# The Information Content of the Yield Curve

As Arturo Rodrigo was riding the early morning Metro-North train from Manhattan to Greenwich, Connecticut, in January 2023, his thoughts turned to the US yield curve. The US yield curve had recently inverted, something that occurred prior to a recession, as 4% short rates exceeded long-term interest rates (**Figure 1**). Indeed, if one took the difference between the 10-year rate and the three-month rate as a measure of the slope of the yield curve, the curve had gone from substantially upward sloping as late as April 2022 to inverted in just six months (**Figure 2**).
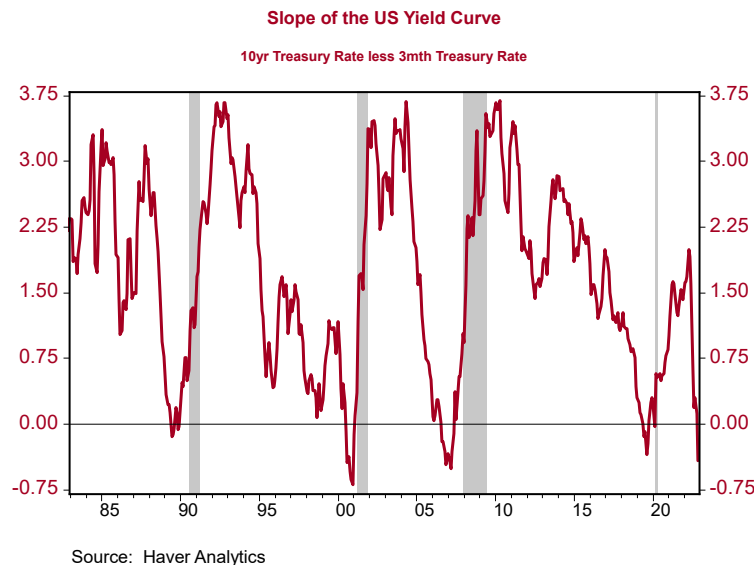
Figure 1. Long and short rates.
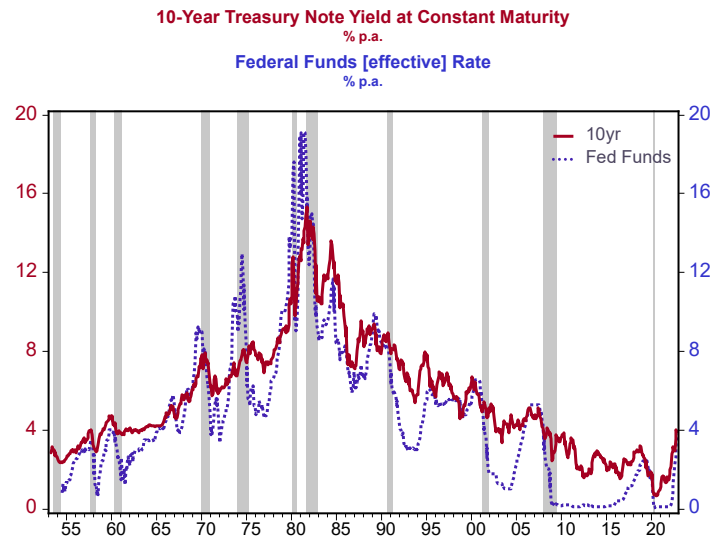
Source: Federal Reserve Board/Haver Analytics

Note: All figures were created by case writer. Monthly data are through October 2021. Quarterly data updated through 2021Q3.

Figure 2. The term spread (10-year Treasury rate less three-month Treasury rate).

Slope of the US Yield Curve

10yr Treasury Rate less 3mth Treasury Rate

Source: Haver Analytics

The yield curve had inverted before every US recession in the past 50 years and did so prior to the 2020 recession. Did the recent inversion mean recession was just around the corner? If so, when exactly would the recession occur? Rodrigo knew that correlation (the fact that the yield curve inverted before recessions) was not causation (did the inversion really cause the recession?) and set out to sift through the evidence on the predictive content of the yield curve. Rodrigo wanted to learn more about what the yield curve could and could not tell him.[1]

The Yield Curve Is a Good Predictor of Recessions...

