bond yield changes. The YC has positive correlation with the former and negative with the latter.[3] While the YC is a poor forecaster of near-

returns, making extrapolative rearview-mirror mindset more natural.

[2] Macaulay (1938) found already before WWII that capital losses due to bond yield rises do not seem to offset an initial yield advantage amid upward-sloping YCs. Instead, capital gains tend to augment it due to yield falls. Fama-Bliss (1987) confirmed this finding with post-war data.

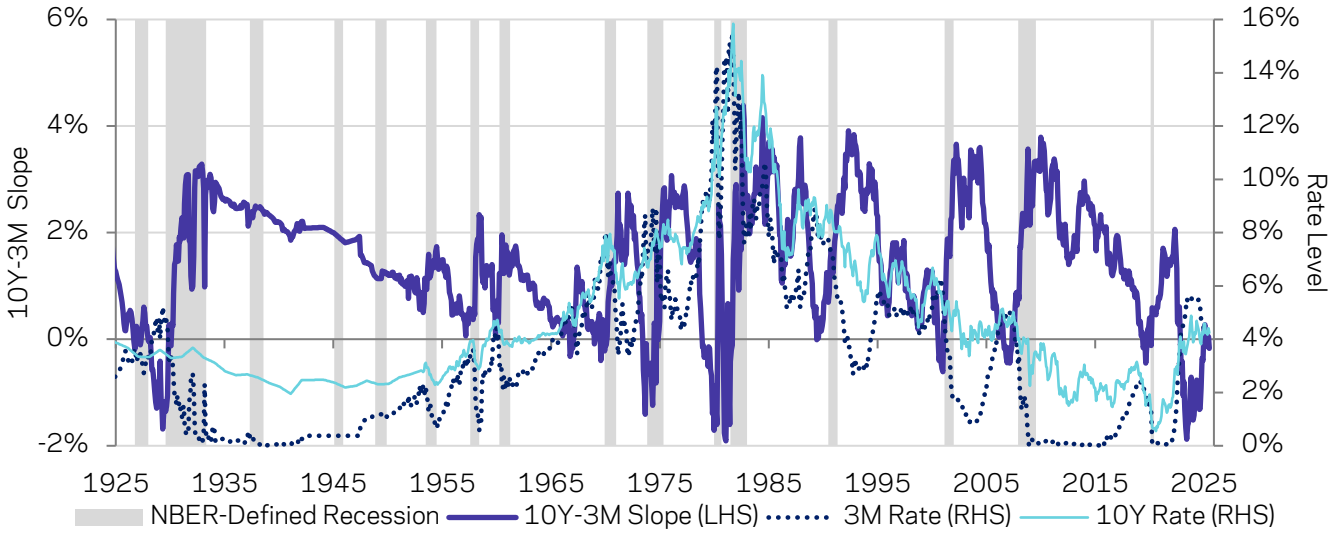
[3] See Ilmanen (2011) chapters 9 and 22. A review shows that the rolling decadal correlation between the YC and near-term excess bond return was pretty consistently positive over the past century. The two exceptions were after sharp bond bear markets in 1958-59 and 2021-22 which began

term changes in long-dated yields (wrong sign for PEH!), it is better at forecasting gradual changes in short-rates over multi-year horizons (more in line with PEH, see Campbell-Shiller (1991)).

Return predictability evidence in other asset classes reinforced idea that the YC predicts excess bond returns. It was just one of the positive-carry strategies that seemed to work in the long run, providing consistent evidence against risk-neutral models which assumed that initial yield advantages would be offset by changing fundamentals or capital losses.[4]

Given all this evidence, the academic consensus gradually shifted away from the PEH and toward time-varying risk premia, but the pendulum probably shifted too far.[5] I will argue that mean-reverting rate expectations have a greater role in YC behavior than the academic consensus appreciates, and there are signs of that consensus changing.

Exhibit 1. U.S. Yield Curve History, with Its Two Components, January 1983 – August 2025



Source: AQR, NBER, St. Louis Fed FRED database.

