Leading Indicators

- Good forecasting is often determined by finding **leading indicators** – variables which reduce the MSE of multi-step forecast errors
- Leading indicators move *in advance* of the forecast variable
- Economic theory can be a good guide to help select leading indicators

Business Cycle

- Measures of the business cycle include
  - GDP growth
  - Unemployment rates
  - Production growth rates
- All of these require leading indicators of the business cycle

Common Leading Indicators

- Housing starts
- Building permits
- Orders for consumer goods
- Term spread (interest rate spread)
  - Difference between Long Rate and Short Rate
- “Junk bond” or “High Yield” spread
  - Difference between rates on low-grade and high-grade bonds, typically corporate

U.S. Treasury Bonds

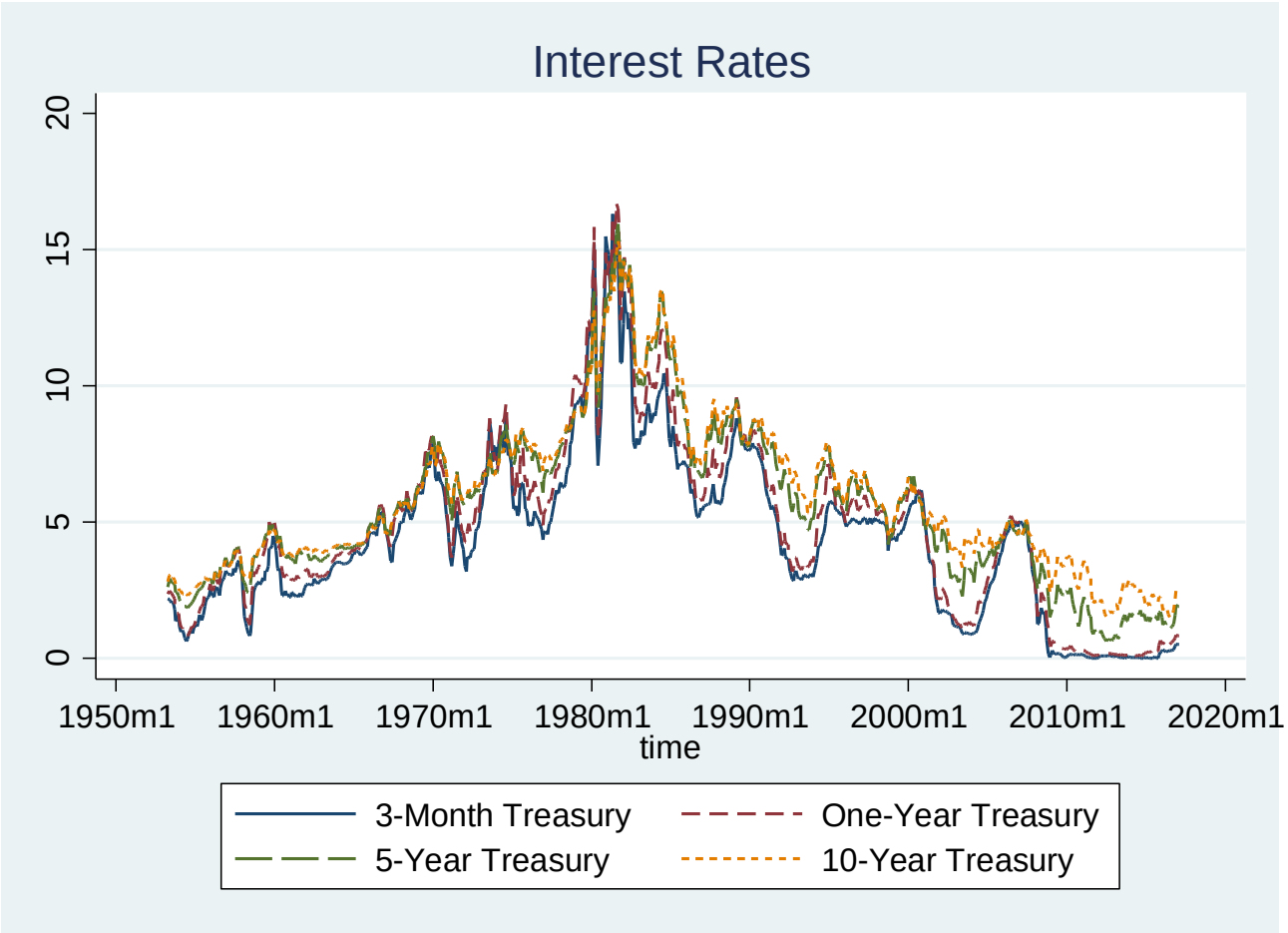
- Highly liquid market
- U.S. Treasury bonds generally viewed as having very low default risk
- Relative pure term structure analysis.

