Economics 442
Macroeconomic Policy
10/5-7/2020
(rev'd 10/6)

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UW Madison
Fall 2020

Outline

- Yield curve inversions and recessions
- Derivation of EHTS
- Regression analysis using probit
- Is this time different?
- Alternative term spreads
- Alternatives using credit spreads
- Recession forecasting by economists
- Survey of economists in 2019

Yield Curve Inversions & Recessions

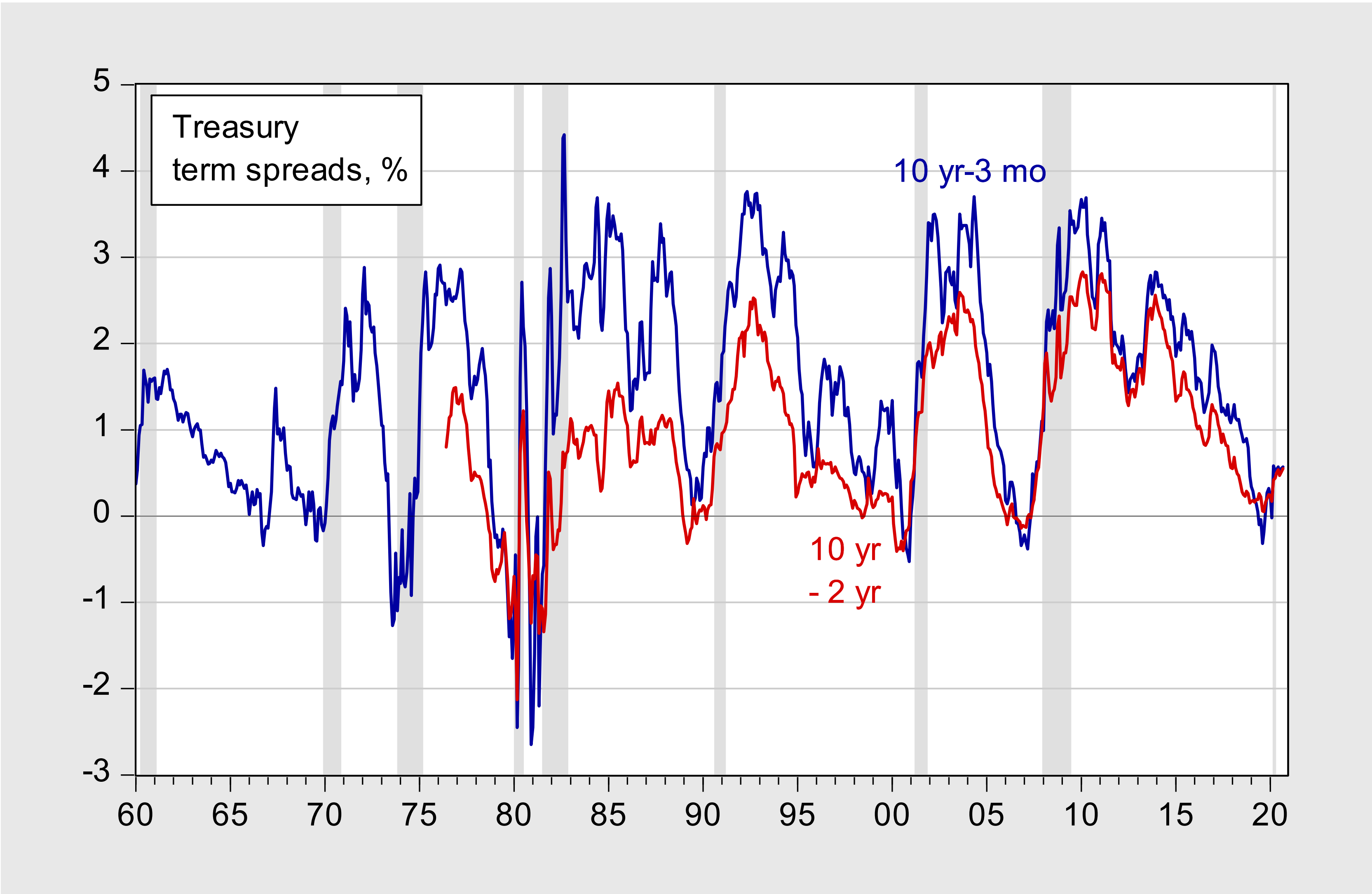
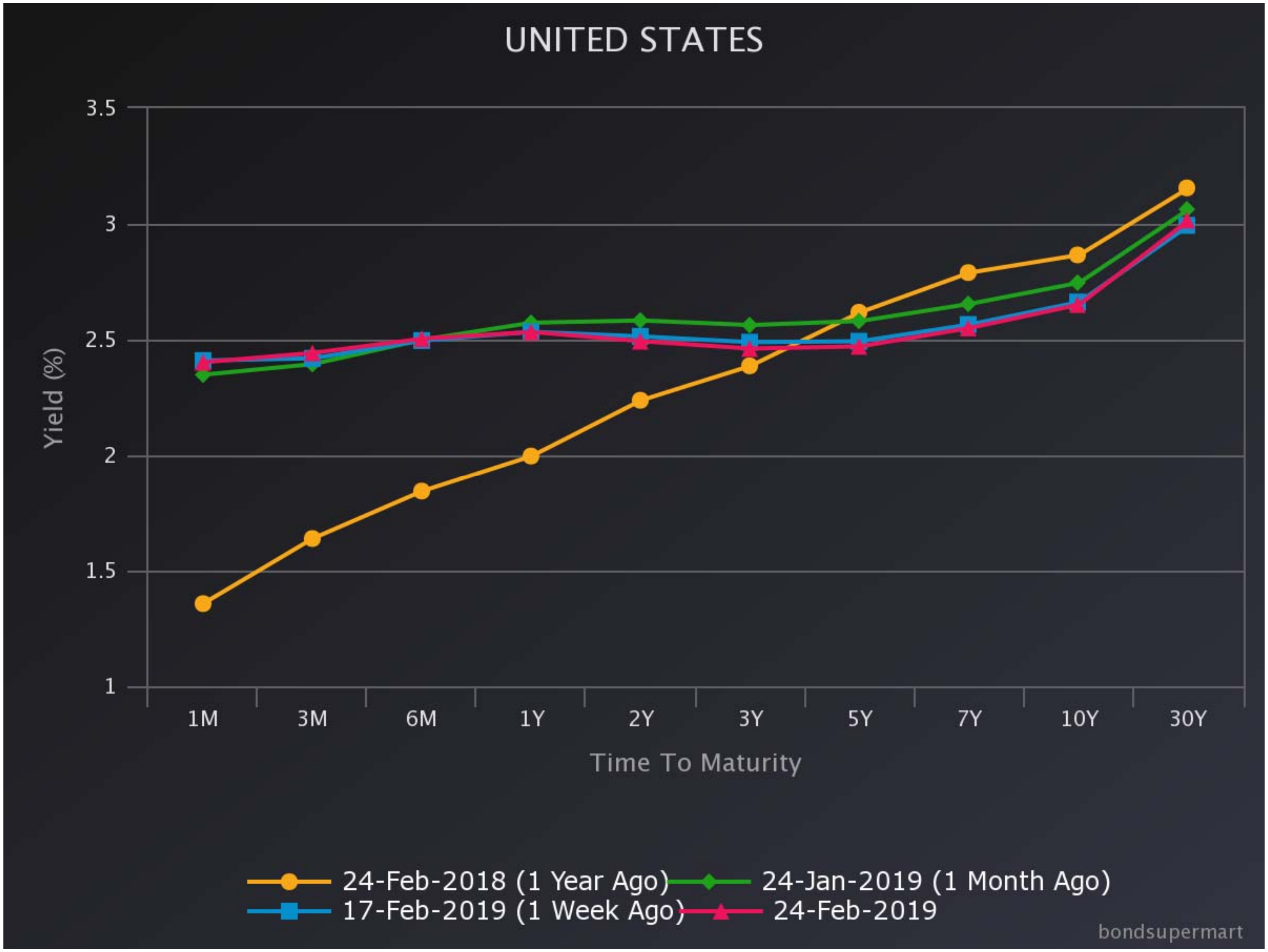


Figure legend corrected 10/5

Yield Curve: Snapshot



Why Do Yield Curve Inversions Precede Recessions?

