Economics

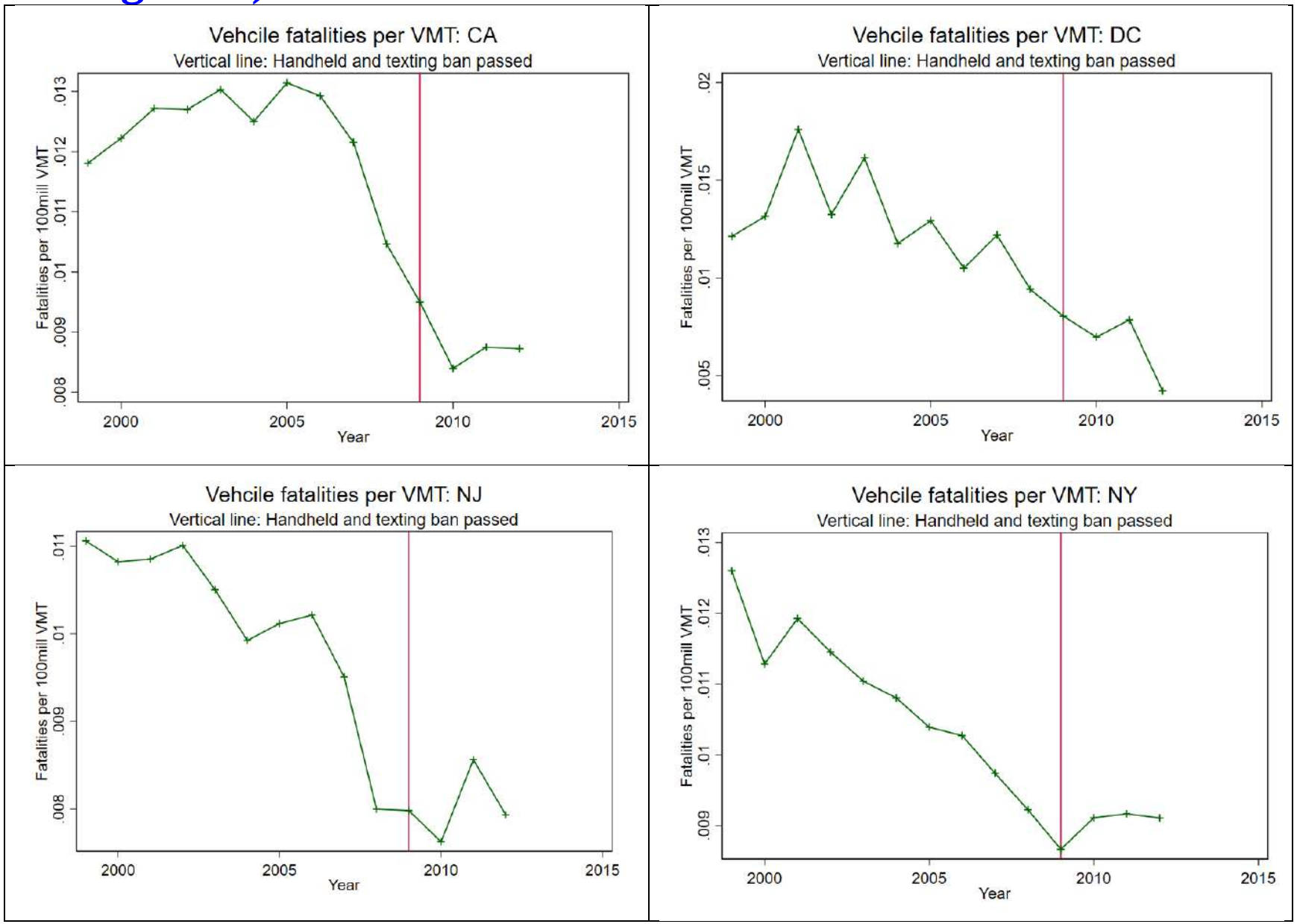
Lecture #22

Forecasting II

Outline (Forecasting I and II)

1. Intro: Economic time series data & econometric issues
2. Lags, differences, autocorrelation, and stationarity
3. Autoregressive (AR) models
4. Autoregressive distributed lag (ADL) models & Granger Causality tests
5. Lag length selection using information criteria
6. Stationarity, nonstationarity, breaks, and model stability
7. Forecast intervals and fan charts

PS 8 – selected state time series plots (states that passed HH & texting bans)