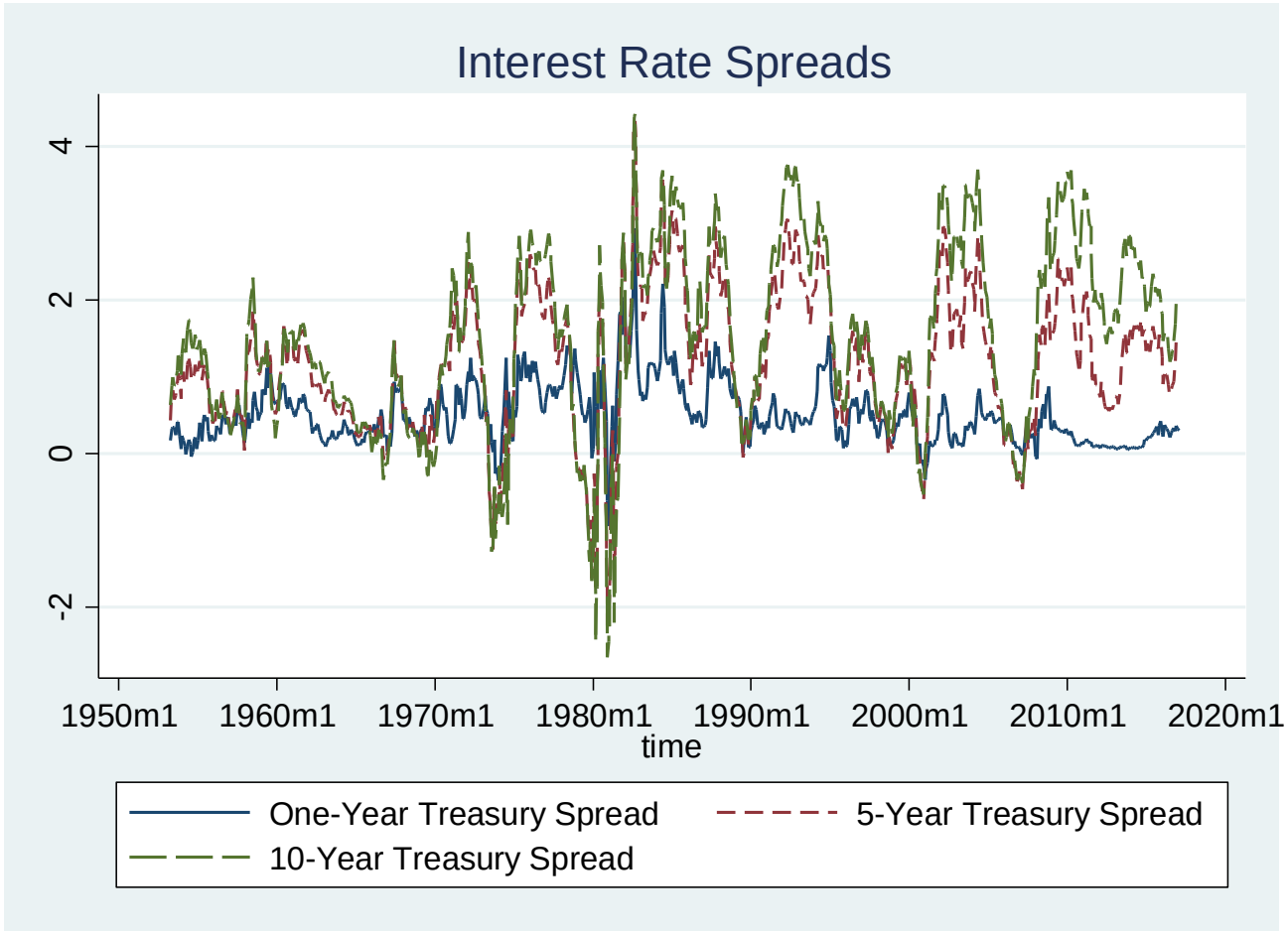
Term Spread

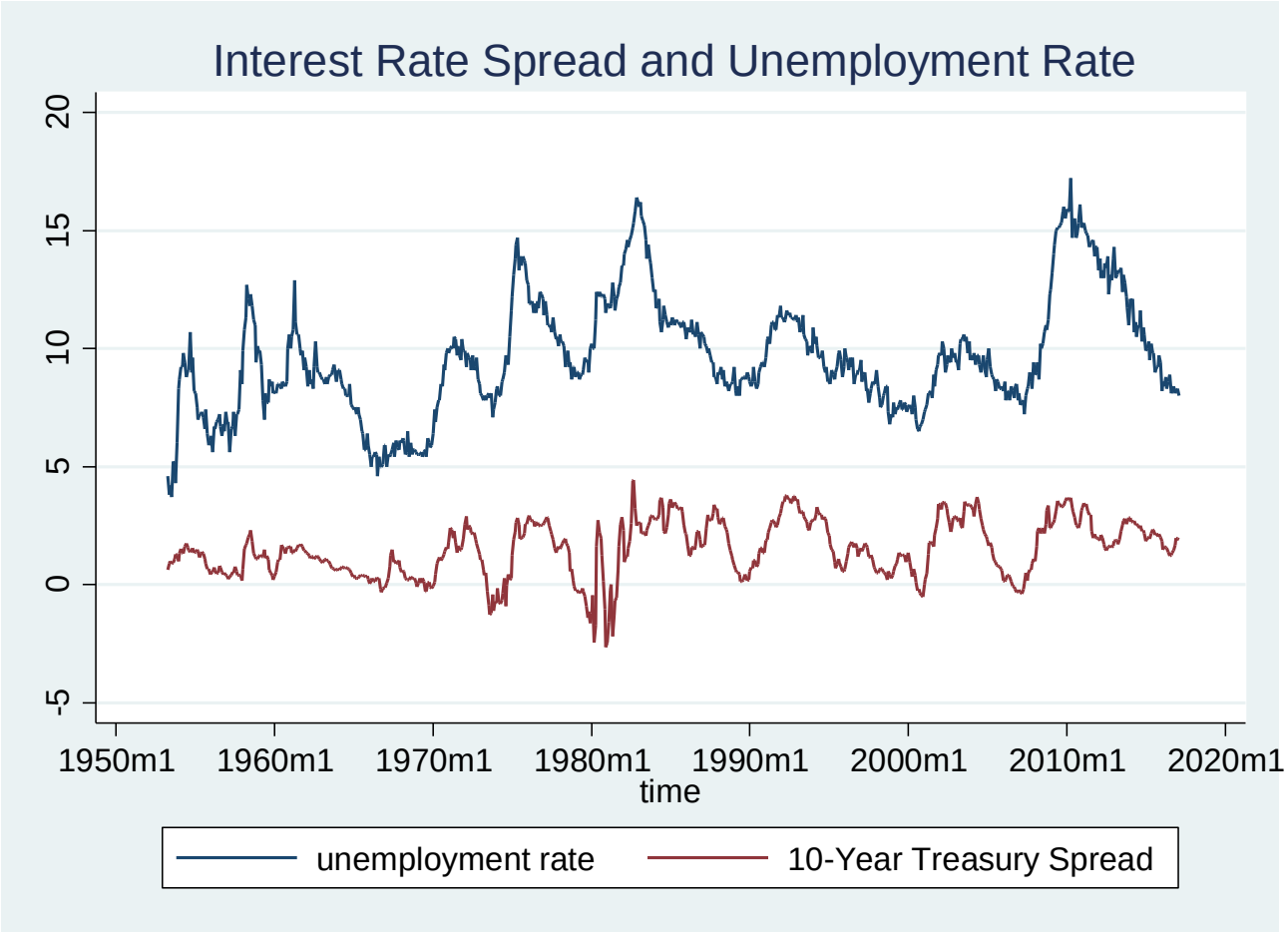
- Spread=Long-Short
- Term Structure theory
  - Long Rate is average of expected short rates
- Asset pricing theory
  - Long Bonds have greater risk
    - Small changes in rates imply large changes in bond price
    - Unless you hold bond until maturity the return is uncertain
  - Risky assets receive a **risk premium**: higher expected returns than low risk assets
- Together, long rates should be higher than short rates, but are forecasts of future short rates.
  - The difference – the spread – is a leading indicator

U.S. Treasury Term Structure February 2015

Term (months)	Rate	Spread (over 3 month)
3	0.02	
12	0.22	0.20
60	1.47	1.45
120	1.98	1.96


Interest Rates
20
15
10
5
0
1950m1
1960m1
1970m1
1980m1
1990m1
2000m1
2010m1
