Economics 442
Fall 2020
University of Wisconsin-Madison

Menzie D. Chinn
Social Sciences 7418

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 what this implies, 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:

$$P_{2t} = \frac{\$100}{(1+i^e_{1t+1})(1+i_{1t})} \qquad (5)$$

We know in fact:

$$P_{2t} = \frac{\$100}{(1+i_{2t})^2} \qquad (6)$$

What will set (5) equal to (6)?

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

Which implies:

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

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

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

$$\boxed{i_{2t} \approx \frac{1}{2}(i^e_{1t+1}+i_{1t})} \qquad (7)$$

$$i^e_{1t+1} = 2i_{2t} - i_{1t} \qquad (8)$$

In general:

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

The Liquidity Premium Theory of the Term Structure

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

$$i_{nt} = \frac{(i_{1t} + i^e_{1t+1} + ... + i^e_{1t+n-1})}{n} + tp_{nt} \quad (10)$$

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 10), 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.

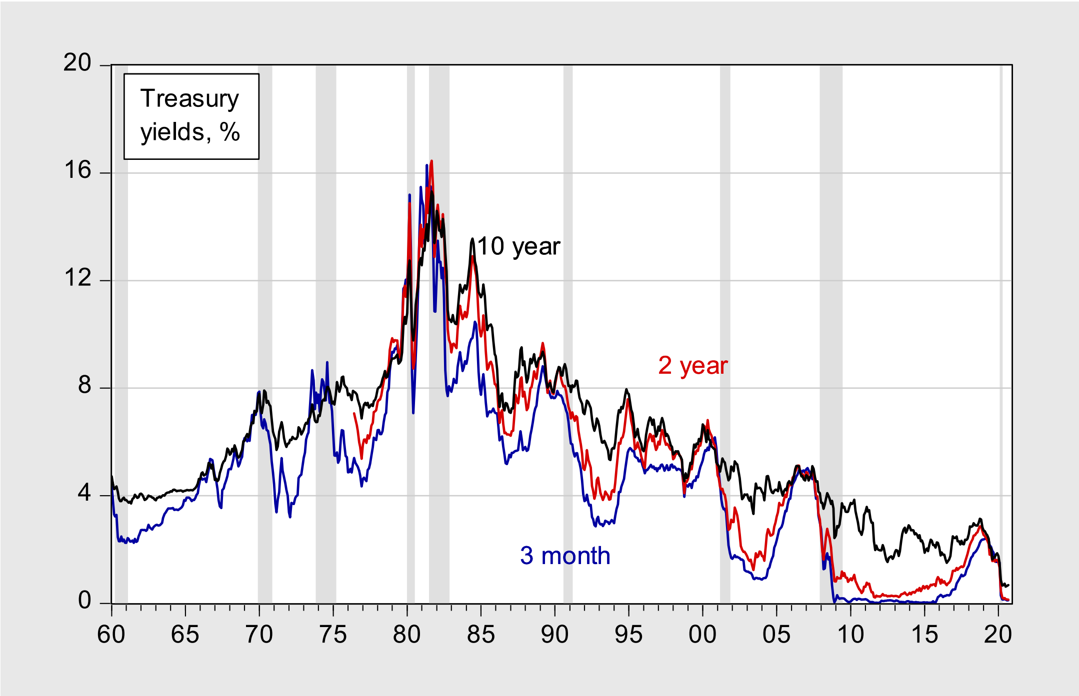


Figure 1: Ten year (black), two year (red), and three month (blue) Treasury yields, % NBER defined recession dates shaded gray. Source: St. Louis Fed FRED, and NBER.