PS 8 – selected regressions

```
. xtreg lvfrtot hhall textall hh_text $cvars1 i.year, fe vce(cluster state_id)

Fixed-effects (within) regression               Number of obs      =       686
Group variable: state_id                        Number of groups   =        49

R-sq:                                           Obs per group:
     within  = 0.7546                                         min =        14
     between = 0.1243                                         avg =      14.0
     overall = 0.1479                                         max =        14

                                                F(21,48)           =     59.14
corr(u_i, Xb)  = -0.8530                        Prob > F           =    0.0000

                                 (Std. Err. adjusted for 49 clusters in state_id)
------------------------------------------------------------------------------
             |               Robust
     lvfrtot |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       hhall |  -.0428101   .0436995    -0.98   0.332    -.1306738    .0450535
     textall |   .0070935   .0251751     0.28   0.779    -.0435244    .0577113
     hh_text |  -.0235807   .0472056    -0.50   0.620     -.118494    .0713326
   lvmttotpc |   .5220621   .3972668     1.31   0.195    -.2766962     1.32082
   lvmturbpc |   .0002042   .1103617     0.00   0.999    -.2216928    .2221012
      unrate |  -.0234727   .0085182    -2.76   0.008    -.0405997   -.0063457
        lpop |  -.6976288   .2114066    -3.30   0.002     -1.12269   -.2725673
     precipm |  -.0494832   .0245379    -2.02   0.049      -.09882   -.0001463
```

```
            |
       year |
       2000 |  -.0178226    .015817    -1.13   0.265    -.0496248    .0139797
       2001 |   .0061997   .0158434     0.39   0.697    -.0256556    .0380549
       2002 |   .0358903   .0176816     2.03   0.048     .0003391    .0714415
       2003 |   .0444039   .0202771     2.19   0.033     .0036341    .0851737
       2004 |   .0201023   .0263416     0.76   0.449    -.0328611    .0730657
       2005 |   .0183229   .0236518     0.77   0.442    -.0292323    .0658782
       2006 |  -.0096639   .0294972    -0.33   0.745    -.0689721    .0496442
       2007 |  -.0646618   .0248846    -2.60   0.012    -.1146957    -.014628
       2008 |  -.1158773   .0301706    -3.84   0.000    -.1765394   -.0552153
       2009 |  -.1095308   .0527152    -2.08   0.043    -.2155218   -.0035399
       2010 |  -.1386848   .0543131    -2.55   0.014    -.2478886    -.029481
       2011 |  -.1775412   .0552717    -3.21   0.002    -.2886724     -.06641
       2012 |  -.1773381   .0572856    -3.10   0.003    -.2925185   -.0621576
            |
      _cons |   13.50535   2.577607     5.24   0.000     8.322719    18.68797
------------+----------------------------------------------------------------
    sigma_u |  .72681311
    sigma_e |  .09024689
        rho |  .98481642   (fraction of variance due to u_i)
------------------------------------------------------------------------------

.   test hhall textall

 ( 1)  hhall = 0
 ( 2)  textall = 0

       F(  2,    48) =    0.48
            Prob > F =    0.6217
```

```
.   test hhall textall hh_text

 ( 1)  hhall = 0
 ( 2)  textall = 0
 ( 3)  hh_text = 0

       F(  3,    48) =    0.71
            Prob > F =    0.5527

.   lincom 1*hhall + 1*textall + 1*hh_text

 ( 1)  hhall + textall + hh_text = 0

------------------------------------------------------------------------------
     lvfrtot |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         (1) |  -.0592973   .0414473    -1.43   0.159    -.1426328    .0240381
------------------------------------------------------------------------------
```

```
. xtreg lvfrtot L(0/1).hhall L(0/1).textall L(0/1).hh_text L(0/1).alljr
$cvars1 i.year,
> fe vce(cluster state_id)

Fixed-effects (within) regression               Number of obs     =       637
Group variable: state_id                        Number of groups  =        49

R-sq:                                           Obs per group:
     within  = 0.7602                                         min =        13
     between = 0.1346                                         avg =      13.0
     overall = 0.1524                                         max =        13

                                                F(25,48)          =     74.57
corr(u_i, Xb)  = -0.8870                        Prob > F          =    0.0000

                              (Std. Err. adjusted for 49 clusters in state_id)
------------------------------------------------------------------------------
             |               Robust
     lvfrtot |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       hhall |
         --. |  -.0632169   .0315942    -2.00   0.051    -.1267413    .0003075
         L1. |    .012926    .056411     0.23   0.820     -.100496     .126348
             |
     textall |
         --. |   .0353531   .0246586     1.43   0.158    -.0142262    .0849325
         L1. |  -.0491441   .0347472    -1.41   0.164     -.119008    .0207199
             |
     hh_text |
         --. |   .0133872   .0438997     0.30   0.762     -.074879    .1016534
```

```
          L1. |  -.0405331   .1024634    -0.40   0.694    -.2465496    .1654834
              |
       alljr |
          --. |    .013376   .0217748     0.61   0.542    -.0304052    .0571573
          L1. |  -.0170445   .0215304    -0.79   0.432    -.0603342    .0262452
              |
     lvmttotpc |   .6677962    .414748     1.61   0.114    -.1661107    1.501703
     lvmturbpc |  -.0352352   .1183281    -0.30   0.767    -.2731497    .2026793
        unrate |  -.0242243   .0089776    -2.70   0.010    -.0422749   -.0061737
          lpop |  -.7895803   .2129782    -3.71   0.001    -1.217802    -.361359
       precipm |  -.0453472   .0265883    -1.71   0.095    -.0988066    .0081123
              |
          year |
          2001 |   .0235622   .0131591     1.79   0.080    -.0028961    .0500204
          2002 |   .0540475   .0184452     2.93   0.005      .016961     .091134
          2003 |   .0634384    .020561     3.09   0.003     .0220978     .104779
          2004 |   .0389619    .030236     1.29   0.204    -.0218316    .0997555
          2005 |   .0398468   .0276706     1.44   0.156    -.0157886    .0954822
          2006 |   .0127978   .0312404     0.41   0.684    -.0500152    .0756107
          2007 |  -.0396245   .0246974    -1.60   0.115     -.089282    .0100329
          2008 |  -.0889544   .0362502    -2.45   0.018    -.1618402   -.0160686
          2009 |  -.0795439   .0635476    -1.25   0.217     -.207315    .0482271
          2010 |  -.1082896   .0648636    -1.67   0.102    -.2387066    .0221274
          2011 |  -.1326788   .0666262    -1.99   0.052    -.2666398    .0012822
          2012 |  -.1279961   .0679146    -1.88   0.066    -.2645475    .0085552
              |
         _cons |    15.3545     2.8091     5.47   0.000     9.706422    21.00257
--------------+----------------------------------------------------------------
       sigma_u |  .82072289
       sigma_e |  .08935331
```

```
         rho |  .98828585   (fraction of variance due to u_i)
------------------------------------------------------------------------------

.   test hhall textall

 ( 1)  hhall = 0
 ( 2)  textall = 0

       F(  2,    48) =    2.46
            Prob > F =    0.0958

.   test hhall textall hh_text

 ( 1)  hhall = 0
 ( 2)  textall = 0
 ( 3)  hh_text = 0

       F(  3,    48) =    1.68
            Prob > F =    0.1848
```

```
. xtreg lvfrtot L.hhall L.textall L.hh_text L.alljr $cvars1 i.year, fe
vce(cluster state
> _id)

Fixed-effects (within) regression               Number of obs     =         637
Group variable: state_id                        Number of groups  =          49

R-sq:                                           Obs per group:
     within  = 0.7588                                         min =          13
     between = 0.1334                                         avg =        13.0
     overall = 0.1496                                         max =          13

                                                F(21,48)          =       59.69
corr(u_i, Xb)  = -0.8959                        Prob > F          =      0.0000

                              (Std. Err. adjusted for 49 clusters in state_id)
------------------------------------------------------------------------------
             |               Robust
     lvfrtot |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       hhall |
         L1. |  -.0362862   .0532782    -0.68   0.499    -.1434091    .0708368
             |
     textall |
         L1. |  -.0220725   .0280311    -0.79   0.435    -.0784328    .0342878
             |
     hh_text |
         L1. |  -.0372138   .0736555    -0.51   0.616    -.1853081    .1108804
             |
       alljr |
```

```
          L1. |  -.0034252   .0181765    -0.19   0.851    -.0399715    .0331211
              |
    lvmttotpc |   .6841629   .4261656     1.61   0.115    -.1727005    1.541026
    lvmturbpc |  -.0429463     .12033    -0.36   0.723     -.284886    .1989934
       unrate |  -.0250812   .0092374    -2.72   0.009    -.0436542   -.0065083
         lpop |  -.8232446   .2077243    -3.96   0.000    -1.240902    -.405587
      precipm |  -.0466779   .0253272    -1.84   0.072    -.0976016    .0042458
              |
         year |
         2001 |   .0241009   .0132384     1.82   0.075    -.0025167    .0507186
         2002 |   .0545414   .0186616     2.92   0.005     .0170197    .0920632
         2003 |   .0656634   .0209171     3.14   0.003     .0236068    .1077201
         2004 |   .0408722   .0306598     1.33   0.189    -.0207735    .1025179
         2005 |   .0415767   .0281596     1.48   0.146    -.0150419    .0981953
         2006 |   .0150995   .0316307     0.48   0.635    -.0484983    .0786974
         2007 |  -.0368568   .0248307    -1.48   0.144    -.0867822    .0130687
         2008 |  -.0828747   .0364328    -2.27   0.027    -.1561278   -.0096217
         2009 |  -.0682057   .0649987    -1.05   0.299    -.1988942    .0624829
         2010 |  -.0876013   .0666542    -1.31   0.195    -.2216186    .0464159
         2011 |  -.1157507   .0687188    -1.68   0.099    -.2539191    .0224177
         2012 |  -.1132939   .0693709    -1.63   0.109    -.2527733    .0261856
              |
        _cons |   15.90094   2.743076     5.80   0.000     10.38562    21.41627
--------------+----------------------------------------------------------------
      sigma_u |   .8546306
      sigma_e |  .08931341
          rho |  .98919663   (fraction of variance due to u_i)
------------------------------------------------------------------------------

.   test L.hhall L.textall
```

```
 ( 1)  L.hhall = 0
 ( 2)  L.textall = 0

       F(  2,    48) =    0.64
            Prob > F =    0.5341

.   test L.hhall L.textall L.hh_text

 ( 1)  L.hhall = 0
 ( 2)  L.textall = 0
 ( 3)  L.hh_text = 0

       F(  3,    48) =    1.27
            Prob > F =    0.2940

.   lincom L.hhall + L.textall + L.hh_text + L.alljr

 ( 1)  L.hhall + L.textall + L.hh_text + L.alljr = 0

------------------------------------------------------------------------------
     lvfrtot |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         (1) |  -.0989977   .0601748    -1.65   0.106    -.2199872    .0219917
------------------------------------------------------------------------------
```

```
. xtreg lvfrbelow08 L.hhall L.textall L.hh_text $cvars1 i.year, fe vce(cluster
state_id)

Fixed-effects (within) regression               Number of obs     =        637
Group variable: state_id                        Number of groups  =         49

R-sq:                                           Obs per group:
     within  = 0.7321                                         min =         13
     between = 0.0962                                         avg =       13.0
     overall = 0.1076                                         max =         13

                                                F(20,48)          =      99.52
corr(u_i, Xb)  = -0.9229                        Prob > F          =     0.0000

                              (Std. Err. adjusted for 49 clusters in state_id)
------------------------------------------------------------------------------
             |               Robust
 lvfrbelow08 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       hhall |
         L1. |  -.0662835   .0594883    -1.11   0.271    -.1858926    .0533257
             |
     textall |
         L1. |  -.0390293   .0276785    -1.41   0.165    -.0946808    .0166221
             |
     hh_text |
         L1. |   -.006826    .066891    -0.10   0.919    -.1413194    .1276675
             |
   lvmttotpc |   .6569602   .3999299     1.64   0.107    -.1471526    1.461073
   lvmturbpc |  -.0672488    .112906    -0.60   0.554    -.2942616    .1597641
```

```
      unrate |  -.0216938   .0086544    -2.51   0.016    -.0390947   -.0042929
        lpop |  -.9659531   .2175838    -4.44   0.000    -1.403435   -.5284716
     precipm |  -.0309324   .0242571    -1.28   0.208    -.0797046    .0178398
             |
        year |
        2001 |   .0202515   .0126538     1.60   0.116    -.0051908    .0456937
        2002 |   .0551645   .0204093     2.70   0.009     .0141288    .0962002
        2003 |   .0726429   .0197473     3.68   0.001     .0329383    .1123475
        2004 |    .064471   .0305532     2.11   0.040     .0030396    .1259024
        2005 |    .058691   .0263509     2.23   0.031      .005709     .111673
        2006 |   .0351487   .0307565     1.14   0.259    -.0266914    .0969888
        2007 |  -.0228493   .0247515    -0.92   0.361    -.0726156    .0269169
        2008 |  -.0585638   .0351558    -1.67   0.102    -.1292492    .0121217
        2009 |  -.0673004   .0631247    -1.07   0.292    -.1942212    .0596204
        2010 |  -.0673523   .0601177    -1.12   0.268    -.1882271    .0535225
        2011 |  -.0844999   .0627228    -1.35   0.184    -.2106126    .0416127
        2012 |  -.0753889    .064984    -1.16   0.252    -.2060479    .0552702
             |
       _cons |   17.38018   2.998853     5.80   0.000     11.35058    23.40978
-------------+----------------------------------------------------------------
     sigma_u |  1.0105546
     sigma_e |   .0922151
         rho |  .99174184   (fraction of variance due to u_i)
------------------------------------------------------------------------------

.   test L.hhall L.textall

 ( 1)  L.hhall = 0
 ( 2)  L.textall = 0
```

```
       F(  2,    48) =    1.75
            Prob > F =    0.1846

.   test L.hhall L.textall L.hh_text

 ( 1)  L.hhall = 0
 ( 2)  L.textall = 0
 ( 3)  L.hh_text = 0

       F(  3,    48) =    3.10
            Prob > F =    0.0352

.   lincom 1*L.hhall + 1*L.textall + 1*L.hh_text

 ( 1)  L.hhall + L.textall + L.hh_text = 0

------------------------------------------------------------------------------
 lvfrbelow08 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         (1) |  -.1121388    .045268    -2.48   0.017    -.2031561   -.0211214
------------------------------------------------------------------------------
```

Summary statistics (selected)

