Economics 442
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University of Wisconsin-Madison

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Early Warning Systems

1. Yield Curve Inversions

Expectations Hypothesis of the Term Structure: Math

If agents are risk neutral, discount bonds are priced as:

$$P_{1t} = \frac{\$100}{1+i_{1t}} \qquad (1) \qquad\qquad P_{2t} = \frac{\$100}{(1+i_{1t})(1+i^e_{1t+1})} \qquad (2)$$

To see why this is true, consider what is true if both one year and two year bonds offer the same one-year return (by arbitrage); then:

$$1+i_{1t} = \frac{P^e_{1t+1}}{P_{2t}} \qquad (3)$$

Rearranging:

$$P_{2t} = \frac{P^e_{1t+1}}{1+i_{1t}} \qquad (4)$$

What is the numerator of the right hand side of (4)? Iterating (1) forward, and taking expectations:

$$P^e_{1t+1} = \frac{\$100}{1+i^e_{1t+1}}$$

This can be substituted into (4) to obtain equation (2):

$$P_{2t} = \frac{\$100}{(1+i^e_{1t+1})(1+i_{1t})} \qquad (2)$$

We know in fact:

$$P_{2t} = \frac{\$100}{(1+i_{2t})^2} \qquad (4)$$

What will set (2) equal to (4)?

$$\frac{\$100}{(1+i_{2t})^2} = P_{2t} = \frac{\$100}{(1+i^e_{1t+1})(1+i_{1t})}$$

Which implies:

$$(1+i_{2t})^2 = (1+i^e_{1t+1})(1+i_{1t})$$

$$(1+2i_{2t}+i_{2t}{}^2) = (1+i^e_{1t+1}+i_{1t}+i^e_{1t+1}i_{1t})$$

$$2i_{2t} \approx i^e_{1t+1}+i_{1t}$$

$$\boxed{i_{2t} \approx \frac{1}{2}(i^e_{1t+1}+i_{1t})} \qquad (5)$$

$$i^e_{1t+1} = 2i_{2t} - i_{1t} \qquad (7)$$

In general:

$$i_{nt} = \frac{(i_{1t} + i^e_{1t+1} + ... + i^e_{1t+n-1})}{n} \quad (8)$$

The Liquidity Premium Theory of the Term Structure

The linkage between the long-term and short-term interest rates can be decomposed thus:

$$i_{nt} = \frac{(i_{1t}+i^e_{1t+1}+...+i^e_{1t+n-1})}{n} + tp_{nt} \quad (9)$$

Where i_{nt} is the interest rate on a bond of maturity n at time t, i^e_{1t+j} is the expected interest rate on a one period bond for period $t+j$, based on information available at time t, and tp_{nt} is the liquidity (or term) premium for the n-period bond at time t. This specification nests the expectations hypothesis of the term structure (EHTS) (corresponding to the first term on the right hand side of equation 9), and the liquidity premium theory (corresponding to the second term).

The EHTS merely posits that the yield on a long-term bond is the average of the one period interest rates expected over the lifetime of the long bond. The liquidity premium theory allows that there will be supply and demand conditions that pertain specifically to bonds of that maturity (this is the segmented markets hypothesis). The presence of idiosyncratic effects associated with a certain maturity of bond is sometimes linked to the "preferred habitat theory", the idea that certain investors have a preference for purchasing assets of specific maturities. Since $l^n_t > 0$ and is expected to rise as n becomes large, the yield curve will slope upward when short rates are expected to be constant over time. The liquidity or term premium is assumed to rise with maturity n because holders of longer term bonds face greater interest rate risk.

Now, for the sake of simplicity, consider the case where $tp_{nt} = 0$ (i.e., the EHTS explains all variation in long rates). Suppose further expected short rates are lower than the short rate today. Then the long rate will be lower than the short rate (i.e., the yield curve inverts).

Since low interest rates are typically associated with decreased economic activity, an inverted yield curve should imply an expected downturn, especially given that $tp_{nt} > 0$, then an inversion should imply a downturn a fortiori.