2020m1
time
3-Month Treasury
One-Year Treasury
5-Year Treasury
10-Year Treasury


Interest Rate Spreads
4
2
0
-2
1950m1
1960m1
1970m1
1980m1
1990m1
2000m1
2010m1
2020m1
time
One-Year Treasury Spread
5-Year Treasury Spread
10-Year Treasury Spread


Interest Rate Spread and Unemployment Rate
20
15
10
5
0
-5
1950m1
1960m1
1970m1
1980m1
1990m1
2000m1
2010m1
2020m1
time
unemployment rate
10-Year Treasury Spread

Term Inversion

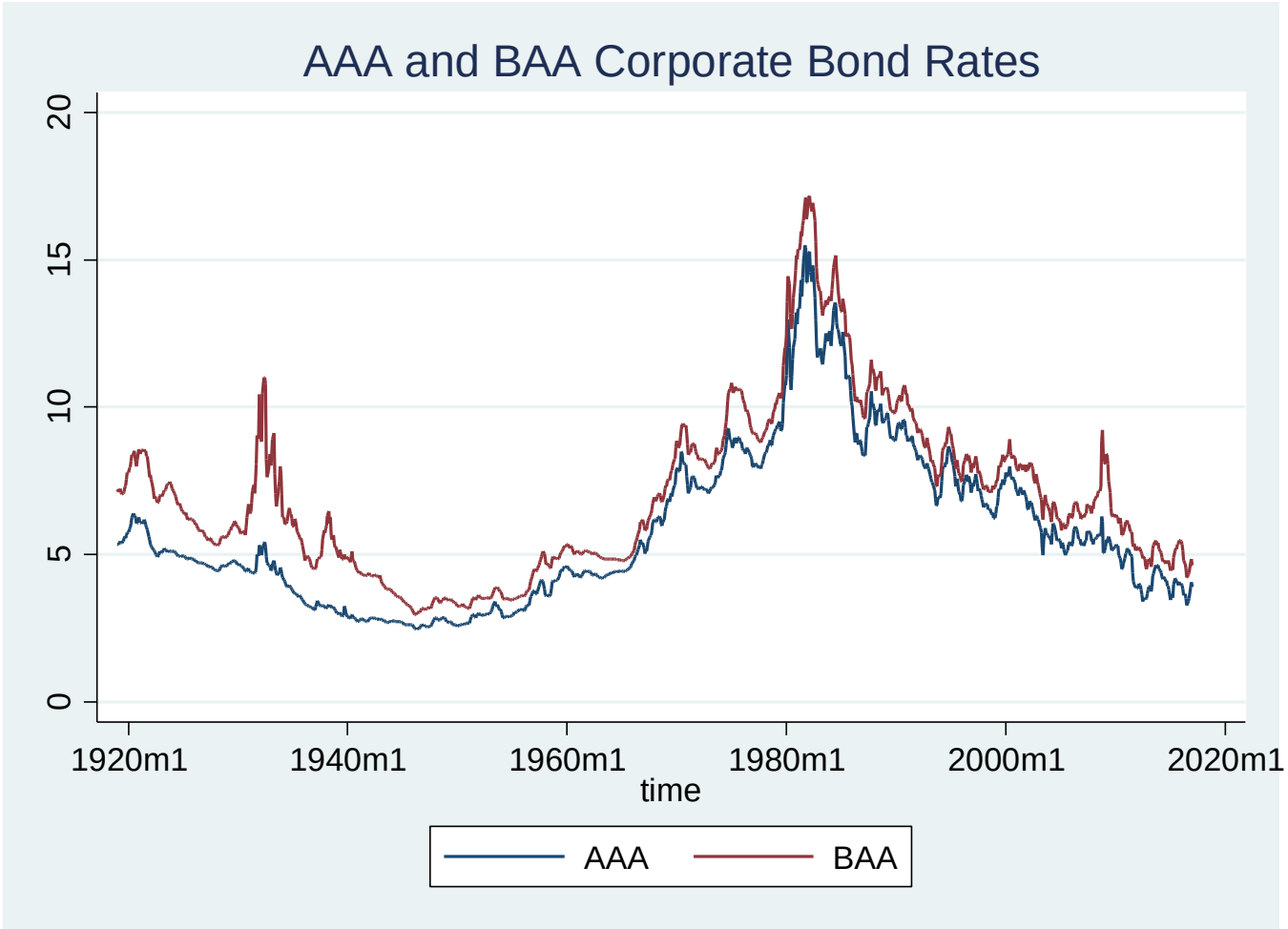
- Before many recessions, the long rate fell below the short rate
  - The spread became negative
  - The market prices a lower return on long term bonds than short term bonds
  - Called a “term structure inversion”
  - Signals that investors expect falling short rates
  - Negative spread predicts a future recession
    - An increase in the unemployment rate