Variable	Obs	Mean	Std. Dev.	Min	Max
year	686	2005.5	4.03407	1999	2012
state_id	686	26.77551	14.4727	1	51
fatalacc	686	723.8907	711.3	14	3849
fatalsabo~08	686	249.0554	255.3927	4	1499
fatalsbel~08	686	549.691	541.3672	11	3068
fatalstot	686	798.7464	788.4438	15	4327
vfrtot	686	1.511268	.6151643	.2368071	3.919917
vfrabove08	686	.4801786	.22839	.0631486	1.41993
vfrbelow08	686	1.03109	.4120414	.1736585	2.648029

Confidence intervals for combined effects, first lag only specifications:

(a) Total VFR

lvfrtot	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
(1)	-.0989977	.0601748	-1.65	0.106	-.2199872	.0219917

In lives per state: (-160, 14)

(b) VFR with BAC < .08

lvfrbelow08	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
(1)	-.1121388	.045268	-2.48	0.017	-.2031561	-.0211214

In lives per state: (-117, -12)

BIC in AR(*p*)

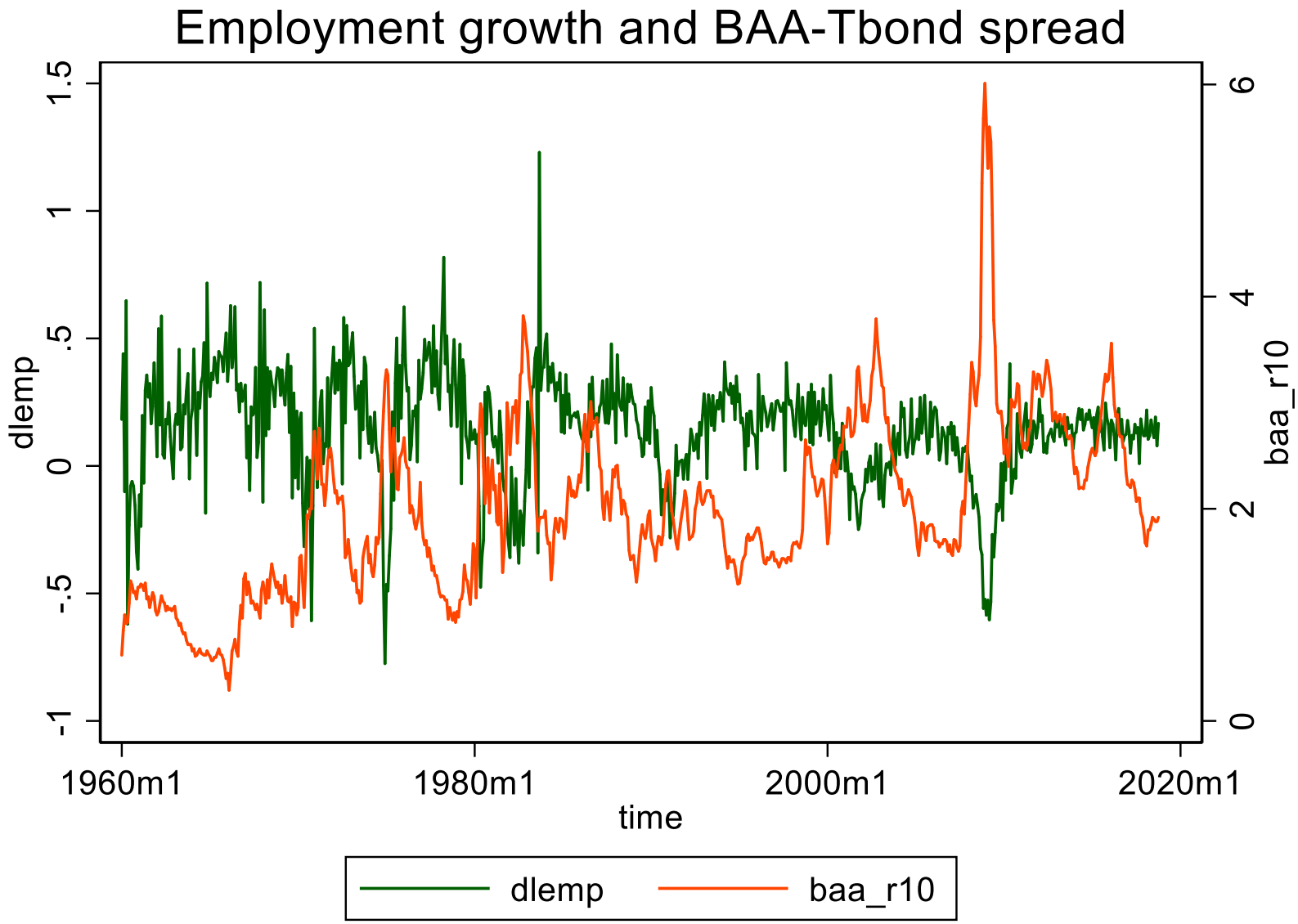
Simple approach in STATA

```
. varsoc dlemp if tin(1962m1,$tnm1), maxlag(6)

  Selection-order criteria
  Sample:  1962m1 - 2016m9                        Number of obs      =       657
 +---------------------------------------------------------------------------+
 |lag |    LL      LR      df    p      FPE       AIC      HQIC      SBIC    |
 |----+----------------------------------------------------------------------|
 |  0 |  85.8531                        .045222  -.258305  -.255656  -.251474  |
 |  1 |  228.439  285.17    1  0.000   .029387  -.689313  -.684017  -.675652  |
 |  2 |  290.685  124.49    1  0.000   .024389  -.875754  -.867809  -.855262  |
 |  3 |  306.297  31.223    1  0.000   .023328  -.920233  -.909641  -.892911* |
 |  4 |  309.291  5.9889*   1  0.014   .023187* -.926305* -.913064* -.892152  |
 |  5 |  309.644  .70495    1  0.401   .023232  -.924334  -.908445   -.88335  |
 |  6 |   309.68  .07222    1  0.788   .023301    -.9214  -.902863  -.873586  |
 +---------------------------------------------------------------------------+
```

BIC in multivariate models: choice of *p*, *q* in ADL(*p*,*q*)

```
* BIC calculation for ADL, max lags of 6,6
local bicmin = 1e+9
forvalues p = 1/6 {
 forvalues q = 1/6 {
  reg dlemp L(1/`p').dlemp L(1/`q').baa_r10 if tin(1962m1,$tn), r
   sca bic = ln(e(rss)/e(N)) + e(df_m)*ln(e(N))/e(N)
   dis "BIC = " bic
   dis "Adjusted Rsquared = " e(r2_a)
   dis "`q'," bic "," e(r2_a)
   cap drop yhat_adl`p'`q'_62tn demp_adl`p'`q'_62tn
   predict yhat_adl`p'`q'_62tn
   qui gen demp_adl`p'`q'_62tn = payems[_n-1]*(yhat_adl`p'`q'_62tn/100)
   if bic < `bicmin' {
     local bicmin = bic
  local qhat = `q'
  local phat = `p'
   }
 }
}
dis "BIC lengths: p = " `phat' "   q = " `qhat'

BIC lengths: p = 4   q = 3
```

Stability/break analysis: Break at a known date (Chow test)



Break test ("Chow test"): Break in 1986 (middle of sample)?

```
gen d85 = 0
 replace d85 = 1 if tin(1985m1,$tn)
gen d85_dlemp = d85*dlemp
gen d85_baa_r10 = d85*baa_r10
reg dlemp L(1/`phat').dlemp L(1/`qhat').baa_r10 ///
   d85 L(1/`phat').d85_dlemp L(1/`qhat').d85_baa_r10 if tin(1962m1,$tn), r
 testparm d85 L(1/`phat').d85_dlemp L(1/`qhat').d85_baa_r10
```

```
Linear regression                               Number of obs     =        682
                                                F(15, 666)        =      57.98
                                                Prob > F          =     0.0000
                                                R-squared         =     0.5273
                                                Root MSE          =     .14513
```

dlemp	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
dlemp						
L1.	.1693184	.0854578	1.98	0.048	.0015193	.3371175
L2.	.2617734	.0688935	3.80	0.000	.1264987	.3970481
L3.	.1688301	.0590402	2.86	0.004	.0529027	.2847575
L4.	.0949334	.050982	1.86	0.063	-.0051714	.1950382
baa_r10						
L1.	-.1298321	.0625494	-2.08	0.038	-.2526499	-.0070144
L2.	-.0435966	.0785873	-0.55	0.579	-.1979054	.1107122
L3.	.1612217	.0589227	2.74	0.006	.045525	.2769184

```
             |
          d85 |  -.0334429   .0436531    -0.77   0.444    -.1191572    .0522713
   d85_dlemp |
          L1. |   .0724783   .1016227     0.71   0.476    -.1270612    .2720179
          L2. |   .0477644   .0869543     0.55   0.583    -.1229731     .218502
          L3. |  -.0014344   .0782289    -0.02   0.985    -.1550394    .1521706
          L4. |   .0354407   .0694926     0.51   0.610    -.1010102    .1718916
 d85_baa_r10 |
          L1. |   .0161228   .0578198     0.28   0.780    -.0974084    .1296539
          L2. |   .0734735   .0659781     1.11   0.266    -.0560766    .2030236
          L3. |  -.0915837   .0463591    -1.98   0.049    -.1826112   -.0005562
        _cons |   .0821034   .0413868     1.98   0.048      .000839    .1633678
------------------------------------------------------------------------------

. testparm d85 L(1/`phat').d85_dlemp L(1/`qhat').d85_baa_r10

 ( 1)  d85 = 0
 ( 2)  L.d85_dlemp = 0
 ( 3)  L2.d85_dlemp = 0
 ( 4)  L3.d85_dlemp = 0
 ( 5)  L4.d85_dlemp = 0
 ( 6)  L.d85_baa_r10 = 0
 ( 7)  L2.d85_baa_r10 = 0
 ( 8)  L3.d85_baa_r10 = 0

       F(  8,   666) =    1.01
            Prob > F =    0.4256
```