Challenges came from many directions:

- When survey data made it possible to get a cleaner proxy of the BRP, it became apparent that the YC is a poor proxy for the long-run BRP, despite its near-term return prediction ability.[6] The survey-based BRP's post-war evolution shares broadly the mountain shape of bond yields (see **Exhibit 1**): a secular rise up to the 1980s and a subsequent secular fall. The mountain shape is apparently related to level-related inflation uncertainty and the resulting inflation risk premium.[7] In contrast, the YC has not exhibited any secular uptrend or downtrend but lots of cyclical variation

during a very steep YC.

[4] The best-known parallel was the Uncovered Interest Parity hypothesis in foreign exchange markets which assumed that currency depreciation would offset any initial short-rate (carry) advantage across countries. Empirical evidence in currency and bond markets and broader evidence of carry strategies' long-run profitability was consistent with positive carry predicting future excess returns rather than being offset by predicted rate or fundamental changes. It was debated, though, whether the cause was rationally time-varying risk premia or irrational biased expectations. See Cochrane (2011), Ilmanen (2011, chapters 13 and 22), and Koijen etal. (2018).

[5] The same evidence guided us a decade ago to use so-called rolling yields for bonds in our capital market assumptions, effectively assuming unchanged (random-walk) yield curves, which gives long bonds carry and rolldown advantage amid upward-sloping yield curves. (We may revisit this choice and give some weight to PEH by using at most partial rolldown return.) For our cash assumptions for the next decade, we include a mix of random-walk assumption and the PEH, recently adding survey-based forecasts as a third input.

[6] See Best-Byrne-Ilmanen (1998), Kim-Wright (2006), and Ilmanen (2011).

[7] See Chapter 9 in Ilmanen (2011) and Part 8 of this series.

between -200bps and +400 bps. Worse, the YC was deeply inverted when inflation uncertainty and the survey-based BRP peaked in the early 1980s. Conversely, the YC was steep in the 2010s when the survey-based BRP was negative.

- While the YC kept predicting future bond returns reasonably well until 2022, many other carry strategies disappointed during and after the Global Financial Crisis, which weakened the broad supportive evidence.
- Academic researchers came up with rational learning models which explained well why forecast errors in rate direction had been so persistent: truly unpredictable structural changes. This analysis suggests that the YC's ability to predict future bond returns had been boosted by these forecast errors and that there is little reason to assume continued systematic errors. We should still expect YC to predict bond returns, but just not as well.

The Role of Mean-Reverting Rate Expectations

Exhibit 1 shows that the US YC has tended to be upward sloping, i.e., positive. The past-century average YC slope is 1.4%, likely reflecting a positive average bond risk premium (term premium). YC inversions have been rare but famously predictive of forthcoming recessions, probably indicative of tight Fed monetary policy to battle high inflation.[8] Markets and economists have been pretty good at predicting short-rate moves related to monetary policy cycles. In contrast, they have been less able to predict the secular uptrend and downtrend in yields. The YC was not particularly steep during the rising-rate decades (1945-1981 average 1.0%), nor particularly flat during the falling-rate decades (1982-2021 average 1.8%), if anything the reverse.

So-called haircharts became, in the 2010s, a popular way to visualize the forecasting failure of both economists and markets when it came to the direction of rates. We already showed in Exhibit 1 of Part 3 charts of both 10-year yields and 3-month rates falling to ever lower levels in the 1990s and 2000s, and then staying near zero in the 2010s until 2021—while economists' consensus forecasts seemingly always predicted rising rates. Being so persistently wrong in forecasts led to questions like "how *could* they (be so dumb)?" or worse.

We will now show that market-based forecasts (inferred from the forward rate path implied by the YC) were no smarter than economists. However, we will also offer a sympathetic explanation of what drove these expectations and why they may have been rational at the time the forecasts were made.

Exhibit 2 shows the hairchart history of US one-year Treasury yield and its forward ("expected") paths each midyear.[9] The prevalence of rising hairs is evident even during the falling-rate

[8] The lead time between YC inversion and a subsequent recession has been increasing in recent decades. The latest inversion began in late 2022 and there has been no US recession by late 2025. Before the 2020s, the only false alarm since the 1950s is 1966 when YC inversion was followed by a mere slowdown as Vietnam war -related fiscal expansion supported economic growth. See AQR (2019) for further discussion.