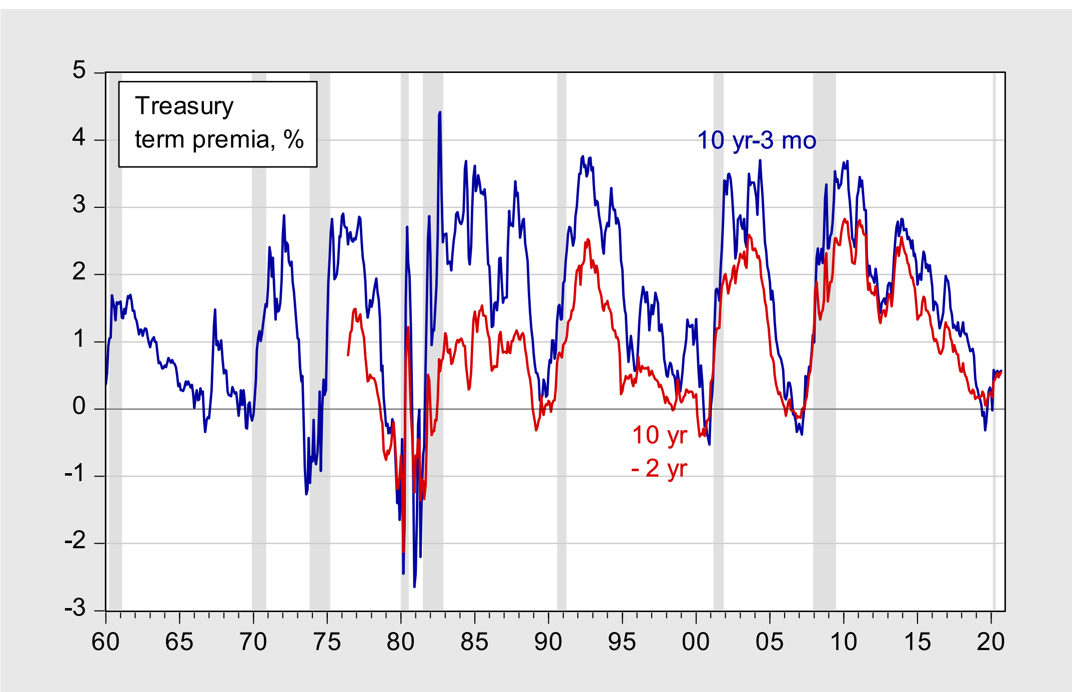


Figure 2: Ten year-three month spread (blue), and ten year-two year spread (red). NBER defined recession dates shaded gray. Source: St. Louis Fed FRED, and NBER.

Notice that inversions of the yield curves (when the lines dip below zero, or come close is) often precede recession. 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.

Cross-country Analysis

The evidence for predictive power across other countries is less developed; see Chinn and Kucko (2015) for discussion. The graphs analogous to Figure 1, for European countries and Japan. These are reproductions of Figure 1 from Chinn and Kucko (2015).

The graphs are suggestive, but do not confirm the posited relationships. This is why we need regression analysis.