Application to the United States

One of the implications of the EHTS is that expectations of a sequence of low short term rates in the near future will result in the long rate being lower than usual. Short term interest rates are typically low when the economy has encountered a slowdown, or has entered in a recession. At the same time, many recessions have been triggered by increases in the short term policy rate (the Fed funds rate). Hence, it is often thought that an inversion of the yield curve presages a recession. In Figure 1, I plot three Treasury yields: (i) 10 year, (ii) 2 year, (iii) 3 month. Those are used to generate two spreads, shown in Figure 2: the 10 year-3 month spread, and the 10 year-2 year spread.

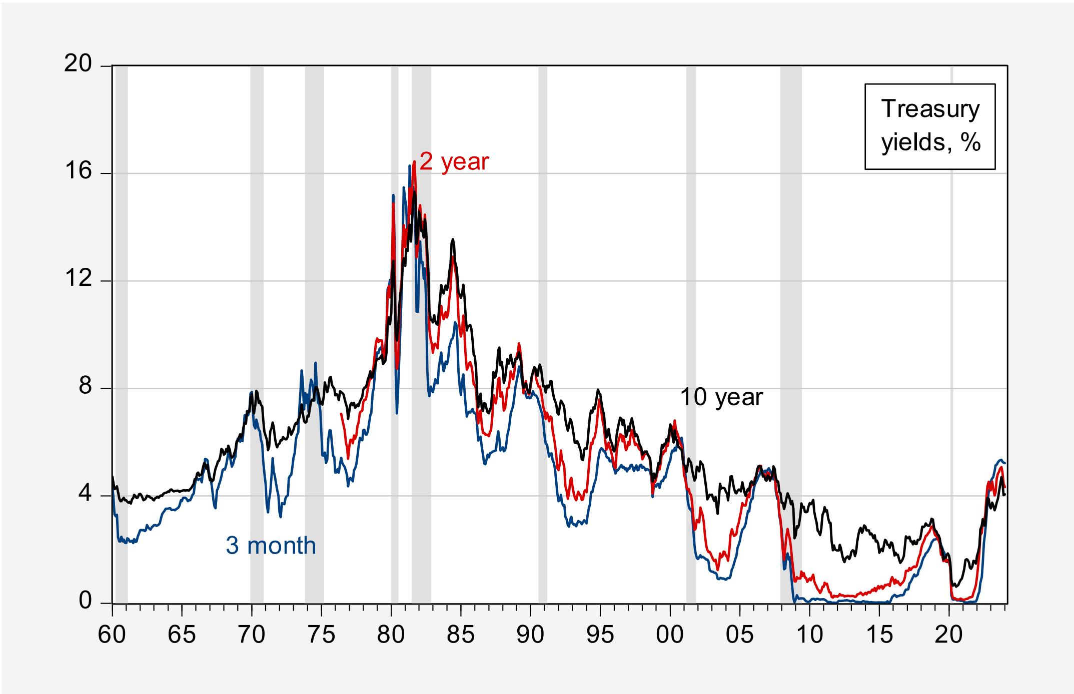

Figure 1: *Ten year (black), two year (red), and three month (blue) Treasury yields, % NBER defined recession dates shaded gray. Source: St. Louis Fed FRED, and NBER.*