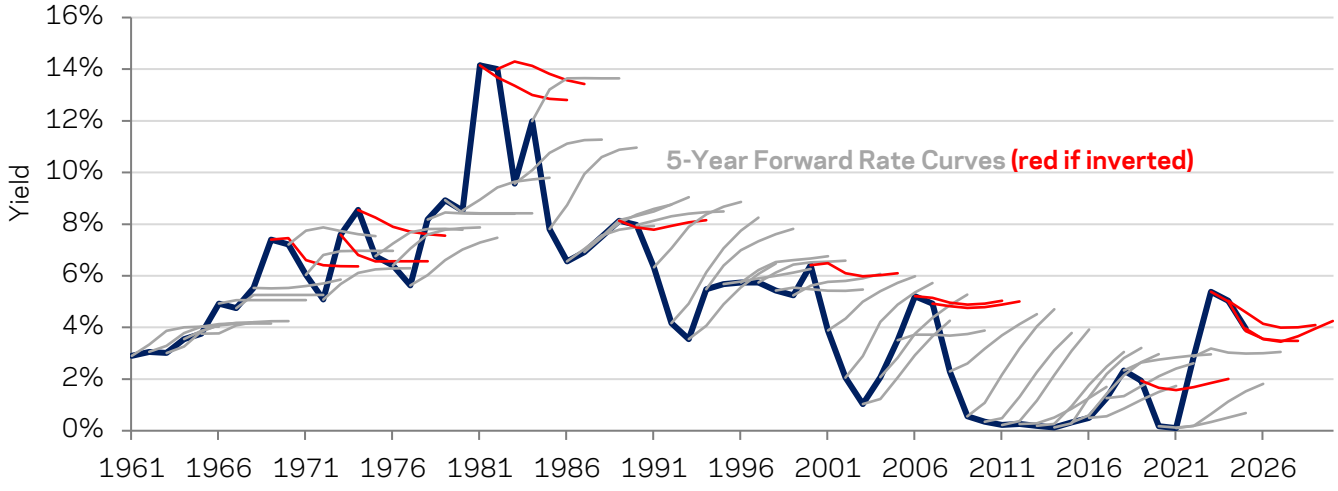
[9] This chart is personal for me, and not just because I've tried to understand the yield curve for several decades. Conveniently, the Fed updates regularly the daily spot rate histories and breakeven forward rate paths of many maturities based on the Gurkaynak-Sack-Wright (2007) study. The sample period happens to cover my lifetime and I chose midyear forward paths to start each year on my birthday (displaying more frequent hairs, i.e. forward paths, would make the chart very messy). Recall that the forward paths reflect market's expectation of future short rates if we assume there are no term premia. Thus the forward paths are closely related to the YC shape; if the 5Y-1Y slope is positive, the hair slopes upwards.

decades. However, when I mark in red the rare exceptions when the hairs are inverted, it becomes apparent that such inversions only occur when the one-year rate is abnormally high compared to its recent past. And those inversions *were* typically followed by a falling one-year rate—so not such a bad predictor after all?

It seems like the variation in YC slope over time mainly reflects mean-reverting rate expectations (plus a relatively stable term premium which gives the YC and the hairs their typical upward slope). This is very different from the Fama-Bliss (1987) finding that the YC shape variation over time reflects time-varying term premia, which became academic conventional wisdom in recent decades.

Eyeballing the hairs in Exhibit 2 hints at a further human pattern. Everyone gets sometimes humbled by the markets and such humbling can reduce our (over)confidence. Instead of seeing particularly strong mean reversion forecasts in 1981 we see only mildly lower rate predictions from the 1981-82 double-digit rate levels, and even a predicted rise from 1984. Having been humbled in the 1970s by missing the rates uptrend, investors no longer made as confident mean-reversion forecasts. Something similar happened in 2020-21 when rates were at record lows and yet investors' mean reversion expectations were more modest after a humbling experience with past predictions of rising rates. Even with our expectations formation process on long-run returns, "what have you done for me lately" matters too much.