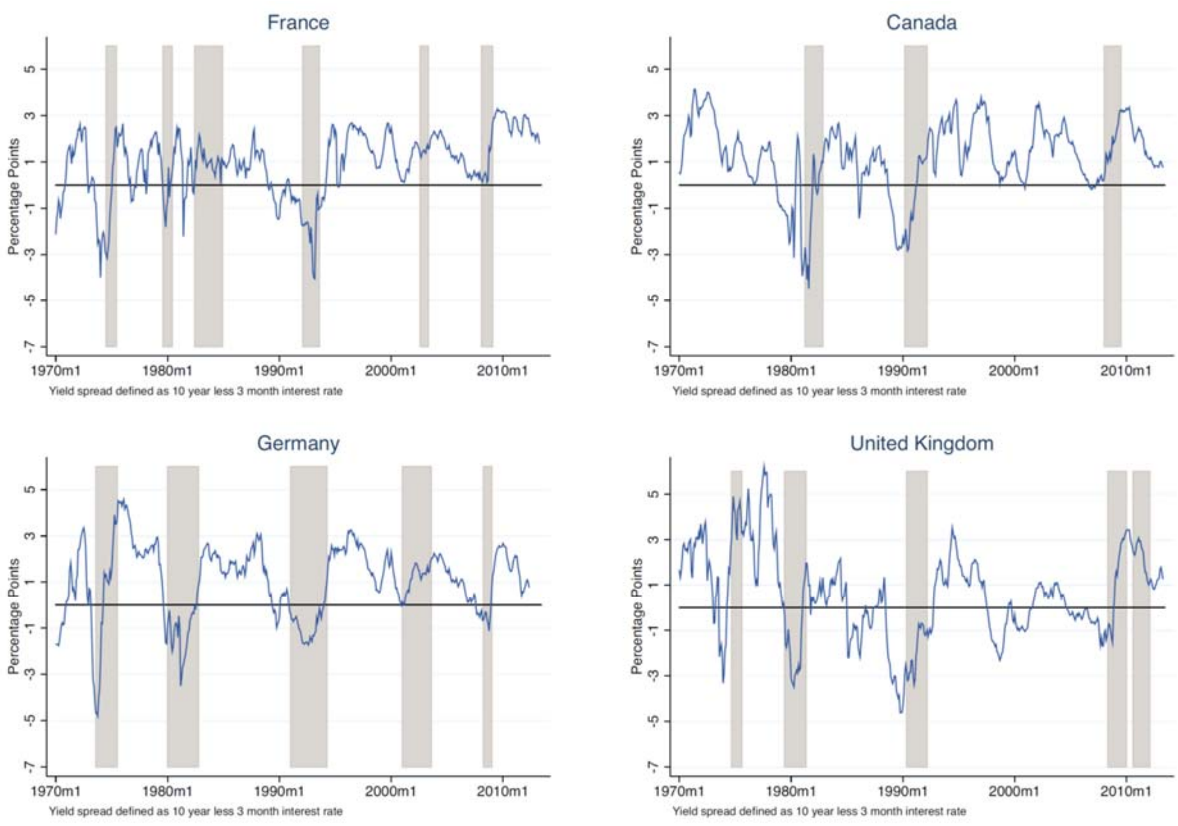


Figure 1: Yield curves and recessions: selected countries.

Table 1: Current Yield Spread as Predictor of Future IP Growth: Full Sample (1970–2013)

	(1) Canada	(2) France	(3) Germany	(4) Italy	(5) Japan	(6) Neth.	(7) Sweden	(8) UK	(9) US
12-month growth									
Spread	1.81	1.22	1.52	0.85	1.23	1.03	0.99	0.69	1.14
	[0.23]***	[0.38]***	[0.30]***	[0.31]***	[0.47]***	[0.27]***	[0.41]**	[0.22]***	[0.22]***
Constant	0.079	−0.022	−0.059	0.84	1.26	0.26	−1.54	0.38	1.71
	[0.65]	[0.72]	[0.71]	[0.80]	[0.95]	[0.58]	[1.02]	[0.49]	[0.61]***
R^2	0.27	0.13	0.23	0.064	0.068	0.11	0.068	0.11	0.20
Observations	501	507	507	495	507	474	495	507	508
Durbin–Watson	0.142	0.245	0.314	0.272	0.133	0.848	0.351	0.286	0.069
White	0.004	0.031	0.001	0.776	0.813	0.050	0.209	0.738	0.002

Table 3: Current Yield Spread as Predictor of Future IP Growth: Late Sample (1998–2013)

	(1) Canada	(2) France	(3) Germany	(4) Italy	(5) Japan	(6) Neth.	(7) Sweden	(8) UK	(9) US
12-month growth									
Spread	1.60	2.45	5.04	2.57	5.86	1.95	6.04	0.44	1.19
	[0.89]	[1.26]	[1.40]***	[1.49]	[5.92]	[1.19]	[1.67]***	[0.53]	[0.50]**
Constant	−1.75	−4.49	−4.25	−5.01	−6.74	−0.99	−8.51	−0.99	−0.38
	[2.27]	[2.72]	[2.22]	[3.00]	[8.53]	[2.01]	[3.00]***	[0.78]	[1.48]
R^2	0.10	0.21	0.46	0.19	0.035	0.13	0.45	0.041	0.14
Observations	165	171	171	171	171	171	171	171	172
Durbin–Watson	0.082	0.202	0.233	0.142	0.152	0.611	0.386	0.178	0.059
White	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002