2b. QLR test: Unknown break date (15% trimming):

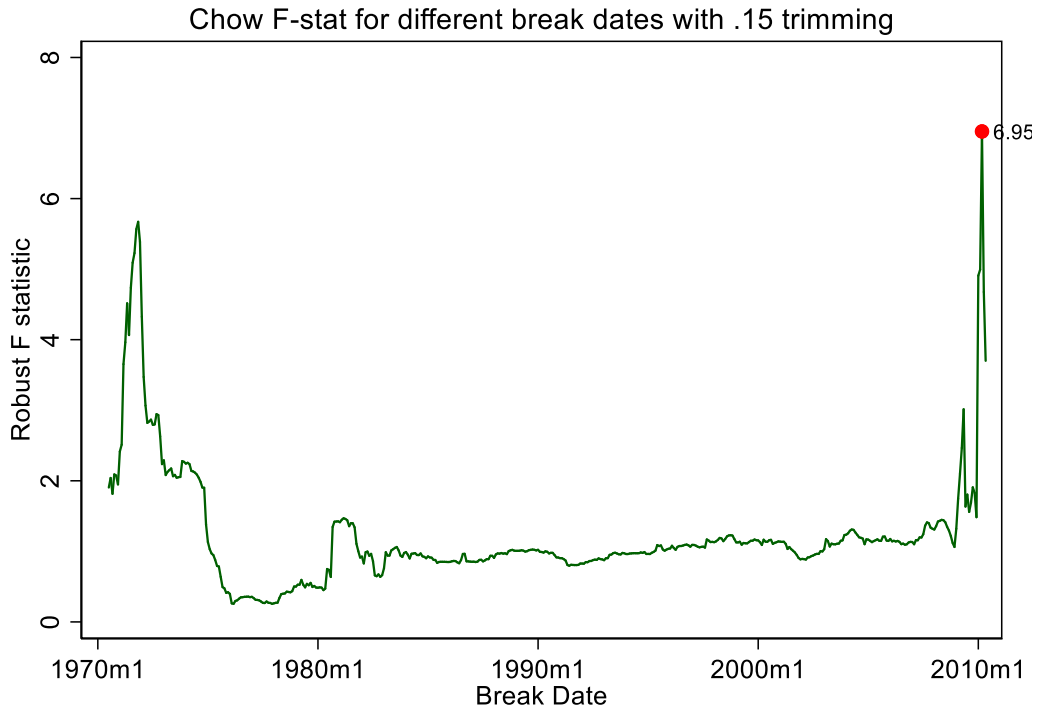
Compute all possible Chow test stats for breaks in central 70% of data and report the largest Chow F-stat.

TABLE 14.6 Critical Values of the QLR Statistic with 15% Trimming

Number of Restrictions (q)	10%	5%	1%
1	7.12	8.68	12.16
2	5.00	5.86	7.78
3	4.09	4.71	6.02
4	3.59	4.09	5.12
5	3.26	3.66	4.53
6	3.02	3.37	4.12
7	2.84	3.15	3.82
8	2.69	2.98	3.57
9	2.58	2.84	3.38
10	2.48	2.71	3.23

These critical values are larger than the $F_{q,\infty}$ critical values – for example, $F_{1,\infty}$ 5% critical value is 3.84.

```
. qlr dlemp L(1/3).dlemp L(1/2).baa_r10 if tin(1962m1,$tn), graph

     +-----------------------------------------+
     |    date           F   restrict   trimming |
     |-----------------------------------------|
  1. |  2010m3     6.95146          8        .15 |
  2. | 1971m11    5.671485          8        .15 |
  3. | 1971m10    5.566554          8        .15 |
  4. | 1971m12     5.38583          8        .15 |
  5. |  1971m9    5.227156          8        .15 |
     +-----------------------------------------+
```