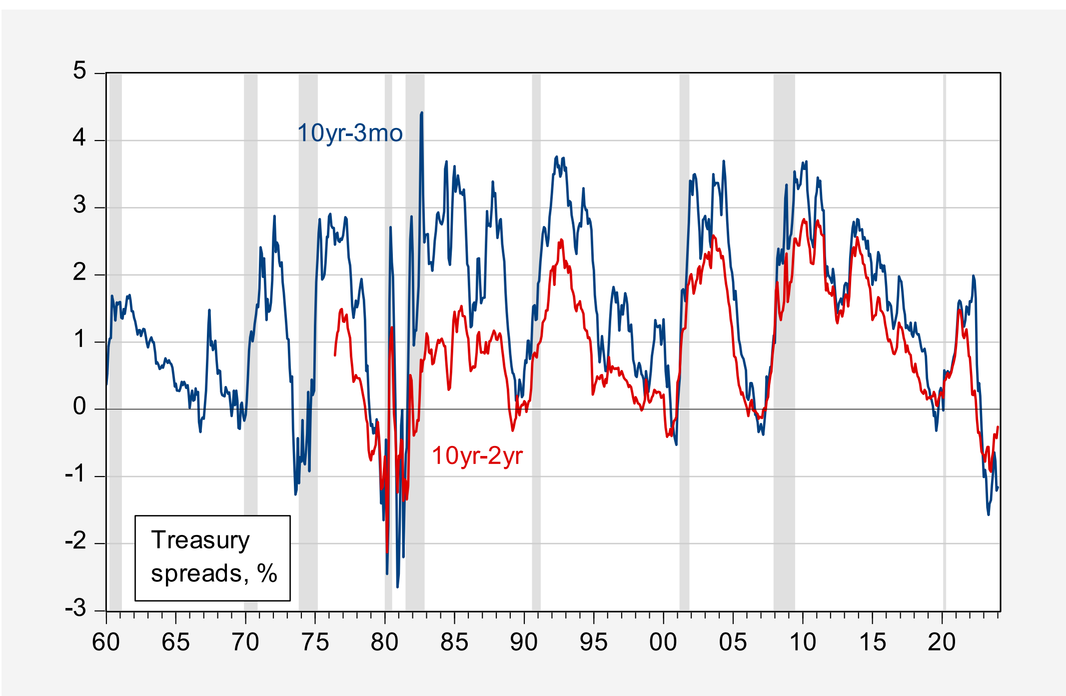

Figure 2: *Ten year-three month spread (blue), and ten year-two year spread (red). NBER defined recession dates shaded gray. Source: St. Louis Fed FRED, and NBER.*

Notice that inversions of the yield curves (when the lines dip below zero, or come close is) often precede recession, as defined by the National Bureau of Economic Research (NBER) Business

Cycle Dating Committee (BCDC).[1] There is a large literature which tries to assess whether the relationship between the yield curve and subsequent economic activity (either growth or recession) is robust. A separate, but related, question whether the term premium provides additional information above and beyond that provided by lagged income and other indicators.

A general reading of the literature is the yield curve did have some predictive power, but was declining over time. Wright (2006) argued that the level (namely, the level of the short term interest rate) as well as the slope of the yield curve needed to be included. Estimating a probit regression (where regression periods take a value of one) on the 10year-3month spread and the 3 month interest rate over the 1989-2022M12 (assuming no recession occurred before 2023M12) period provides the estimated recession probabilities shown as the tan line in Figure 3 below.