Some of the strongest statements about the predictive content of the slope of the yield curve have come from the Federal Reserve Bank of New York, primarily through the work of Arturo Estrella, an economist.[2] A summary of the information made available by the New York Fed follows:

- The slope of the yield curve—the difference between long-term and short-term interest rates—predicts subsequent US real GDP with a lead time of about four to six quarters. The relationship is positive; when the yield curve is positively sloped (i.e., when long rates are higher than short rates), economic growth should be strong over the next four to six quarters (**Figure 3**), and when the yield curve is inverted, growth should subsequently slow. The interest rates used are those on Treasury securities, to minimize the impact of any potential credit risk premium, and while many maturities can be used, the 10-year Treasury bond and three-month Treasury bill seem to yield the most robust results. The yield curve has a stellar record, predicting every US recession since 1950; its only "false" signal foresaw a recession in all but name—the credit crunch and slowdown in production of 1967.

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[1] For a primer on models of interest rate determination as well as discussions on yield curves and the relationship between short and long rates, see Francis E. Warnock, "The Determinants of Interest Rates," UVA-BP-0489 (Charlottesville, VA: Darden Business Publishing, 2006).

[2] For articles, answers to FAQs, and a "recession probability" chart that is updated monthly, see http://www.newyorkfed.org/research/capital_markets/ycfaq.html (accessed Dec. 21, 2022).

- Although the level of the term spread is what has predictive power, a given change (say, 50 basis points) is more meaningful the smaller the magnitude of the spread. That is, while a change in the slope from 350 to 300 basis points might not be meaningful, the same 50-point decrease when the slope is much flatter would greatly increase the probability of recession. Note that the slope of the yield curve is indeed one of the Conference Board's leading indicators of economic activity.

- The source of a change in the term spread—that is, whether it was caused by movements in the short end or the long end (or both)—does not matter. Nor does one need to wait for an inversion; it is the level of the term spread, not whether the slope is positive or negative, that matters. Signals that last only a day should probably be ignored, but those that last a month or more are likely important. Finally, the yield curve's slope does quite well on its own; including additional variables in the model does not improve the predictive power.

Figure 3. GDP growth and the term spread.

Source: Bureau of Economic Analysis/Haver Analytics
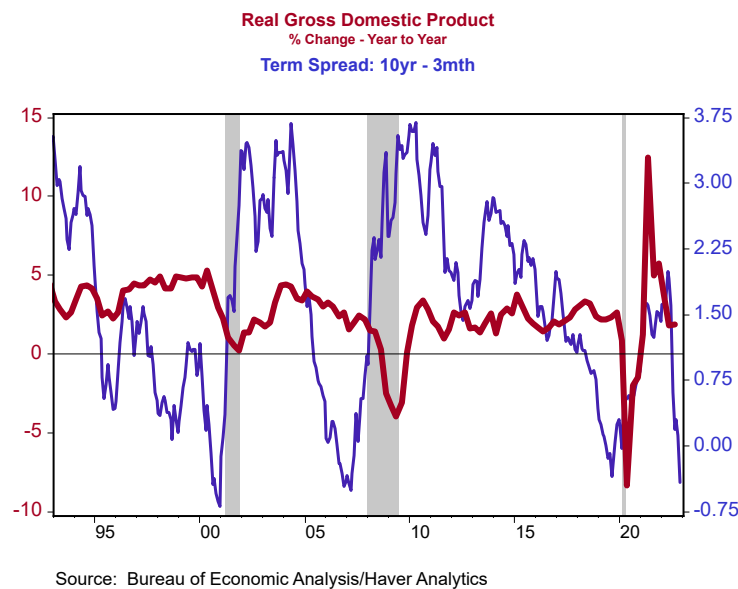
...Or Is It?

…the empirical linkage to weaker economic growth is tenuous, at best.