Table 5: Current Yield Spread as Predictor of Future Recession: Full Sample (1970–2013)

	(1) Canada	(2) France	(3) Germany	(4) Italy	(5) Japan	(6) Sweden	(7) UK	(8) US
Next 6 months								
Spread	−0.39	−0.37	−0.68	−0.094	−0.059	−0.29	−0.067	−0.46
	[0.11]***	[0.091]***	[0.17]***	[0.093]	[0.095]	[0.12]**	[0.10]	[0.085]***
Constant	−0.73	−0.43	0.11	−0.51	−0.42	−0.21	−0.68	−0.64
	[0.23]***	[0.19]**	[0.23]	[0.19]***	[0.18]**	[0.19]	[0.19]***	[0.19]***
R^2	0.18	0.12	0.34	0.016	0.0045	0.10	0.0094	0.27
Observations	519	519	509	505	519	519	519	519
Next 12 months								
Spread	−0.49	−0.44	−0.63	−0.053	−0.020	−0.29	−0.11	−0.69
	[0.12]***	[0.10]***	[0.15]***	[0.089]	[0.099]	[0.13]**	[0.099]	[0.12]***
Constant	−0.50	−0.14	0.31	−0.36	−0.23	−0.047	−0.51	−0.29
	[0.22]**	[0.20]	[0.24]	[0.19]	[0.18]	[0.19]	[0.19]***	[0.20]
R^2	0.24	0.15	0.29	0.0050	0.00051	0.11	0.025	0.38
Observations	519	519	509	505	519	519	519	519

Is This Time Different?

A commonly heard refrain is that this time, the inversion of the yield curve will not predict a recession. The argument is that the 10 year term premium has changed behavior, now becoming negative, rather than positive (as has been posited historically). This phenomenon could be true because of quantitative (more accurately "credit") easing, or because of the possibility of deflation (as noted by James Hamilton in his presentation).

One can in principle get a "pure" expectations component (first term on right hand side of equation (10)) by subtracting an estimate of the term premium. Doing this yields the top graph in

Figure 3 below (the bottom graph is the estimate of tp_{10t} from the NY Fed, based on the methodology of Adrian, Crump and Moench (2013)).