Corporate/Municipal Bonds

- Major method for corporate financing
- A promise to pay in the future
- Corporations may default on bond payments in the event of bankruptcy
- This *default risk* requires a higher interest rate
  - Relative to low risk Treasury bonds
- Not all corporations have equal default risk
  - Different interest rates

Bond Ratings

- Credit rating agencies assess default risk of corporations and other borrowers, and give each a rating:
  - AAA, AA, A, BBB, BB, B, CCC, CC, C
  - Different agencies uses different labels
- Highest rated (AAA) are viewed as near-zero default risk
- Lower rating means higher default risk
- Grade BB and lower are called
  - “Below investor grade”
  - “High-yield”
  - “Junk”
- Low grade bonds earn higher interest rates
  - Higher average returns to investors
  - Higher average costs to corporations
  - Higher risk of default

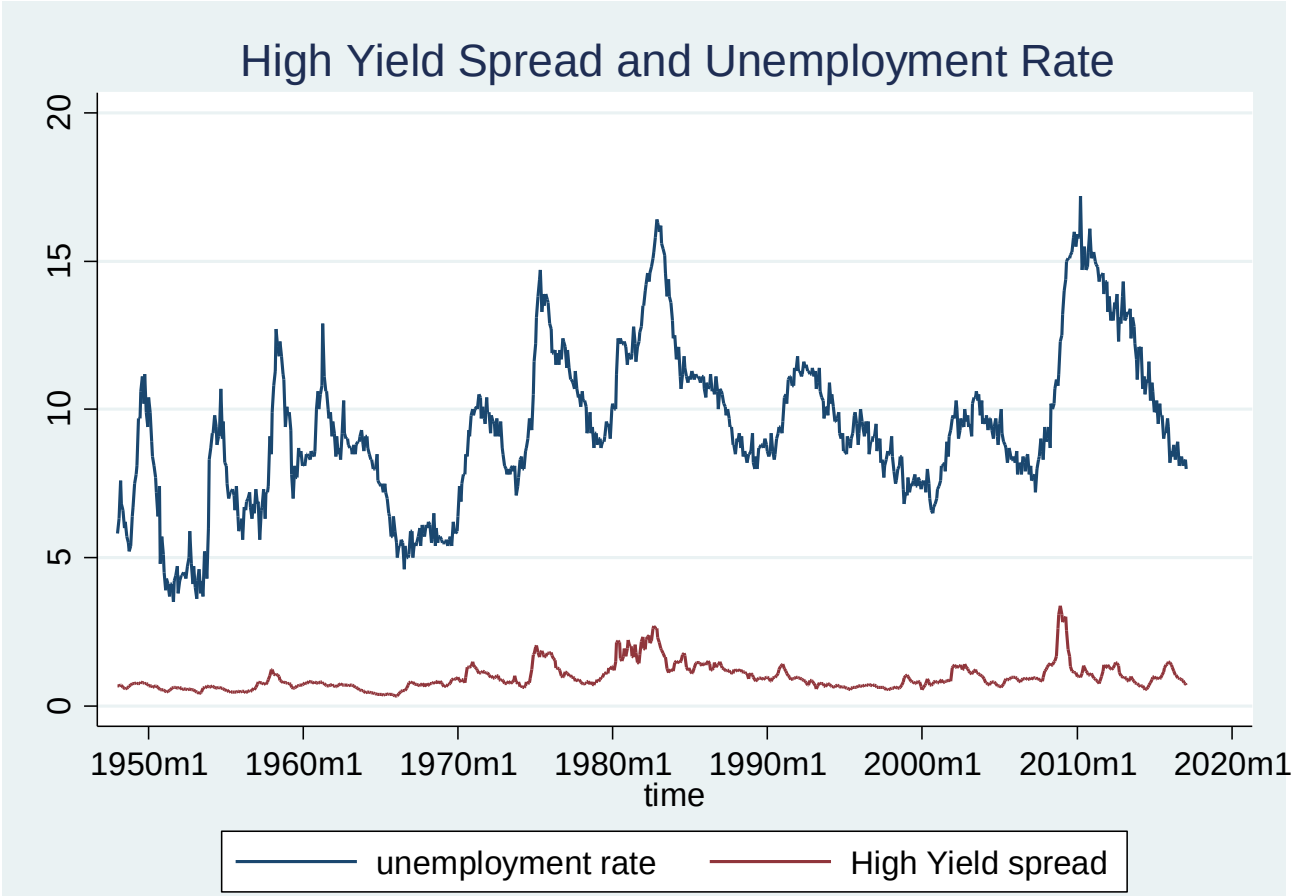

AAA and BAA Corporate Bond Rates
20
15
10
5
0
1920m1
1940m1
1960m1
1980m1
2000m1
2020m1
time
AAA
BAA

Junk Bond Spread as Leading Indicator

- Idea due to Mark Gertler and Cara Lown
  - Gertler is a 1973 UW grad, currently professor at NYU
- Increased junk bond spread is a financial symptom of the business cycle
- Useful leading indicator
- One measure = BAA - AAA

High-Yield (Junk) Bond Spread

- Corporate bankruptcies are more common in economic downturns (recessions). Thus bond defaults are more common in recessions.
- If investors perceive the risk of recession is high, they will view high-yield (junk) bonds as high risk, and only hold such bonds if their interest rate increases
- But, high grade and low grade bond rates move up and down together as interest rates rise and fall, so the level of high-yield bond rates by itself is not a good signal concerning recession risk
- Instead, the spread (difference) between the interest rates of low grade and high grade corporate bonds is a good signal
- Junk bond spread = Rate on Low-Grade – Rate on High-grade
- We use: Junk = BAA – AAA
- Theory: The junk spread will be positively related with economic downturns.


High Yield Spread and Unemployment Rate
20
15
10
5
0
1950m1
1960m1
1970m1
1980m1
1990m1
2000m1
2010m1
2020m1
time
unemployment rate