—Brian Sack[i]

Not everyone was convinced of the predictive power of the yield curve. In 2005, Brian Sack—at the time an economist at Macroeconomic Advisers before moving to the New York Fed to head its Financial Markets Group—provided evidence to the contrary. He did not deny that one could find econometric evidence supportive of a role for the term spread. Indeed, he showed one such model in which real GDP growth over the subsequent year was explained by real GDP growth over the previous year (to capture any inertia in economic growth rates) and the current slope of the yield curve. He used the 10-year yield and the federal funds rate (similar results would be found if a three-month rate were used for the short rate) and estimated the regression using quarterly data from 1961 through 2004. Sack found that, sure enough, the slope of the yield curve and subsequent economic growth were positively related.

But Sack was not convinced. He noted that the standard error in such estimates was so large that the 95% confidence interval spanned seven percentage points; that is, a prediction of 3.5% growth should be read as "I am confident that real GDP growth next year will be between 0% and 7%." Moreover, he worried that the statistical significance found in such regressions was not robust for two reasons. First, any statistical relationship should be robust to the exclusion of a few observations; that is, the relationship should not be driven by a few overly influential outliers. He noted that if the particularly sharp inversions of 1971, 1975, 1981, and 1983 were removed, the statistical relationship disappeared. Second, any statistical relationship should be robust to being estimated over different time periods. Sack noted that if one began the sample in 1984, the statistical relationship disappeared.

Sack's final concern was also important. He noted that at time t the 10-year rate could be written as the expected average of the next 10 one-year rates plus a term premium (tp), or (**Equation 1**):

[handwritten annotation: Term premium: Risk premium on long term bonds.]

[handwritten annotation: Strict expectation hypothesis]

$$i_t^{10} = \frac{1}{10}\sum_{j=0}^{9} E_t\left[i_{t+j}^1\right] + tp_t, \qquad (1)$$

[handwritten annotation: ← 10 1yr yields → ← additional compensation for locking in 10yrs now →]

where the superscripts denote the maturity of the bond and $E[.]$ denotes expected value. Subtracting the first one-year rate from both sides of **Equation 1** produces an equation (**Equation 2**) that shows that the slope of the yield curve is an average of expected *changes* in the short rate plus the term premium:

[handwritten annotation: If Term Spread < 0 ⟹ 10yr < 3 mon]

$$i_t^{10} - i_t^1 = \sum_{j=1}^{9} \frac{10-j}{10} E_t\left[\Delta i_{t+j}^1\right] + tp_t. \qquad (2)$$

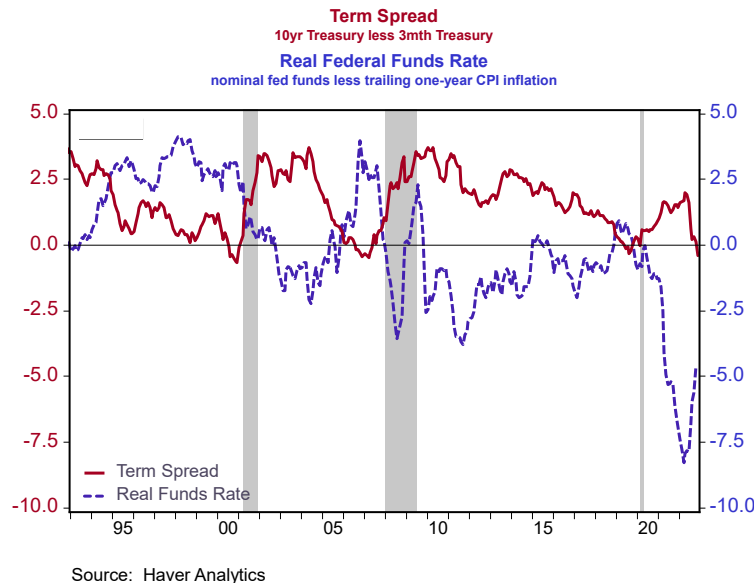*[handwritten annotation: ← Term Spread →   ← Term Premium →]*

Sack argued that evidence supportive of the predictive role of the slope of the yield curve focused just on the first term of the right-hand side of **Equation 2**. If the slope was positive, we should expect short rates to rise, which typically occurred when growth was strong; if the slope was negative, we should expect short rates to fall, as often occurred during an economic slowdown.

[handwritten annotation: Term premium is how much is not explained by strict expectation hypothesis.]