Exhibit 2. A Big Mistake? Hairchart of One-Year Treasury Yield and Its 5-Year Forward Rate Paths Each Year, June 30, 1961 - June 30, 2025



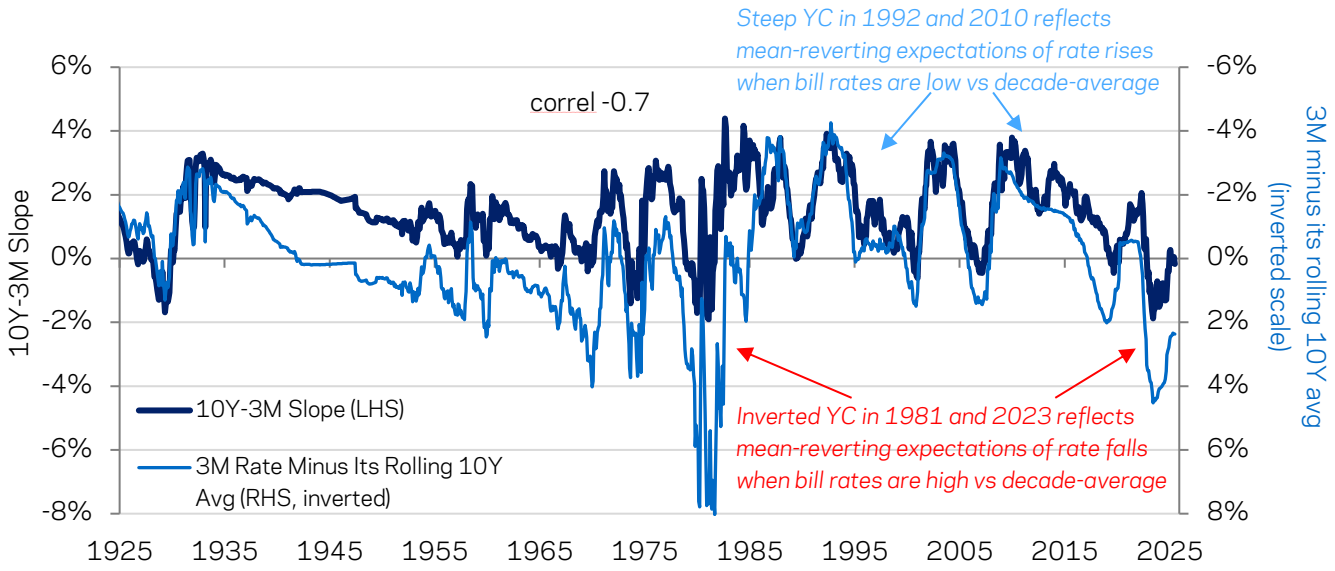
Source: https://www.federalreserve.gov/econres/feds/the-us-treasury-yield-curve-1961-to-the-present.html.

Exhibit 3 tells the same story in a different way. It plots the YC with a detrended short-term rate (the latter on a second axis with an inverted scale). The close co-movement is visually impressive. It also explains why the yield curve was inverted in 2022-24—people expected normalization toward the near-zero rates of 2010s since our most salient memories are for the past decade. Just as an inverted YC is typical when short rates are elevated relative to recent history, an abnormally steep YC (like in the early 2010s) is typical when short rates are abnormally low relative to recent history.[10]

[10] The chart shows the negative correlation of -0.7 between the two series. We can also sort the detrended short rate series into five quintiles (ranging from -2.6% to +2.6%); the average YC for these quintiles are 2.7%, 1.7%, 1.6%, 1.0%, 0.2%.

This evidence strongly suggests that the evolution of the YC over time mainly reflects mean-reverting rate expectations. However, the mean has not been constant over time. It shifted gradually higher for decades until 1981 and then shifted gradually lower, reflecting secular trends in both expected inflation and expected real rates (as discussed in Part 8). As shown in Part 3, similar patterns hold for survey-based economist forecasts as for market forward rates, and for both short rates and long yields. Further analysis (not shown here) suggests that mean reversion is stronger in real rate expectations than in inflation expectations.

Exhibit 3. Mean-Reverting Rate Expectations Drive YC Evolution, January 1925 – June 2025



Source: St. Louis Fed (FRED database), AQR.