High Yield spread

Example: Leading Indicators for Unemployment Rate

- Interest Rate Term Spreads
  - spread1=t1year-t3month (1 year versus 3 month)
  - spread5=t5year-t3month (5 year versus 3 month)
  - spread10=t10year-t3month (10 year versus 3 month)
- High-Yield Bond Spread
  - corporate=AAA-BAA
- All available starting 1953m4

Leading Indicator Model

- Y = unemployment rate
  - p autoregressive lags
- X = interest rate spread
  - q distributed lags

$$y_t = \mu + \alpha_1 y_{t-1} + \cdots + \alpha_p y_{t-p} + \beta_1 x_{t-1} + \cdots + \beta_q x_{t-q} + e_t$$

Baseline

- To start, we need a baseline AR model for the unemployment rate
- Estimate AR models, order 1, 2, 4, 6, 8, 10, 12

$$y_t = \mu + \alpha_1 y_{t-1} + \cdots + \alpha_p y_{t-p} + e_t$$

AR Model Selection

- Restrict estimation to start 1954m4
- Lowest AIC attained by AR(6) or AR(8)
- Lowest BIC by AR(6)
  - Pick AR(6)

```
. estimates stats ar1 ar2 ar4 ar6 ar8 ar10 ar12

Akaike's information criterion and Bayesian information criterion
```

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
ar1	755	-1736.974	-571.9867	2	1147.973	1157.227
ar2	755	-1736.974	-548.3693	3	1102.739	1116.619
ar4	755	-1736.974	-545.8971	5	1101.794	1124.928
ar6	755	-1736.974	-537.6887	7	1089.377	1121.764
ar8	755	-1736.974	-535.5206	9	1089.041	1130.682
ar10	755	-1736.974	-533.643	11	1089.286	1140.18
ar12	755	-1736.974	-532.5933	13	1091.187	1151.334

AR(6) for UR

ur	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ur						
L1.	.7253743	.0451306	16.07	0.000	.6367765	.813972
L2.	.2848219	.0473967	6.01	0.000	.1917756	.3778682
L3.	.0574817	.0486302	1.18	0.238	-.0379862	.1529495
L4.	.0149055	.0519847	0.29	0.774	-.0871479	.1169588
L5.	.0152515	.0496768	0.31	0.759	-.0822711	.112774
L6.	-.1205517	.0432885	-2.78	0.005	-.2055332	-.0355702
_cons	.2174539	.0787788	2.76	0.006	.0628	.3721078

- Notice 1st, 2nd and 6th lags are largest in magnitude

Unemployment Rate on Interest Rate Spreads

- All regressions include 6 autoregressive lags
- Consider 1, 2, 4, 6 lags on interest rate spreads
- X = Long (10 year) minus Short (3 month) Rate

$$y_t = \mu + \alpha_1 y_{t-1} + \cdots + \alpha_p y_{t-p}$$
$$+ \beta_1 x_{t-1} + \cdots + \beta_q x_{t-q} + e_t$$