- The long term rate is an average of expected future short term rates
- Plus a term to account for risk at the longer term
- Hence, inversion means future short rates expected to be lower than current short rate (which is often raised just before a recession)

Derivation of Expectations Hypothesis of Term Structure (EHTS)

Derivation of EHTS

If agents are risk neutral.

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

To see this, 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:

$$\boxed{i_{nt} = \frac{(i_{1t}+i^e_{1t+1}+\ldots+i^e_{1t+n-1})}{n}} \qquad (9)$$

The Liquidity Premium Theory of the Term Structure

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

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

When Are Long Rates below Current Short Rates?

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

- When the $t+n-1$ short rates are expected to be low
- And when period t short rate is high
- As in just before a recession

When Are Long Rates below Current Short Rates?

Inversion & Recession in Other Countries

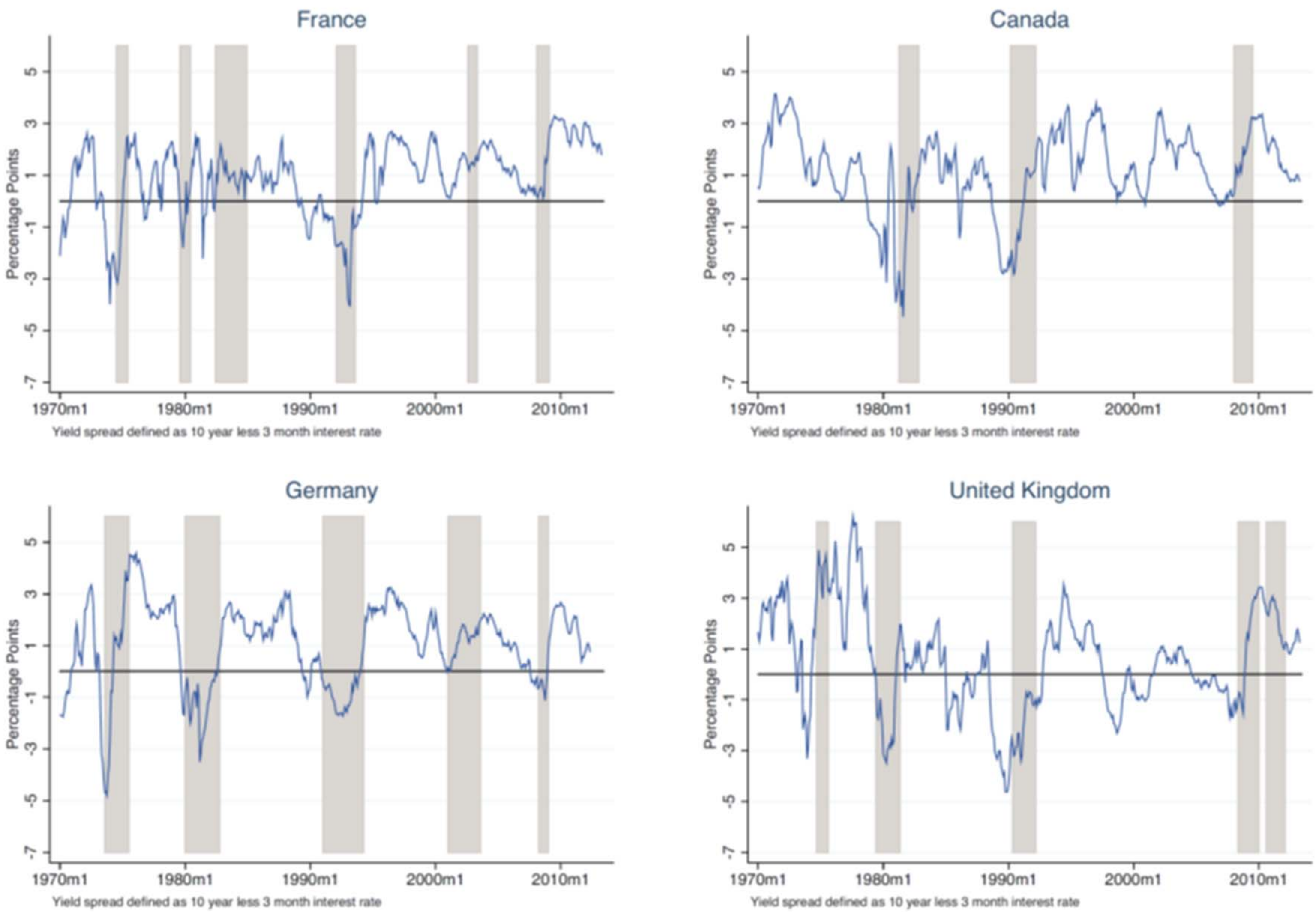


Figure 1: Yield curves and recessions: selected countries.

Chinn, Kucko (2015).

Regression Analysis Using Probit

Recession

- Define recession as binary variable: 1, 0
- Use ECRI definition (similar to NBER's)
- Estimate "Probit" regression on lagged spread

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

Chinn, Kucko (2015).

Growth

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

Chinn, Kucko (2015).

US Extended to 2019M01

Dependent Variable: RECESSIONLEAD
Method: ML - Binary Probit (Newton-Raphson / Marquardt steps)
Date: 10/03/20 Time: 23:13
Sample: 1960M01 2019M01
Included observations: 709
Convergence achieved after 7 iterations
Coefficient covariance computed using observed Hessian

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.392682	0.086983	-4.514467	0.0000
SPREAD	-0.733325	0.072119	-10.16824	0.0000

McFadden R-squared	0.272469	Mean dependent var	0.129760
S.D. dependent var	0.336277	S.E. of regression	0.291729
Akaike info criterion	0.567195	Sum squared resid	60.16968
Schwarz criterion	0.580069	Log likelihood	-199.0705
Hannan-Quinn criter.	0.572168	Deviance	398.1410
Restr. deviance	547.2497	Restr. log likelihood	-273.6248
LR statistic	149.1086	Avg. log likelihood	-0.280776
Prob(LR statistic)	0.000000		

Obs with Dep=0	617	Total obs	709
Obs with Dep=1	92		

Calculations

Plug in data:

Prob(Rec) =

= -0.393 -0.733×(0.29)

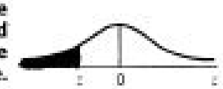
= -0.393 – 0.213

= -0.606

➡ 27.3% prob

Table IV Standard Normal Distribution Table

The entries in this table give the cumulative area under the standard normal curve to the left of z with the values of z equal to 0 or negative.



z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
−3.4	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0002
−3.3	.0005	.0005	.0005	.0004	.0004	.0004	.0004	.0004	.0004	.0003
−3.2	.0007	.0007	.0006	.0006	.0006	.0006	.0006	.0005	.0005	.0005
−3.1	.0010	.0009	.0009	.0009	.0008	.0008	.0008	.0008	.0007	.0007
−3.0	.0013	.0013	.0013	.0012	.0012	.0011	.0011	.0011	.0010	.0010
−2.9	.0019	.0018	.0018	.0017	.0016	.0016	.0015	.0015	.0014	.0014
−2.8	.0026	.0025	.0024	.0023	.0023	.0022	.0021	.0021	.0020	.0019
−2.7	.0035	.0034	.0033	.0032	.0031	.0030	.0029	.0028	.0027	.0026
−2.6	.0047	.0045	.0044	.0043	.0041	.0040	.0039	.0038	.0037	.0036
−2.5	.0062	.0060	.0059	.0057	.0055	.0054	.0052	.0051	.0049	.0048
−2.4	.0082	.0080	.0078	.0075	.0073	.0071	.0069	.0068	.0066	.0064
−2.3	.0107	.0104	.0102	.0099	.0096	.0094	.0091	.0089	.0087	.0084
−2.2	.0139	.0136	.0132	.0129	.0125	.0122	.0119	.0116	.0113	.0110
−2.1	.0179	.0174	.0170	.0166	.0162	.0158	.0154	.0150	.0146	.0143
−2.0	.0228	.0222	.0217	.0212	.0207	.0202	.0197	.0192	.0188	.0183
−1.9	.0287	.0281	.0274	.0268	.0262	.0256	.0250	.0244	.0239	.0233
−1.8	.0359	.0351	.0344	.0336	.0329	.0322	.0314	.0307	.0301	.0294
−1.7	.0446	.0436	.0427	.0418	.0409	.0401	.0392	.0384	.0375	.0367
−1.6	.0548	.0537	.0526	.0516	.0505	.0495	.0485	.0475	.0465	.0455
−1.5	.0668	.0655	.0643	.0630	.0618	.0606	.0594	.0582	.0571	.0559
−1.4	.0808	.0793	.0778	.0764	.0749	.0735	.0721	.0708	.0694	.0681
−1.3	.0968	.0951	.0934	.0918	.0901	.0885	.0869	.0853	.0838	.0823
−1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0985
−1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
−1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
−0.9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
−0.8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
−0.7	.2420	.2389	.2358	.2327	.2296	.2266	.2236	.2206	.2177	.2148
−0.6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
−0.5	.3085	.3050	.3015	.2981	.2946	.2912	.2877	.2843	.2810	.2776
−0.4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
−0.3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
−0.2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
−0.1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
0.0	.5000	.4960	.4920	.4880	.4840	.4801	.4761	.4721	.4681	.4641