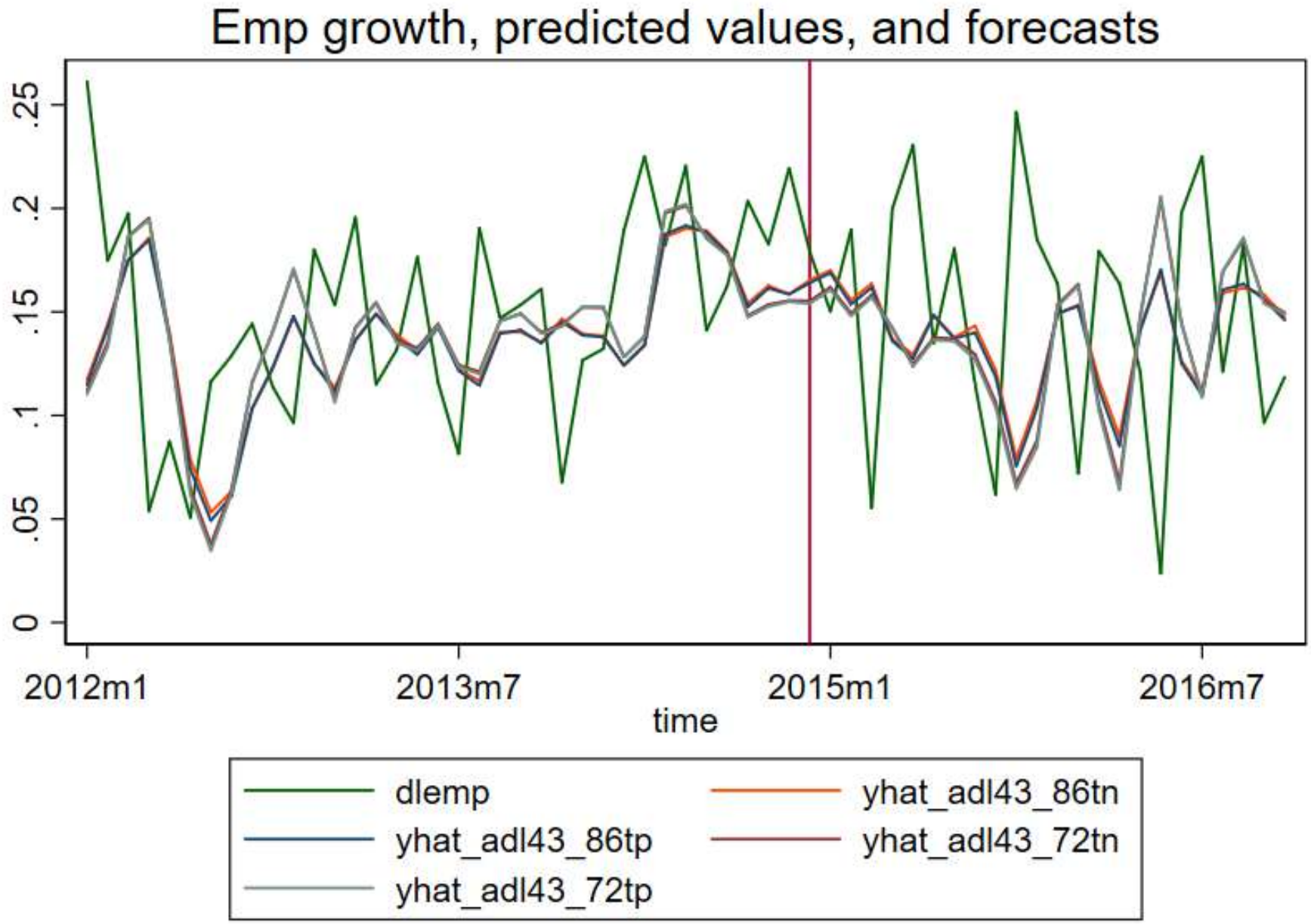


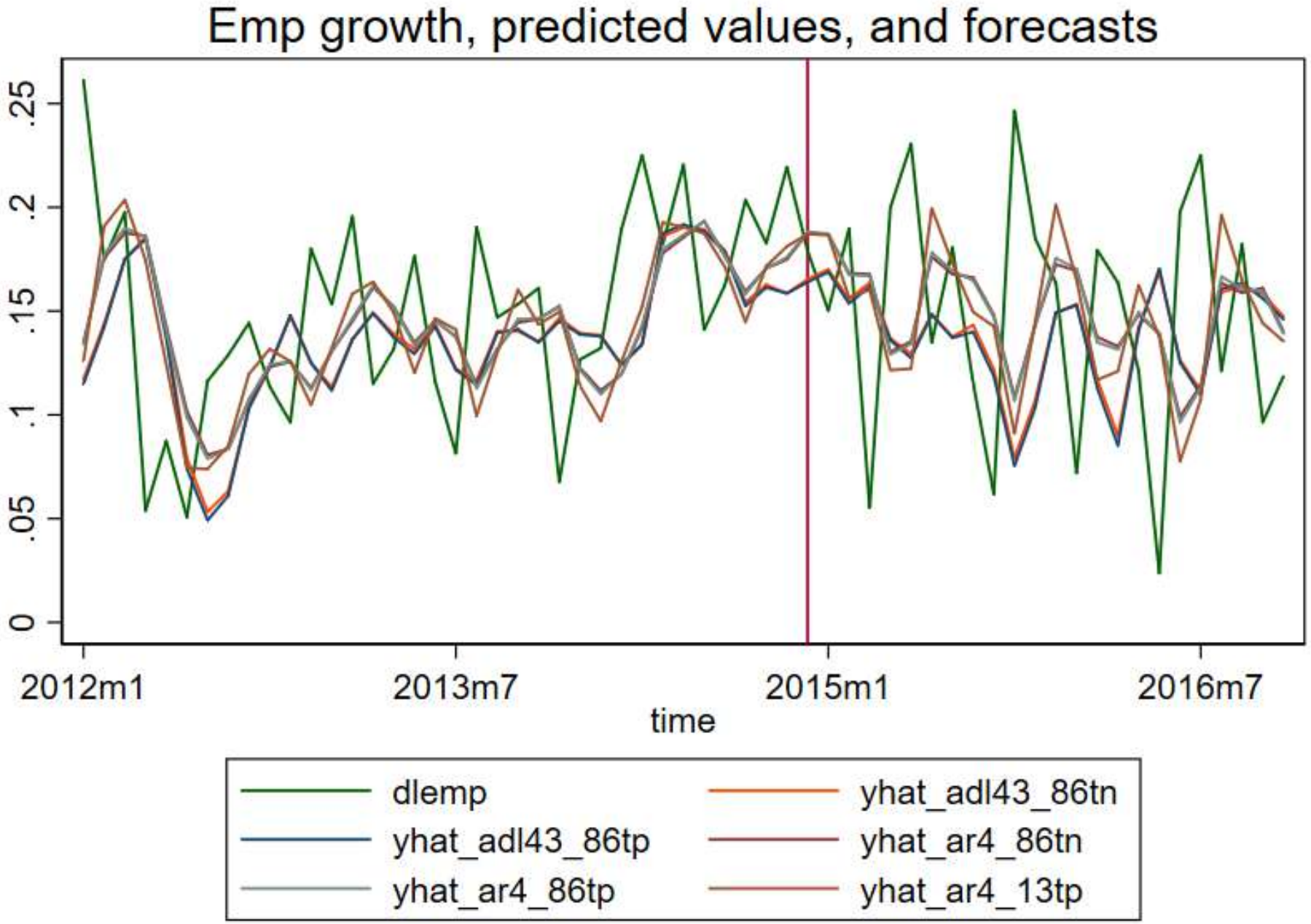
End of sample stability checks:

Estimate through 2014m12, check performance 2015m1 – end

```
. global tp "2012m12"
. reg dlemp L(1/`phat').dlemp L(1/`qhat').baa_r10 if tin(1972m1,$tp), r

Linear regression                               Number of obs     =        516
                                                F(7, 508)         =      87.57
                                                Prob > F          =     0.0000
                                                R-squared         =     0.6061
                                                Root MSE          =      .1337
------------------------------------------------------------------------------
             |               Robust
       dlemp |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       dlemp |
         L1. |   .2368979   .0952696     2.49   0.013      .049727    .4240687
         L2. |    .349425   .0557016     6.27   0.000     .2399911    .4588589
         L3. |   .1584489   .0589444     2.69   0.007     .0426442    .2742537
         L4. |   .0399633   .0457087     0.87   0.382     -.049838    .1297646
             |
     baa_r10 |
         L1. |  -.1438489   .0401305    -3.58   0.000    -.2226911   -.0650066
         L2. |   .0031071   .0612409     0.05   0.960    -.1172096    .1234238
         L3. |   .1250056   .0478669     2.61   0.009     .0309641    .2190471
             |
       _cons |    .062125    .030093     2.06   0.039      .003003    .1212471
------------------------------------------------------------------------------
```

```
* 72 - tn
reg dlemp L(1/`phat').dlemp L(1/`qhat').baa_r10 if tin(1972m1,$tn), r
 predict yhat_adl`phat'`qhat'_72tn
 gen demp_adl`phat'`qhat'_72tn = payems[_n-1]*(yhat_adl`phat'`qhat'_72tn/100)
* 72 - tp
reg dlemp L(1/`phat').dlemp L(1/`qhat').baa_r10 if tin(1972m1,$tp), r
 predict yhat_adl`phat'`qhat'_72tp
 gen demp_adl`phat'`qhat'_72tp = payems[_n-1]*(yhat_adl`phat'`qhat'_72tp/100)
* 86 - tn
reg dlemp L(1/`phat').dlemp L(1/`qhat').baa_r10 if tin(1986m1,$tn), r
 predict yhat_adl`phat'`qhat'_86tn
 gen demp_adl`phat'`qhat'_86tn = payems[_n-1]*(yhat_adl`phat'`qhat'_86tn/100)
* 86 - tp
reg dlemp L(1/`phat').dlemp L(1/`qhat').baa_r10 if tin(1986m1,$tp), r
 predict yhat_adl`phat'`qhat'_86tp
 gen demp_adl`phat'`qhat'_86tp = payems[_n-1]*(yhat_adl`phat'`qhat'_86tp/100)
*
* graph the different in-sample fitted values and POOS forecasts
twoway tsline dlemp yhat_adl`phat'`qhat'_72tn yhat_adl`phat'`qhat'_72tp ///
 yhat_adl`phat'`qhat'_86tn yhat_adl`phat'`qhat'_86tp if tin(2002m1,2016m11), ///
 title("Emp growth, predicted values, and forecasts")
 graph export fig\dlemp_poos.emf, replace
```


Emp growth, predicted values, and forecasts
0
.05
.1
.15
.2
.25
2012m1
2013m7
2015m1
2016m7
time
dlemp
yhat_adl43_86tp
yhat_adl43_72tp
yhat_adl43_86tn
yhat_adl43_72tn


Emp growth, predicted values, and forecasts
0
.05
.1
.15
.2
.25
2012m1
2013m7
2015m1
2016m7
time
dlemp
yhat_adl43_86tp
yhat_ar4_86tp
yhat_adl43_86tn
yhat_ar4_86tn
yhat_ar4_13tp

Check RMSEs: do the in-sample models fit a lot better than the pseudo out-of-sample models? Look at the forecast errors:

Forecast error = actual – predicted

```
gen e_adl`phat'`qhat'_72tn = demp - demp_adl`phat'`qhat'_72tn
gen e_adl`phat'`qhat'_72tn_2 = e_adl`phat'`qhat'_72tn*e_adl`phat'`qhat'_72tn
su e_adl43_72tn_2 e_adl43_72tp_2 e_adl43_86tn_2 e_adl43_86tp_2 if
      tin($tp,$tnp1)
```

Summary statistics for squared forecast error over pseudo out of sample period:

Variable	Obs	Mean	Std. Dev.	Min	Max
e_ar2_13tp_2	47	9591.721	11127.17	.063319	49019.5
e_ar4_72tp_2	47	8377.997	10360.5	2.291895	37608.59
e_adl4~2tp_2	47	10037.8	15410.83	4.214157	68598.75
e_ar4_86tp_2	47	8287.914	10125.43	.0841138	39613.93
e_adl4~6tp_2	47	8806.949	12499.92	.0828002	59371.02
e_ar2_13tn_2	47	9539.629	11077.59	.0032533	48675.44
e_ar4_72tn_2	47	8317.895	10308.77	4.492891	37317.93
e_adl4~2tn_2	47	9847.371	15071.32	11.99753	67430.69
e_ar4_86tn_2	47	8137.385	9991.039	2.592544	38623.08
e_adl4~6tn_2	47	8589.311	12148.67	1.569336	56790.43

Forecast RMSE for 8612 model is sqrt(8138) = 90.2k jobs (!)

How do the forecasts compare?

AR(4) and ADL(4,3) forecasts of the change in employment for Oct and November, 86-18m10, and AR(2), 2013m1-2018m10

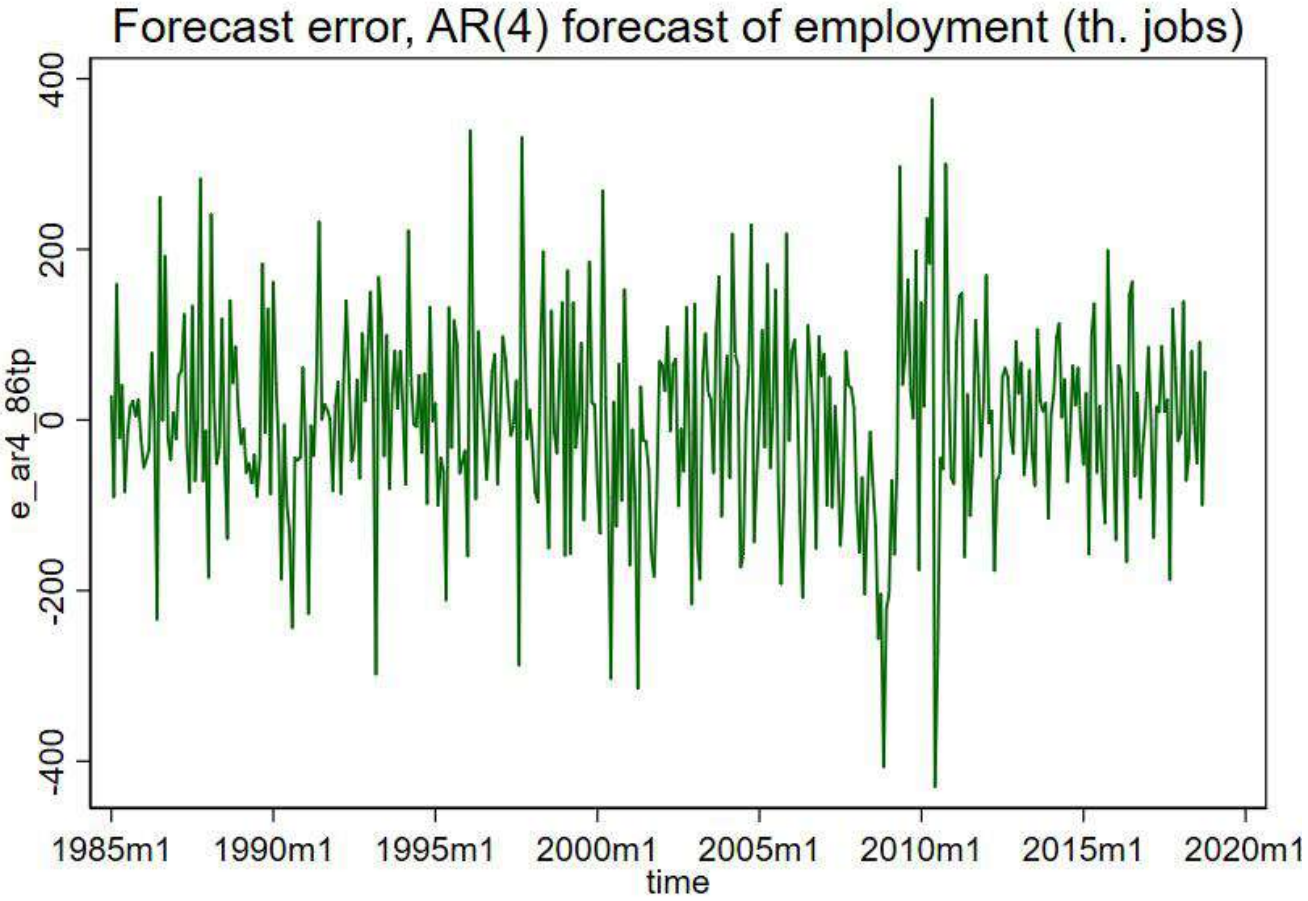
time	baa_r10	demp	d~4_86tn	d~3_86tn	demp~3tn
2018m9	1.88	118	218.02	228.5924	214.4359
2018m10	1.92	250	193.3913	205.5838	198.0245
2018m11	.	.	194.6607	195.5899	178.6618