Mean-Reverting Expectations Turned Out Wrong, Ex Post

So, mean-reverting rate expectations can explain well how bond investors form their expectations, and I'll soon return to the subject of this pattern being very different from extrapolative equity return expectations. But let's first deal with that question, "How could they get it so wrong for so long?" Economists' and the market's predictions of rate rises (back toward past norms) were persistently wrong from the 1980s to 2021. The anticipated mean reversion did not materialize until 2022.

Some academics ignored survey data and were impressed by the YC's ability to predict near-term bond returns—taken as evidence of rationally time-varying required term premia. However, once academics turned to survey-based rate expectations, it became clear that there were persistent forecast errors; both survey and market forecasts overpredicted short rates for multiple decades (after having systematically underpredicted them before the 1980s). The initial interpretation was some form of irrationality in expectations. However, the most recent research points to a more sympathetic explanation: rational learning about slow structural shifts—which rates experienced over these decades—is really hard.

The return predictability regressions which suggested that the YC predicts bond returns due to time-varying term premia rely on the so-called FIRE assumption (full information and rational expectations). The full information assumption can embed substantial hindsight, in this case about the interest rate process and the gradual shift in the rate mean, first higher until 1981 and then lower. In real time, investors and econometricians hardly recognized this shift (it would have been very valuable information), yet such hindsighted knowledge is presumed to be part of "full information."

A new line of research allows more realism by recognizing that investors and econometricians face incomplete information about the rates process, and they must gradually learn about any changes. Gradual structural changes in an unobservable series—like long-run target mean of inflation or real rates—are particularly pernicious. A recent study by Farmer, Nakamura and Steinsson (2023) shows that a Bayesian rational learner could have made just the kind of forecasts (and persistent forecast errors) we've described above and would have only learned very slowly about the gradually shifting rate level. The observed forecast errors are thus not a sign of irrational expectations, but of the exceptionally persistent one-way surprises that seem almost perfectly designed to wrong-foot forecasters and make them look foolish with hindsight.[11]

Contrasting Bond and Equity Return Expectations Formation

Bond investors (as proxied by the YC) have had some success in predicting mean-reverting cyclical variation in rate levels, likely related to monetary policy cycles. In contrast, they have made systematic forecast errors in not foreseeing the secular shifts in the long-run rate mean. Whether these forecast errors reflected irrationality or slow rational learning of structural changes (my money is on the latter), they boosted the YC's ability to predict near-term bond returns. Simply put, the upward-sloping YC predicted rising rates partly by mean-reversion logic, yet repeated economic surprises meant that the predicted mean reversion never happened (well, until 2022). Thus, long bonds' positive-carry advantage amid an upward-sloping YC was not offset by capital losses due to predicted rate rises.[12]

As we have seen, academics long attributed the YC's predictive ability fully to rationally time-varying term premia and ignored the role of mean-reverting rate expectations. This may explain why the contrasting expectations formation patterns—contrarian for bonds, extrapolative for equities—has gone unnoticed. Part 3 of this series focused on that contrast by arguing that while rates investors tend to expect mean reversion after a

[11] I feel a little smug in having made a similar argument about rational learning amid structural uncertainty in both my 2011 and 2022 books, emphasizing the difficulty of making predictions when the long-run rate level and the persistence of the rate generation process undergo significant changes. Many studies—Bacchetta et al. (2009), Piazzesi-Salomao-Schneider (2015), Bauer-Rudebusch (2020), Crump et al. (2023) and Farmer-Nakamura-Steinsson (2024)—highlight the usefulness of survey evidence and the difficulty posed by gradual structural changes for real-time forecasters (unlike econometricians who are given unrealistic foresight). Survey evidence suggests that much of the observed asset return predictability in classic predictive regressions is not related to ex ante (survey-based) risk premia but rather to systematic forecasting errors—perhaps just to hindsight by the econometrician running those predictive regressions.

[12] To be clear, the YC has some return predictive ability we can still count on—just the average positive YC slope and average term premium, plus likely some predictable time variation in returns—but recent decades displayed more bond return predictability than we should expect in the future. Looking ahead, a survey-based BRP should be a better predictor of near-term bond returns than the YC because it cleans the latter from the rates expectation content.

bullish (falling-rates) decade, equity analysts and investors tend to extrapolate more of the same after a bullish decade. Part 3 also explored reasons for this difference and conjectured that salience arguments dominate.[13] Bonds are quoted and discussed in yields, making bond investors naturally forward-looking and mildly contrarian. Equities are quoted in prices and mainly discussed in terms of past returns, making equity investors naturally more prone to a rearview mirror mindset and extrapolative expectations.