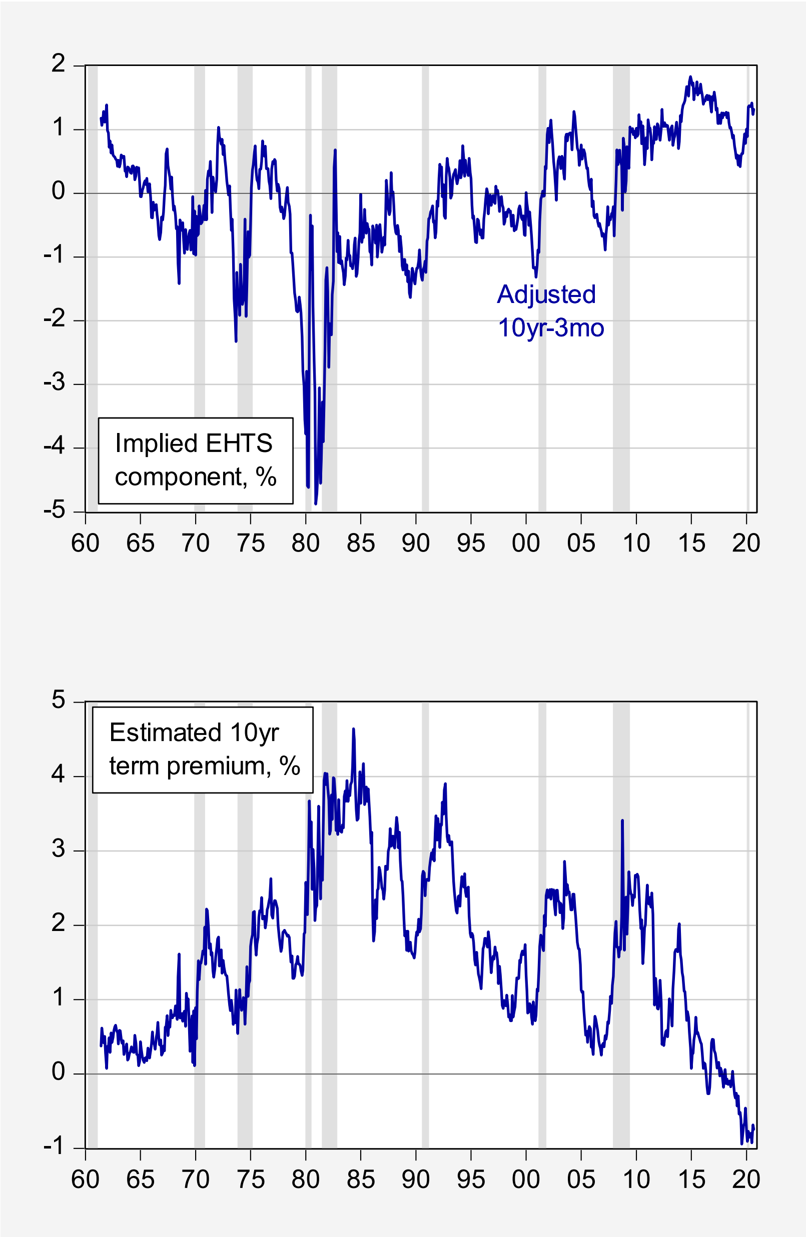


Figure 3: Top graph: Ten year-three month spread adjusted by estimated ten year term premium. Bottom graph: Ten year estimated term premium. NBER defined recession dates shaded gray. Source: St. Louis Fed FRED, NBER, and NY Fed.

Notice inversions of the 10yr-3mo term premium adjusted spread are not necessarily always precursors of a recession. Through the 1980s and mid-1990's, the adjusted spread is negative and no recession follows. Moreover, the adjusted spread did not invert prior to the current ongoing recession.

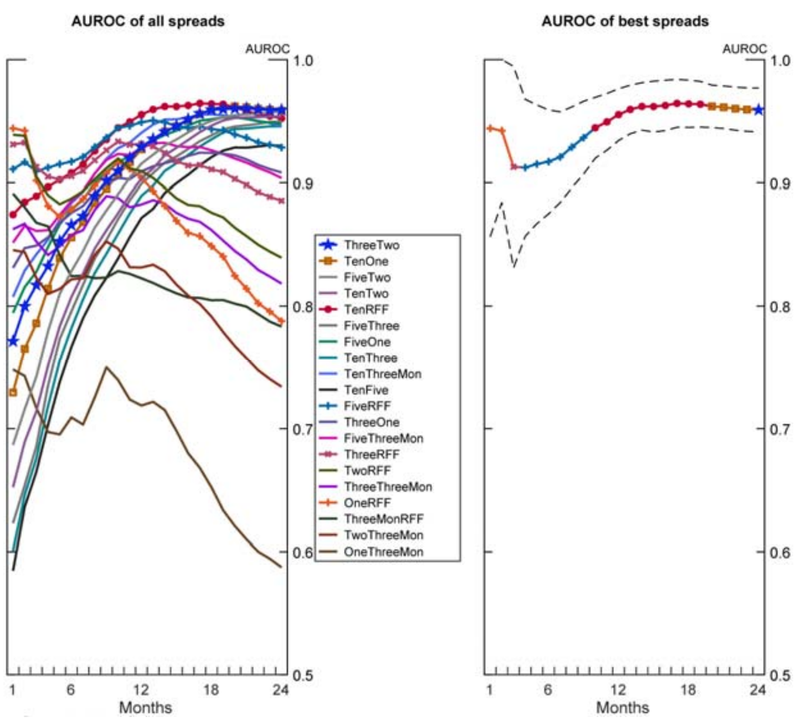
However, there are different estimates of the term premium, and as noted by Chinn (2019), different adjustments lead to different implied probabilities of recession. Using the SF Fed estimate would yield a higher probability of recession than using the NY Fed's estimate.