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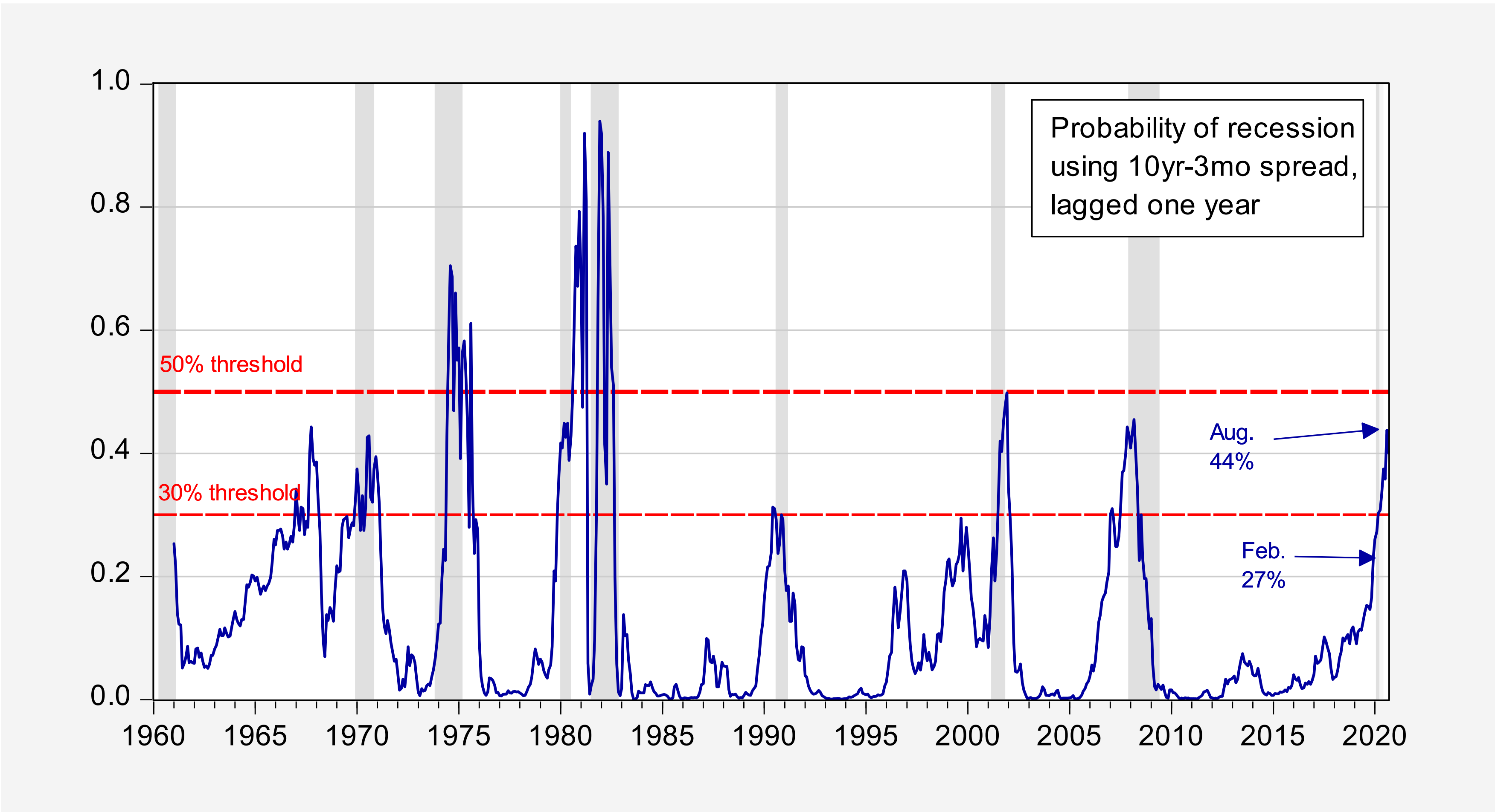
Forecasting using 2019M02 Spread



Expectation-Prediction Evaluation for Binary Specification
Equation: STD_PROBIT_NEW
Date: 10/03/20 Time: 23:28
Success cutoff: C = 0.5

	Estimated Equation			Constant Probability		
	Dep=0	Dep=1	Total	Dep=0	Dep=1	Total
P(Dep=1)<=C	607	77	684	617	92	709
P(Dep=1)>C	10	15	25	0	0	0
Total	617	92	709	617	92	709
Correct	607	15	622	617	0	617
% Correct	98.38	16.30	87.73	100.00	0.00	87.02
% Incorrect	1.62	83.70	12.27	0.00	100.00	12.98
Total Gain*	-1.62	16.30	0.71			
Percent Ga...	NA	16.30	5.43			

	Estimated Equation			Constant Probability		
	Dep=0	Dep=1	Total	Dep=0	Dep=1	Total
E(# of Dep=0)	556.80	60.95	617.75	536.94	80.06	617.00
E(# of Dep=1)	60.20	31.05	91.25	80.06	11.94	92.00
Total	617.00	92.00	709.00	617.00	92.00	709.00
Correct	556.80	31.05	587.85	536.94	11.94	548.88
% Correct	90.24	33.75	82.91	87.02	12.98	77.42
% Incorrect	9.76	66.25	17.09	12.98	87.02	22.58
Total Gain*	3.22	20.78	5.50			
Percent Ga...	24.81	23.87	24.34			

*Change in "% Correct" from default (constant probability) specification
**Percent of incorrect (default) prediction corrected by equation

Expectation-Prediction Evaluation for Binary Specification
Equation: STD_PROBIT_NEW
Date: 10/03/20 Time: 23:29
Success cutoff: C = 0.3

	Estimated Equation			Constant Probability		
	Dep=0	Dep=1	Total	Dep=0	Dep=1	Total
P(Dep=1)<=C	580	42	622	617	92	709
P(Dep=1)>C	37	50	87	0	0	0
Total	617	92	709	617	92	709
Correct	580	50	630	617	0	617
% Correct	94.00	54.35	88.86	100.00	0.00	87.02
% Incorrect	6.00	45.65	11.14	0.00	100.00	12.98
Total Gain*	-6.00	54.35	1.83			
Percent Ga...	NA	54.35	14.13			