AIC comparisons

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
ar6	755	-1736.974	-537.6887	7	1089.377	1121.764
spread10L1	755	-1736.974	-537.333	8	1090.666	1127.68
spread10L2	755	-1736.974	-535.673	9	1089.346	1130.986
spread10L4	755	-1736.974	-532.8523	11	1087.705	1138.599
spread10L6	755	-1736.974	-532.4539	13	1090.908	1151.055

- All models include 6 autoregressive lags
- Lowest AIC with 4 lags of interest rate spread
- Lower AIC than AR(6) alone

10-year spread

```
. reg ur L(1/6).ur L(1/4).spread10 if time>=tm(1954m4), r
```

spread10						
L1.	.0800945	.0614558	1.30	0.193	-.0405529	.2007418
L2.	-.078494	.1161621	-0.68	0.499	-.3065384	.1495504
L3.	.0819467	.109832	0.75	0.456	-.1336707	.2975642
L4.	-.1189071	.0639921	-1.86	0.064	-.2445338	.0067195

- Include 4 autoregressive lags
- Alternating signs of roughly equal magnitude
  - Increase in spread predicts short-term changes in unemployment, long-term impact small (or zero)

5-year spread as regressor

- Now replace 10-year spread with 5-year spread
- Repeat analysis and compare
- Will select model with lowest AIC

5-Year (60 month) spread

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
ar6	755	-1736.974	-537.6887	7	1089.377	1121.764
spread5L1	755	-1736.974	-537.2727	8	1090.545	1127.559
spread5L2	755	-1736.974	-536.0751	9	1090.15	1131.791
spread5L4	755	-1736.974	-533.9958	11	1089.992	1140.886
spread5L6	755	-1736.974	-533.8954	13	1093.791	1153.938

- No model better than the AR(6)

1-year spread as regressor

- Now try 1-year spread
- Repeat analysis and compare
- Will select model with lowest AIC

1-year (12 month) spread

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
ar6	755	-1736.974	-537.6887	7	1089.377	1121.764
spread1L1	755	-1736.974	-537.5543	8	1091.109	1128.122
spread1L2	755	-1736.974	-537.4321	9	1092.864	1134.505
spread1L4	755	-1736.974	-537.2347	11	1096.469	1147.363
spread1L6	755	-1736.974	-535.833	13	1097.666	1157.813

- No model better than AR(6)
- 10-year spread preferred regressor among the three considered

High yield spread as regressor

- Now try high-yield spread (AAA-BAA)
- Repeat analysis and compare
- Will select model with lowest AIC

High Yield Spread

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
ar6	755	-1736.974	-537.6887	7	1089.377	1121.764
spread10L4	755	-1736.974	-532.8523	11	1087.705	1138.599
corporate1	755	-1736.974	-515.7028	8	1047.406	1084.419
corporate2	755	-1736.974	-515.1791	9	1048.358	1089.999
corporate4	755	-1736.974	-514.7457	11	1051.491	1102.385
corporate6	755	-1736.974	-513.5742	13	1053.148	1113.296

- Considerably Lower AIC obtained with high-yield spread
  - AR(6): AIC = 1089.4
  - With 10-year spread: AIC = 1087.7
  - With high-yield spread: AIC = 1047.4
  - Lowest AIC with 1 lag

High Yield spread

```
. reg ur L(1/6).ur L.corporate if time>=tm(1954m4), r
```

corporate						
L1.	.3488216	.0550661	6.33	0.000	.240719	.4569243

- Includes 6 autoregressive lags
- Coefficient on high-yield spread positive
  - Increase in high-yield spread predicts increase in unemployment rate

Combined Spreads

- Combined model:
  - AR(6) in unemployment rate rates
  - 1 lags of corporate spread (BAA over AAA)
  - 1, 2, 4 or 6 lags of Spread10 (ten year over 3 month)
- No combined model does better than with just corporate spread
- Next best is model with 4 lags of Spread10
  - For comparison we show that model

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
ar6	755	-1736.974	-537.6887	7	1089.377	1121.764
spread10L4	755	-1736.974	-532.8523	11	1087.705	1138.599
corporate1	755	-1736.974	-515.7028	8	1047.406	1084.419
combine1	755	-1736.974	-515.6556	9	1049.311	1090.952
combine2	755	-1736.974	-514.7133	10	1049.427	1095.694
combine4	755	-1736.974	-512.1622	12	1048.324	1103.845
combine6	755	-1736.974	-512.0588	14	1052.118	1116.892

Coefficients on Combined model

ur	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ur						
L1.	.655063	.0445345	14.71	0.000	.5676344	.7424915
L2.	.2601412	.0439952	5.91	0.000	.1737714	.346511
L3.	.0590838	.0469972	1.26	0.209	-.0331794	.151347
L4.	.0271221	.0504369	0.54	0.591	-.0718938	.126138
L5.	.0369146	.0485258	0.76	0.447	-.0583494	.1321786
L6.	-.0902083	.0431178	-2.09	0.037	-.1748555	-.0055611
spread10						
L1.	.0657165	.0577627	1.14	0.256	-.0476811	.1791141
L2.	-.0544635	.1101448	-0.49	0.621	-.2706956	.1617686
L3.	.0763093	.1031593	0.74	0.460	-.126209	.2788276
L4.	-.1102021	.0590964	-1.86	0.063	-.2262179	.0058138
corporate						
L1.	.3387935	.0544674	6.22	0.000	.2318653	.4457217