2. Alternative Term Spread Prediction

Miller (2019) undertakes a systematic analysis of term spreads and their ability to predict, minimizing the ratio of true positives to false positives (AUROC, automatic receiver operator characteristic). His conclusion:

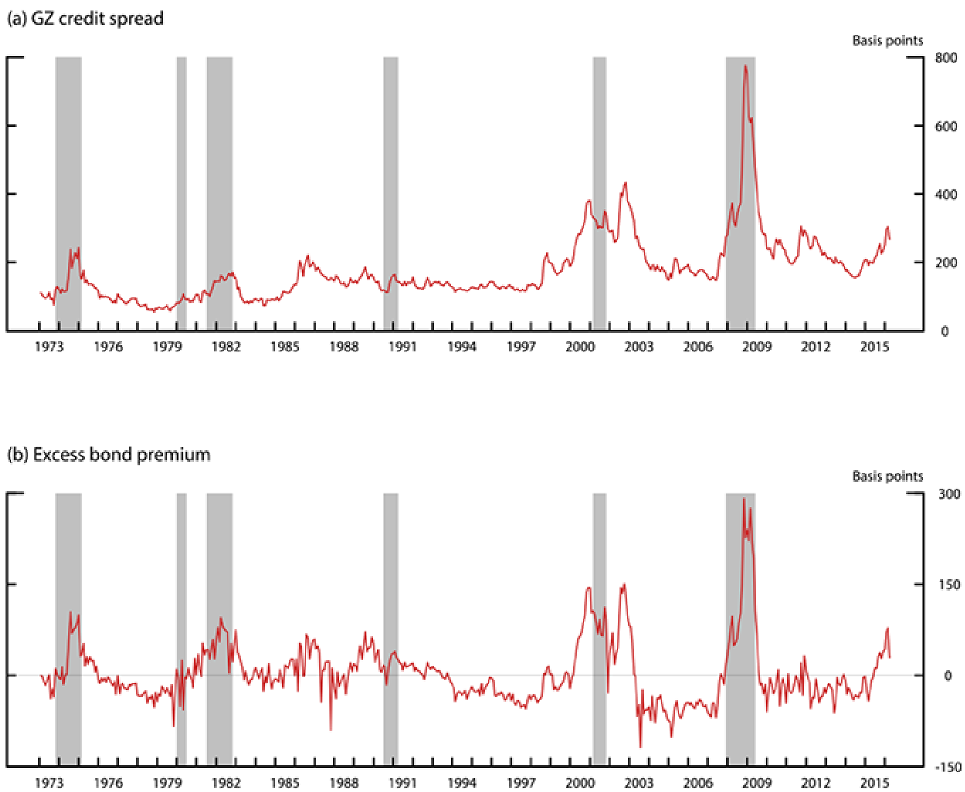
> "While there is no unique best predictor, there are general guidelines as to which term spread to use to predict recessions at different horizons. To predict recessions at short horizons, use a spread between short and very short Treasuries. To predict at medium horizons, use a spread between long and very short Treasuries. To predict at long horizons, use a spread between medium and short Treasuries. The strength of the yield curve to predict recessions at very long horizons (2 years) is surprisingly strong. Overall, if you can only use a single term spread derived measure, use the principal components of the yield curve …"

Figure 2 from Miller shows which spreads work best (as having the highest AUROC) as each horizon.