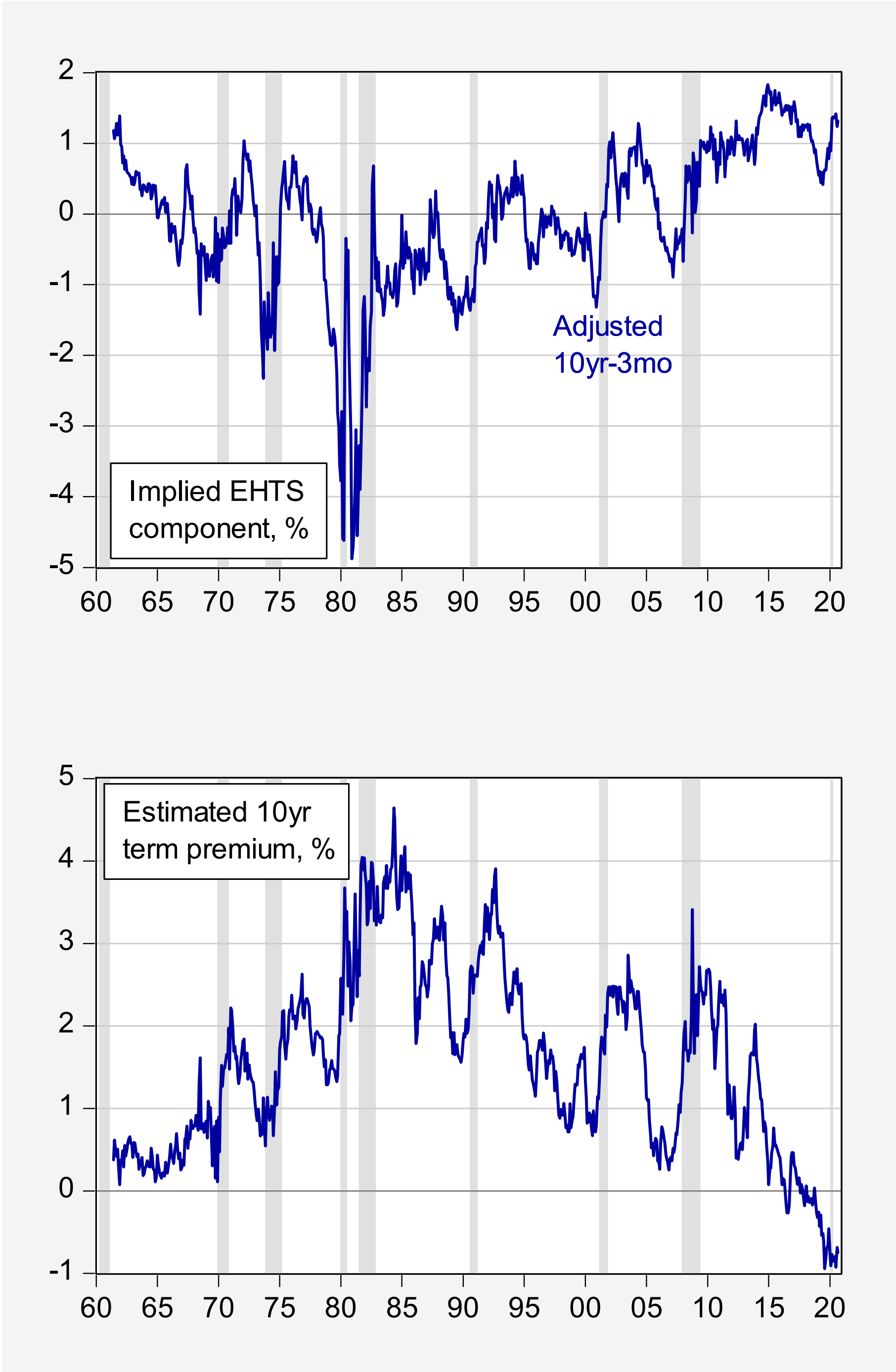
	Estimated Equation			Constant Probability		
	Dep=0	Dep=1	Total	Dep=0	Dep=1	Total
E(# of Dep=0)	556.80	60.95	617.75	536.94	80.06	617.00
E(# of Dep=1)	60.20	31.05	91.25	80.06	11.94	92.00
Total	617.00	92.00	709.00	617.00	92.00	709.00
Correct	556.80	31.05	587.85	536.94	11.94	548.88
% Correct	90.24	33.75	82.91	87.02	12.98	77.42
% Incorrect	9.76	66.25	17.09	12.98	87.02	22.58
Total Gain*	3.22	20.78	5.50			
Percent Ga...	24.81	23.87	24.34			

*Change in "% Correct" from default (constant probability) specification
**Percent of incorrect (default) prediction corrected by equation

Is This Time Different?

Is This Time Different?

- Inversion implies lower future short rates, when term premium is positive
- Term premium is positive presumably because of inflation risk
- But there is greater risk of deflation
- And quantitative easing/credit easing might’ve pushed downward premium



Consider term spread subtracting estimated term premium

If EHTS component is predictive, we can use as predictor

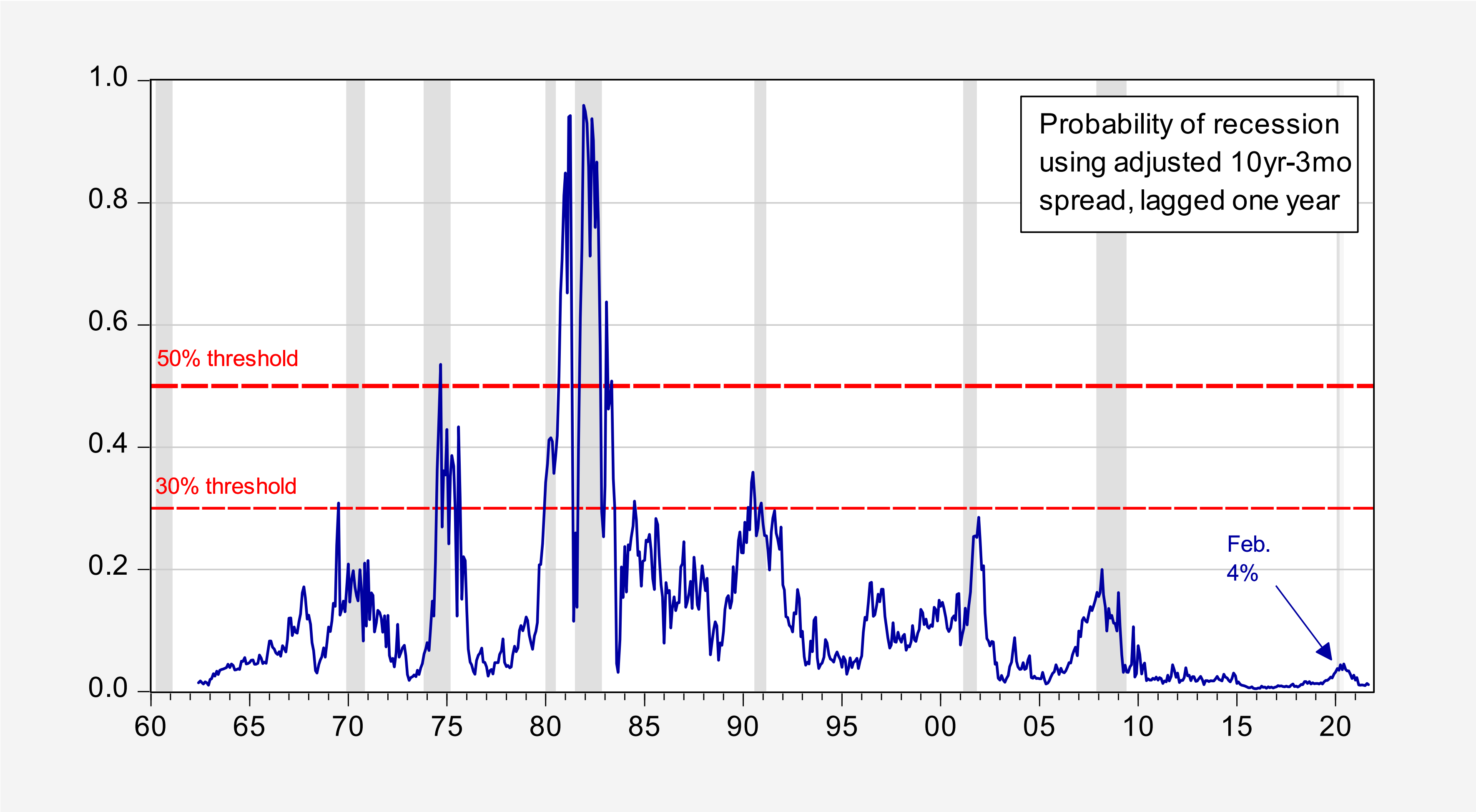
Dependent Variable: RECESSIONLEAD
Method: ML - Binary Probit (Newton-Raphson / Marquardt steps)
Date: 10/04/20 Time: 21:19
Sample (adjusted): 1961M06 2019M01
Included observations: 692 after adjustments
Convergence achieved after 5 iterations
Coefficient covariance computed using observed Hessian

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-1.423055	0.079985	-17.79142	0.0000
EHTS10	-0.649620	0.067377	-9.641558	0.0000