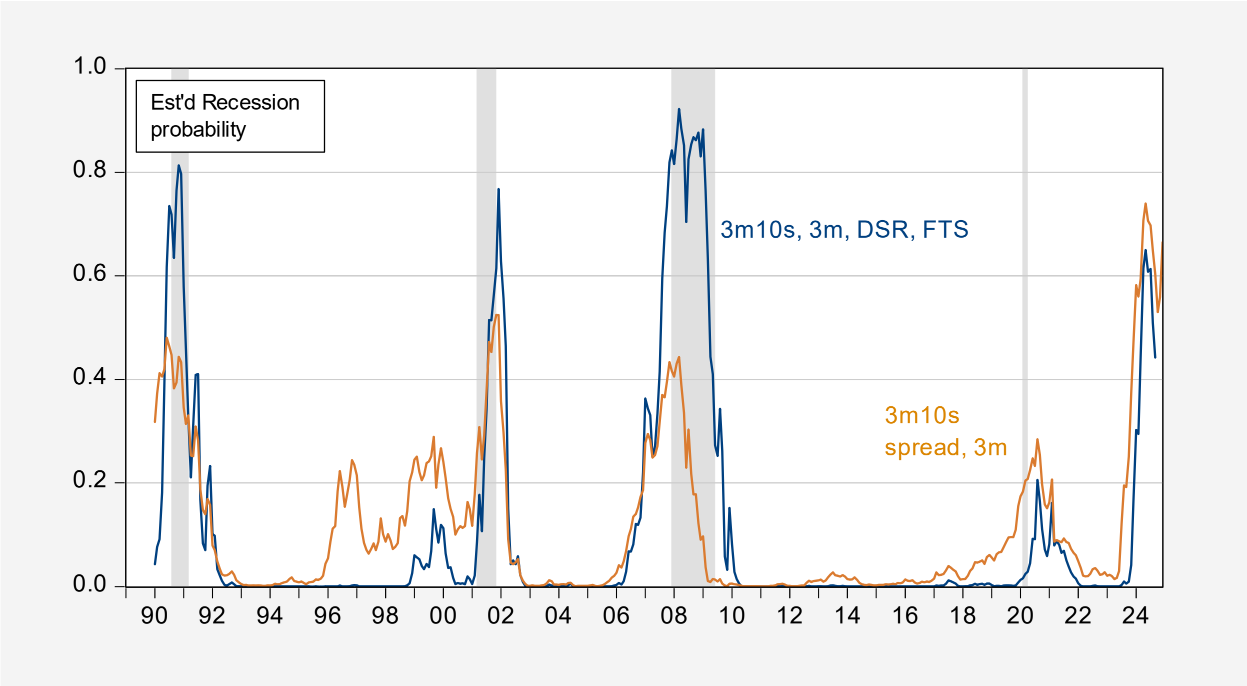

Figure 3: *Recession probabilities.* ***Source:*** *Chinn (2024).*

Cross-country Analysis

The evidence for predictive power across other countries is less developed; see Chinn and Ferrara (2024) and Chinn and Kucko (2015) for discussion. The graphs analogous to Figure 1, for two European countries, as well as Canada and Japan. These are a reproduction of part of of Figure 1 from Chinn and Ferrara (2024).

[1] We use the NBER definition of recession, rather than the informal definition of two consecutive quarters of negative GDP growth as using this informal definition would result in the dating of recessions changing as the GDP data are revised. An example of this phenomenon is the 2001 recession, which using current data does not fulfill the 2 consecutive quarter rule.