But the second term—the term premium—was also important to consider. All else equal, if the term premium tightened, the yield curve would flatten. Would that suggest slower growth? Sack argued the opposite—that a compression of term premium would make a given monetary policy stance more stimulative, as long rates fell. If changes in the slope of the yield curve were driven by changes in the term premium, yield curve flattening would be stimulative, which was exactly the opposite of findings that a flattening precedes a growth slowdown.

So Sack came to a conclusion directly counter to the impressive evidence amassed by the New York Fed. But he had a constructive conclusion. What really mattered, in his opinion, was the real (i.e., inflation-adjusted) federal funds rate. If the real funds rate was high, growth should slow. When it was low (or negative), growth should pick up. To be sure, the real funds rate and the term spread were correlated with one another—when the real funds rate is high, the nominal funds rate is also high, and all else equal, the yield curve will be flatter—but the relationship was not exceedingly tight (**Figure 4**).

Figure 4. The term spread and the real federal funds rate.

Term Spread
10yr Treasury less 3mth Treasury
Real Federal Funds Rate
nominal fed funds less trailing one-year CPI inflation

Source: Haver Analytics

The Term Premium

Sack reminded us that we must consider how the term premium is evolving when assessing the predictive ability of the yield curve. So how exactly does it evolve?

To answer that, Rodrigo first had to figure out what exactly, in a tangible sense, the term premium was. This was a disappointing exercise. In practical, tangible terms, the term premium does not exist, but is an unobservable construct. There were different ways to estimate a term premium, but at the end of the day, they all produce just that—an estimate.

But even if the term premium were not observable, Rodrigo could still think about it conceptually. If the notion that the slope of the yield curve had predictive power for future economic growth was really a statement about the future-expected short-rates aspect of the yield curve, it would be important to be aware of changes in the term premium component of long rates. Sack thought the term premium had compressed around 2005, thus naturally flattening the yield curve a bit. Richard Berner, chief US economist at Morgan Stanley, agreed.[ii] In 2005, Berner noted that institutions' newfound demand for long-duration bonds squeezed the term premium. In his own work, he focused on demand by pension funds for long-dated assets; a surge in such demand would compress the term premium. He also noted work that originated at the Federal Reserve Board (FRB) on foreign governments' increased demand for Treasury bonds.[3] The increased demand for long-dated assets would, as both Berner and the FRB research noted, tend to flatten the yield curve. All else equal, rather than signaling poor economic growth prospects, this flattening would be stimulative because it would put downward pressure on borrowing costs.

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[3] The FRB work was first released as Francis E. Warnock and Veronica Cacdac Warnock, "International Capital Flows and U.S. Interest Rates," *International Finance Discussion Paper*s 840 (September 2005), available at http://www.federalreserve.gov/Pubs/Ifdp/2005/840/default.htm (accessed Dec. 21, 2022), and later published in *Journal of International Money and Finance* 28 (2009): 903–19.

In 2005, Berner put forward another factor behind a compression in the term premium: the Fed's conduct and policy. The Great Moderation,[4] with its historically low inflation and its stability, meant that investors did not need to be compensated as much for holding long-dated fixed-rate assets. If volatility were low, you would not require as much protection against price and reinvestment risk. Moreover, the Fed's move toward greater transparency also eliminated some uncertainty. Put it all together, and Berner argued that the term premium had been permanently compressed.

Subsequent estimates of the term premium from researchers at the New York Fed suggested that the term premium had not been permanently compressed but was somewhat volatile (**Figure 5**). Readily apparent in the ACM term premium was the compression during the conundrum years of 2004 to 2006 as well as during the Fed's quantitative-easing policies. Indeed, other than a spike following the May 2013 "taper tantrum," the ACM term premium had pretty much been near zero or negative since year-end 2011.