Units of the forecasts are thousands of jobs, monthly change
November Employment Situation is released 8:30am Dec. 7, 2018

Forecast intervals

Use root mean squared (forecast) error

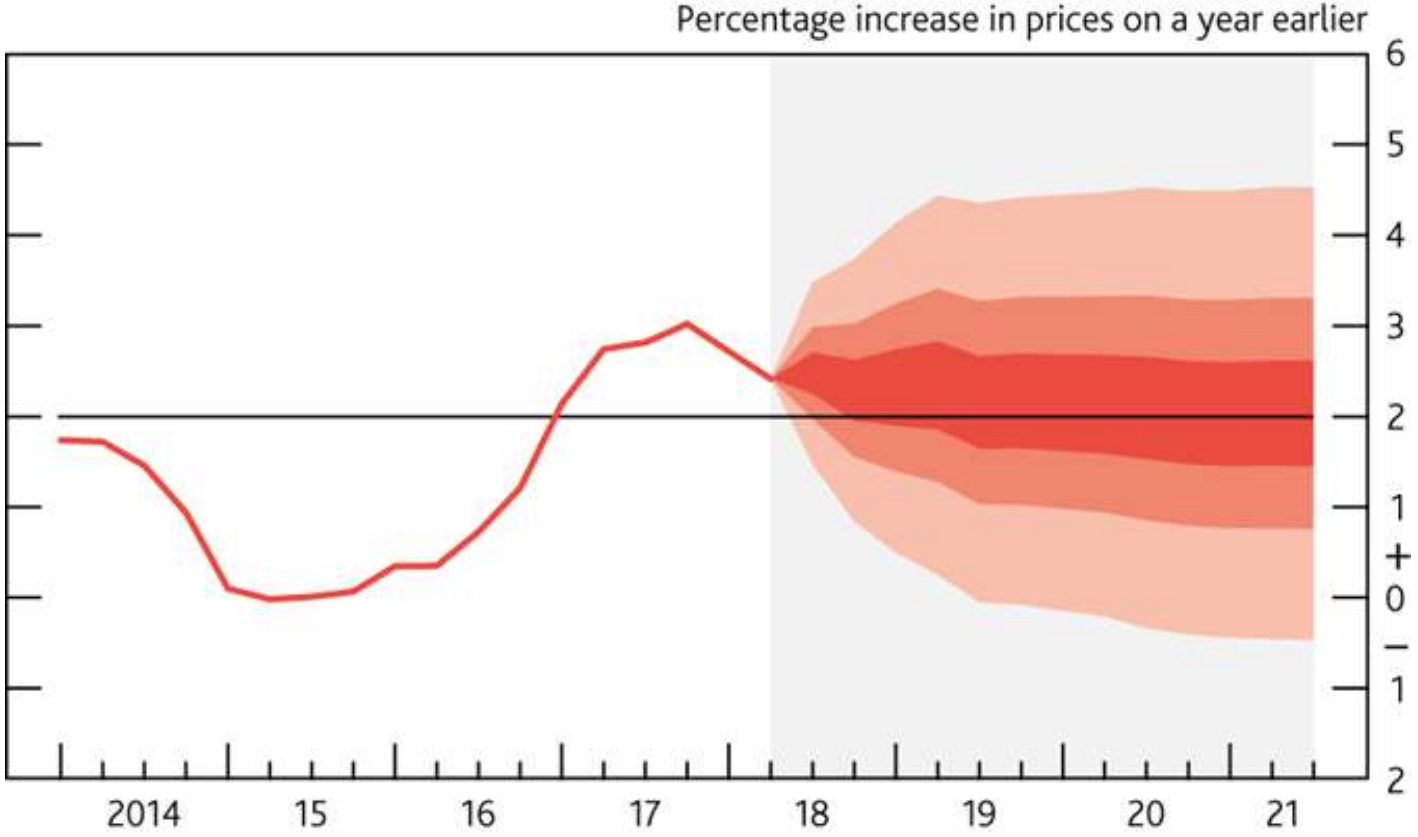
RMSFE = 90.2k over 2015-2018 (POOS estimate)



- 67% forecast interval for Nov 2016 = 195k ± 90k (AR(3) model estimated 1986m1-2018m10)

Forecast distributions:
Bank of England Inflation "Fan Chart", November 2016

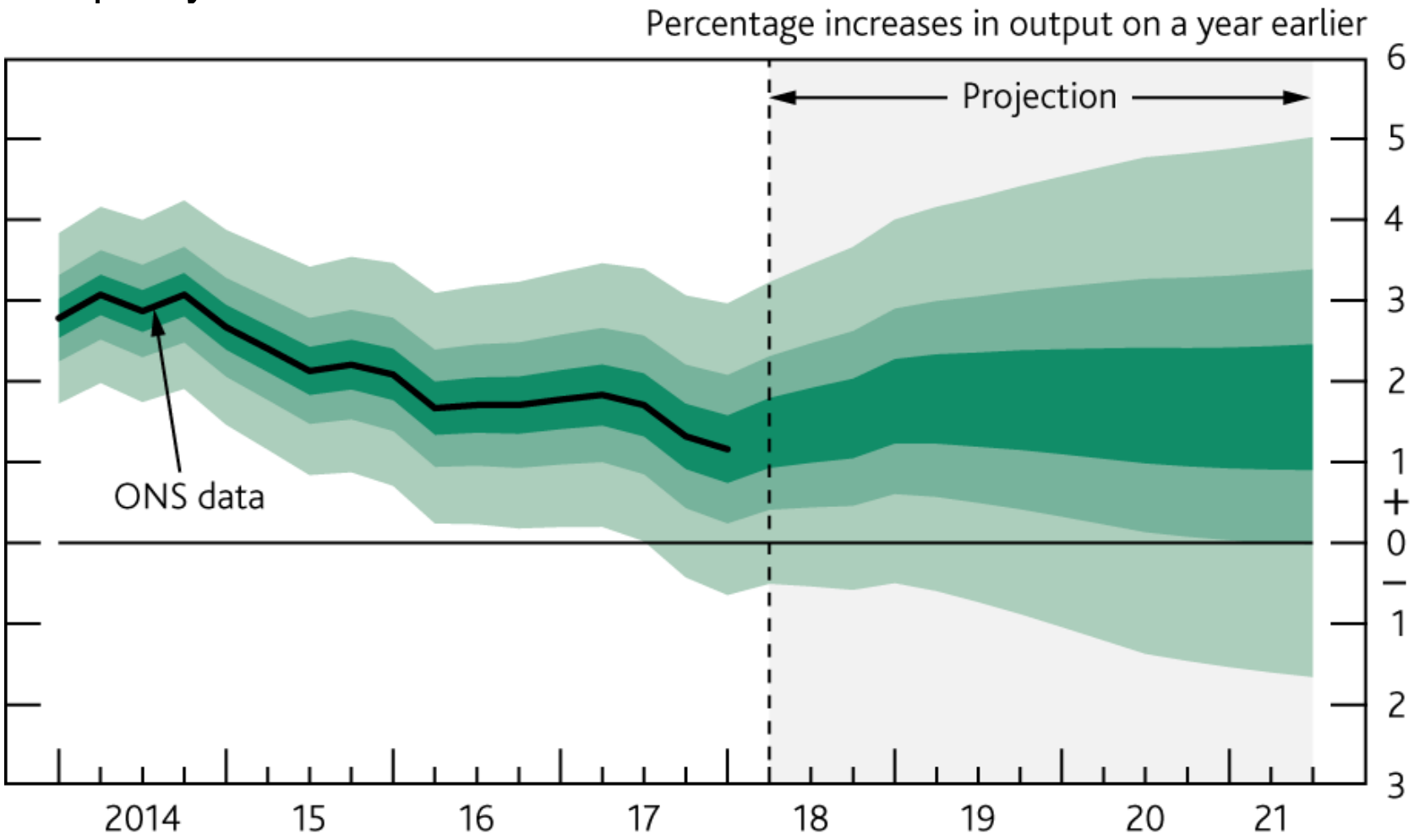
Chart 5.3 CPI inflation projection based on market interest rate expectations, other policy measures as announced



https://www.bankofengland.co.uk/inflation-report/2018/august-2018

Forecast distributions: Bank of England GDP fan chart, 8/2018

Chart 5.1 GDP projection based on market interest rate expectations, other policy measures as announced