McFadden R-squared	0.219682	Mean dependent var	0.130058
S.D. dependent var	0.336610	S.E. of regression	0.303687
Akaike info criterion	0.608961	Sum squared resid	63.63587
Schwarz criterion	0.622081	Log likelihood	-208.7004
Hannan-Quinn criter.	0.614035	Deviance	417.4007
Restr. deviance	534.9113	Restr. log likelihood	-267.4556
LR statistic	117.5105	Avg. log likelihood	-0.301590
Prob(LR statistic)	0.000000		

Obs with Dep=0	602	Total obs	692
Obs with Dep=1	90		

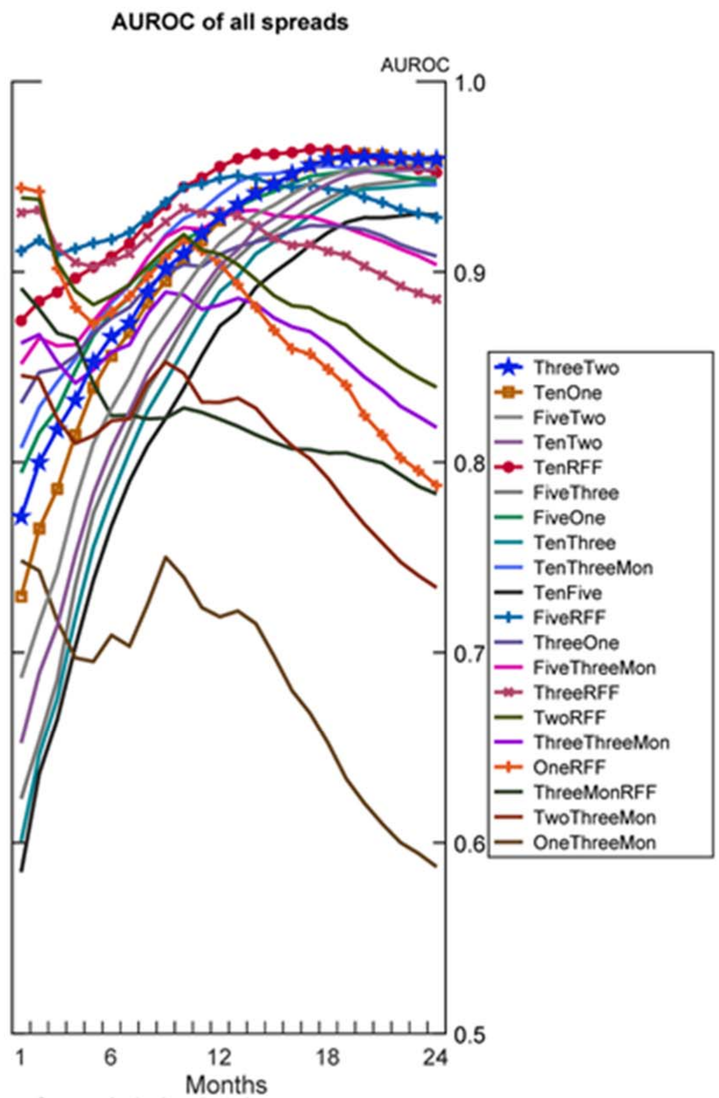
Adjusted Spread Predicted No Recession

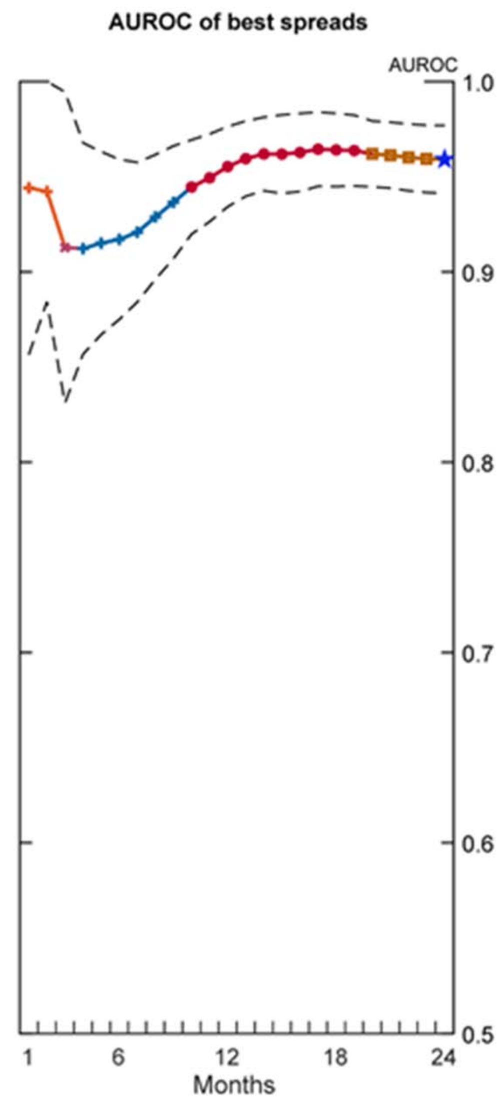


Alternative Term Spreads

Many Different Spreads

- AUROC -- area under receiver characteristic curve – maximum ratio of true positives to false positives
- Different term spreads work at different horizons (1984-2018)



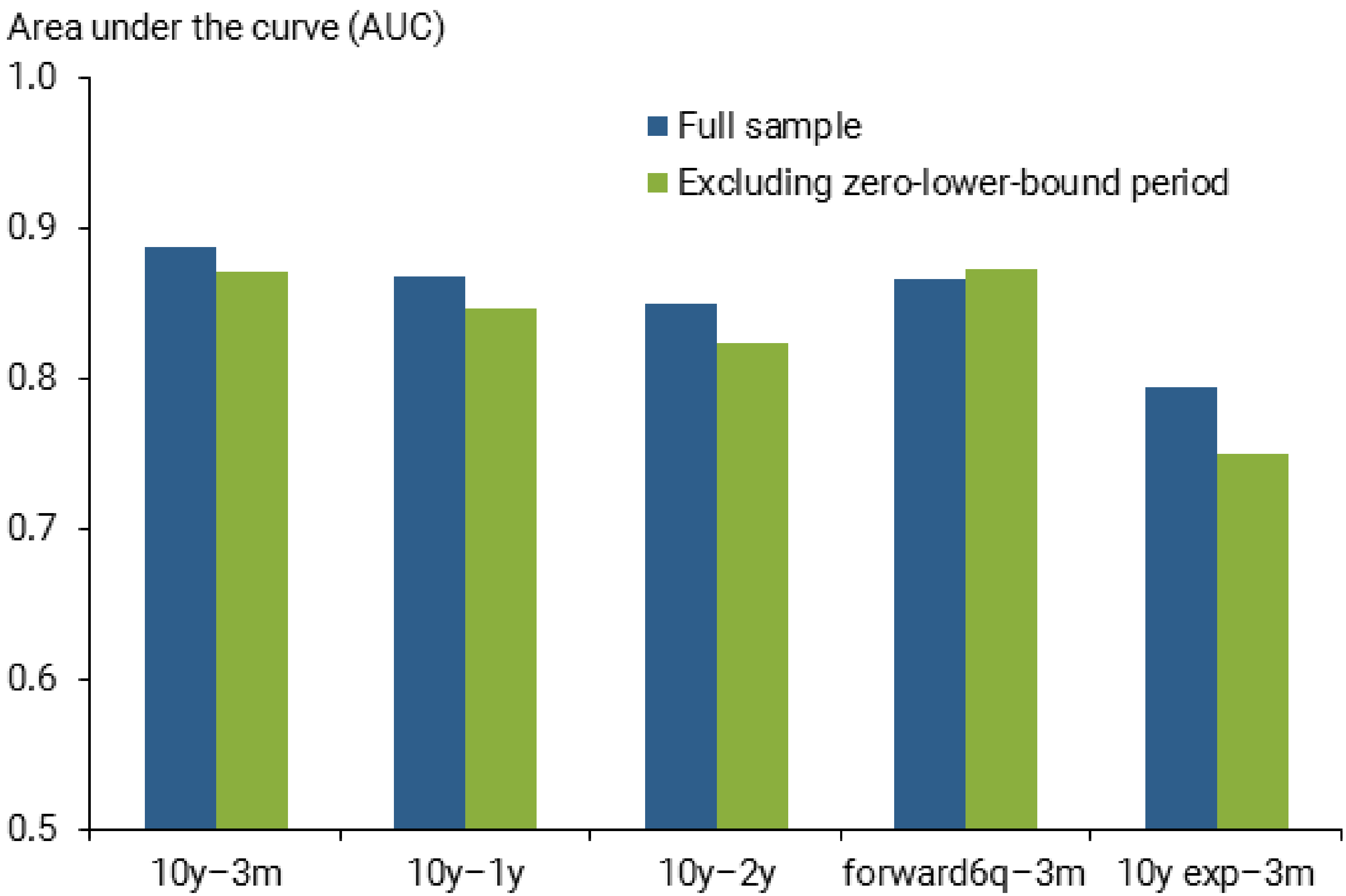


Source: Miller (2019)