Figure 5. The ACM term premium.[5]

ACM Term Premium: 10 Year

EOP, %
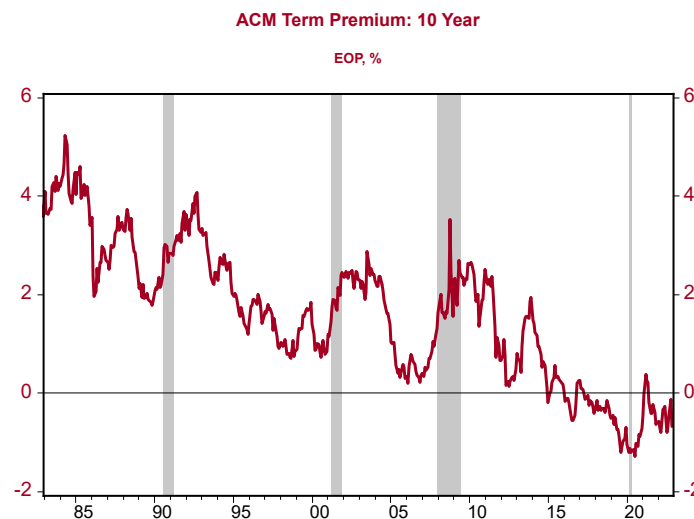
Source: Federal Reserve Bank of New York/Haver Analytics

The Yield Curve in the Darkest Days of the Global Financial Crisis

In late 2008, Lehman Brothers had failed, and the insurance behemoth AIG and mortgage giants Fannie Mae and Freddie Mac were taken over by the US government. Upon waking up each day, one wondered whether the global financial system would survive the week. Global economic activity plummeted.

At that time, in the darkest days of the global financial crisis and amid the longest US recession since the Great Depression, the yield curve was signaling that strong economic growth was just around the corner. With the Fed pushing short rates toward zero and the 10-year at roughly 3%, the yield curve was about as steep as it ever gets. At a time when the *Wall Street Journal*'s survey of forecasters produced an average projection of only

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[4] The Great Moderation is the period following the high inflation of the 1970s and early 1980s during which inflation and interest rates steadily declined. For more on this period, see Francis E. Warnock, "Greenspan's Conundrum and Bernanke's Nightmare," UVA-BP-0544 (Charlottesville, VA: Darden Business Publishing, 2009).

[5] The New York Fed "ACM" term premia are based on a five-factor, no-arbitrage term structure model. See its Treasury Term Premia website, https://www.newyorkfed.org/research/data_indicators/term-premia-tabs#/overview (accessed Dec. 21, 2022).

0.5% growth in 2009, and almost half of the professional forecasters were predicting negative growth for the year, the Cleveland Fed noted that based on the steepness of the yield curve, real economic growth in 2009 should be quite strong at roughly 3%.[6] There seemed to be a point here. A graph of real GDP growth and the four-quarter-ahead term spread—so the term spread at any point on the graph corresponded with a rule-of-thumb yield-curve-based forecast of next year's real GDP growth—showed a reasonably tight (but not perfect) correlation (**Figure 6**).

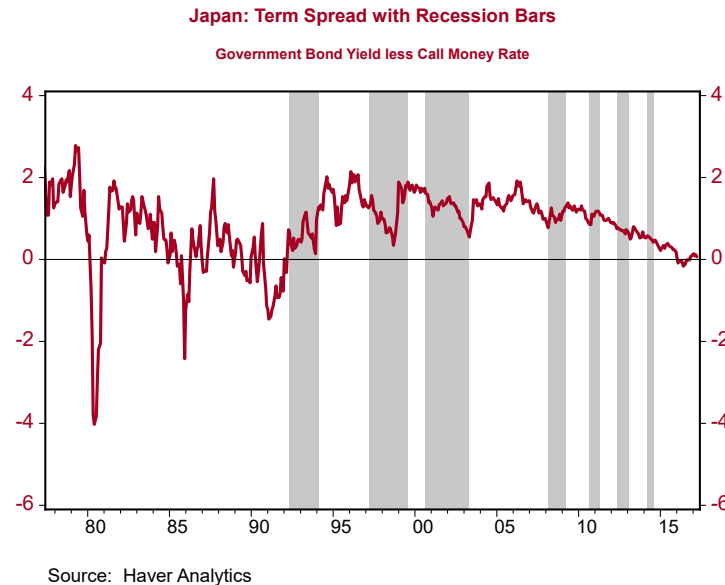Figure 6. The term spread (four quarters ahead) and GDP growth.
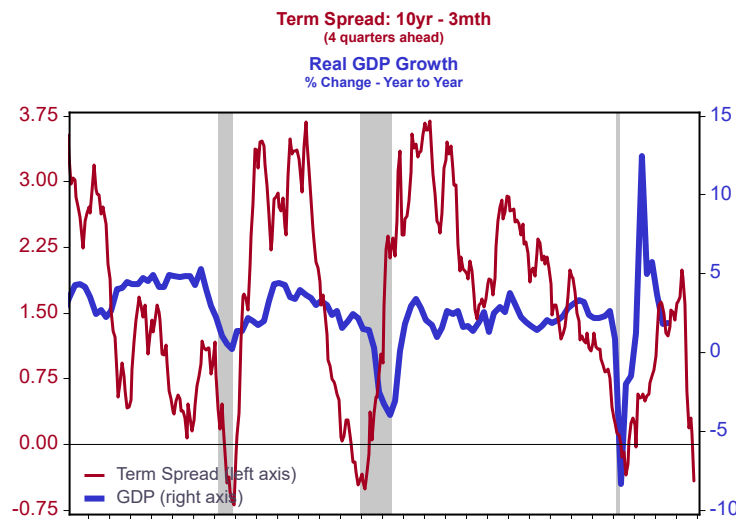
Source: Bureau of Economic Analysis/Haver Analytics