STATA code for lectures 21-22

```
chdir c:\courses\e1123\stata\macro
clear
set scheme s1color
cap log close
cap program drop _all
log using e1123_f18_lect_21_22.txt, text replace
set more 1
************************************************************
* e1123_f18_lect_21_22.do
*   Ec1123 TS lectures
************************************************************
*aaa             float  %9.0g                 Moody's Seasoned Aaa Corporate Bond Yield
*ambsl           float  %9.0g                 St. Louis Adjusted Monetary Base
*awhi            float  %9.0g                 Aggregate Weekly Hours Index: Total Private
Industries
*baa             float  %9.0g                 Moody's Seasoned Baa Corporate Bond Yield
*bogambsl        float  %9.0g                 Board of Governors Monetary Base, Adjusted
for Changes in Reserve
*cpiaucns        float  %9.0g                 Consumer Price Index for All Urban
Consumers: All Items - NSA
*cpiaucsl        float  %9.0g                 Consumer Price Index for All Urban
Consumers: All Items - SA
*cpilfens        float  %9.0g                 Consumer Price Index for All Urban
Consumers: All Items Less Food & Energy - NSA
*cpilfesl        float  %9.0g                 Consumer Price Index for All Urban
Consumers: All Items Less Food & Energy - SA
*cpn1m           float  %9.0g                 1-Month AA Nonfinancial Commercial Paper
Rate
*cpn3m           str4   %9s                   3-Month AA Nonfinancial Commercial Paper
Rate
*dspi            float  %9.0g                 Disposable Personal Income - current dollar
```

```
*dspic96        float  %9.0g                 Real Disposable Personal Income
*gs10           float  %9.0g                 10-Year Treasury Constant Maturity Rate
*houst          int    %8.0g                 Housing Starts: Total: New Privately Owned
Housing Units Started
*hsn1f          int    %8.0g                 New One Family Houses Sold: United States
*isratio        float  %9.0g                 Inventory to Sales Ratio: Total Business
*m1sl           float  %9.0g                 M1 Money Stock
*m2sl           float  %9.0g                 M2 Money Stock
*mich           float  %9.0g                 University of Michigan Inflation Expectation
- 1 year
*oilprice       float  %9.0g                 Spot Oil Price: West Texas Intermediate
*payems         long   %12.0g                Total Nonfarm Payrolls: All Employees
*pce            float  %9.0g                 Personal Consumption Expenditures - current
dollar
*pcec96         float  %9.0g                 Real Personal Consumption Expenditures -
chained 20065 dollars
*pcedgc96       float  %9.0g                 Real Personal Consumption Expenditures:
Durable Goods
*pcendc96       float  %9.0g                 Real Personal Consumption Expenditures:
Nondurable Goods
*pcepi          float  %9.0g                 Personal Consumption Expenditures: Chain-
type Price Index
*pcepilfe       float  %9.0g                 Personal Consumption Expenditures: Chain-
Type Price Index Less Food & Energy
*pcesc96        float  %9.0g                 Real Personal Consumption Expenditures:
Services
*pi             float  %9.0g                 Personal Income - current dollars
*psavert        float  %9.0g                 Personal Saving Rate
*tb3ms          float  %9.0g                 3-Month Treasury Bill: Secondary Market Rate
*umcsent        float  %9.0g                 University of Michigan: Consumer Sentiment
*unrate         float  %9.0g                 Civilian Unemployment Rate
*time           float  %tm
*************************************************************
use \macrodata\data\macro_update_m.dta
```

```
tsset time
drop if tin(,1958m12)
desc
global tnm1 "2016m9"
global tn   "2018m10"
global tnp1 "2018m11"
global tp   "2014m12"
*************************************************************
* additional data constructions
*************************************************************
gen ldspi = ln(dspi)
gen dldspi = 1200*D.ldspi
gen lcpi = ln(cpiaucsl)
gen infcpi = 1200*(D.lcpi)
gen infcpi12 = 100*(lcpi - L12.lcpi)
gen r90 = tb3ms
gen r10 = gs10
gen r10_r90 = r10-r90
 replace baa = 4.34 if tin(2016m10,2016m10)
gen baa_r10 = baa-r10
replace houst = houst/1000
gen dhoust = D.houst
gen lindpro = ln(indpro)
gen dlindpro = 100*D.lindpro
gen lemp = ln(payems)
gen dlemp = 100*D.lemp
gen demp = D.payems
* Annual employment growth
gen d12lemp = 100*(lemp-L12.lemp)
*************************************************************
* Time series plots
*************************************************************
*
twoway tsline infcpi, title("Monthly inflation rate, CPI")
```

```
 graph export fig\infcpi.emf, replace
twoway tsline infcpi12, title("12-month inflation rate, CPI")
 graph export fig\infcpi12.emf, replace
twoway tsline payems, title("Payroll employment in U.S. (thousands of workers)")
 graph export fig\empl.emf, replace
twoway tsline lemp, title("Payroll employment, logs")
 graph export fig\lempl.emf, replace
twoway tsline dlemp, title("Payroll employment, monthly % change")
 graph export fig\dlempl.emf, replace
twoway tsline d12lemp, title("Payroll employment: growth over previous 12 months")
 graph export fig\d12lempl.emf, replace
twoway tsline unrate, title("Civilian unemployment rate, U.S.")
 graph export fig\unrate.emf, replace
twoway tsline tb3ms, title("Interest rate on 90-day Treasury bills")
 graph export fig\tb3ms.emf, replace
twoway tsline gs10, title("Yield on 10-year Treasury bonds")
 graph export fig\gs10.emf, replace
twoway tsline baa, title("Moody's Seasoned Baa Corporate Bond Yield")
 graph export fig\baa.emf, replace
twoway tsline baa r10 baa_r10, title("Baa bonds, 10-yr Tbond rates, & spread")
 graph export fig\baa_r10.emf,replace
twoway tsline dlemp baa_r10, title("Employment growth and BAA-Tbond spread")
 graph export fig\dlemp_baar10.emf,replace
twoway (tsline dlemp) (tsline baa_r10, yaxis(2)) if tin(1960m1,$tnp1), ///
 title("Employment growth and BAA-Tbond spread")
 graph export fig\dlemp_baar10_6015.emf,replace
twoway (tsline dlemp) (tsline baa_r10, yaxis(2)) if tin(2005m1, $tnp1), ///
 title("Employment growth and BAA-Tbond spread")
 graph export fig\dlemp_baar10_0515.emf,replace
twoway (tsline dlemp) (tsline houst, yaxis(2)) if tin(1960m1,$tnp1), ///
 title("Employment growth and Housing Starts")
 graph export fig\dlemp_houst_6015.emf,replace
twoway (tsline dlemp) (tsline houst, yaxis(2)) if tin(2005m1, $tnp1), ///
 title("Employment growth and Housing Starts")
```

```
*
*************************************************************
* autocorrelations
*************************************************************
*
corrgram unrate
corrgram dlemp
list time payems demp lemp dlemp if tin(2018m1,$tn)
su demp if tin(2011q1,$tn)
gen demp_mn = r(mean)
tsline demp demp_mn if tin(2011q1,$tn), ///
 title("Monthly change in employment (th. jobs)") legend(off) ttitle("")
*
*************************************************************
* AR(1) - AR(6) models of employment growth
*************************************************************
*
reg dlemp if tin(1962m1,$tnm1), r
  sca bic = ln(e(rss)/e(N)) + e(df_m)*ln(e(N))/e(N)
  dis "BIC = " bic
  dis "Adjusted Rsquared = " e(r2_a)
  dis 0 "," bic "," e(r2_a)
 predict yhat_ar0_62tn
forvalues p = 1/6 {
 reg dlemp L(1/`p').dlemp if tin(1962m1,$tnm1), r
   sca bic = ln(e(rss)/e(N)) + `p'*e(df_m)*ln(e(N))/e(N)
   dis "BIC = " bic
   dis "Adjusted Rsquared = " e(r2_a)