Alternative Term Spreads

Bauer & Mertens (August 2018), Figure 1

Alternative Term Spreads



Bauer & Mertens (August 2018), Figure 1

Alternatives Using Credit Spreads

Combining Term and Credit Spreads

Giovanni Favara, Simon Gilchrist, Kurt F. Lewis, and Egon Zakrajšek

- Use corporate bond credit spread adjusted for maturity.
- Strip out investor attitude to risk, retain default risk.
- Run probit regression:

P(NBERt,t+12=1)=Φ(α+β1SGZt+γ1TSt+γ2RFFt)

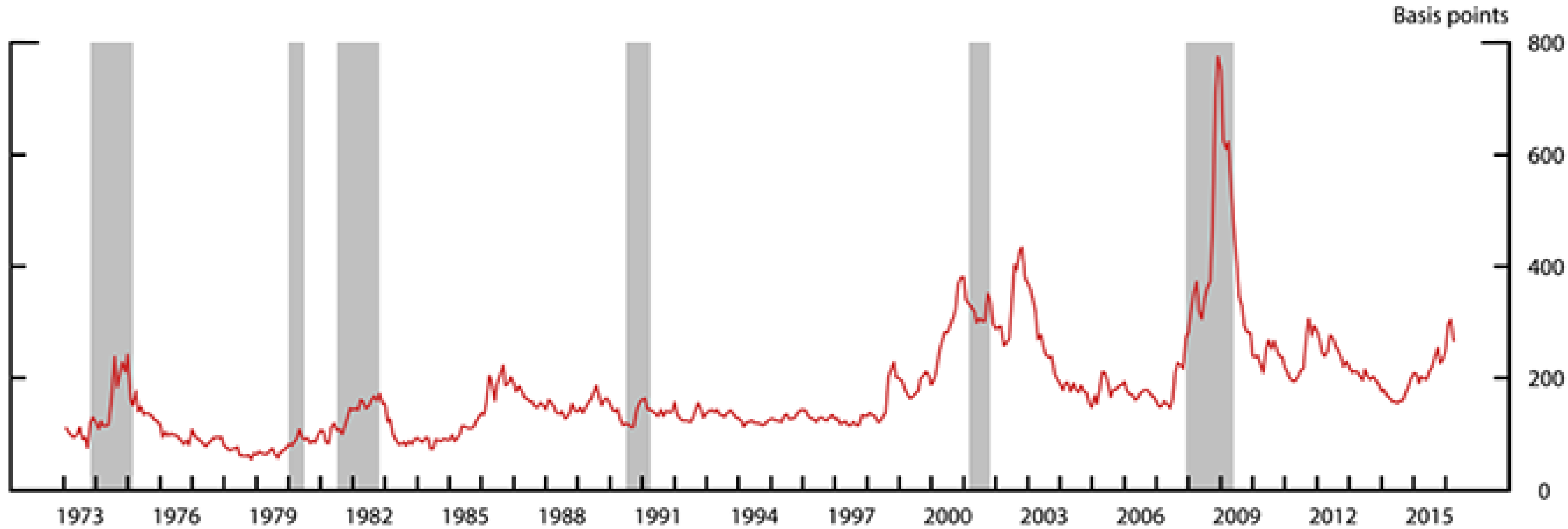
P(NBERt,t+12=1)=Φ(α+β1S^GZt+β2EBPt+γ1TSt+γ2RFFt).

https://www.federalreserve.gov/econresdata/notes/feds-notes/2016/recession-risk-and-the-excess-bond-premium-20160408.html