Nobel laureate Paul Krugman disagreed with the Cleveland Fed's assessment.[iii] The crux of Krugman's argument was the zero-bound on nominal interest rates. With the federal funds rate already at roughly 0%, it was thought that they could not go any lower.[7] Prior US-based analysis of the predictive power of the yield curve did not have to contend with the zero-bound. Krugman noted that the one country that has had extensive experience with near-zero short rates, Japan, had a positively sloped yield curve throughout its lost decade of the 1990s (**Figure 7**).

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[6] For the Cleveland Fed's latest yield-curve-based forecast, see https://www.clevelandfed.org/en/our-research/indicators-and-data/yield-curve-and-gdp-growth.aspx. For its forecast as of year-end 2008, see https://www.clevelandfed.org/en/our-research/indicators-and-data/yield-curve-and-gdp-growth/yield-curve-archives/yc-20081217.aspx. For a year-end 2008 discussion of the *Wall Street Journal*'s survey of forecasts, see "GDP Prospects: Mean Estimates Fall and Dispersion Increases," *Econbrowser*, November 23, 2008, http://econbrowser.com/archives/2008/11/gdp_prospects_m (all accessed Nov. 15, 2021).

[7] By early 2015, a number of countries had negative nominal interest rates, leading to a reassessment of just how negative the lower bound on nominal rates might be. In late 2020, more than $17 trillion of investment grade bonds had negative yields.

Figure 7. Japan: Term spread and recessions.

Japan: Term Spread with Recession Bars

Government Bond Yield less Call Money Rate

Source: Haver Analytics

Sifting Through the Evidence

Rodrigo had a lot to think about. An economist at the New York Fed made a strong case for the predictive content of the yield curve, and the yield curve had inverted before every US recession in the past 50 years; the one-time head of the very powerful Markets Group at the New York Fed disagreed rather strongly with those conclusions. The Cleveland Fed made a strong case; Krugman disagreed. And much, but not all, of the controversy seemed to be about the term premium, something unobservable, yet something that, in early 2023, had been abnormally low for much of the past decade.

The experts were divided, but Rodrigo had to make a decision. In January 2023, the US term spread was upward slightly and steepening. And with the federal funds rate still near zero and increasing, the real federal funds rate was very negative (**Figure 4**). What exactly did all this tell Rodrigo about the future path of the US economy?

Notes

[i] Brian Sack, "Yield Curve Inversions, Do They (Still) Matter?," *Monetary Policy Insights* (St. Louis: Macroeconomic Advisers, November 4, 2005).

[ii] Richard Berner, "Yield Curve Angst," *Global Economic Forum* (New York: Morgan Stanley, November 21, 2005).

[iii] Paul Krugman, "The Yield Curve (Wonkish)," *The Conscience of a Liberal* (blog), December 27, 2008, http://krugman.blogs.nytimes.com/2008/12/27/the-yield-curve-wonkish/ (accessed Dec. 21, 2022).