12-step Forecast Regression

```
. reg ur L(12/16).ur L12.corporate L(12/15).spread10
```

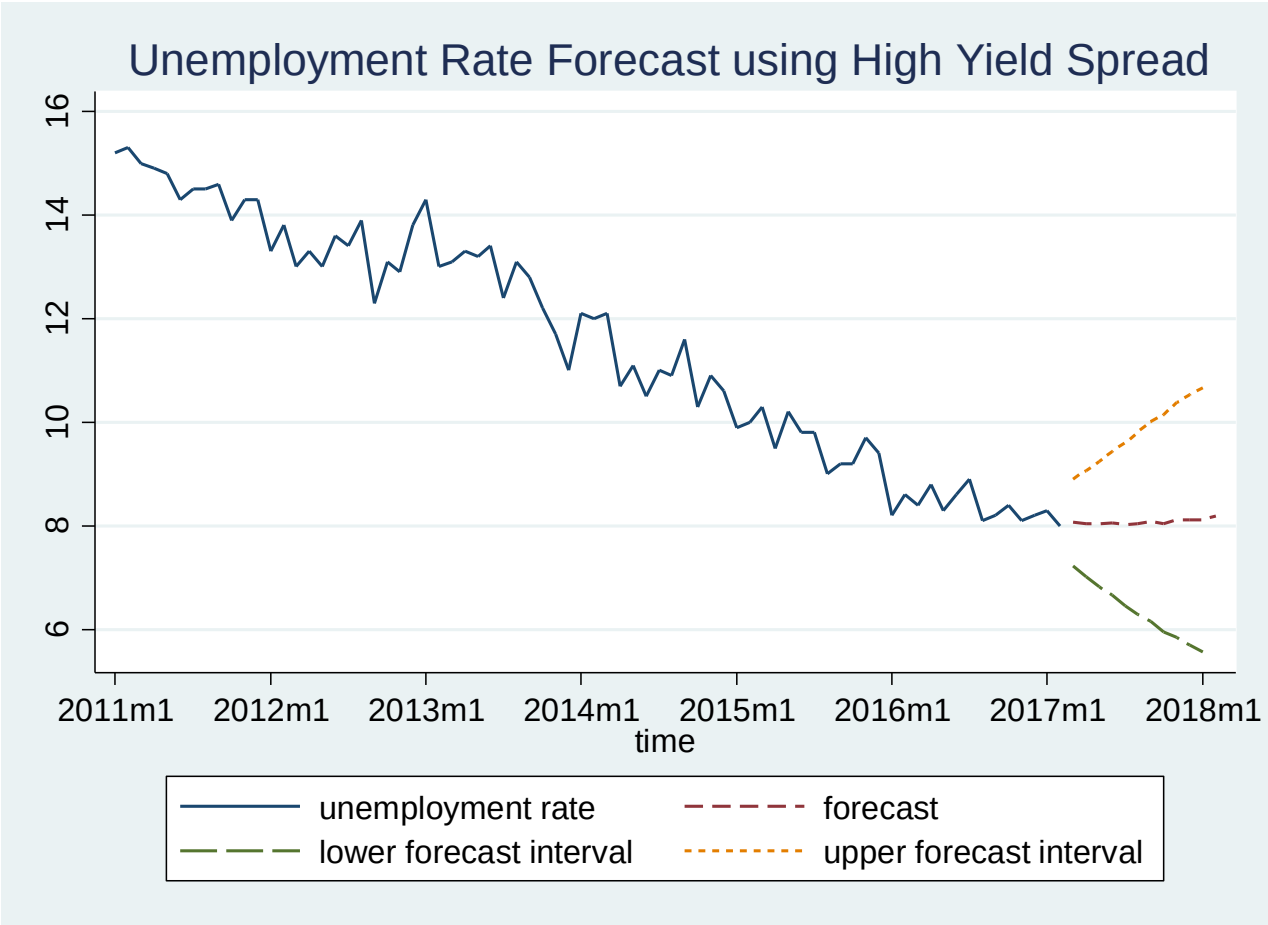
ur	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ur						
L12.	.5719	.1058251	5.40	0.000	.3641472	.7796527
L13.	.1844392	.1289212	1.43	0.153	-.0686552	.4375336
L14.	-.0816686	.1316008	-0.62	0.535	-.3400234	.1766861
L15.	-.0531393	.1288693	-0.41	0.680	-.3061318	.1998531
L16.	-.0006827	.1042727	-0.01	0.995	-.2053878	.2040223
corporate						
L12.	1.869379	.1556841	12.01	0.000	1.563745	2.175013
spread10						
L12.	-.0078499	.1662905	-0.05	0.962	-.3343065	.3186067
L13.	-.0655583	.2607342	-0.25	0.802	-.5774241	.4463075
L14.	-.0218886	.2600778	-0.08	0.933	-.5324657	.4886885
L15.	-.3332782	.1652764	-2.02	0.044	-.6577439	-.0088124