   dis `p' "," bic "," e(r2_a)
  predict yhat_ar`p'_62tn
  qui gen demp_ar`p'_62tn = payems[_n-1]*(yhat_ar`p'_62tn/100)
  testparm L(1/`p').dlemp
  if `p'>1 {
   testparm L(2/`p').dlemp
```

```
  }
}
*
* simpler command to produce BIC
varsoc dlemp if tin(1962m1,$tnm1), maxlag(6)*
list time payems demp dlemp yhat_ar1_62tn if tin(2015m1,$tnp1), noobs
*
*************************************************************
* ADL(1,1) and ADL(4,4) models using Baa-10 year T-bond spread
* including Granger Causality test (4 lags)
*************************************************************
*
reg dlemp L1.dlemp L1.baa_r10 if tin(1962m1,$tnm1), r
 dis "Adjusted Rsquared = " e(r2_a)
reg dlemp L(1/4).dlemp L(1/4).baa_r10 if tin(1962m1,$tn), r
 dis "Adjusted Rsquared = " e(r2_a)
 cap drop yhat_adl44_62tn
 predict yhat_adl44_62tn
 testparm L(1/4).baa_r10
 testparm L(2/4).baa_r10
 testparm L(2/4).dlemp
*
gen demp_adl44_62tn = payems[_n-1]*(yhat_adl44_62tn/100)
 list time demp demp_ar1_62tn demp_ar2_62tn demp_adl44_62tn if tin(2016m1,$tnp1), noobs
*
*************************************************************
* ADL(p,q) models using Baa-10 year T-bond spread, p = 1,..., 6, q = 1,..., 6
*************************************************************
*
reg dlemp L(1/3).dlemp if tin(1962m1,$tn), r
 dis "BIC = " ln(e(rss)/e(N)) + e(df_m)*ln(e(N))/e(N)
 dis "Adjusted Rsquared = " e(r2_a)
local bicmin = 1e+9
forvalues p = 1/6 {
```

```
 forvalues q = 1/6 {
  reg dlemp L(1/`p').dlemp L(1/`q').baa_r10 if tin(1962m1,$tn), r
   sca bic = ln(e(rss)/e(N)) + e(df_m)*ln(e(N))/e(N)
   dis "BIC = " bic
   dis "Adjusted Rsquared = " e(r2_a)
   dis "`q'," bic "," e(r2_a)
   cap drop yhat_adl`p'`q'_62tn demp_adl`p'`q'_62tn
   predict yhat_adl`p'`q'_62tn
   qui gen demp_adl`p'`q'_62tn = payems[_n-1]*(yhat_adl`p'`q'_62tn/100)
   if bic < `bicmin' {
     local bicmin = bic

local qhat = `q'

local phat = `p'
   }
 }
}
dis "BIC lengths: p = " `phat' "   q = " `qhat'
*
************************************************************
* In-sample predicted values
************************************************************
*
list time dlemp yhat_ar1_62tn yhat_ar4_62tn yhat_adl44_62tn if tin(2016m1,$tn), noobs
list time demp demp_ar1_62tn demp_ar2_62tn demp_adl44_62tn demp_adl`phat'`qhat'_62tn if
tin(2016m1,$tn), noobs
*
************************************************************
* Stability analysis: Chow test for break mid sample (1986)
************************************************************
reg dlemp L(1/`phat').dlemp L(1/`qhat').baa_r10 if tin(1962m1,1985m12), r
reg dlemp L(1/`phat').dlemp L(1/`qhat').baa_r10 if tin(1986m1,$tn), r
*
```

```
gen d85 = 0
 replace d85 = 1 if tin(1985m1,$tn)
gen d85_dlemp = d85*dlemp
gen d85_baa_r10 = d85*baa_r10
reg dlemp L(1/`phat').dlemp L(1/`qhat').baa_r10 ///
   d85 L(1/`phat').d85_dlemp L(1/`qhat').d85_baa_r10 if tin(1962m1,$tn), r
 testparm d85 L(1/`phat').d85_dlemp L(1/`qhat').d85_baa_r10
*
*************************************************************
* Stability analysis: QLR test (note: the QLR test is slow)
*************************************************************
*
qlr dlemp L(1/`phat').dlemp L(1/`qhat').baa_r10 if tin(1962m1,$tn), graph
  graph export fig\qlr_adl`phat'`qhat'_sprd_62_2015.png,replace
*
*************************************************************
* end-of-sample Pseudo out-of-sample performance, 2013-end
*************************************************************
global tp "2014m12"
* 72 - tn
reg dlemp L(1/`phat').dlemp if tin(1972m1,$tn), r
 predict yhat_ar`phat'_72tn
 gen demp_ar`phat'_72tn = payems[_n-1]*(yhat_ar`phat'_72tn/100)
reg dlemp L(1/`phat').dlemp L(1/`qhat').baa_r10 if tin(1972m1,$tn), r
 predict yhat_adl`phat'`qhat'_72tn
 gen demp_adl`phat'`qhat'_72tn = payems[_n-1]*(yhat_adl`phat'`qhat'_72tn/100)
* 72 - tp
reg dlemp L(1/`phat').dlemp if tin(1972m1,$tp), r
 predict yhat_ar`phat'_72tp
 gen demp_ar`phat'_72tp = payems[_n-1]*(yhat_ar`phat'_72tp/100)
reg dlemp L(1/`phat').dlemp L(1/`qhat').baa_r10 if tin(1972m1,$tp), r
 predict yhat_adl`phat'`qhat'_72tp
 gen demp_adl`phat'`qhat'_72tp = payems[_n-1]*(yhat_adl`phat'`qhat'_72tp/100)
* 86 - tn
```

```
reg dlemp L(1/`phat').dlemp if tin(1986m1,$tn), r
 predict yhat_ar`phat'_86tn
 gen demp_ar`phat'_86tn = payems[_n-1]*(yhat_ar`phat'_86tn/100)
reg dlemp L(1/`phat').dlemp L(1/`qhat').baa_r10 if tin(1986m1,$tn), r
 predict yhat_adl`phat'`qhat'_86tn
 gen demp_adl`phat'`qhat'_86tn = payems[_n-1]*(yhat_adl`phat'`qhat'_86tn/100)
* 86 - tp
reg dlemp L(1/`phat').dlemp if tin(1986m1,$tp), r
 predict yhat_ar`phat'_86tp
 gen demp_ar`phat'_86tp = payems[_n-1]*(yhat_ar`phat'_86tp/100)
reg dlemp L(1/`phat').dlemp L(1/`qhat').baa_r10 if tin(1986m1,$tp), r
 predict yhat_adl`phat'`qhat'_86tp
 gen demp_adl`phat'`qhat'_86tp = payems[_n-1]*(yhat_adl`phat'`qhat'_86tp/100)
*
* 2013 - AR(2)
reg dlemp L(1/2).dlemp if tin(1986m1,$tp), r
 predict yhat_ar2_13tp
 gen demp_ar2_13tp = payems[_n-1]*(yhat_ar2_13tp/100)
reg dlemp L(1/2).dlemp if tin(1986m1,$tn), r
 predict yhat_ar2_13tn
 gen demp_ar2_13tn = payems[_n-1]*(yhat_ar2_13tn/100)

* graph the different in-sample fitted values and POOS forecasts
label var yhat_ar`phat'_72tn "yhat_ar`phat'_72tn"
label var yhat_ar`phat'_72tp "yhat_ar`phat'_72tp"
label var yhat_ar`phat'_86tn "yhat_ar`phat'_86tn"
label var yhat_ar`phat'_86tp "yhat_ar`phat'_86tp"
label var yhat_ar2_13tn "yhat_ar`phat'_13tn"
label var yhat_ar2_13tp "yhat_ar`phat'_13tp"
label var yhat_adl`phat'`qhat'_72tn "yhat_adl`phat'`qhat'_72tn"
label var yhat_adl`phat'`qhat'_72tp "yhat_adl`phat'`qhat'_72tp"
label var yhat_adl`phat'`qhat'_86tn "yhat_adl`phat'`qhat'_86tn"
label var yhat_adl`phat'`qhat'_86tp "yhat_adl`phat'`qhat'_86tp"
twoway tsline dlemp yhat_adl`phat'`qhat'_86tn yhat_adl`phat'`qhat'_86tp ///
```

```
 yhat_adl`phat'`qhat'_72tn yhat_adl`phat'`qhat'_72tp if tin(2012m1,2016m11), ///
 title("Emp growth, predicted values, and forecasts") tline($tp)
 graph export fig\dlemp_poos_adl.png, replace
twoway tsline dlemp yhat_adl`phat'`qhat'_86tn yhat_adl`phat'`qhat'_86tp ///
                    yhat_ar`phat'_86tn yhat_ar`phat'_86tp yhat_ar2_13tp if
tin(2012m1,2016m11), ///
 title("Emp growth, predicted values, and forecasts") tline($tp)
 graph export fig\dlemp_poos_ar_adl.png, replace
*
* compare forecast errors over the POOS period
*
global vlist ""
foreach nn in "tp" "tn" {
 gen e_ar2_13`nn' = demp - demp_ar2_13`nn'
 gen e_ar2_13`nn'_2 = e_ar2_13`nn'*e_ar2_13`nn'
 global vlist "$vlist  e_ar2_13`nn'_2"
 foreach tt in "72" "86" {
   gen e_ar`phat'_`tt'`nn' = demp - demp_ar`phat'_`tt'`nn'
   gen e_ar`phat'_`tt'`nn'_2 = e_ar`phat'_`tt'`nn'*e_ar`phat'_`tt'`nn'
   gen e_adl`phat'`qhat'_`tt'`nn' = demp - demp_adl`phat'`qhat'_`tt'`nn'
   gen e_adl`phat'`qhat'_`tt'`nn'_2 = e_adl`phat'`qhat'_`tt'`nn'*e_adl`phat'`qhat'_`tt'`nn'
   global vlist "$vlist  e_ar`phat'_`tt'`nn'_2 e_adl`phat'`qhat'_`tt'`nn'_2"
 }
}
su $vlist if tin($tp,$tnp1)
*
************************************************
* Forecasts and forecast interval
************************************************
su e_ar`phat'_86tp_2 if tin($tp,$tn)
dis "POOS RMSE = " sqrt(r(mean))
*
tsline e_ar`phat'_86tp if tin(1985m1,2018m12), ///
 title("Forecast error, AR(4) forecast of employment (th. jobs)")
```

```
 graph export fig\e_ar`phat'_86tp.png, replace
*
* forecasts for November
list time baa_r10 demp demp_ar`phat'_86tn demp_adl`phat'`qhat'_86tn demp_ar2_13tn if
tin(2018m1,2018m11), noobs
*
**********************
log close
```