Thoughtful readers might challenge me on my critical attitude toward equity analysts' overoptimistic and overextrapolative growth forecasts, compared to my sympathetic attitude toward bond investors' persistent overpredictions of rates in recent decades. Both groups have made systematic forecast errors, but it is the equity analysts' EPS growth forecasts that I say we should avoid as inputs to capital market assumptions. Why? The key difference is that equity analysts tend to make irrational forecasts which actually have negative market timing ability. We should not poison our objective expected return estimates by incorporating analysts' extra bullishness at times like 2000 and 2021 after a strong decade when market valuations are very high. In contrast, bond investors' rates forecast errors were likely not irrational but a case of rational learning amid abnormal structural changes, so we should not expect these systematic errors to repeat in the future.[14] In short, we can *explain* past forecast errors in both earnings growth and interest rates, but we can *justify* only the latter.

Appendix: Understanding Yield Curve Components

This section presents simple bond math on returns, yields and the curve.

Realized and expected bond return

I first describe some identities before turning to theories and evidence (which are more open to debate). For illustration, I use a 10-year maturity to represent the long bond and a 1-year maturity for the short-term rate.[15]

Realized bond return (H10) over a year has two components: the yield income earned over time, and the capital gain or loss due to yield changes (approximated by minus bond duration times yield change):

$$H10 \approx Y10 - Duration10 * \Delta Y10$$

We can subtract the return of the short-term asset (Y1) and take expectations to get a variant of the

[13] Part 3 further explored the possibility that investors have simply learned from history that they should be multi-year contrarian with bonds and multi-year extrapolative with equities. However, historical evidence on long-run return autocorrelations suggests the opposite. (Interestingly, real bond yields have exhibited a centuries-long downtrend but cyclical variation around this trend. The zero-rate floor in nominal rates may in any case stop this downtrend.)

[14] There will inevitably be errors but we don't know their direction in advance. Anyway, the past errors augmented the YC's ability to predict future returns instead of damaging it. If anything, the new emphasis on the role of mean-reverting expectations suggests that we may consider modifying our bond CMA approach. Our CMA for 10-year Treasuries is the rolling yield which assumes that an unchanged YC is the best base case, so bonds should earn all of their carry and roll advantage. We made this design choice more than a decade ago, guided by the Fama-Bliss evidence. If we now think that the YC partly reflects required term premia and partly rate expectations, we could move away from this corner solution and assume that part of the carry and roll advantage will get offset. In a similar spirit, our cash rate forecasts for the next decade reflect as inputs the current short rate (in line with an unchanged YC), long rate (in line with PEH), and economists' consensus forecasts (survey evidence).

[15] The choice of a one-year horizon lets me ignore annualization terms in the exposition. The analysis is approximate since I ignore so-called convexity, rolldown, and credit risk effects, but it captures the key elements of yield curve behavior. For details, see Ilmanen (1996). This section follows Ilmanen (2011) chapter 9.

bond risk premium (or term premium) in next-year *expected returns*:

$BRP_H \equiv$ E(excess bond return over the one-year riskless rate) ≈ (Y10 – Y1) – Duration10 * E(ΔY10)

If the yield curve is upward sloping, longer bonds have an initial yield advantage over the riskless shorter bond, which gives them some cushion against capital losses caused by rising bond yields. Break-even (forward) yields show how much the bond yield can rise next year before this cushion is just offset. Longer bonds have a smaller cushion because their long duration makes their prices more interest rate sensitive. If no yield changes materialize, bonds will earn their "positive-carry" cushion measured by curve steepness (ignoring rolldown).