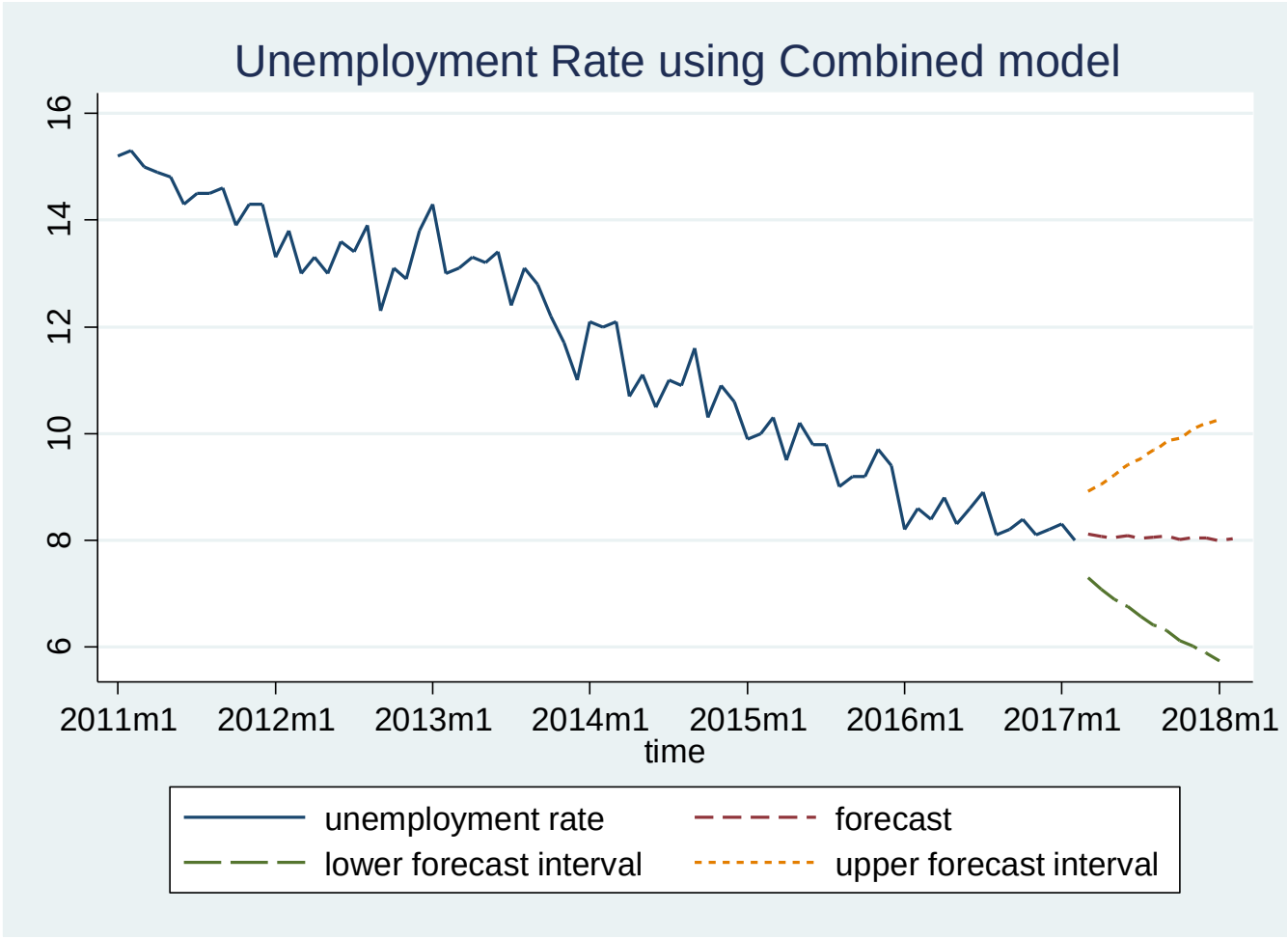
Forecast Inputs (March)

- Current Unemployment rate= 8.0%
- corporate spread= 0.7%
- 10-year spread = 1.9%

```
reg ur L(1/6).ur L(1/4).spread10 L.corporate
predict y1
predict sf1,stdf
gen y1L=y1-1.645*sf1
gen y1U=y1+1.645*sf1

reg ur L(2/7).ur L(2/5).spread10 L2.corporate
predict y2
predict sf2,stdf
gen y2L=y2-1.645*sf2
gen y2U=y2+1.645*sf2
…
egen p=rowfirst(y1 y2 y3 y4 y5 y6 y7 y8 y9 y10 y11 y12) if time>=tm(2017m3)
egen pL=rowfirst(y1L y2L y3L y4L y5L y6L y7L y8L y9L y10L y11L y12L) if time>=tm(2017m3)
egen pU=rowfirst(y1U y2U y3U y4U y5U y6U y7U y8U y9U y10U y11U y12U) if
time>=tm(2017m3)
label variable p "forecast"
label variable pL "lower forecast interval"
label variable pU "upper forecast interval"
tsline ur p pL pU if time>=tm(2011m1), title(Unemployment Rate Forecast using High Yield
Spread) lpattern (solid dash longdash shortdash)
```


Unemployment Rate Forecast using High Yield Spread
16
14
12
10
8
6
2011m1
2012m1
2013m1
2014m1
2015m1
2016m1
2017m1
2018m1
time
unemployment rate
forecast
lower forecast interval
upper forecast interval


Unemployment Rate using Combined model
16
14
12
10
8
6
2011m1
2012m1
2013m1
2014m1
2015m1
2016m1
2017m1
2018m1
time
unemployment rate
forecast
lower forecast interval
upper forecast interval

Assignments

- Diebold, Chapter 15
- Problem Set #9
  - Due Tuesday (4/11)
- Read Chapter 9 from *The Signal and the Noise*
  - Reading Reflection
  - Thursday (4/6)