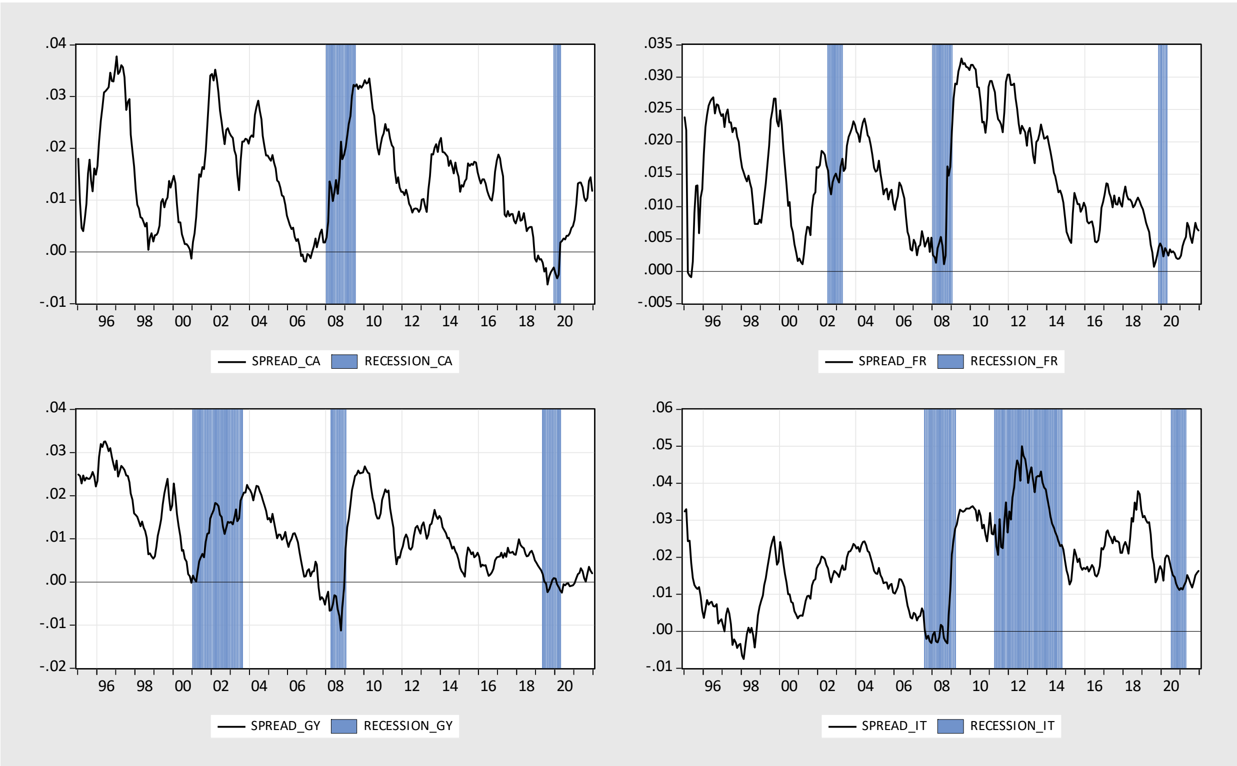

Figure 3*: Canadian, French, German and Italian 10 year-3 month spreads, %. ECRI defined recession dates shaded blue.*

The graphs are suggestive, but do not confirm the posited relationships. This is why we need regression analysis. The results from Chinn and Ferrara (2024) using spread and short rate are in Table 2 from the paper.

Table 2: Recession Twelve months ahead, Spread and Short Rate, 1995-2022

coefficient	CA	FR	GY	IT	JP	SN	UK	US
constant	**-0.890**	**-0.977**	**-1.156**	**-1.285**	**-1.027**	**-0.599**	**-1.163**	**-1.08**
	0.270	0.233	0.169	0.216	0.133	0.206	0.196	0.34
spread	**-86.763**	**-55.338**	**-43.386**	**27.781**	**53.862**	**-60.905**	10.425	**-55.23**
	19.123	15.569	10.436	7.555	11.563	17.243	8.370	15.90
3 mo rate	6.489	**12.601**	**27.871**	-0.015	26.471	-8.978	1.104	**13.61**
	6.592	4.904	4.792	3.488	23.094	5.107	4.307	6.64
Pseudo R sq.	0.223	0.131	0.177	0.056	0.083	0.103	0.008	0.22
N	324	324	324	324	324	324	324	32

Notes: Probit regression coefficients (standard errors in parentheses). Bold face denotes significance at 5% marginal significance level.

2. Financial Conditions Indexes, Debt-Service Ratios, Foreign Term Spreads

Some researchers have pointed to Financial Conditions Indexes (FCI's) – composite measures of term and credit spreads, and other financial indicators – as predictors of recessions. Borio, Drehman and Xia (2020) show that the debt-service ratio – how much the nonfinancial sector has to pay in order to service their debt – is possibly an even more important determinant of recessions. Chinn and Ahmed (2023) show that the foreign term spread is an even better predictor of US recessions than the US term spread. At the 12 month horizon, the FCI does not seem to be useful, so we exclude that from our specification. To maximize the sample size, we rely on the Chicago Fed's National Financial Conditions Index, to obtain the following estimates of recession probabilities, shown in Figure 3 as the blue line.

Note that the estimated recession probabilities for February 2024 are 56% for the spread plus short rate, and 29.5% for the full specification. This means just because there are no obvious indications of the recession's onset as of January doesn't mean that we have necessarily dodged a recession. May 2024 are maximal probabilities.

References

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