3. Credit Spreads

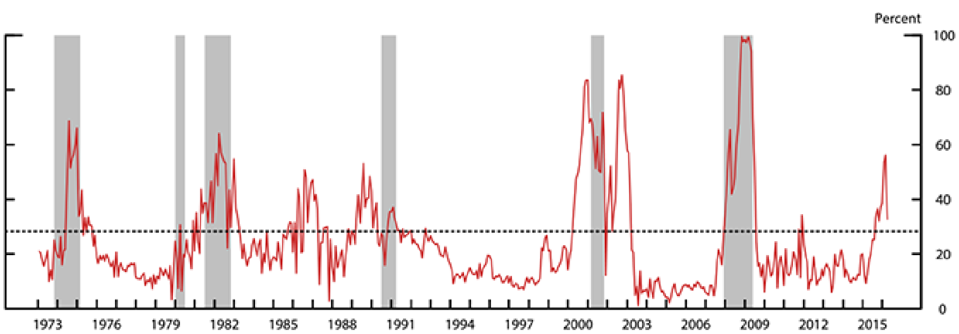
Favara et al. (2016) augment the term spread (10yr-Fed funds) with the real Fed funds rate and a credit spread. Credit spreads reflect the riskiness of private assets relative to Treasury bonds. In principle, we hope to measure the spread for a given maturity. Using the Moody's AAA or BAA bond yields is problematic because those bond yield summary measures incorporate different maturities. Favara et al. correct for this, and purge of firm idiosyncratic credit risk, to obtain an "excess bond premium" or EBP. "EBP [is] a residual component that can be thought of as capturing investor attitudes toward corporate credit risk--that is, credit market sentiment." The EBP is shown below:



Estimating the regressions, both augmented and unaugmented yields the results in Table 1 from the article:

Explanatory Variables	(1)	(2)	(3)
GZ credit spread (SGZt)	0.140***	.	.
	(0.037)		
Term spread (TSt)	-0.079**	-0.092***	.
	(0.034)	(0.029)	
Real federal funds rate (RFFt)	0.047**	0.017	
	(0.021)	(0.016)	
Predicted GZ credit spread (S^GZt)	.	-0.018	.
		(0.057)	
Excess bond premium (EBPt)	.	0.300***	0.327***
		(0.055)	(0.075)
Pseudo R^2	0.426	0.527	0.288

And the following prediction, based on Column 3. The dating is such that each probability pertains to 12 months ahead:



In other words, it can be argued that credit spreads properly measured may be useful in predicting recessions.

References

Adrian, Tobias, Richard K. Crump, and Emanuel Moench, "Pricing the Term Structure with Linear Regressions," Journal of Financial Economics 110, no. 1 (October 2013): 110-38

Chinn, Menzie, "An Ad Hoc Term Premium Adjusted Term Spread Model," Econbrowser, August 25, 2019. http://econbrowser.com/archives/2019/08/an-ad-hoc-term-premium-adjusted-term-spread-recession-model

Chinn, Menzie and Kavan Kucko, “The Predictive Power of the Yield Curve across Countries and Time,” *International Finance*, 18(2): 129–262 (Summer 2015).

Favara, Giovanni, Simon Gilchrist, Kurt F. Lewis, and Egon Zakrajsek (2016). "Recession Risk and the Excess Bond Premium," *FEDS Notes*. Washington: Board of Governors of the Federal Reserve System, April 8, 2016, http://dx.doi.org/10.17016/2380-7172.1739.

Miller, David S., "There is No Single Best Predictor of Recessions," *FEDS Notes*. Washington: Board of Governors of the Federal Reserve System, May 21, 2019, https://doi.org/10.17016/2380-7172.2367

Wright, Jonathan, “The Yield Curve and Predicting Recessions,” *Finance and Economic Discussion Series* No. 2006-07, Federal Reserve Board, 2006.

E442_ews_f20
5.10.2020