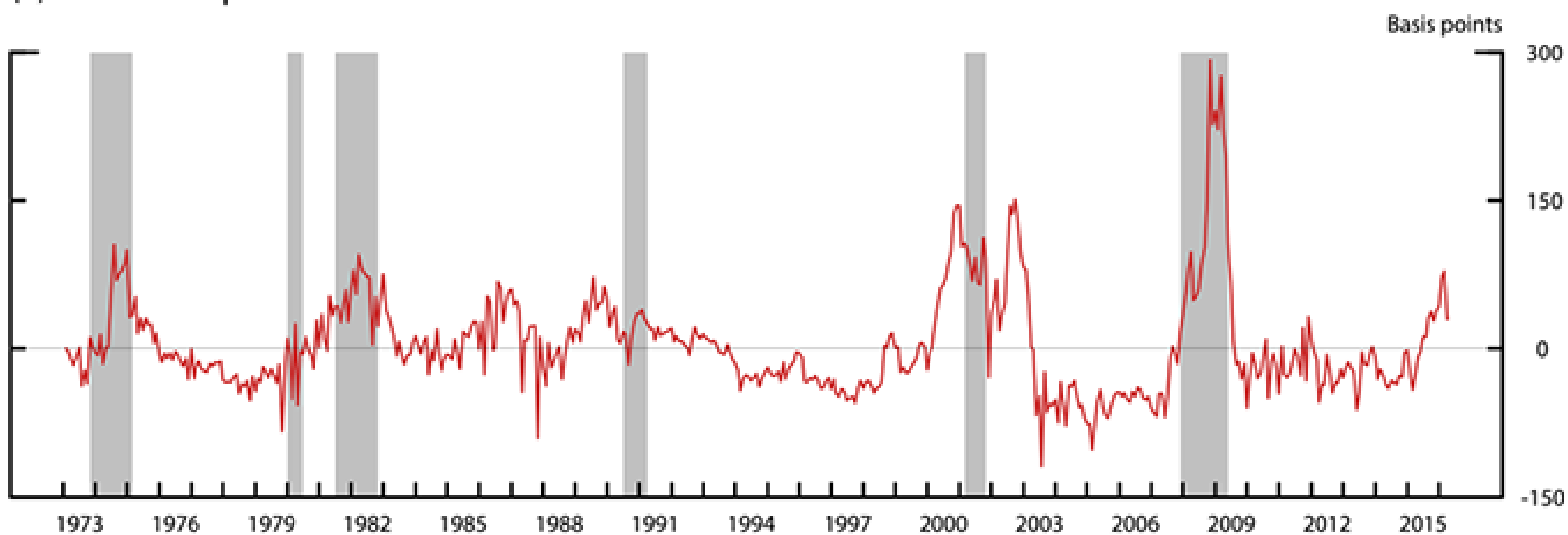
Probit Regression Results

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

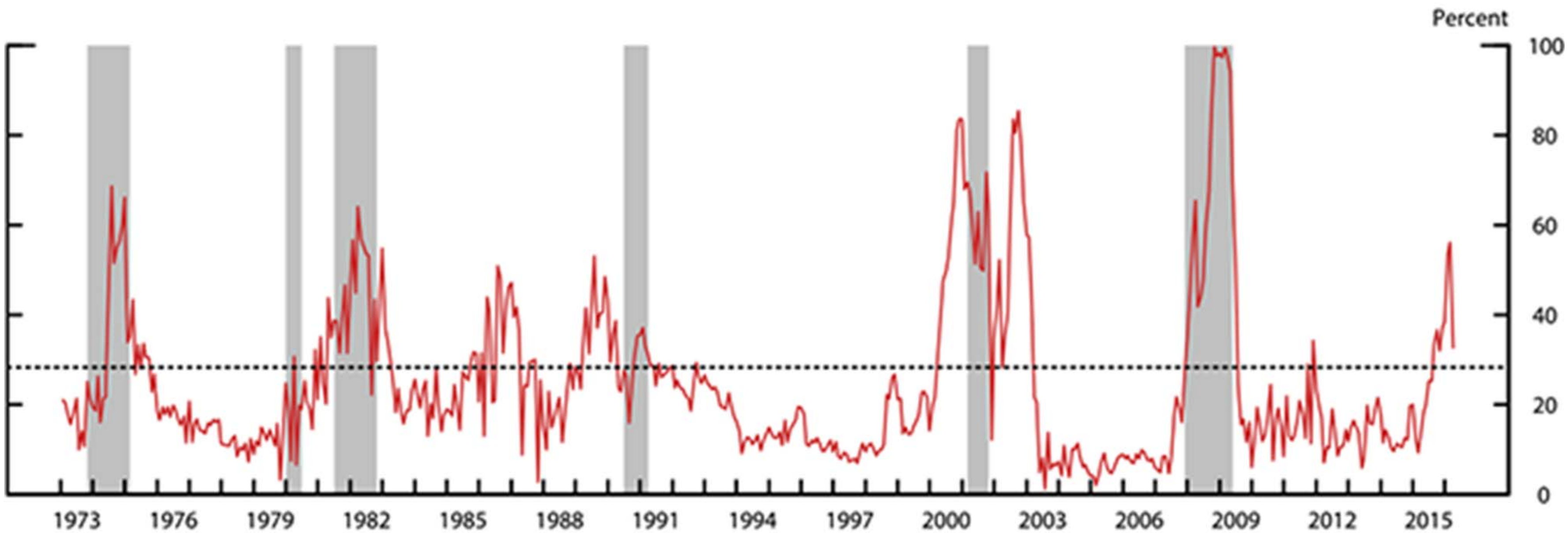
(a) GZ credit spread



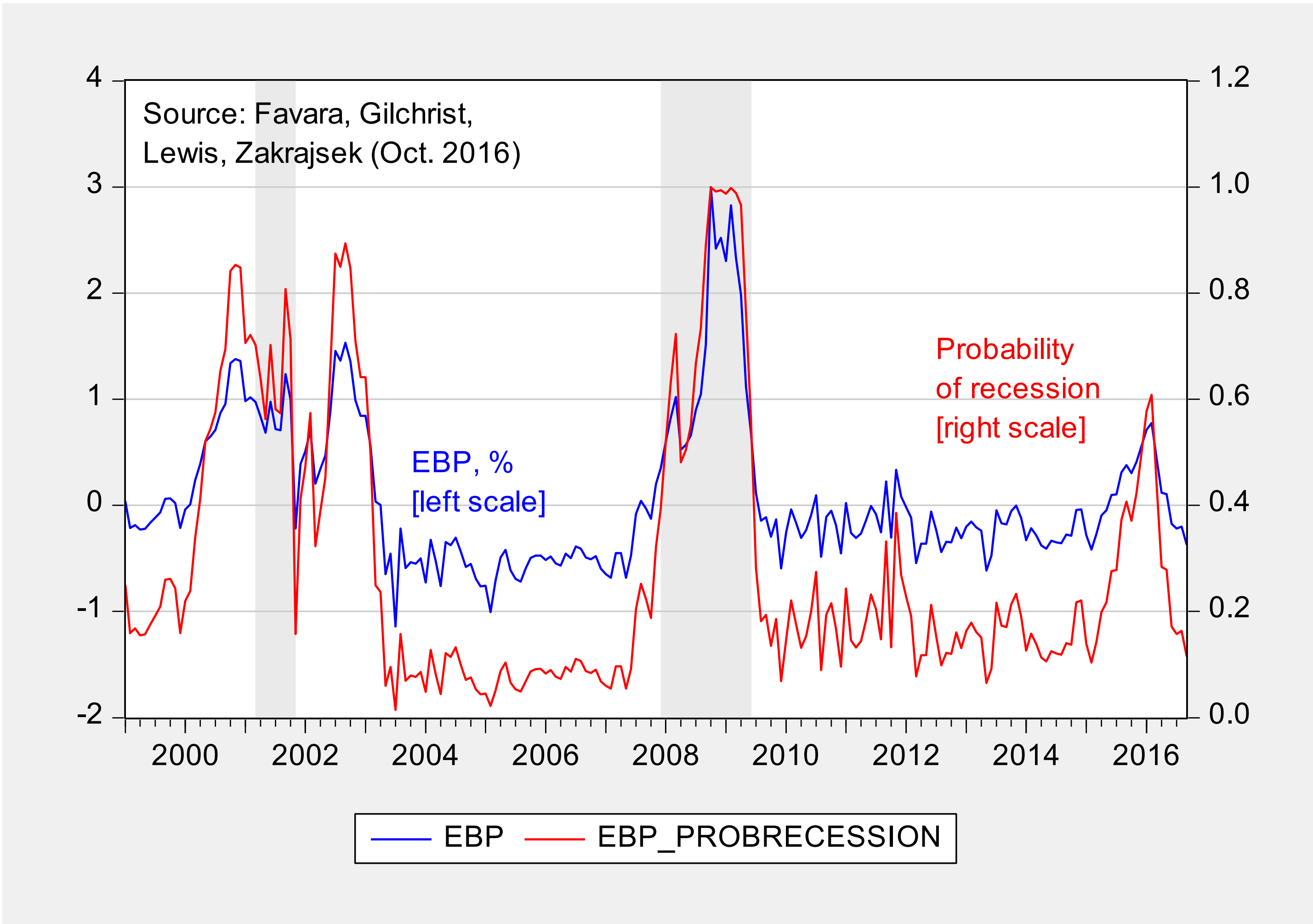
(b) Excess bond premium



Recession Probability Based on EBP Only



Latest Avail. Recession Probabilities



https://www.federalreserve.gov/econresdata/notes/feds-notes/2016/updating-the-recession-risk-and-the-excess-bond-premium-20161006.html

Recession Forecasting by Economists

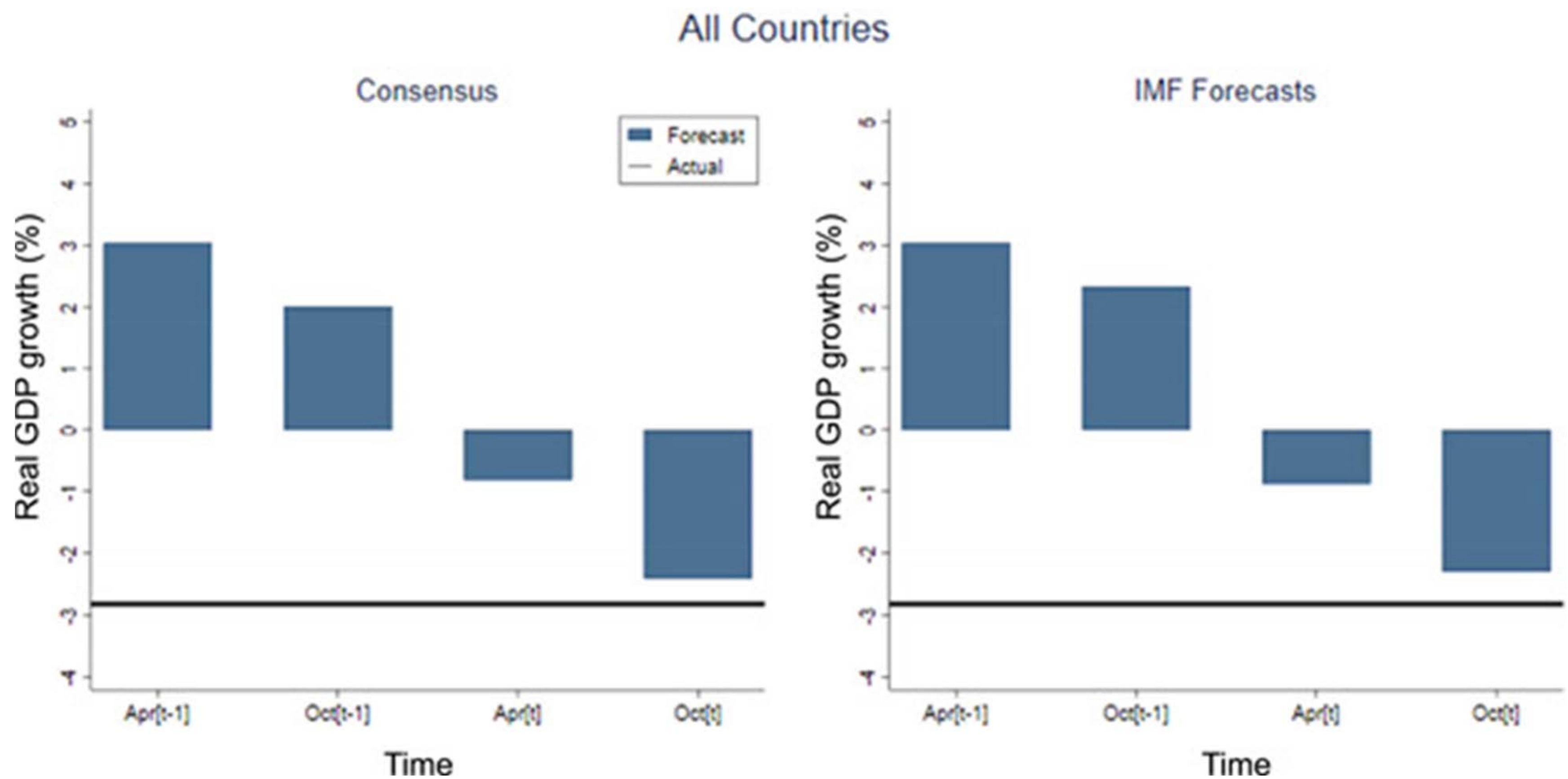
An, Jalles, Loungani (2018)