Bond yield

Here is a brief explanation on how bond yields reflect the market's rate expectations and required bond risk premia. Break-even (forward) rates are, by construction, a sequence of future short rates such that an investor rolling over short-term securities at those rates would earn exactly the same return as the long bond. If investors are risk-neutral, these break-even rates equal the market's expectations and the long yield equals the expected average of future short rates. If not, the long yield also contains a bond risk premium. This observation merely states a consistency requirement for expectations: if the market long-term yield is currently high while future short-term yields are expected to be low, then long-term bond yield includes a positive required bond risk premium.[16]

10-year yield ≈ Expected average 1-year rate over the next decade + Bond risk premium.

$$\text{or } Y10 \approx E(\text{avgY1}) + BRP_Y$$

This BRP_Y is the average expected return of the bond *over its life* in excess of a sequence of riskless 1-year investments. The two BRP variants, BRP_Y and BRP_H above, are closely related: BRP_Y is an average of the bond's expected future BRP_H each year (a 10-year bond's BRP_H for the coming year, 9-year bond's BRP_H for the following year, etc.). Feel free to ignore the distinction between these BRPs.

Curve steepness

A steep YC reflects either market expectations of rising yields or high required bond risk premia—or, more likely, some combination of the two. The rate expectation component can be expressed either in terms of expected multi-year changes in the 1-year yield over the next decade or, alternatively, as the expected next-year change in the 10-year yield, scaled by its (end-of-horizon) duration. The first YC equation below focuses on gradual changes in short rates and the yield-based BRP_Y while the second equation focuses on near-term changes in long yields and the return-based BRP_H.

$YC \equiv Y10 - Y1 = [E(\text{avgY1}) - Y1] + BRP_Y = E(\Delta\text{avgY1}) + BRP_Y$

$$\text{or } YC \approx \text{Duration10} * E(\Delta Y10) + BRP_H$$

[16] We could further slice nominal rate expectations into inflation and real rate expectations, as we did in Part 8 with its three-way yield decomposition: Y10 ≈ E(avgInf) + E(avgR1) + BRP_Y.

References

AQR *Alternative Thinking* Q3 2019, "Inversion Anxiety: Yield Curves, Economic Growth, and Asset Prices," white paper.

Bacchetta, P., E. Mertens, and E. van Wincoop, 2009, "Predictability in Financial Markets: What Do Survey Expectations Tell Us?" *Journal of International Money and Finance*, 28(3).

Bauer, M., and Rudebusch, 2020, "Interest Rates Under Falling Stars," American Economic Review 110(5).

Best, P., A. Byrne, and A. Ilmanen, 1998, "What Really Happened to U.S. Bond Yields," *Financial Analysts Journal,* 54(3).

Campbell, J., and R. Shiller, 1991, "Yield Spreads and Interest Rate Movements: A Bird's Eye View," *Review of Economic Studies,* 58.

Cochrane, J., 2011, "Presidential Address: Discount Rates," *Journal of Finance,* 66(4).

Crump, R., S. Eusepi, E. Moench, and B. Preston, 2023, "Chapter 17: The Term Structure of Expectations," in the *Handbook of Economic Expectations*.

Fama, E., and R. Bliss, 1987, "The Information in Long Maturity Forward Rates," *American Economic Review,* 77.

Farmer L., E. Nakamura, and J. Steinsson, 2024," Learning about the Long Run," *Journal of Political Economy*, 132(10).

Gurkaynak, R., B. Sack, and J. Wright, 2007, "The U.S. Treasury Yield Curve: 1961 to the Present," *Journal of Monetary Economics,* 54.

Ilmanen, A. (1996), "Market Rate Expectations and Forward Rates," *Journal of Fixed Income,* 6(2).

Ilmanen, A., 2011, *Expected Returns,* John Wiley and Sons.

Ilmanen, A., 2022, *Investing Amid Low Expected Returns,* Wiley.

Kim, D., and J. Wright, 2005, "An Arbitrage-free Three-factor Term Structure Model and the Recent Behavior of Long-term Yields and Distant-Horizon Forward Rates," *FEDS working paper,* 2005-33, Board of Governors of the Federal Reserve System.

Koijen, R., T. Moskowitz, L. Pedersen and E. Vrugt, 2018, "Carry," *Journal of Financial Economics,* 127(2).

Macaulay, F., 1938, *The Movements of Interest Rates, Bond Yields and Stock Prices in the United States since 1856,* National Bureau of Economic Research.

Piazzesi, M., J. Salomao, and M. Schneider, 2015, "Trend and Cycle in Bond Premia", Stanford University working paper.

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