"We find that the ability to predict turning points is limited. While forecasts in recession years are revised each month, they do not capture the onset of recessions in a timely way and the extent of output decline during recessions is missed by a wide margin. This holds true for both private sector and official sector forecasts."

An, Jalles, Loungani

- What is rare is a recession that is forecast in advance.
- (Recession defined differently – negative output decline for year)
- Examine forecasts for 63 countries from 1992 to 2014
- It is only as the year is ending that forecasts catch up with reality
- F'casting performance of int'l organisations similar to surveys of private analysts

An, Jalles, Loungani



Evolution of forecasts in the run-up to recessions

An, Jalles, Loungani

TABLE 1 Recessions in actual and consensus forecasts

	Consensus forecasts: Apr [*t*-1]			Consensus forecasts: Oct [*t*]		
Actual	**Non-recession**	**Recession**	**Total**	**Non-recession**	**Recession**	**Total**
Non-recession	1145	8	1153	1120	33	1153
Recession	148	5	153	35	118	153
Total	1293	13	1306	1155	151	1306

Source: IMF World Economic Outlook and Consensus Forecasts.

AJL: Information Rigidity

- Forecasts look like they are over-smoothed
- Efficient forecasts (full information, RatEx) imply f'cast revisions should follow martingale

$$Rev_{it,h} = \alpha_h + \beta_h Rev_{it,h+k} + \mu_{i,h} + \varepsilon_{it,h} \quad (1)$$

- Under H_0: $\beta_h = 0$

AJL: Informational Rigidities

TABLE 5 Information rigidity—Nordhaus (1987)

Dependent variable:	**Consensus**			**IMF**		
Revision	**All**	**Advanced**	**Emerging**	**All**	**Advanced**	**Emerging**
Lagged revision	0.35***	0.29***	0.38***	0.21***	0.09*	0.27***
	(0.04)	(0.04)	(0.06)	(0.04)	(0.05)	(0.05)
Constant	0.06***	0.03*	0.07***	0.05**	0.02	0.05**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)
No. of obs.	1306	639	667	1306	639	667
R^2	0.18	0.12	0.21	0.08	0.01	0.13

Source: IMF World Economic Outlook, Consensus Forecasts, and authors' estimates.

Note: The dependent variable is the forecast revision made between Oct[t] and Apr[t]. The independent variables are the forecast revision made between Apr[t] and Oct[t-1], dummy variable for recession, and their interaction. Country fixed effects are included but omitted for reasons of parsimony. Robust standard errors are reported in parentheses. *, **, *** denote statistical significance at the 10, 5, and 1 percent levels, respectively

AJL: Info. Rigidities around Recessions

Is there serial correlation when recession is underway?

$$Rev_{it,h} = \alpha_h + \beta_h Rev_{it,h+k} + \gamma_h Rec_{it} + \theta_h Rev_{it,h+k}{}^{*}Rec_{it} + \mu_{i,h} + \varepsilon_{it,h} \quad (2)$$

TABLE 6 Information rigidity during recession episodes—Nordhaus (1987)

Dependent variable:	Consensus			IMF		
Revision	**All**	**Advanced**	**Emerging**	**All**	**Advanced**	**Emerging**
Lagged revision	0.35***	0.36***	0.33***	0.13**	0.22**	0.07
	(0.06)	(0.12)	(0.06)	(0.05)	(0.09)	(0.06)
Lagged Rev.*Rec.	−0.26*	−0.34	−0.29*	−0.11	−0.45**	0.00
	(0.14)	(0.25)	(0.16)	(0.12)	(0.21)	(0.12)
Recession	−1.59***	−1.10**	−2.61***	−1.60***	−1.46***	−2.44***
	(0.32)	(0.42)	(0.34)	(0.34)	(0.46)	(0.38)
Constant	0.15***	0.10***	0.21***	0.16***	0.12***	0.20***
	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
No. of obs.	1306	639	667	1306	639	667
R^2	0.25	0.17	0.35	0.15	0.12	0.27
p-Value	0.40	0.90	0.76	0.82	0.11	0.34

Source: IMF World Economic Outlook, Consensus Forecasts, and authors' estimates.
Note: The dependent variable is the forecast revision made between Oct[t] and Apr[t]. The independent variables are the forecast revision made between Apr[t] and Oct[t-1], dummy variable for recession, and their interaction. Country fixed effects are included but omitted for reasons of parsimony. Robust standard errors are reported in parentheses. *, **, *** denote statistical significance at the 10, 5, and 1 percent levels, respectively.

Surveys of Economists in 2019

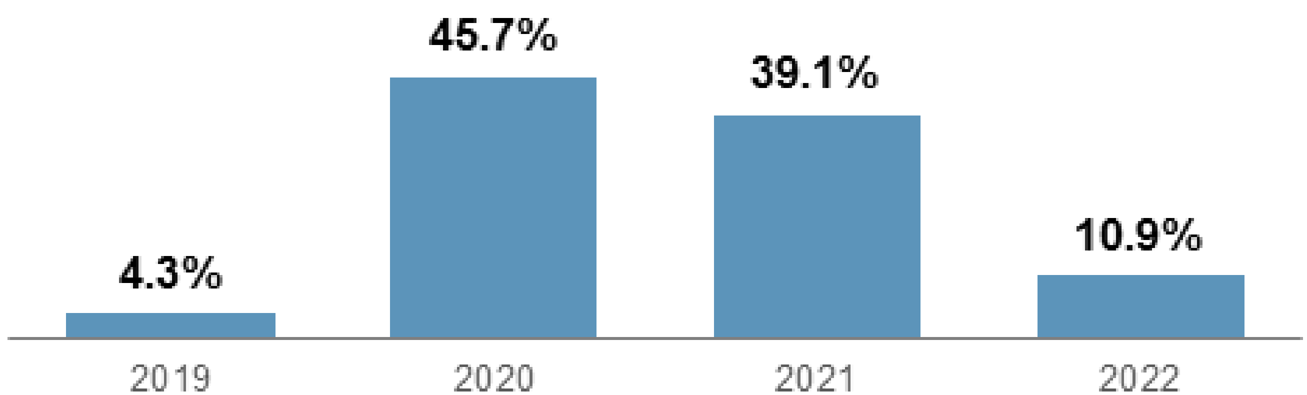
Normative Assessments

- Survey of Professional Forecasters (quarterly)

https://www.philadelphiafed.org/research-and-data/real-time-center/survey-of-professional-forecasters/

- WSJ February 2019 survey (monthly)

http://projects.wsj.com/econforecast/



WSJ February Survey:

- Tight f'cast in 2019
- 2020 has some negative growth
- 2021 is recovery
- Notice: Outliers (James Smith/Parsec)
- There are institutional incentives, that have ambiguous effects